APEC Low Carbon Model Town (LCMT) Project Dissemination Phase 3

FINAL REPORT

APEC Energy Working Group

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Executive Summary

1. What is the APEC LCMT Project Dissemination

The APEC Low-Carbon Model Town (LCMT) Project Dissemination Phase 1, which succeeds LCMT Project Phases 1-7, seeks to accelerate the dissemination of low-carbon towns in order to manage rapidly growing energy consumption in the APEC region.

The key activities are: 1) to hold the 2nd LCMT Symposium for the dissemination of the “Concept of the Low-Carbon Town in the APEC Region (Concept)” through utilizing APEC Low-Carbon Town Indicator (LCT-I) System; and 2) to conduct Feasibility Studies for a specific area of three towns participated as the LCT-I volunteer towns in the 1st LCMT Symposium in the LCMT Project Phase 7. The nominations of the LCT-I volunteer towns are on a voluntary basis and three LCT-I volunteer towns are planned to be selected through the EWG.

The key objectives of the project are:

1) To disseminate the basic ideas and effective approaches of the Concept through utilizing the LCT-I System, which helps evaluate the progress and status of low-carbon development of various areas in the APEC region;

2) To provide Feasibility Studies of a specified area of low-carbon development projects selected as the LCT-I volunteer towns in the LCMT Project Phase 7 and identify how to improve the low-carbon development plans through the Feasibility Studies; and

3) To share best practices and real-world experiences of low-carbon town design with planners and policymakers throughout the APEC region.

Source: APEC Homepage

2. Scope of work

This project will be undertaken according to the following procedure.

Prepare Low-Carbon Development (LCD) Strategy for the three volunteer towns’ Low-Carbon Town development projects.

1. Background research and data collection
2. Develop a high-level Low-carbon vision
3. Define the CO2 emission baseline as BAU (Business As Usual) scenario
4. Define comprehensive, specific and feasible Low-carbon measures

Analyze CO2 emission reduction and costs for selected design measures

5. Perform scenario analysis of implementation alternatives and analyze CO2 reduction efficiency

Study the implementation methodology and action plans of proposed CO2 reduction measures

6. Identify regulatory agencies and approval process and develop the business model required for Low-carbon methodologies in three volunteer towns
7. Governance Development
8. Analysis financial efficiency of Low-carbon business model in three volunteer towns

3. Overview of three volunteer towns

As shown in the figure below, this project will conduct Feasibility Study for three volunteer town in La Molina District, Peru and Khon Kaen Municipality, Thailand and Phu Quoc District, Viet Nam.

Fig. 0-1. Location of Three Volunteer Town
Source: Project Team (NSRI)

3-1. La Molina District, Peru

Lima is the capital of the Republic of Peru. It is the center of politics, culture, finance, commerce and industry, with a population of about 10 million and 43 districts.

La Molina is a district of the Lima Province in Peru. It is located, geographically, in a boundary area, between what constitutes the upper part of the Chala region and the lower part of the Yunga region, which is between Chala Hanan and Yunga Hurin.

Officially, the district is established on February 6, 1962. The district has a total land area of 65.75 km². Its administrative center is located 241 m above sea level. The district has been divided into 7 sectors for better administration in the municipal service.

Fig. 0-2. Location of La Molina District

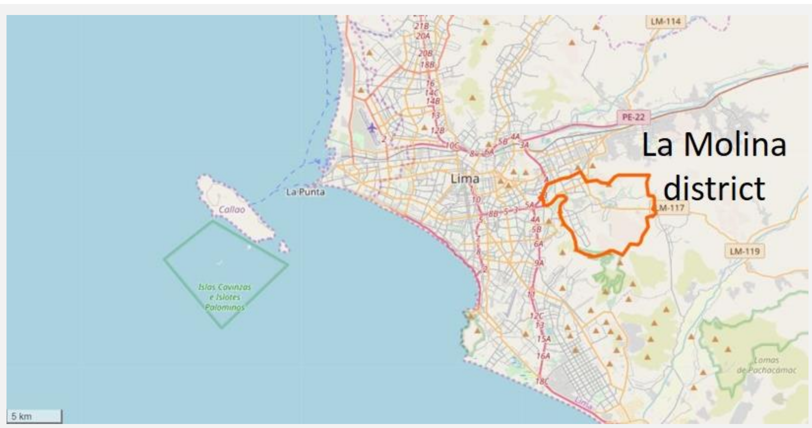


Fig. 0-3. Location of La Molina District
Source: Open Street Map

According to the 2018 census by the INEI, the district has 183,930 inhabitants, a population density of 2139,6 person/km². The population in the La Molina district increase from 2009 to 2018 by around 3.0% each year.

The estimation of future population and population density in the Lima-Callao metropolitan area. The population of the La Molina area in 2030 is about 240,000 and is expected to increase 1.2 times in 10 years.

Table. 0-1. Future Population projection, 2012-2030

Area	District Name	Area (ha)	2012		2020		2030	
			Population	Population Density	Population	Population Density	Population	Population Density
East Lima	Ate	7,772	573,948	73.8	720,347	92.7	897,166	115.4
	Chaclacayo	3,950	43,180	10.9	44,417	11.2	45,897	11.6
	El Agustino	1,254	189,924	151.5	196,726	156.9	205,050	163.5
	La Molina	6,575	157,638	24.0	194,308	29.6	238,757	36.3
	Lurigancho	23,647	201,248	8.5	247,707	10.5	304,039	12.9
	San Juan de Lurigancho	13,125	1,025,929	78.2	1,206,300	91.9	1,426,300	108.7
	Santa Anita	1,069	213,561	199.8	253,639	237.3	302,521	283.0

Source: DATA COLLECTION SURVEY ON URBAN TRANSPORT FOR LIMA AND CALLAO METROPOLITAN AREA FINAL REPORT（JICA, 2013）

The climate of the La Molina district is generally mild. This is a subtropical desert, with a warm season from December to April and a cool, humid and cloudy season from June to October, with May and November as transitional months.

During winter, from June to September, the sky is almost always cloudy, and there is a kind of mist, the garúa, which can deposit a bit of moisture on the ground. Temperatures are mild, but the lack of sunshine and high air humidity increase the feeling of cold, also because houses are not heated. Thermal inversion favors the accumulation of pollutants on the ground, despite the proximity to the sea.

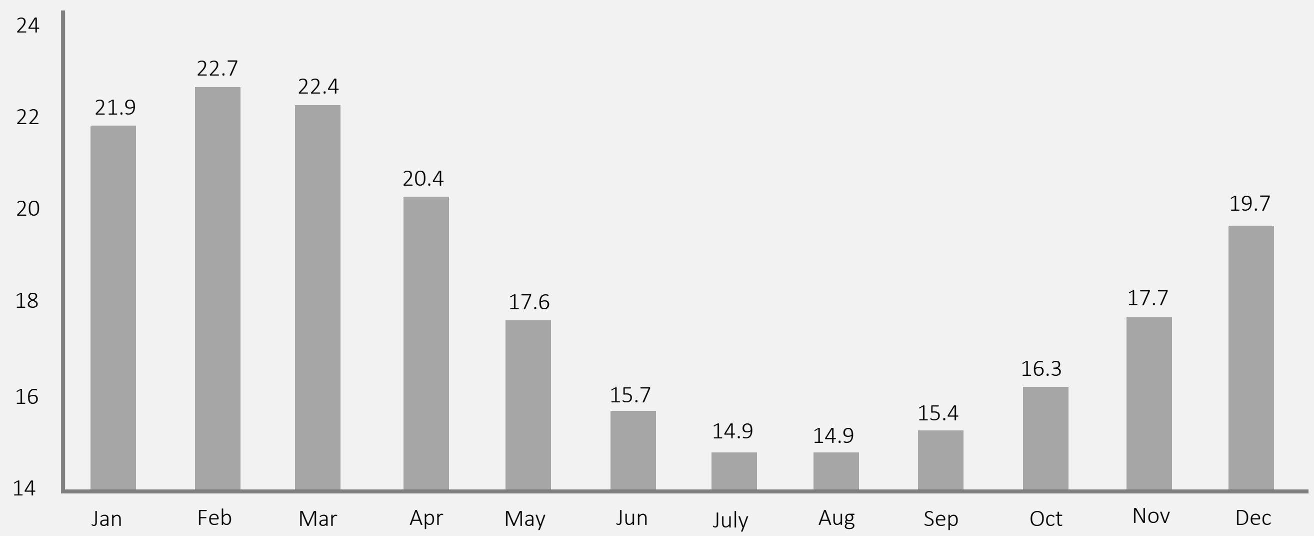


Fig. 0-4. Future Population projection, 2012-2030

Source: DATA COLLECTION SURVEY ON URBAN TRANSPORT FOR LIMA AND CALLAO METROPOLITAN AREA FINAL REPORT（JICA, 2013）

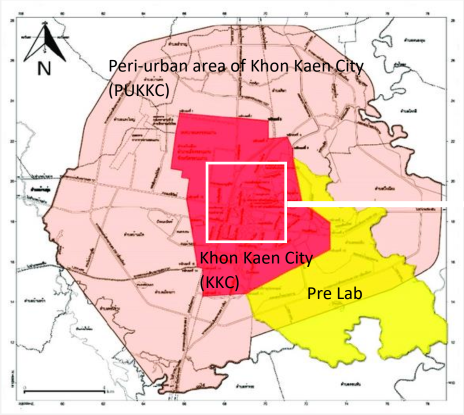
3-2. *Khon Kaen Municipality, Thailand*

Khon Kaen Municipality is the largest city of Khon Kaen province located in the northeastern part of Thailand. The location of the Municipality is approximately 450 km northeast of Bangkok. Neighbouring provinces of Khon Kaen from the north-clockwise direction are Nongbualampoo, Udornthani, Kalasin, Mahasarakham, Buriram, Nakornratchasima, Chaiyapoom, and Petchchaboon provinces. Access from other cities such as Bangkok is convenient via road, rail, and air.

Khon Kaen is divided into 26 districts (called Amphoe) as demonstrated. The district is subdivided into 199 sub-districts (called Tambon) and 2,331 villages.

The Municipality has a total land area (targets are) of 45.21 km². Khon Kaen Province has a total area of 10,886 km².

Fig. 0-5. Location of Khon Kaen city Municipality



Land Area: 953.4 km²

Fig. 0-6. Location of Khon Kaen Province
Source: Research Gate

Land Area: 45.21 km²

Fig. 0-7. Location of Khon Kaen Municipality
Source: Google map

The population is currently decreasing year by year, but the number of households is increasing year by year, contrary to the population, and it is thought that the number of one- or two-person households is increasing.

Moreover, according to the "UN's Forecast population projection", in Thailand, after the peak in 2030, the population is projected to decline, and the population in Khon Kaen is expected to continue declining even more than current.

Table. 0-2. Current Population, 2017-2020

		2017	2018	2019	2020
Khon Kaen Municipality	Population	119,265	118,080	114,459	111,607
	Household	52,820	53,185	53,397	53,505

Source: Project Team (BMC)

Table. 0-3. Forecast Population projection, 2020-2050 unite: Thousand

		2020	2025	2030	2035	2040	2045	2050
Thailand	Population	69,800	70,329	70,346	69,899	69,008	67,672	65,940

Source: World Population Prospects 2019, Medium fertility variant, United Nation

Khon Kaen has a tropical savanna climate (Köppen climate classification Aw). Winters are dry and very warm, and summers are very hot. The hottest month is April with a monthly average temperature of about 30.0 °C. The monsoon season is from May to

October with heavy rain. The average annual rainfall is about 1,214 millimeters. Recently, due to global climate change, dry seasons have become longer and more intense. Heavy rainfall occurs more frequently and causes flooding (Marks, 2019).

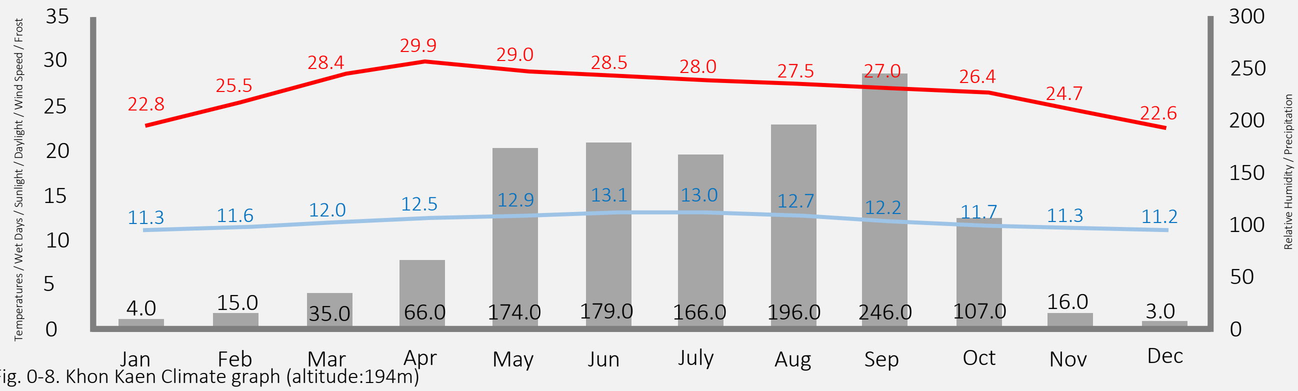


Fig. 0-8. Khon Kaen Climate graph (altitude:194m)
Source: ClimaTemps

3-3. Phu Quoc District, Viet Nam

Phú Quốc Island in the Mekong Delta province of Kiên Giang is pouring more investment in tourism and transport infrastructure to become a driving force for development in the region.

Economic development and urbanisation in recent years are striking on Phú Quốc, an island of scenic beauty referred to as the “Emerald Island”, with provision of an international airport and progress in urban development as a resort island. The largest of Viet Nam is about 589 km2 in the Gulf of Thailand. The An Thới islands extend south of the island. The Phú Quốc District, made up of Phú Quốc and nearby islands, is part of Kiên Giang Province.

Fig. 0-9. Location of Kien Gian Province

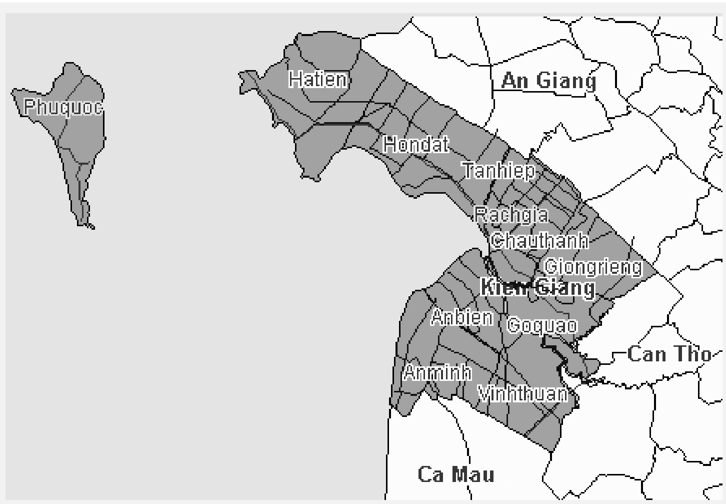


Fig. 0-10. Map of Khon Kaen Province
Source: Viet Nam Beach Tour

Fig. 0-11. Map of Phu Quoc District (Island)
Source: dulichadaophuquoc.org

Phu Quoc is in middle of the Gulf of Thailand. It consists of 28 islands with a total area of 589 km2. The island runs nearly 50 kilometers north to south and 27 kilometers east to west, with a population of over 146,000, population density of 247 persons per km2 with nearly 76,000 of urban residents (GSO, 2019). Its largest town is Dương Đông, located in the northwest of the island.

The population in Viet Nam is projected to continue to grow, and the population in Phu Quoc is expected to continue to grow too.

The island is said to have 99 mountains and hills, with geographical features of all shapes and sizes, including magnificent mountains, and the Cua Can and Duong Dong rivers that flow from their sources in the northeast into the sea. Known as the last paradise, the island boasts rich vegetation and beautiful beaches such as Long Beach (Truong Beach) and Sao Beach, some of the very few places in Viet Nam where the sunset can be seen over the sea both west and east coasts.

Table. 0-4. Forecast Population projection, 2020-2050 unite: Thousand

		2020	2025	2030	2035	2040	2045	2050
Viet Nam	Population	97,339	101,107	104,164	106,296	107,795	108,901	109,605

Source: World Population Prospects 2019, Medium fertility variant, United Nation

With a tropical monsoon climate, the island's average annual precipitation is 2,879 mm. Phu Quoc weather changes throughout the year, rainy season on Phu Quoc Island falls between July and September. Expect heavy rainfall in the late afternoon. Its average monthly rainfall ranges between 190mm and 361mm.

The average temperature is 27 ℃. January is the month with the coldest seawater, with an average sea temperature of 27℃ . Water temperature between 25℃ and 29℃ is regarded as very warm.

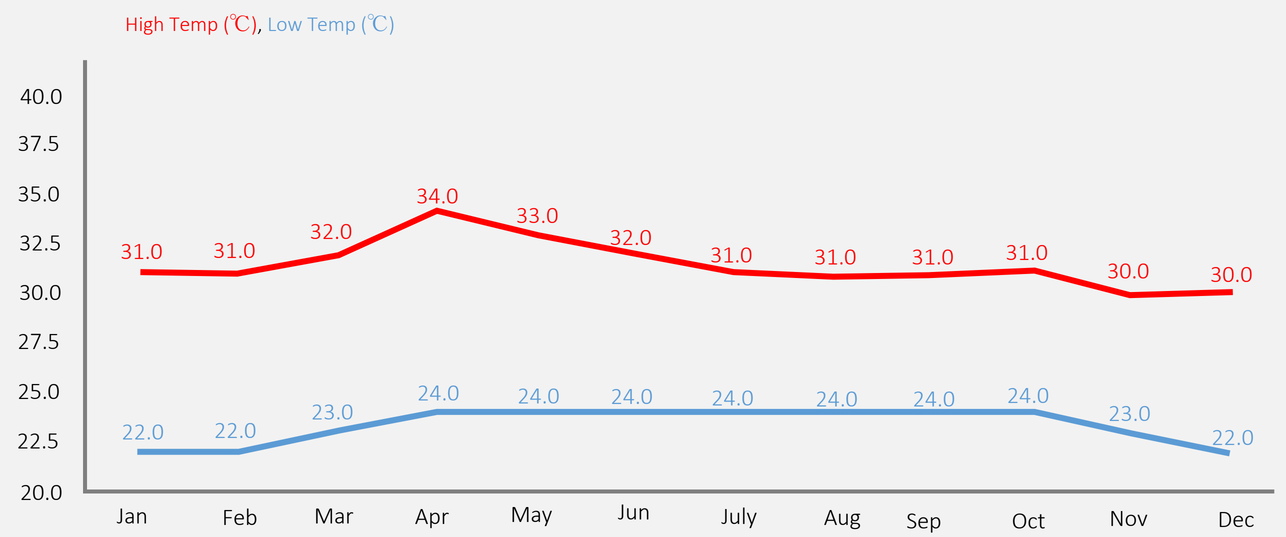


Fig. 0-12. Temperature Phu Quoc, Viet Nam
Source: Project Team (IRSD)

4. Principles and Methodologies of Feasibility Study

4-1. Background research and define baseline in BAU scenario

The background and data collection for low carbon decision in environment aspect includes the factors that affect town energy consumption and carbon emission both in demand-side and supply-side.

(1) Factors in supply-side

The factors in supply side refers to the current situation of energy supply, energy resource structure and related town infrastructure. Generally, the existing condition analysis is based on the town data.

(2) Factors in demand-side

The factors in demand-side include economic condition, lifestyle and existing building conditions and energy system. The survey covers the following items:

Table. 0-5. The survey items for energy and environment

Related factors	Survey items
Economics	GDP. Income
Lifestyle	Non-residential: ▪ Working time, energy system operation schedule Residential: ▪ Daily Lifestyle
Building condition	Non-residential ▪ Existing Energy Conservation efforts ▪ Energy consumption condition Residential ▪ Building condition and usual layout ▪ End-use energy consumption ▪ Indoor thermal comfort
Building energy system	Non-residential ▪ Heat resource ▪ Main building energy system and facilities Residential ▪ The appliance in residential for high-income, middle income and Low income ▪ The general schedule for electronic appliance

Source: Project Team (NSRI)

4-2. Develop a high-level low-carbon vision

The study conducted by Project teams suggests that all the 3 volunteer towns have been selected as the pilot projects in their economies and have already implemented low carbon measurements in their development.

This study will develop based on the existing low carbon initiatives, but also take advantage of NSRI's experiences.

The basic concepts for 3 volunteer towns are including:

1) Environmental, social and economic aspects should be comprehensively stressed in the study

2) The plan and business model that consider all the stake holders are vital

3) The vision should both consider the local features and their expansion

4) Design, implementation and operation

4-3. Define CO2 emission baseline in BAU scenario

1) The approach to define the baseline in BAU

The approach to define the baseline in BAU scenario is conducted by the following steps:

- Data collection and define the baseline in BAU;

  The base year and target year in BAU will be decided according to the low carbon action plan in the economies or states of the three volunteer towns and existing low carbon that have already been planned by government or stakeholders.

- Data collection and define the baseline in BAU;

  Though the detail information is different according to the different features, target and scale of the three volunteer towns, the following parameters will be collected for defining the baseline:
  - Existing population, economic factors;
  - Infrastructure information, facility information,
  - Energy consumption in building sectors and traffic sectors;

- Make projections of carbon emission in the target year

  The study will predict the future carbon emission in the target year according to the changing economic factors and populations. The target year includes mid-term and long-term.

- Review and estimate the existing low carbon technologies (EXT)

  All the three volunteer towns have their own low carbon action plan which has already been planned or partially implemented by the government. Therefore, the EXT is the special BAU condition that should be evaluated and predicted. The study will estimate and predict their effect in the target year.
- Set target domain as alternative planning scenario (APS)

The analysis for BAU and EXT will be used for set target for alternative planning scenario, which means additional measures which are possible to be implemented in the target year.

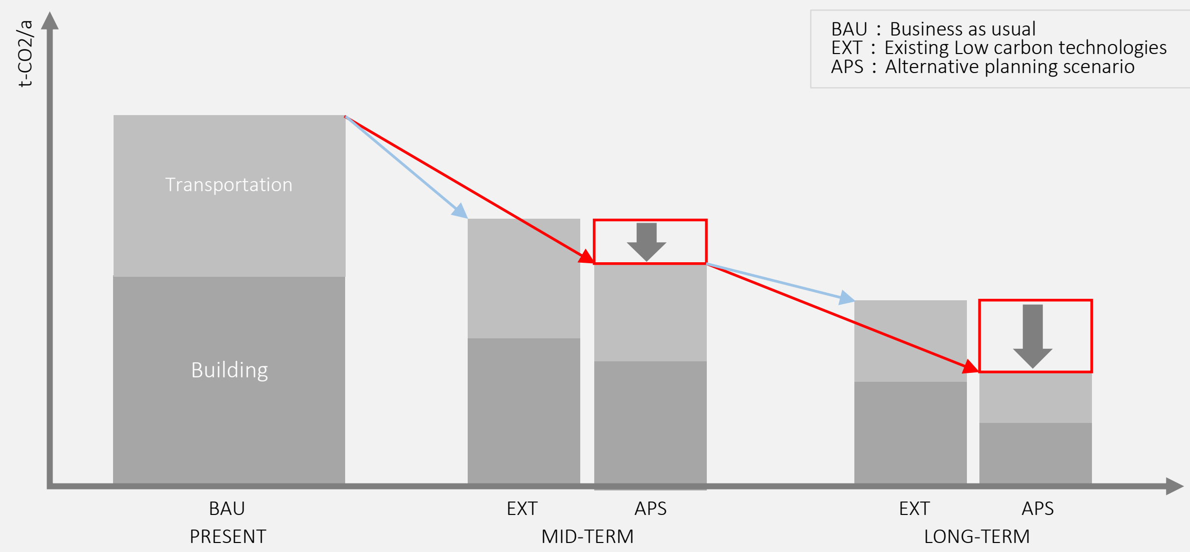


Fig. 0-14. Output example for CO2 reduction targets
Source: Project Team (NSRI)

2) The method for BAU setting in building sectors

The Existing carbon emission from energy sector refers to the carbon emission from building energy consumption

(1) The existing building energy consumption

Building energy consumption is estimated as

$$\Sigma \text{Building energy consumption} = \Sigma(\text{Building energy consumption unit}^{1)} \text{ for different type} \times \text{ building area})$$

(2) The Method for estimate the BAU in short-term and long-term

There are two methods to decide the BAU

- The relationship with GDP growth rate or Population prospects
  The energy consumption has a firmly relationship with GDP. For example, in the residential buildings, the household appliance increases with the GDP growth and causes increase of energy consumption. For the office and the commercial buildings, the increasing GDP growth rate also cause the longer of Business hours and increase of energy consumption. The factors that can represent the relationship between GDP growth rate and the energy consumption growth rate is Energy-GDP elasticity. It can be calculated as below'

Energy Growth rate = GDP Growth rate ×Energy-GDP elasticity
or
Energy Growth rate = Population prospects X Energy-Population elasticity

While uses this method, the BAU is predicated with the existing energy consumption that set in (1) and the energy growth rate with predicted by GDP growth rate and the Energy-GDP elasticity value for each economy.
This method is especially fit for the area that with less development.

- The relationship with urban development
  The other method, which used in the area where are still not yet be developed decides BAU by the increasing of building floor area.

(3) The principles for setting low carbon targets

The principles for setting low carbon targets is generally as follows.

- Low carbon targets must be realistic (they must be both appealing and realistic)
- Low carbon targets and indexes will comprise "Low Carbon Targets," "other Indexes"
- Targets and indexes will be composed of quantifiable and visible categories.
- Stakeholders in the 3 volunteer towns will jointly aim at reaching the low carbon targets and indexes and will also share data regarding them together
- Targets and indexes will require ongoing efforts throughout the life cycle of the project

4-4. *CO2 reduction scenario*

1) Define comprehensive, specific and feasible low carbon measure

The study for the three main parts.

A) Define the CO2 emission reduction and environment target of the town

Based on the step3, our study will define CO2 emission reduction and environment target of three volunteer towns according to the existing condition (BAU) and the low carbon measures that have already been implemented by government or stakeholders (EXT).

B) Prepare a Low carbon guideline for categories of low carbon town design challenges.

Based on the analysis of LCT-I, and prediction for BAU, a comprehensive and interactive low carbon design guideline will be provided for three volunteer towns with the technologies in demand, supply, demand and supply, governance aspects.

C) Select CO2 emission reduction measures in each design

With our experience in LCMT development, NSRI has low carbon technologies packages which is developed based on LCT-I. Therefore, in this section, we will propose a package of low carbon solutions suitable for 3 volunteer towns while considering the actual situation of each town and propose a system that is balanced from both technology level and cost.

The following show 5 design categories that can help 3 volunteer towns realize their low-carbon development vision, provided that the development of each is in full alignment with the on-the-ground realities and institutional context of each town.

The guidelines and feasibility assessment for each of the 5 design categories and the specific CO_2 avoidance/reduction measures it identifies as promising for 3 volunteer towns will include the following information:

Fig. 0-15. CO2 Reduction Categories
Source: Project Team (NSRI)

- Assessment of potential CO_2 avoidance and reductions of specific measures
- Identification of an appropriate and effective implementation methodology
- Estimates of implementation timeline and costs for each measure
- Ideas for implementers funding sources and funding mechanisms
- How quality of life, quality of the environment and the quality of natural resource usage will be improved

2) Perform scenario analysis of implementation alternatives and analyze CO2 reduction efficiency

From the view of implementation, we will propose a roadmap towards achieving CO2 targets in the mid and long term. The low carbon measures will be selected according to the target and reduction amount of CO2 reduction.

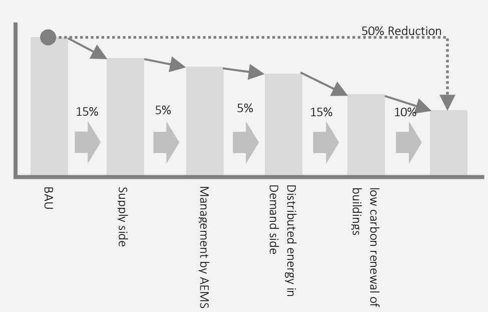


Fig. 0-16. Roadmap for achieving CO2 target example
Source: Project Team (NSRI)

4-5. Business Scheme

The CO2 reduction methods in each region are described previously. In this chapter, we would like to study to implement these methods. Specifically, it is necessary to clarify the leadership and to be able to self-sustain as a sustainable mechanism in the region with the methods established as a business to some extent.

1) Basic concepts

In promoting the mechanism for low carbon of each area, the following are examples of current issues.

- Lack of implementation body

- Lack of legal institutional framework

- Lack of cooperation among multiple entities

For tackling with these issues, the basic concepts for building a business model in this study is as follows.

(1) Setting an administrator or management body (PPP) as a Low Carbon methods promoter

Maximizing regional Quality Of Life is a major objective by promoting low carbonization in the region as an official position. It is necessary to construct an ecosystem to continue sustainably in the future, such as entity involved establishing as business to some extent rather than raising profit.

(2) Combination of multiple businesses

In considering the business feasibility as described above, even if it is not always possible to establish in individual methods, it may be possible to establish business by combining multiple methods. With public entities managing at the top, it is easier to collaborate with multiple companies.

(3) Collaboration with existing businesses

In considering the above, some of the contents proposed here have already been entered by other companies and established as a business. It is not favorable that public sector manage similar business and interfere with them. In other words, it is necessary to work cooperatively with companies that are likely to collaborate flexibly.

2) Examples of business model

After considering the potential players and feasibility of each method in each district, we would like to propose a possible business model. Following examples are our initial ideas and should be examined in detail later. In any case, while considering possibility as a player and the possibility of business feasibility, several business models will be proposed by taking advantage of the characteristics of the area further.

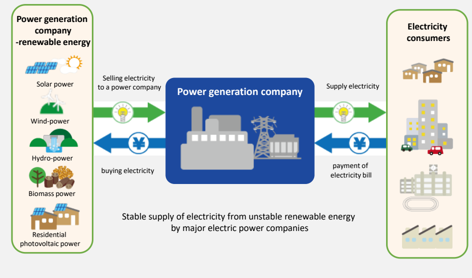


Fig. 0-17. Business Scheme A
Source: Project Team (NSRI)

5. Low-carbon scenario for three volunteer town

5-1. La Molina District, Peru

1) Concepts

The main concept for La Molina District is "Toward to Low-Carbonization"

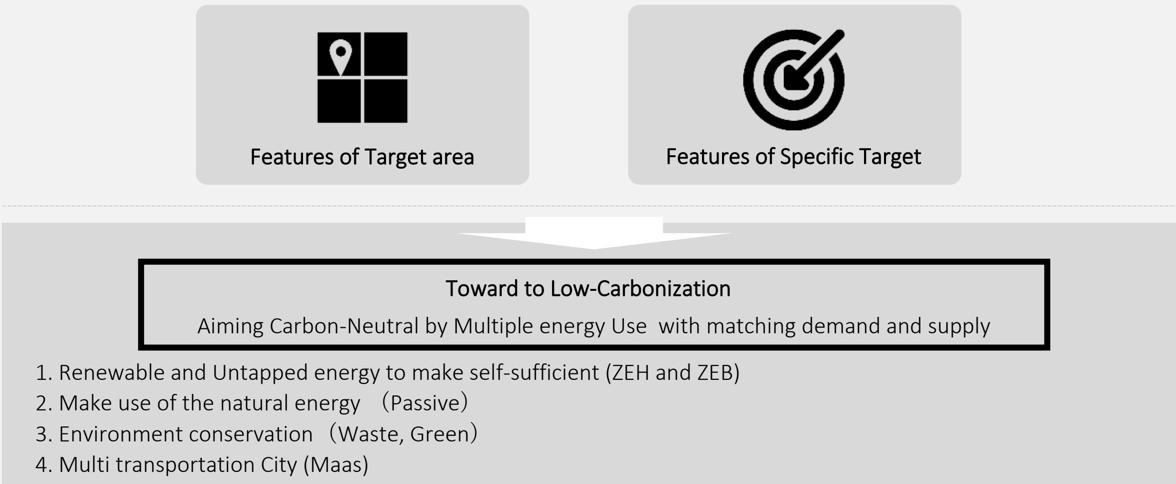


Fig. 0-18. Image of Concept

Source: Project Team (NSRI)

2) Define BAU of CO2 emission baseline in Building sectors

(1) Calculation of CO2 reduction rate in a typical house in the residential area

In the table below are shown the calculation of CO2 reduction rate base on the countermeasure items for the building in a residential area. In the residential area are included buildings from the low, medium and high residential area. The contribution rate is calculated based on the CO2 emissions in the residential sector by sources and uses provided by the National Balance of Energy of Peru.

Table.0-6. Calculation of CO2 reduction rate in a typical house in the residential area

Countermeasure items for the building in residential area	CO2 reduction rate for each item	Contribution for each application	CO2 reduction
Building insulation	10%	10%	1%
Air-conditioning	20%		2%
Lighting	30%	3%	0.9%
Hot water supply	30%	5%	1.5%
Home appliances (electricity)	20%~60%	74%	14.8%~44.4%
Others	20%~50%	8%	1.6%~4.0%

Source: Projcet Team (NSRI)

(2) Calculation of energy consumption ratio in a typical building in the commercial area

Additionally, the CO2 reduction rate base on the countermeasure items for the building in the commercial sector is calculated. In the commercial sector are included commercial buildings, educational and hospitals. The contribution rate is calculated based on the CO2 emissions in the commercial sector by sources and uses provided by the National Balance of Energy of Peru.

Table.0-7. Calculation of CO2 reduction rate in a typical building in the commercial area

Countermeasure items for the building in commercial area	CO2 reduction rate for each item	Contribution for each application	CO2 reduction
Building insulation	10%	30%	3%
Air-conditioning	20%		6%
Lighting	30%	3%	0.9%
Hot water supply	30%	5%	1.5%
Home appliances (electricity)	20%~60%	54%	10.8%~32.4%
Others	20%~50%	8%	1.6%~4.0%

Source: Projcet Team (NSRI)

(3) Setting the CO2 reduction rate for each target case (BAU2030 and BAU2050) in the residential area

The table below is shown the CO2 reduction rate for each target case in the residential area. The countermeasure items from energy savings and energy generation from PV are represented for the low, medium and high residential areas.

Table.0-8. Setting the CO2 reduction rate for each target case in the residential area

Countermeasure items for residential buildings	2030	2050
Building insulation	1%	1%
Air-conditioning	2%	2%
Lighting	0.9%	0.9%
Hot water supply	1.5%	2.9%
Home appliances (electricity)	14.8%	17.8%
Others	1.6%	1.6%
AEMS	5%	10%
Total(1)	26.8%	36.2%
Energy Generation from PV, etc.	5%	15%
Total(2)	31.8%	51.2%

Source: Projcet Team (NSRI)

(4) Setting the CO2 reduction rate for each target case (BAU2030 and BAU2050) in the commercial area

The CO2 reduction rate for each target case in the commercial rate is calculated using the countermeasure items from energy savings and energy generation from PV for commercial buildings, educational buildings and hospitals.

Table.0-9. Setting the CO2 reduction rate for each target case in the commercial area

Countermeasure items for commercial buildings	2030	2050
Building insulation	3%	3%
Air-conditioning	6%	6%
Lighting	0.9%	0.9%
Hot water supply	1.5%	2.9%
Home appliances (electricity)	10.8%	17.8%
Others	1.6%	1.6%
AEMS	5%	10%
Total(1)	28.8%	42.2%
Energy Generation from PV, etc.	5%	15%
Total(2)	33.8%	57.2%

Source: Projcet Team (NSRI)

(5) The estimation of CO2 emissions in BAU scenario in 2021, 2030 and 2050

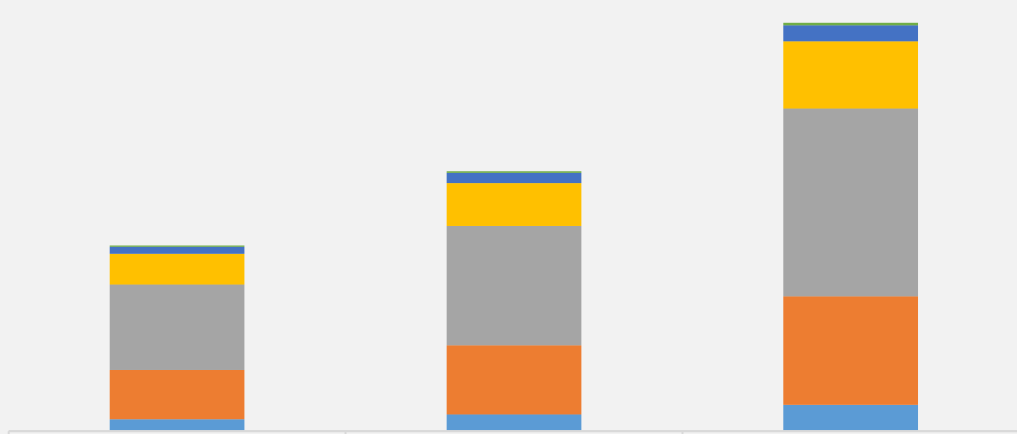
CO2 emission in 2021 in the building =
Electricity consumption by type of building × total area by type of building in La Molina × CO_2 emission factor for Peru

CO2 emission in 2030 and 2050 in the building =
Electricity consumption by type of building × total area by type of building in La Molina × CO_2 emission factor for Peru[1] × estimated coefficient trend for 2030 and 2050[2]

[1]Emission factor of Peru for 2017 (0.52144 tCO2eq / MWh)

[2] The estimated coefficient are calculate based on the future trend for the electricity consumption in Lima Callao.

The most up-to-date value of the Emission Factor of the Peruvian electricity grid and recommended by MINAM is the one calculated by the developer of the project 'Central Hidroeléctrica Poechos II', for the CDM (Clean Development Mechanism) validation of the same project, corresponding to the year 2017, which is the most updated, whose value is: 0.52144 tCO2eq / MWh.



	Year 2021	Year 2030	2050
Hospitals	3	4	7
Education area	21	29	46
Commercial	87	122	192
Medium residential	244	342	537
Low residential	141	198	311
Very Low residential	34	48	75

Fig. 0-19. The estimation of BAU scenario in 2021, 2030 and 2050
Source: Projcet Team (NSRI)

(6) The estimation of energy savings and CO2 saving effects

We have estimated the CO2 saving based on the secondary energy consumption, expressing the energy-saving amount as primary energy.

For the residential sector in La Molina, the estimation of the energy reduction rate is considered using the countermeasure items shown in the table below. This includes:

- Use of LED lighting
- Use of heat pumps for hot water supply,
- Improvement of heat insulation performance
- Shielding from solar radiation
- Improvement of home appliance efficiency
- Improvement of cooking appliances (electricity)
- Strengthening insulation of the building envelope and reducing internal heat generation
- Use of natural lighting and ventilation
- Transforms the energy from the sun into electricity using photovoltaics

For the buildings in the commercial, education and health sector the estimation of the energy reduction rate are considered using the countermeasure items shown below:

- Improvement of LED lighting
- Control the heat load through insulation, etc.,

- Actively use natural ventilation and lighting,
- Actively use natural heating
- Improve the efficiency of equipment systems,
- Improvement of energy efficiency
- Improvement of water pumping equipment
- Improvement of cooking appliances (for hospitals and hotels)
- Strengthening insulation of the building envelope and reducing internal heat generation
- Transforms the energy from the sun into electricity using photovoltaics
- Improvement the energy usage status of the target area, solar power generators, storage batteries, power supply facilities, etc., are managed
- Installation of a green roof

The detailed information regarding the implementation measures in La Molina could be found in the next chapter. The contribution for each application was calculated based on the estimation of CO2 emissions for each sector by source and uses in Table 0-10.

Table. 0-10. Countermeasure items in the building sector

Countermeasure items in the building sector	
Residential sector	Commercial, education and health sector
1. Promotion of ZEH	1. Promotion of ZEB
2. Passive design: Load control, Use of natural lighting and ventilation, Optimization of indoor environment	2. Passive design: Load control, Use of natural lighting and ventilation, Optimization of indoor environment
3. Active design: Higher efficiency of air conditioning and ventilation equipment, lighting equipment, hot water supply equipment, etc.	3. Active design: Higher efficiency of air conditioning and ventilation equipment, lighting equipment, hot water supply equipment, etc. Introduction of renewable energy: Photovoltaic power generation, wind power generation, etc.
4. Introduction of Home energy management system (HEMS)	4. Introduction of Area energy management system (AEMS)
5. Introducing the Untapped Energy and especially Geothermal cooling	5. Introducing the Untapped Energy and especially Geothermal cooling
6. Renewable Energy and especially solar rooftop and solar heating	6. Renewable Energy and especially solar rooftop, solar heating, urban photovoltaic system, etc.
7. Installation of green roof	7. Installation of green roof
8. Waste management and implementation of recycling program including Zero Waste Program	8. Waste management and implementation of bio-waste recycling system
9. Education program for residents	9. Education program for workers, officers, government, universities, etc.
10. Policy Framework that includes setting up the committee, goals and identify the problems in residential area La Molina District.	10. Policy Framework that includes the development and implementation of the policy for La Molina District.

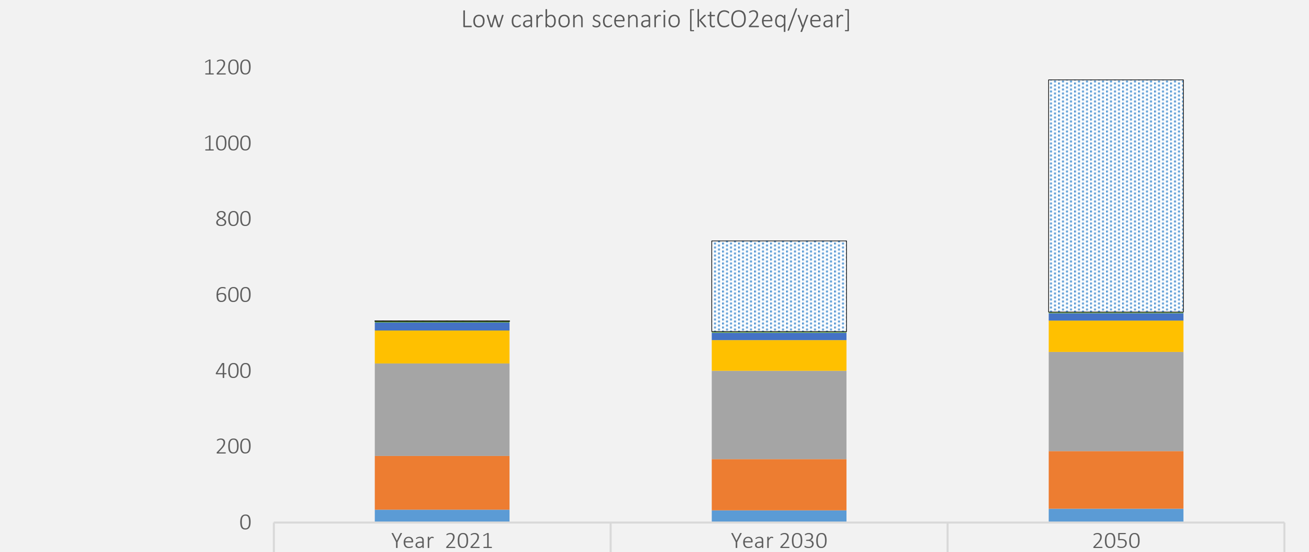
Source: Project Team (NSRI)

In the figure below are shown the low carbon scenario in La Molina based on the building type in 2021, 2030 and 2050.

- The CO2 emissions in 2030 through the introduction of low-carbon methods in buildings are estimated to be reduced by 31.8% and 33.8% for a residential and commercial area or total up to 239 ktCO2eq/year respectively compared to BAU in 2030.

- In 2050, the CO2 emissions are estimated to be reduced by 51.2% and 57.2% for a residential and commercial area or total up to 613 ktCO2eq/year respectively compared to BAU in 2050.

- The CO2 emission reduction is contributed by energy conservation and energy generation from PV.



	Year 2021	Year 2030	2050
Down from BAU	0	239	613
Hospitals	3	3	3
Education area	21	19	20
Commercial	87	81	82
Medium residential	244	233	262
Low residential	141	135	152
Very Low residential	34	33	37

Low residential Medium residential Commercial Education area Hospitals Down from BAU

Fig. 0-20. The estimation of low-carbon scenario in 2021, 2030 and 2050

Source: Projcet Team (NSRI)

5-2. Khon Kaen Municipality, Thailand

1) Concepts

The main concept for Khon Kaen Municipality is “Optimization of Energy Network KHON KAEN”

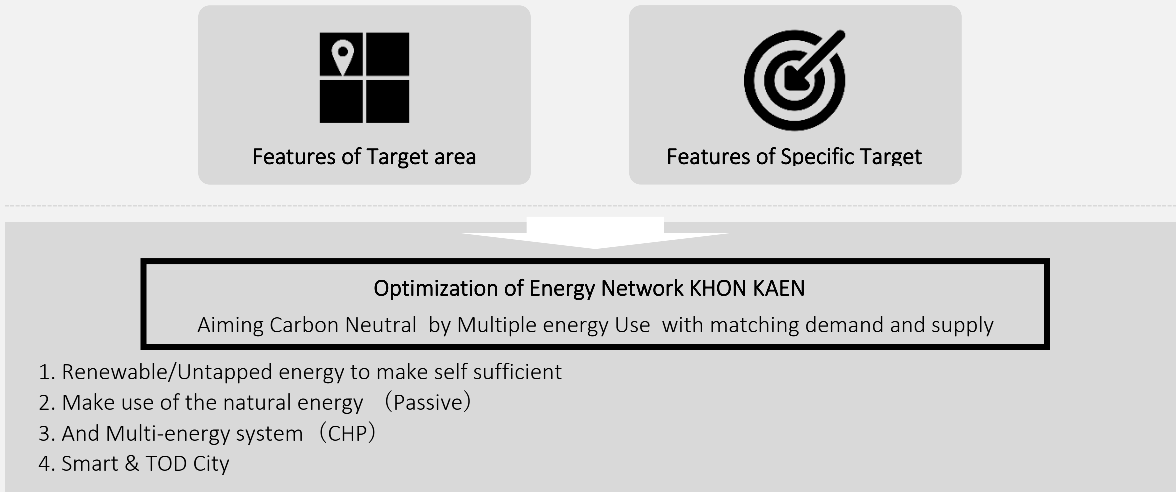


Fig. 0-21. Image of Concept
Source: Project Team (NSRI)

2) Define BAU of CO2 emission baseline in Building sectors

The carbon dioxide emissions of commercial buildings were calculated as follows: Based on the consumption of electricity, gas, etc. in representative buildings in Khon Kaen, the CO2 emissions of each building were calculated (Table. 5.2.1). The CO2 emission of a building is greatly affected by the total floor area of the building and the building use; the CO2 emission per total floor area was calculated for a typical building in Khon Kaen and averaged for each use to calculate the CO2 emission per total floor area for each use in Khon Kaen (Table. 0-11).

Table. 0-11. CO2 emissions of a typical building in Kohn Kaen

building name	building type	Fuel				CO2				Total CO2 emission	Total Floor Area	CO2 emission per total floor area
		Electricity	Diesel	LPG	Bunker Oil C	Total Electricity	Diesel	LPG	Bunker Oil C			
		kWh	L	kg	L	kg-CO2	kg-CO2	kg-CO2	kg-CO2	kg-CO2	m2	kgCO2/m2/year
Central Plaza Khon Kaen	Commercial	23,459,011				12,847,715				12,847,715	250,000	51
C.P. Tower Khon Kaen 2	Office	630,780				345,457				345,457	7,431	46
Training Center of Provincial Police Region 4 KhonKaen	Office	438,060				239,911				239,911	23,120	10
Khon Kaen Ram Hospital	Hospital	2,604,000				1,426,124				1,426,124	60,242	24
Siam Makro	Commercial	4,534,120				2,483,186				2,483,186	13,703	181
Tesco Lotus Branch 2	Commercial	7,814,502				4,279,741				4,279,741	17,600	243
Kosa Hotel	Hotel	2,503,405	360	38,400		1,371,031	943	226,944		1,598,918	26,667	60
Charoen Thani Hotel	Hotel	7,603,030	780	113,673	270,626	4,163,925	2,043	671,807	811,878	5,649,653	43,608	130
Pullman Hotel	Hotel	5,443,560	2,438			2,981,256	6,385			2,987,641	36,093	83
CP Tower Khon Kaen 2	Office	2,151,390				1,178,244				1,178,244	7,431	159
Training Center of Provincial Police Region 4	Office	2,213,475				1,212,246				1,212,246	23,120	52
Khon Kaen Provincial Agriculture and Cooperatives Office	Office	418,430				229,160				229,160	2,322	99
Rajamangala University of Technology Isan Khon Kaen Campus	Academy	2,722,674				1,491,117				1,491,117	43,210	35
Khon Kaen-Ram Hospital	Hospital	5,197,560				2,846,530				2,846,530	60,242	47

Source: Database of Designated Building, DEDE, 5 March 2019

Table. 0-12. CO2 emissions per total floor area

Building Type	CO2 emission per total floor area kgCO2/m2/year
Office	73
Hotel	91
Hospital	35
Commercial	159
Academy	35

Source: Project Team (NSRI)

Carbon dioxide emissions of residential buildings were calculated as follows: Annual carbon dioxide emissions per household were calculated using the statistics of domestic energy consumption for 300 households in Bangkok, Thailand by Shimizu et al. (2020).

Table. 0-13. CO2 Emissions from household in Bangkok, Thailand

	Electricity	LPG	total	unit
Annual secondary energy consumption	13.3	2.9	16.2	GJ/year/household
Annual CO2 emission	2.07	0.16	2.23	t-CO2/year/household

Source: Shimizu et al. RESEARCH ON HOUSEHOLD ENERGY CONSUMPTION AND DATABASE DEVELOPMENT IN THAILAND, VIET NAM, AND CAMBODIA (PART 1): THE DEVELOPMENT OF A HOUSEHOLD ENERGY CONSUMPTION DATABASE IN SOUTHEAST ASIA, 2020,https://doi.org/10.3130/aije.85.535

As described above, the carbon dioxide emissions of Khon Kaen were calculated by multiplying the number of buildings by the carbon dioxide emissions by total floor area and use for commercial buildings, and by the carbon dioxide emissions by household for residential buildings (Table. 0-13). The future projections for 2030 and 2050 were calculated based on the GDP projections for Thailand, assuming that emissions would increase or decrease in proportion to the GDP.

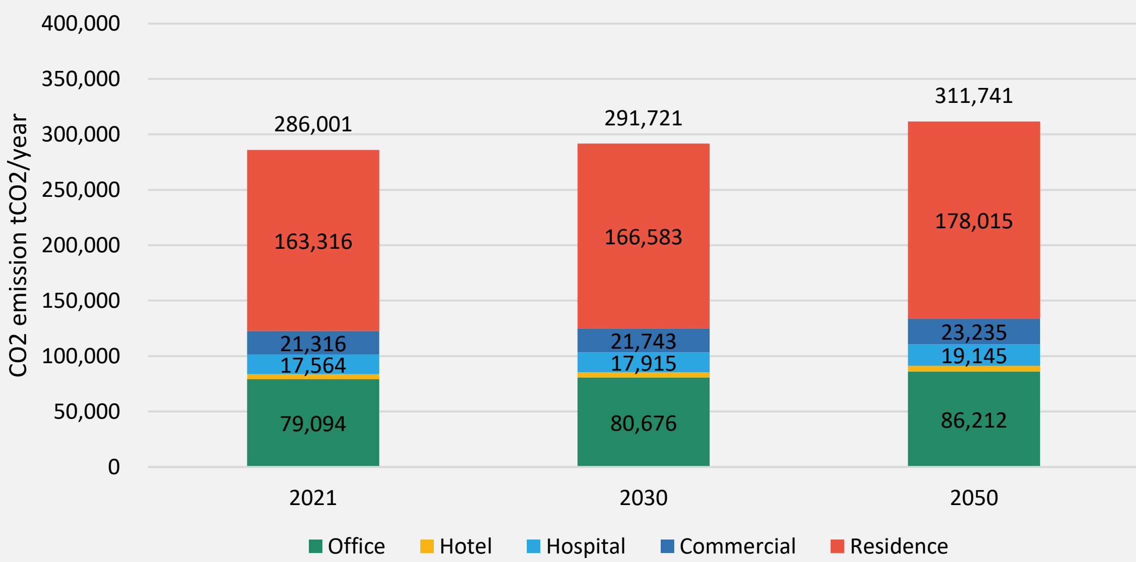


Fig.0-22. Define BAU of CO2 emission baseline
Source: Project Team (NSRI)

3) CO2 reduction effect

To reduce CO2 emissions in the building sector, the most important things to do are (1) to save energy thoroughly, and (2) to use renewable energy sources such as PV.

With regard to energy efficiency and conservation methods, for residential buildings, (a) use of heat pumps for hot water supply, (b) improvement of heat insulation performance, (c) shielding from solar radiation, and (d) LED lighting are particularly important as energy efficiency and conservation measures. In particular, heat insulation and solar radiation shielding can greatly improve not only CO2 emissions but also occupant performance. For commercial buildings, it is important to (a) electrify, (b) control the heat load through insulation, etc., (c) actively use natural ventilation and lighting, (d) improve the efficiency of equipment systems, and (e) continuously manage energy.

With regard to the use of renewable energy, the most common method is the installation of PV on roofs and rooftops. PV is particularly effective because the demand curve for cooling and the power generation curve for PV often show a similar trend.

A low-carbon scenario for 2030 and 2050 was developed, in which the most effective measures described in Section 5.3.2 and later are implemented in a systematic manner, resulting in a reduction of 22% in 2030 compared to BAU, and 44% in 2050 compared to BAU.(Fig. 0-23)

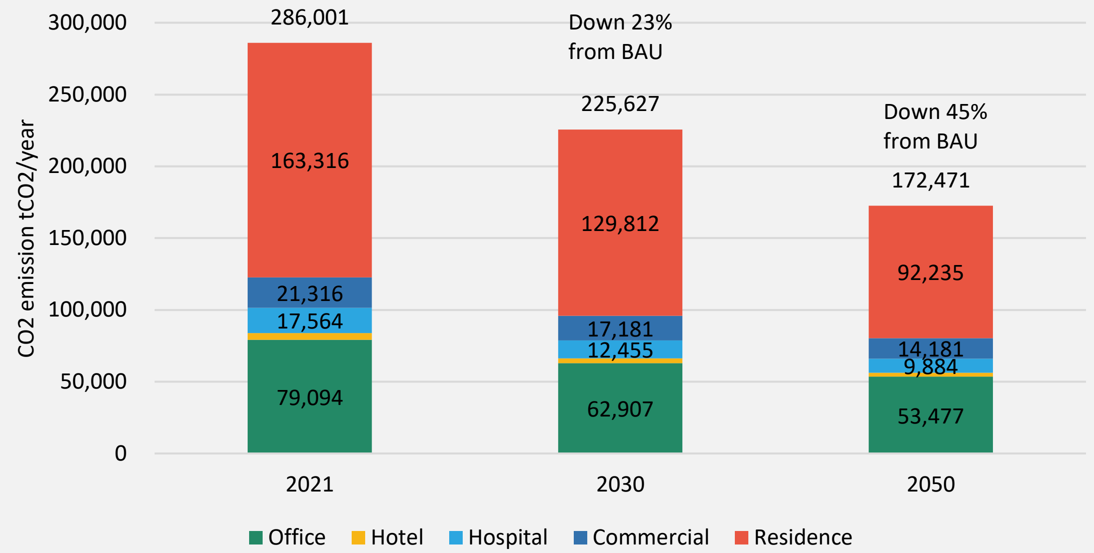


Fig.0-23. Low carbon scenario for the building sector

Source: Project Team (NSRI)

Methods are shown in the next section

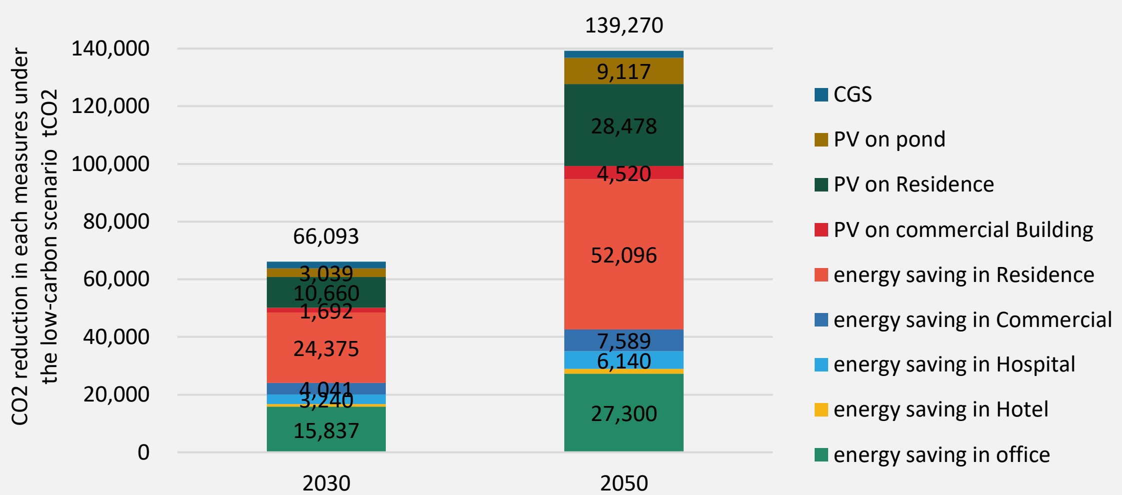


Fig.0-24. CO2 emissions reduction in each sector under the low-carbon scenario

Source: Project Team (NSRI)

(1) Non-residential buildings (e.g., office, hotel, commercial etc.)

To calculate the low-carbon scenario, the total floor area of each building use in Khon Kaen was assumed (table 0-16), and the energy consumption of each use was calculated from the breakdown of energy consumption (table 0-15), multiplied by the reduction ratio of each measure (table 0-14).

Table. 0-14. Building Energy Conservation Technologies

Target	Low carbon measures	Target Energy Conservation ratio	Office	Commercial	Hospital	Hotel
			Introduction rate 2030 / 2050			
Heat source	High-efficiency equipment	0.28	50% / 100%			
Heat source	Reduction of internal heat generation	0.05				
Heat source auxiliary	Inverter	0.13				
Water conveyance	Inverter	0.18				
Air conveyance	High efficiency fan	0.10				
Air conveyance	Inverter	0.26				
Hot water	Conversion to heat pumps	0.29	0% / 0%		50% / 100%	
Lighting	Human Sensor	0.03	50% / 100%			
Lighting	Illuminance correction	0.11				
Lighting	High efficiency of lighting equipment	0.38				
Outlet	Reduced power	0.02				
Ventilation	Total heat exchanger	0.07				
Ventilation	High efficiency fan	0.13				
Ventilation	Introduction of CO concentration control of parking fans	0.20				
Water supply and drainage	Improve pump performance	0.15				
Elevator	Smart operation	0.10				
Other	Introduction of high efficiency transformers	0.09				
Heat source	Glass performance improvement	0.10				

Source: Project Team (NSRI)

Table. 0-15. Energy consumption ratio in a typical building

	Heat source	Heat source auxiliary	Water conveyance	Air conveyance	Hot water	Lighting	Outlet	Ventilation	Water supply and drainage	Elevator	Others	Total
office	25.8%	4.5%	3.1%	11.8%	1.4%	20.2%	18.4%	6.2%	0.8%	2.5%	5.3%	100%
commercial	24.7%	4.4%	1.1%	4.0%	0.9%	20.8%	19.2%	12.8%	0.9%	5.4%	5.8%	100%
hospital	27.2%	4.8%	2.5%	9.5%	18.0%	10.9%	10.1%	7.0%	1.0%	3.0%	6.0%	100%
hotel	30.6%	5.4%	2.3%	8.7%	12.0%	12.0%	11.0%	8.3%	1.2%	3.5%	5.0%	100%

Source: Project Team (NSRI)

Table. 0-16. Total floor area of buildings in Khon Kaen calculated

Original Building Type	The number of buildings	Building Type for CO2 calculation	Typical total floor area	Total floor area in Khon Kaen Municipality
	-	-	m2	m2
Hospital	11	Hospital	20,000	220,000
Hotel	59	Hotel	1,000	59,000
Shopping Mall & Discount Stores	15	Commercial	10,000	150,000
Building	241	Office	500	120,500
Shop	234	Commercial	500	117,000
Office	97	Office	5,000	485,000
Company	14	Office	300	4,200
Government agency	1245	Office	100	124,500
State enterprise	17	Office	15,000	255,000
Foundation	3	Office	500	1,500
Academy	3	Academy	40,000	120,000

Source: The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan. Net Zero Energy Building Advanced Case Collection

(2) Residential buildings

The low-carbon methods for housing can be summarized as follows

Table. 0-17. Key elements for low carbon residential buildings

	thermal environment	Air environment	Light Environment	Others
Use of natural energy	• Solar water heating	• Natural Ventilation	• daylight use • Solar power generation	
Thermal insulation of building envelope	• Improved thermal insulation • Solar radiation shielding			
Energy-saving equipment	• Cooling system planning		• Lighting equipment planning	• High-efficiency appliance • Heat pump hot water systems

Source: National Institute for Land and Infrastructure Management. Design Guideline toward Low Energy Houses with Validated Effectiveness, NSRI

The method of calculating the effect of low-carbon methods for residential buildings is shown: the number of households in Khon Kaen is estimated from the number of residential buildings, and the low-carbon scenario is calculated from the breakdown of energy use by household and the effect of low-carbon methods by energy use destination.

Table. 0-18. Effectiveness of low-carbon methods for housing

Target	Low carbon measures	**Target** Energy Conservation ratio	Introduction rate 2030 / 2050
Cooling	External wall insulation + solar radiation shielding	0.25	50% / 100%
Cooling	Roof insulation	0.05	
Cooling	High efficiency of cooling equipment	0.15	
Lighting	High efficiency of lighting equipment	0.30	
Hot water supply	High efficiency of hot water supply equipment	0.30	
Home appliances	High efficiency of home appliances	0.30	
Cooking	High efficiency of cooking appliances	0.05	

Source: Project Team (NSRI)

Table. 0-19. Energy consumption ratio in a typical housing

Cooling	Ventilation	Hot water supply	Lighting	Home appliances	Cooking	total
15.5%	4.7%	20.7%	20.4%	32.1%	6.6%	100.0%

Source: Project Teams (NSRI)

Table. 0-20. Assumptions for calculating the number of households in Khon Kaen

Original housing Type	The number of housing	Number of floors in a typical housing	Floor Area of one floor in a typical housing	Total floor area per household	The number of household per housing	Occupied Floor area per household	vacancy rate
			m2	m2		m2/house hold	
Houses (detached house, twin house)	53,505	2	50	100	1	100	15%
Dormitory	450	3	50	150	2	75	15%
Row house (fire protection construction materials)	794	4	50	200	2	100	15%
Row house (not fire protection construction materials)	139	4	50	200	2	100	15%
Flat	2,137	2	200	400	4	100	15%
Apartment	5,082	2	200	400	4	100	15%
Temporary house	552	1	50	50	1	50	15%
Boat & raft	5	1	50	50	1	50	15%
Non registred house	7	1	50	50	1	50	15%
Temporary house registration (foriegner)	1	2	50	100	1	100	15%
Civil servant residence	448	2	50	100	1	100	15%

Source: Project Team (BMC, NSRI estimation)

4) Define BAU of CO2 emission baseline in Transporter sectors

The process of CO2 emission is showed as blow figure.

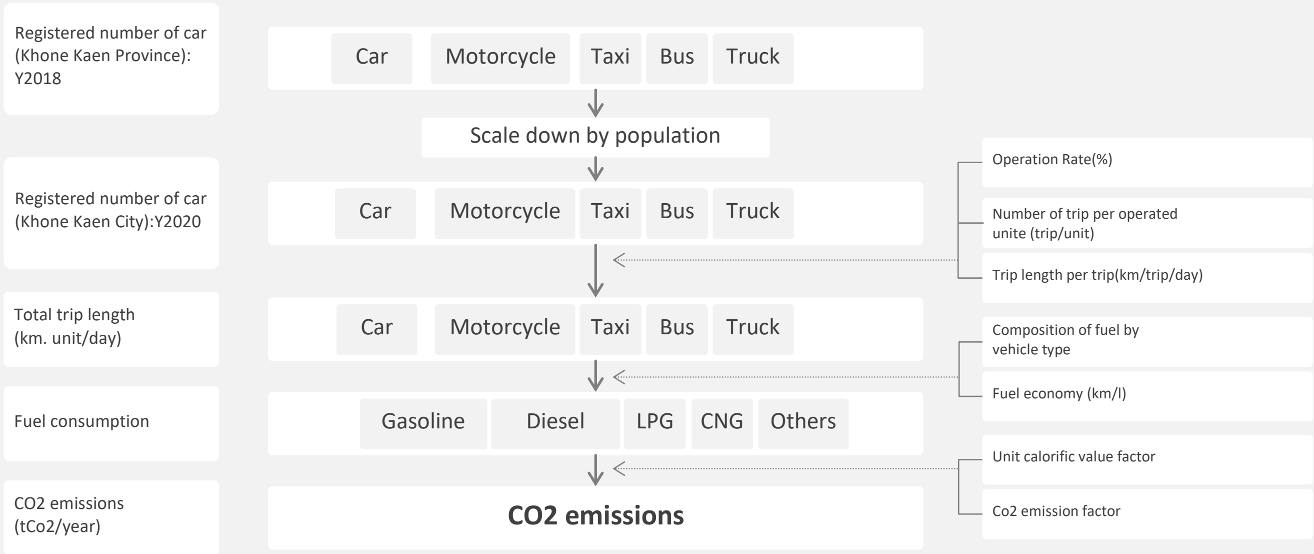


Fig. 0-25. The process of estimation of CO2 emission in transport sector
Source: Project Team (NSRI)

Result of estimation of BAU.

Table. 0-21. Number of Vehicle of Khon Kaen City

Type of Vehicle	Total	Gasoline	Diesel	LPG	CNG	Others
Car	24,376	7,598	15,611	869	289	9
Motorcycle	28,607	28,605	0	0	0	2
Taxi	88	4	1	81	2	0
Bus	601	16	536	12	36	1
Truck	1,790	1	1,496	2	32	259
Others	908	0	905	0	0	3
Total	56,370	36,224	18,549	964	359	274

Source:Project Team NSRI calculated above number from number of vehicle of Khone Kaen Province(2018))

Table. 0-22. Total trip length by vehicle type

Type of Vehicle	(a) Number of vhicle	(b) Operation Rate(%)	(c) Number of trip per opereted unite (trip/unit)	(d) Trip length per trip(km/trip/day)	(e) Total trip length(km/day)
Car	24,376	60%	3.21	12.59	590,453.6
Motorcycle	28,607	60%	3.21	8.39	461,960.0
Taxi	88	60%	3.21	12.59	2,131.6
Bus	601	86%	3.12	11.50	18,585.5
Truck	1,790	55%	6.17	14.67	89,673.2
Others	908	28%	3.09	7.33	5,686.0
Total	56,370				1,168,489.8

Source:Project Team (NSRI calculated above number from number of vehicle of Khone Kaen Province (2018))

Table. 0-23. Total trip length by Fuel type

Type of Vehicle	Total	Gasoline	Diesel	LPG	CNG	Others
Car	1,180,907	368,089	756,282	42,099	14,001	436
Motorcycle	554,352	554,313	0	0	0	39
Taxi	2,558	116	29	2,354	58	0
Bus	22,303	594	19,890	445	1,336	37
Truck	179,346	100	149,889	200	3,206	25,950
Others	5,686	0	5,667	0	0	19

Source: Project team (NSRI)

Table. 0-24. Fuel economy

Type of Vehicle	Gasoline	Diesel	LPG	CNG	Others
Car	15.8	15.8	9.8	9.8	9.8
Mortorcycle	60	60.0	60.0	60.0	60.0
Taxi	15.8	15.8	9.8	9.8	9.8
Bus	5.7	5.7	5.7	5.7	5.7
Truck	7.24	7.2	7.2	7.2	7.2
Others	2.01	2.01	2.01	2.01	2.01

Source: Project team (NSRI)

Table. 0-25. Total Fuel Consumption by Fuel Type(kl/day)

Type of Vehicle	Gasoline	Diesel	LPG	CNG	Others
Car	23.3	47.9	4.3	1.4	0.0
Motorcycle	9.2	0.0	0.0	0.0	0.0
Taxi	0.0	0.0	0.2	0.0	0.0
Bus	0.1	3.5	0.1	0.2	0.0
Truck	0.0	20.7	0.0	0.4	3.6
Others	0.0	2.8	0.0	0.0	0.0
Total	32.7	74.9	4.7	2.1	3.6

Source: Project team (NSRI)

Table. 0-26. Result of CO2 emission

Fuel Consumption	Gasoline	Diesel	LPG	CNG	Others	Total
(a)Unit calorific value factor(GJ/kl)	34.6	37.7	50.8	50.8	34.6	-
(b)Co2 emission factor(tC/GJ)	0.0183	0.0187	0.0161	0.0161	0.0183	-
(c)Co2 emission(tCO2/day)	76	194	14	6	8	298
(d)Co2 emission(000tCO2/Year)	28	71	5	2	3	109

Source: Project team (NSRI)

Estimation of CO2 emission for transportation in 2030,2050

CO2 emission in 2030,2050 is calculated by population growth rate in Khon Kaen City based on estimated CO2 emission in 2020.

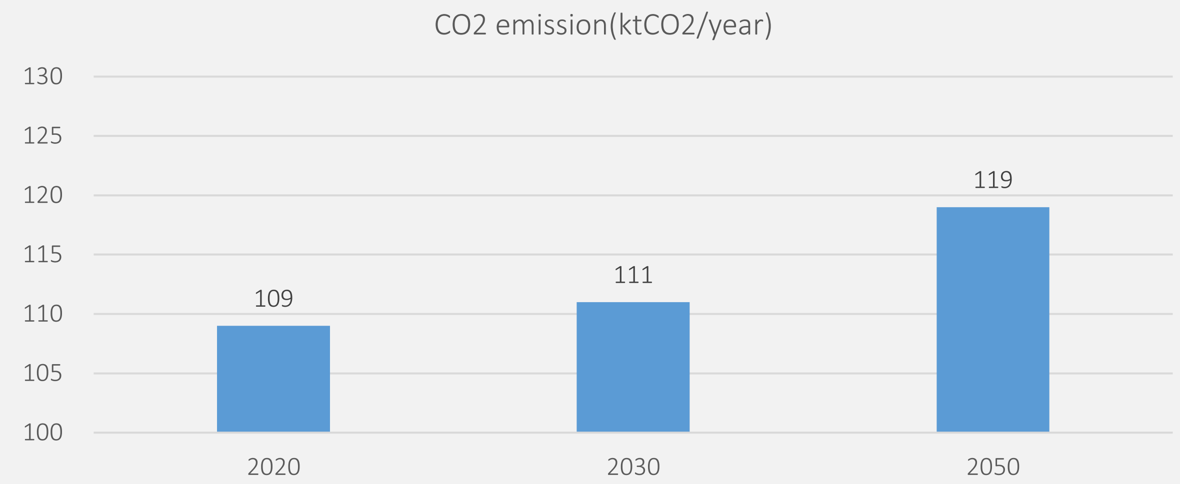


Fig. 0-26. CO2 Emission
Source: Project team (NSRI)

5) CO2 reduction effect from the CO2 reduction measures

(1) Shifting public transportation with developing the LRT network

With the LRT in the center of Khone Kaen City, it is expected that some passengers might use the LRT and public transport from cars. On this study, the service area of the LRT route is covered whole Khone Kaen City. Assumption of changing rate from automobiles and motorcycles to LRT is set as shown in the below table.

The changing rate is set based on the existing survey results * 1). (* 1: Designing Low Carbon Transport System for Khone Kaen)

Table. 0-27. Assumption of shifting rate to LRT

	Vichle	Y2030	Y2050
Shift to LRT	Car	15%	30%
	Mortorcycle	10%	20%

Source: Project team (NSRI)

The result of calculated CO2 emission is showed in below table.

Table. 0-28. Result of CO2 emission due to shifting to LRT Unite: Unite:000tCO2/Year

	Current	2030	2050
BAU	109	111	119
M1-Shft to LRT	-	98	96

Source: Project team (NSRI)

(2) Developing a TOD (Transit Oriented Development) City along the LRT lines.

It is expected that buildings will be concentrated around the LRT station due to TOD development. Generally, users of buildings near the station have a higher utilization rate of public transportation such as LRT or buses, so set the shift rate to public transportation as follows.

Table. 0-29. Assumption of shifting rate to LRT

	Vihcle	Y2030	Y2050
TOD	Car	5%	10%
	motorcycle	5%	10%

Source: Project team (NSRI)

The result of calculated CO2 emission is showed in below table.

Table. 0-30. Result of CO2 emission due to shifting to LRT Unite: Unite:000tCO2/Year

	Current	2030	2050
BAU	109	111	119
M2-TOD	-	107	107

Source: Project team (NSRI)

(3) Shifting petro vehicles towards EV

Set the EV penetration rate in Thailand in 2030 and 2050 as follows

Table. 0-31. Result of CO2 emission due to shifting to EV

Vehicle	Y2030	Y2050
Car	10%	30%
motorcycle	20%	40%

Source: Project team (NSRI)

The result of calculated CO2 emission is showed in below table.

Table. 0-32. Result of CO2 emission due to introducing PM Unite: Unite:000tCO2/Year

	Current	22030	2050
BAU	109	111	119
M3-EV	-	102	88

Source: Project team (NSRI)

(4) CO2 reduction by measures

The amount of CO2 reduction by the above measures is shown in the table below.

The CO2 emission in 2030 is estimated to be 84,000tCO2 / year, and in 2050 it is estimated to be 45,000tCO2 / year. The one with the largest reduction rate for BAU is the development of LRT and the introduction of EV in 2030, and the introduction of EV in 2050.

Table. 0-33. Result of CO2 emission by measure

Unite:000tCO2/Year

		CO2 Emission		Reduction Rate	
Year	2020	2030	2050	2030	2050
BAU	109	111	119	100.0%	100.0%
M1-Shft to LRT		98	96	88.3%	80.7%
M2-TOD	-	107	107	96.4%	89.9%
M3-EV	-	102	88	91.9%	73.9%
M4-PM	-	110	111	99.1%	93.3%
Total		84	45	75.7%	37.8%

Source: Project team (NSRI)

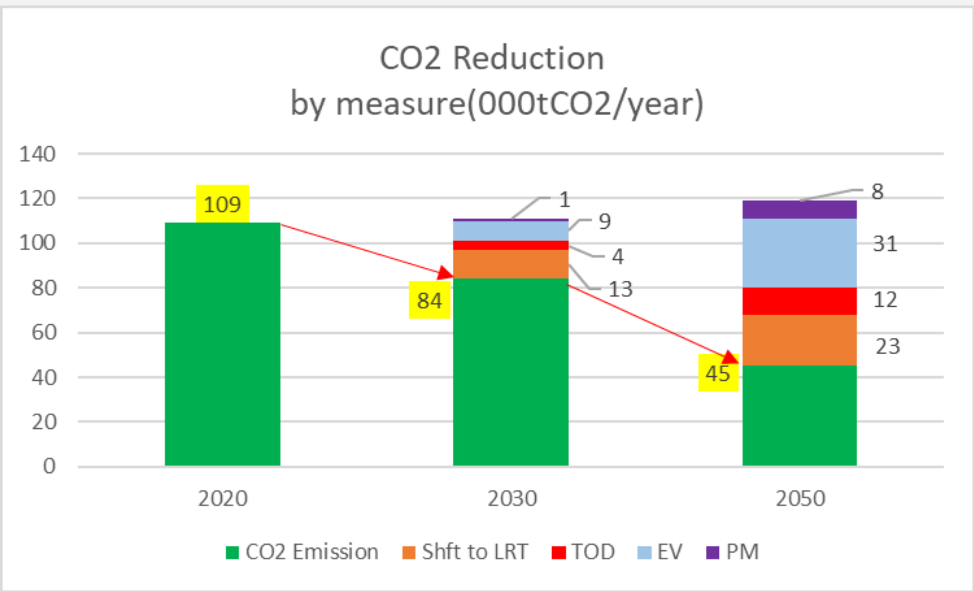


Fig. 0-27. CO2 Emission by measures

Source: Project team (NSRI)

5-3. Phu Quoc District, Viet Nam

1) Concepts

The main concept for Phu Quoc District is “Toward to Carbon-Neutral Island”

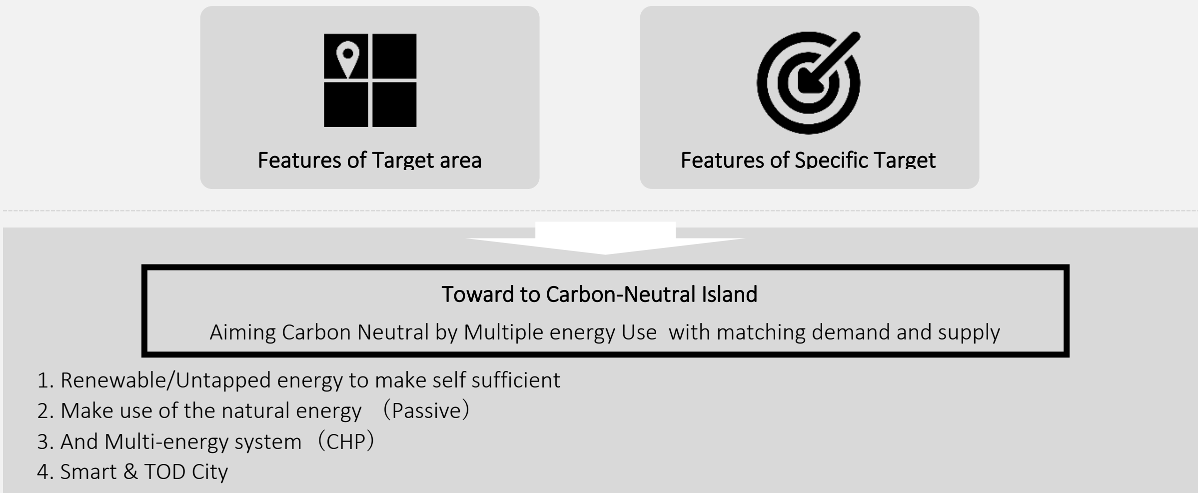


Fig. 0-28. Image of Concept
Source: Project Team (NSRI)

2) Define BAU of CO2 emission baseline in Building sectors

The CO_2 emissions from building sectors is estimated by building floor area and energy consumption unit of different types of building.

> Building energy consumption＝ Σ ｛Building energy consumption unit according to building use(MJ/ m2) × Building floor area (m2)｝

The CO_2 emissions BAU was calculated from the electricity demand Scenario in baseline case and the area for each sector. For emission factors, IGES list of grid emission factors were used; combined Margin EF ： 0.599 ton CO2/MWh.

The calculation result of BAU is shown below. The annual CO2 emissions in the current situation of building sector in the Phu Quoc is about 258,000 t-co2. It’ll increase about 270 % by 2030. This is because areas are developed and improvement of energy standards.

In addition, CO2 emissions in 2050 were set according to the growth rate from 2021 to 30. It’ll increase about 330 % by 2050

Table. 0-34. Energy consumption on Phu Quoc in the period 2020-2030 – Baseline Scenario

No	Sector	Land use area in 2021			Year 2020		energy consumption per sqm	Land use area in 2030			Year 2030		energy consumption per sqm	Growth rate (%/year)	Land use area in 2050	Year 2050
		ha	floor area ratio*1	thousand sqm	A (MWh)	%A	kWh/sqm	ha	floor area ratio*1	thousand sqm	A (MWh)	%A	kWh/sqm	21-30	ha	A (MWh)
1	Industry – Construction	193	10%	193	61,290	14%	317.0	215	10%	215	120,183	10%	559.0	7%	245	137,009
2	Agriculture – Forestry – Fishery	44,735	5%	22,367	1,000	0%	0.0	41,383	5%	20,692	3,106	0%	0.2	-	37,311	2,800
3	Commerce - Services	2,644	40%	10,576	326,541	47%	30.9	3,627	40%	14,508	911,140	53%	62.8	12%	4,381	1,109,443
4	Offices - Residences					29%						26%		9%		
5	Other	10,075	10%	10,075	41,139	10%	4.1	13,699	10%	13,699	127,770	11%	9.3	12%	16,987	158,435
6	Unused area	1,280						0								
	Commercial volume	**58,927**			**429,970**			**58,924**			**1,162,199**				**58,924**	**1,407,687**

*1 Assumed based on aerial photographs and sample area
Source:Project Tema (Calculated by NSRI based on electricity demand and land use plan)

Table. 0-35. CO2 emission on Phu Quoc in the period 2020-2030 – Baseline Scenario

		Year 2020	Year 2030	Year 2050
Industry	t-CO2	36,713	71,990	82,068
Agriculture	t-CO2	599	1,860	1,677
Commerce, Office, Residence	t-CO2	195,598	545,773	664,556
Others	t-CO2	24,642	76,534	94,902
Total	t-CO2	257,552	696,157	843,204

* Combined Margin EF ： 0.599 ton CO2/MWh (IGES List of Grid Emission Factors)
Source:Project Team(Calculated by NSRI based on electricity demand and land use plan)

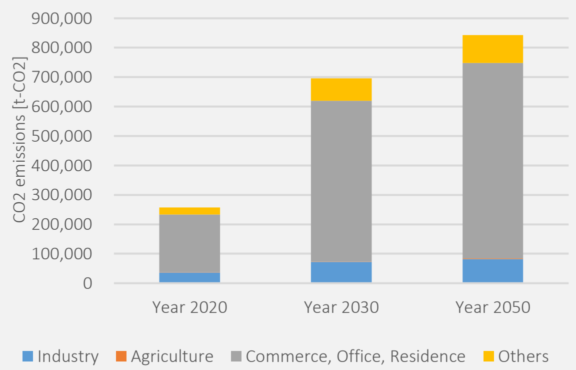


Fig. 0-29. Estimation of BAU CO2 emission in Phu Quoc
Source: Project Team (Calculated by NSRI based on electricity demand and land use plan)

3) CO2 reduction effect

To reduce CO2 emissions in the building sector, the most important things to do are (1) to save energy thoroughly, and (2) to use renewable energy sources such as PV.

With regard to energy efficiency and conservation methods, for residential buildings, (a) use of heat-pumps for hot water supply or Solar water heating system, (b) improvement of heat insulation performance, (c) LED lighting are particularly important as energy efficiency and conservation measures. In particular, heat insulation and high-efficiency hot water supply system can greatly improve not only CO2 emissions but also occupant performance.

For commercial buildings, it is important to (a) high efficiency heat source such as district cooling, Multi energy system, etc., (b) use of Untapped Energy (c) control the heat load through insulation and actively use natural ventilation and lighting, (d) improve the efficiency of equipment systems.

With regard to the use of renewable energy, the most common method is the installation of PV on roofs and rooftops. PV is particularly effective because the demand curve for cooling and the power generation curve for PV often show a similar trend.

A low-carbon scenario for 2030 and 2050 was developed, in which the most effective measures described in Building reduction measures and later are implemented in a systematic manner, resulting in a reduction of 25% in 2030 compared to BAU, and 54% in 2050 compared to BAU.

Table.0-36. Reduction of CO2 emissions in each method in Low carbon scenario for the building sector

	Year 2030			Year 2050		
	Energy saving rate	Install rate	Amount of energy saving (t-CO2)	Energy saving rate	Install rate	Amount of energy saving (t-CO2)
Energy saving in buildings	35%	50%	95,510	60%	70%	279,114
District cooling	6%	30%	9,824	9%	30%	17,943
Incineration plant	6%	5%	1,853	9%	5%	3,360
Seawater Heat source	6%	5%	1,637	9%	5%	2,991
Solar heat	2%	5%	546	2%	5%	665
PV (lake, MEGA)	-	0.5%	43,971	-	1%	126,861
CGS	11%	30%	18,011	13%	30%	25,918
CO2 emissions	-	-	524,805	-	-	386,355
rate	-	-	75%	-	-	46%

Source: Project Team (NSRI)

Table.0-37. Install capacity of PV and reduction of CO2 emissions

	Year 2030				Year 2050			
	Install area	Install capacity	Amount of CO2 reduction		Install area	Install capacity	Amount of CO2 reduction	
	ha	MW	t-CO2/MW	t-CO2	ha	MW	t-CO2/MW	t-CO2
PV (lake, MEGA)	207	14	3,188	43,971	373	40	3,188	126,861

Source: Project team (NSRI)

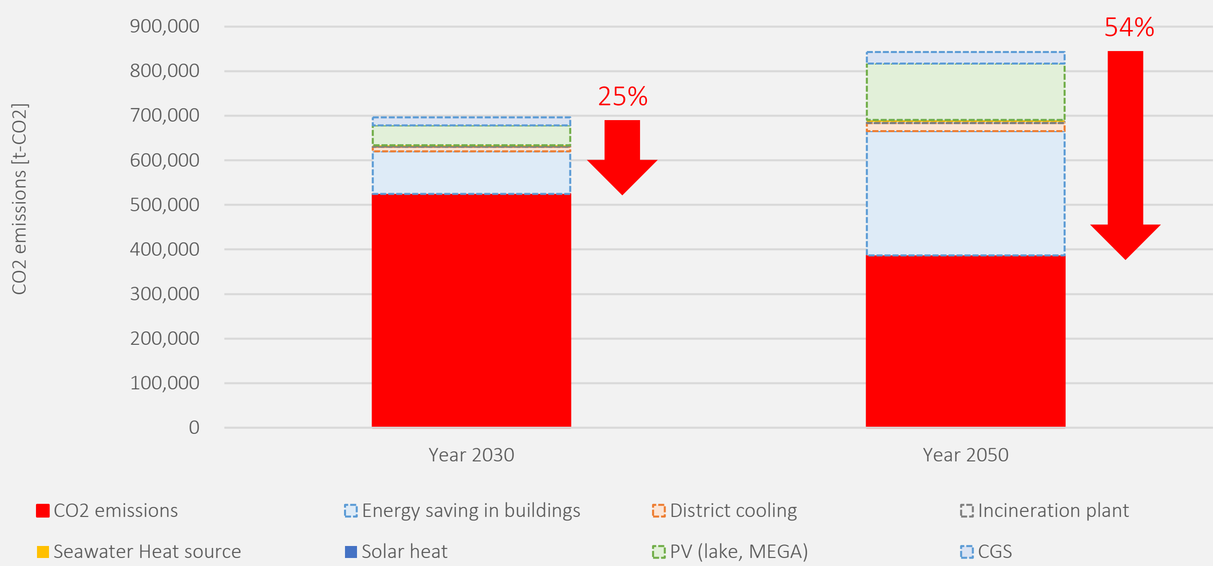


Fig.0-30. Reduction of CO2 emissions in each method in Low carbon scenario for the building sector

Source: Project team (NSRI), https://www.triplepundit.com/story/2012/combined-heat-and-power-pros-and-cons/81856

4) Define BAU of CO2 emission baseline in Transporter sectors

CO2 in the traffic field is mainly emitted by private automobiles. One reason for this is because, as compared with public transportation such as railways and buses, automobiles emit a large amount of CO2 per person. In order to reduce CO2, it is effective to control the traffic volume of automobiles, use forms of public transportation with less CO2 emissions, reduce travel distance and reduce the amount of CO2 emitted by each car. In addition, it is effective to change bus transportation, which is the main form of public transportation, to vehicles with low CO2 emissions, and to reduce the amount of CO2 emitted by each bus.

Due to lack of data of the total number of vehicles running (on road) in Phu Quoc Island, the Master Plan was referred. The Mater Plan indicate total number of yearly tourists with target years of 2020 and 2030. The same number has been considered for person trip on our study. In the long-term roadmap, BAU will be estimated with a target year of 2050 based on the capacity of Phu Quoc International Airport being upgraded to handle 7.0 million visitors per year.

In this study, the CO2 emissions expected from the future increase of tourists and defined as BAU in the transport sector. Most of the tourists are expected to travel by bus from the airport to the commercial facilities and hotels in the city center, this study assumes that 80% of the trip is by bus, and the other means are private cars (and hired cars).

To calculate the CO2 emissions for tourists, multiply the Traffic volume in each vehicle and Travel distance. To that value, CO2 emission indicator is integrated to calculate the CO2 emissions of the car.

CO2 emission = Traffic (Traffic volume) × Travel distance (Distance traveled) × Emission factor (Emission intensity)

The following are estimates of CO2 emissions by tourists in transport sectors.

Table. 0-38. CO2 emission in Transport sectors (BAU)

	Share ratio	2020	2030	2050
Bus	80%	166,720,00 g-CO2	416,800,000 g-CO2	583,520,000 g-CO2
Car	20%	281,400,00 g-CO2	703,500,000 g-CO2	1,969,800,000 g-CO2
Total	**100%**	**448,120,000 g-CO2**	**1,120,300,000 g-CO2**	**2,533,800,000 g-CO2**

Source: Project Team (NSRI)

6. Business scheme for three volunteer towns

Project team has estimated the CO2 reduction from proposed measures and studied business model for implement the low carbon town.

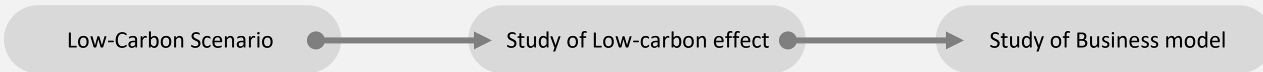


Fig. 0-31. Overall flow of business scheme
Source: Project Team (NSRI)

As we studied realistic business scheme for each towns, we have considered the current situation and characteristic of each towns.

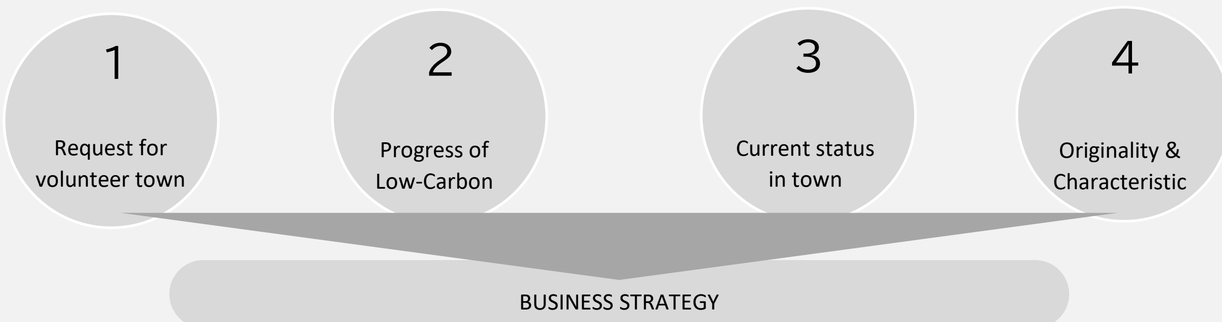


Fig. 0-32. Image of basic approach for conducting strategy
Source: Project Team (NSRI)

6-1. Prioritization of low carbon scenarios

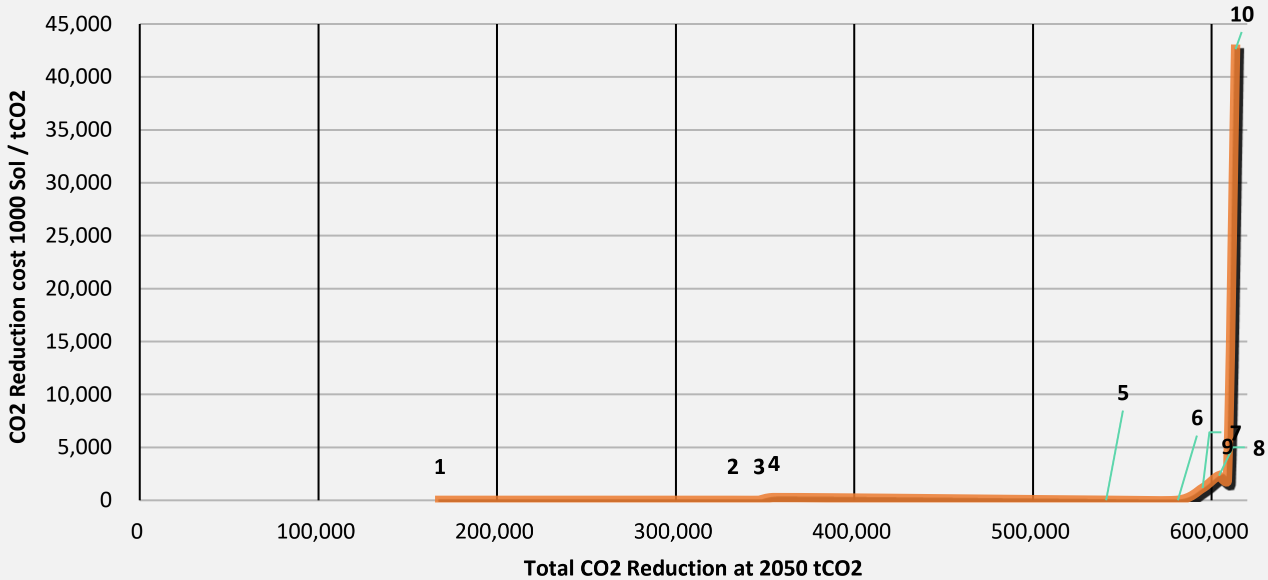
1) La Molina District, Lima, Peru

The CO2 emissions in 2030 and 2050 through the introduction of low-carbon methods in buildings are estimated to be reduced by 32% (up to 239 ktCO2eq/year) and 52% (up to 613 ktCO2eq/year) respectively compared to BAU in 2030 and 2050. The CO2 emission reduction is contributed by energy conservation, PV power generation, etc.

The below Figure shows the CO2 reduction in 2050 [tCO2] and the CO2 reduction cost [1000 sol / tCO2] in La Molina District. The CO2 emission reduction is contributed by energy conservation, PV power generation, etc. For more information, refer to Table 0-39..

The measures, especially those for buildings, that has a cost of zero, means that they can be implemented without additional cost (Table 0-39). In La Molina District, such a measure are high efficiency of appliances and cooking equipment. The recommended level of achievement is within Y2025 which means that such an intervention has a short span for implementation.

It is important to be implemented measures that combine high-efficiency equipment and solar power generation in the existing and future buildings. In the La Molina district, because of the typical architecture and shape of the buildings (mostly the buildings have a flat roof), and because of the warm and sunny climate, the PV system is highly recommended. Our estimations show that at both residential and commercial areas in La Molina District, the installation of PV is possible on approximately 50% of the roof area of the total number of the buildings.



※Cost prices were adjusted based on the International Construction Costs 2020

Fig. 0-33. Cost estimation in La Molina District Low carbon scenario

Source: Project Team (NSRI)

Table 0-39. Low carbon method and level of achievement

Item	Low carbon methods	CO2 reduction volume in 2050 [tCO2]	CO2 Reduction cost [1000 sol/t-CO2]	Level of achievement
1	Others	168,000	※	Mid-Long
2	High efficiency of appliances (residential and commercial)	163,925	0	Short
3	High efficiency of cooking equipment (residential and commercial)	14,768	0	Short
4	Lighting equipment (residential and commercial)	8,307	259	Short
5	PV on residential buildings (50% coverage)	185,990	6	Mid-Long
6	PV on commercial building (50% coverage)	40,133	6	Mid-Long
7	Hot water supply (residential and commercial)	13,845	1,154	Long
8	High efficiency of cooling equipment (residential and commercial)	9,230	2,331	Long
9	Building insulation: Roof thermal barrier coating (residential and commercial)	4,615	1,865	Long
10	Thermal insulation and solar radiation shielding (residential and commercial)	4,615	42,618	Long

※For reference, in the calculation of the reduction volume are added “others low carbon methods”. The others include greenery and waste management. The cost estimation of greenery and waste management methods depend on the future master plan and waste management policies in 2050 in La Molina District.

Source: Project Team (NSRI)

2) Kohn Kaen Municipality, Thailand

To achieve low carbon, it is important to develop priorities for low carbon scenarios. The Marginal Abatement Cost Curves can be used as a reference for prioritization. The vertical axis shows the CO2 Reduction cost per CO2 reduction, and the horizontal axis shows the total CO2 reduction of Khon Kaen in 2050. The horizontal axis shows Khon Kaen's total carbon dioxide reduction in 2050. The CO2 reduction costs per unit of carbon dioxide reduction are numbered in order of decreasing cost.

The costs are estimated by NSRI in local currency, considering local construction prices. Many of the measures, especially those for buildings, have a cost of zero, which means that they can be implemented without additional cost at the time of the next equipment renewal for existing buildings, or at the design stage for new buildings.

The recommended time spans were divided into short, middle, and long spans so that the total carbon dioxide reduction for each would be roughly equal. The recommendations for the short span are No.1 to No.14, which are mainly measures related to building equipment. In particular, the replacement of high-efficiency home appliances in No. 9 and the replacement of heat source equipment for air conditioning with high-efficiency ones in No. 12 have a particularly large impact.

As for the middle term recommendations, the promotion of solar panels (No.19 and No.20) will have a great impact, as the mega-solar power plant (No.19) is located on the water and can be expected to improve power generation efficiency. As a recommendation for the long term, No. 23, the use of heat pumps for hot water supply in houses, will have a significant impact. In recent years, the price of heat pumps for hot water supply has gradually become cheaper. In addition, although the cost of heat insulation and solar radiation shielding in the house No. 30 is rather high, it also has the effect of improving the comfort of the indoor environment through improved heat insulation performance.

Thus, it will be important to combine measures such as solar power generation and the use of heat pumps for hot water supply with measures for building facilities.

The following section is a list of methods that may be effective in implementing each measure.

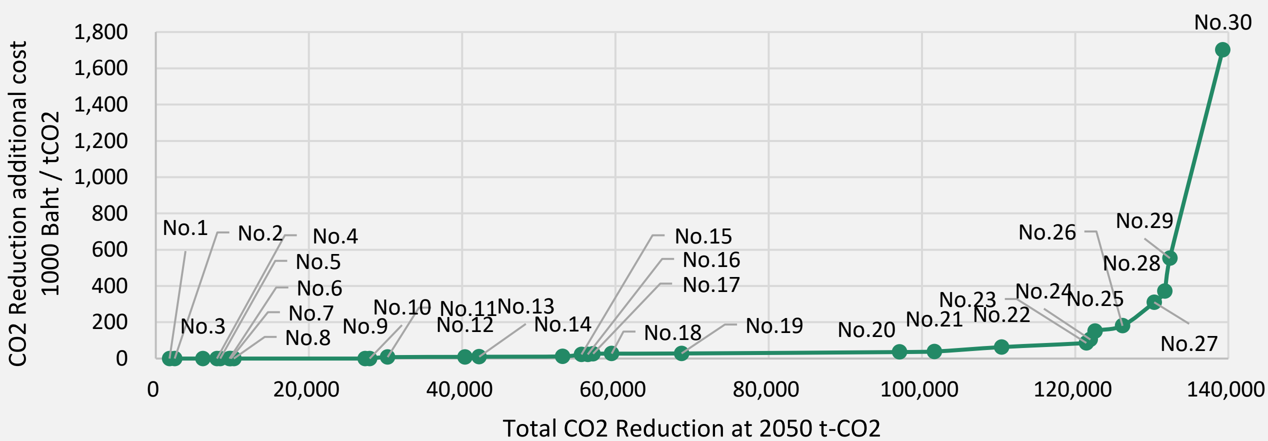


Fig. 0-34. Marginal Abatement Cost Curves at Khon Kaen Low carbon scenario
Source: Project Team (NSRI) Cost prices were adjusted based on the International Construction Costs 2020.

Table. 0-40. Low carbon method and recommended time span

No	Low carbon methods	CO_2 reduction volume (at 2050)	CO_2 Reduction Additional costs	Recommended time span
		t-CO_2	1000 Baht/t-CO_2	
No.1	Reduction of internal heat generation (Non-residential building)	1,791	0	Short
No.2	Inverter (Water conveyance) (Non-residential building)	674	0	Short
No.3	Inverter (Air conveyance) (Non-residential building)	3,697	0	Short
No.4	Conversion to heat pumps (Non-residential building)	1,820	0	Short
No.5	Reduced power (Outlet) (Non-residential building)	427	0	Short
No.6	High efficiency fan (Non-residential building)	1,214	0	Short
No.7	Improve pump performance (Non-residential building)	181	0	Short
No.8	Smart operation elevator (Non-residential building)	382	0	Short
No.9	High efficiency of home appliances(residential)	17,143	0	Short
No.10	High efficiency of cooking equipment(residential)	587	0	Short
No.11	High efficiency fan (Non-residential building)	2,346	8	Short
No.12	High-efficiency heat source equipment (Non-residential building)	10,104	9	Short
No.13	Introduction of CO concentration control of parking fans (Non-residential building)	1,854	10	Short
No.14	Lighting equipment (LED, Organic EL) (residential)	10,895	12	Short
No.15	Illuminance correction (Non-residential building)	2,453	23	Middle
No.16	Inverter (Heat source auxiliary) (Non-residential building)	816	23	Middle
No.17	Human Sensor (Lighting) (Non-residential building)	701	26	Middle
No.18	CGS (hotel, hospital)	2,428	27	Middle
No.19	PV on pond	9,117	28	Middle
No.20	PV on residence	28,478	36	Middle
No.21	PV on commercial building	4,520	39	Long
No.22	High efficiency of lighting equipment (LED, Organic EL, Non-residential building)	8,783	63	Long
No.23	Hot water supply equipment (residential)	11,055	86	Long
No.24	CO_2 ventilation control (Non-residential building)	528	105	Long
No.25	Introduction of high efficiency transformers (Non-residential building)	610	151	Long
No.26	Glass performance improvement (Non-residential building)	3,583	180	Long
No.27	High efficiency of cooling equipment (residential)	4,139	310	Long
No.28	Roof thermal barrier coating (residential)	1,380	372	Long
No.29	Total heat exchanger (Non-residential building)	668	554	Long
No.30	Thermal insulation + solar radiation shielding (residential)	6,898	1,702	Long

Source: Project Team (NSRI) Cost prices were adjusted based on the International Construction Costs 2020.

3) Phu Quoc District, Kien Giang Province, Viet Nam

To achieve low carbon, it is important to develop priorities for low carbon scenarios. The Marginal Abatement Cost Curves can be used as a reference for prioritization. The vertical axis shows the CO2 Reduction cost per CO2 reduction, and the horizontal axis shows the

To achieve low carbon, it is important to develop priorities for low carbon scenarios. The Marginal Abatement Cost Curves can be used as a reference for prioritization. The vertical axis shows the amount of CO2 reduction, and the horizontal axis shows the investment cost of Phu Quoc in 2030. The horizontal axis shows Phu Quoc's total investment cost in 2030, about 600 million USD.

NSRI calculated the amount of CO2 reduction and investment amount up to 2030. The costs are estimated by NSRI in local currency, considering local construction prices. The cost of each item is calculated at the ratio of the construction cost in consideration of Viet Nam’s condition. However, CGS and Seawater Heat source system calculated based on Japan’s cost, because they are supplied by machinery equipment manufacturer.

Regarding the amount of CO2 reduction compared to the investment amount, PV was the highest, followed by energy-saving investment on the building side and machinery equipment such as CGS was low.

In the future, it will be possible to make more accurate calculations using total floor area data by each use.

Table.0-41. Reduction of CO2 emissions and investment cost

	Year 2030		
	Investment cost	Amount of CO2 reduction	USD/t-CO2
	Million USD	t-CO2	USD/t-CO2
PV (lake, MEGA)	12	43,971	282
Energy saving in buildings	413	95,510	4,329
Solar heat	2	546	4,546
Incineration plant	9	1,853	4,963
District cooling	52	9,824	5,303
CGS	109	18,011	6,038
Seawater Heat source	12	1,637	7,576

Source: Project team (NSRI)

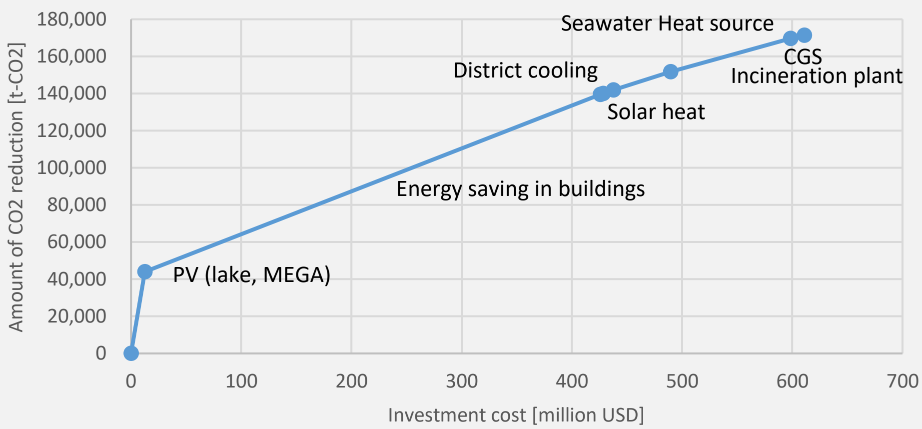


Fig.0-35. Reduction of CO2 emissions and investment cost
Source: Project team (NSRI),

6-2. Buildings

1) Green Roof subsidy

It is expected that the greening the rooftop has not only the thermal insulation effect of the green soil and the effect of blocking the sunlight by the plants themselves, which suppresses the rise in indoor temperature and the energy-saving effect, but also the effect of mitigating the temperature rise of the outdoor space by the transpiration of the plants. In other words, the improvement of the thermal environment due to the rooftop greening is a measure that has various effects such as improvement of indoor environment and economic effect, creation of comfortable rooftop space, and environmental improving effect of the whole city. Actually, in various economies there is a support system.

Table 0-42. Green Roof subsidy

City	Condition	Subsidiary aid	Credit limit
Chicago	Maintain for 5 years	-	$5,000
Toronto	More than 50% of the roof area	$10 / m2	$20,000
Berlin	-	50% of the Cost	-
Basel	-	SFr.20 / m2	-
Stuttgart	-	50% of the Cost	-
Montreal	-	$54 / m2	-

Source: Ministry of the Environment, Japan

2) Cool Roof subsidy

A cool roof is a brightly colored roof that has high reflectance of sunlight and emissivity of solar heat. It is expected that reflecting sunlight and solar heat, could suppress the heat that enters the house and has the effect of cooling the house. In Southern Europe, in the Mediterranean region, there are towns with white houses, which have a meaning of cultural landscape but it is a traditional method to prevent the strong sunlight and heat that are typical for the Mediterranean region.

Compared to the above rooftop greening, few economies have adopted a system to promote cool roofs, but the system is being developed mainly in North America.

Table 0-43. Cool Roof subsidy

City	Condition	Subsidiary aid
California	Reflectance・emissivity 0.75~	$0.20 / square feet
Chicago	Reflectance 0.65~	$0.50 / Square feet
Georgia	Reflectance・emissivity 0.75~	Obligation
New York	Reflectance 0.65~	Obligation

Source: Ministry of the Environment, Japan

3) Zero Emission point program

"Home Zero Emission Action Promotion Project (Tokyo Zero Emi Point)" is a gift certificate and LED for Tokyo residents who have replaced the installed air conditioner / refrigerator / water heater with an air conditioner / refrigerator / water heater with high energy-saving performance. This is a business that grants "Tokyo Zero Emi Points" that can be exchanged for discount coupons.

In this program, points will be given to residents of Tokyo, Japan who have replaced their products with air conditioners, refrigerators, and water heaters that have high energy-saving performance. Approximately 80% of the applicants chose home appliances with high energy-saving performance as a result of this project.

Such a program could be very beneficial for la Molina District in order to reduce CO2 emissions using replacing the installed air conditioner / refrigerator / water heater with an air conditioner / refrigerator / water heater with high energy-saving performance.

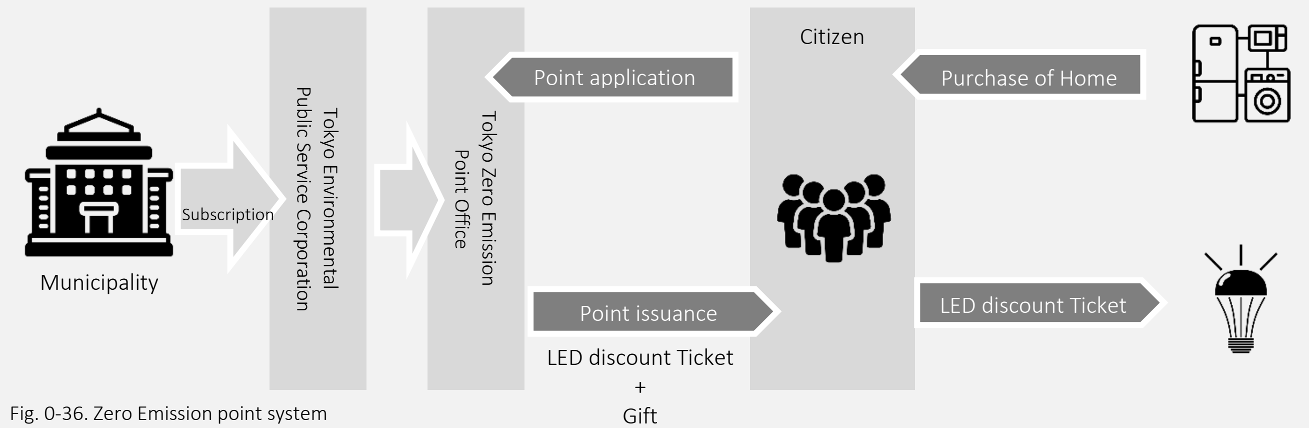


Fig. 0-36. Zero Emission point system
Source: Tokyo Metropolitan Government

4) Green Deal program

The Green Deal was a UK government policy initiative that gave homeowners, landlords and tenants the opportunity to pay for energy efficient home improvements through the savings on their energy bills from 2012 to 2015. At the heart of the Green Deal was the rule that savings on bills would exceed the cost of the work. By meeting this 'Golden Rule', consumers were able to receive energy savings without direct cost. Consumers then paid back the cost of such improvements through the expected savings in their energy bills. However, there is no guarantee that the eventual savings made by consumers will match the cost of the loans they take out to make the improvements and industry bodies recognised there was a risk consumers could end up out of pocket.

There were 45 different types of improvements available under the Green Deal, ranging from loft and cavity wall insulation, innovative hot water systems and condensing boilers to more costly measures such as solar thermal energy or solid wall insulation.

This was a unique financial structure with no debtor, instead the burden stayed with the property no matter the tenant. This means new tenants or owners become liable for the payments for the energy efficiency improvements, requiring new legislation in English law

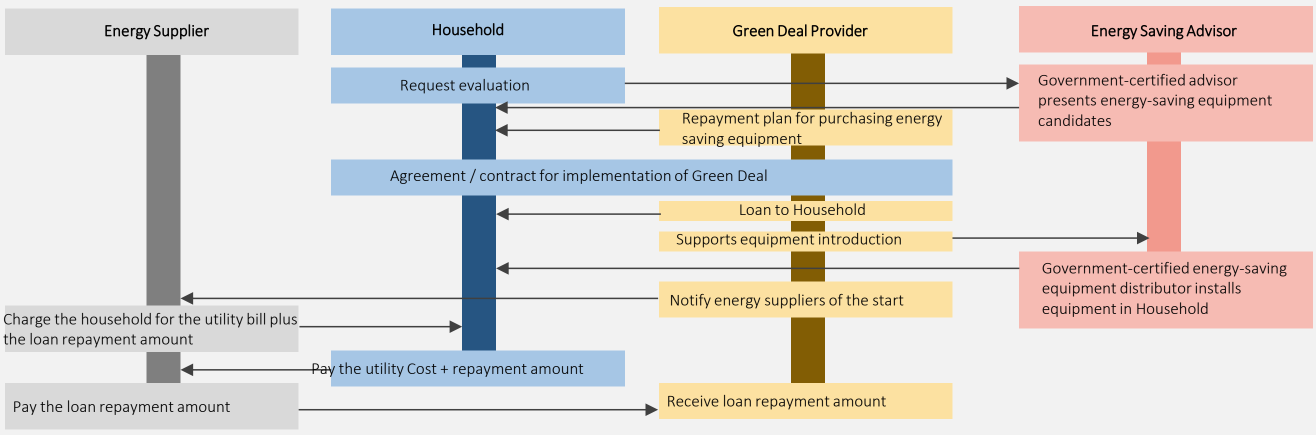


Fig. 0-37. Green Deal program scheme
Source: Ministry of the Environment, Japan

5) Green Building program

The submission system of building environment plan is designed to clarify environment-friendly approaches to buildings and highly evaluate excellent approaches. The system was introduced in June 2002 with the aim of creating a market where environment-friendly and high-quality buildings are highly evaluated.

It is required for those buildings that will be newly built or extended and whose total floor area exceeds 5,000 square meters to submit their building environment plans. Moreover, those buildings that will be newly built or extended and whose total floor area exceeds 2,000 square meters may submit their building environment plans on a voluntary basis. Details of plans and the results of evaluation of environment-friendly approaches are opened to the public on the official website of the Tokyo Metropolitan Government (TMG).

The submission system of building environment plan has four evaluation points, i.e., "streamlining of energy use," "appropriate utilization of resources," "protection of natural environment" and "mitigation of heat island phenomenon" (details are shown in the table below). Moreover, it was made mandatory in January 2010 to consider the introduction of equipment to use renewable energies. From now on, renewable energies such as sunlight, solar heat and others are expected to come into wider use in large-scale newly-built buildings, only a few of which have introduced renewable energy to date.

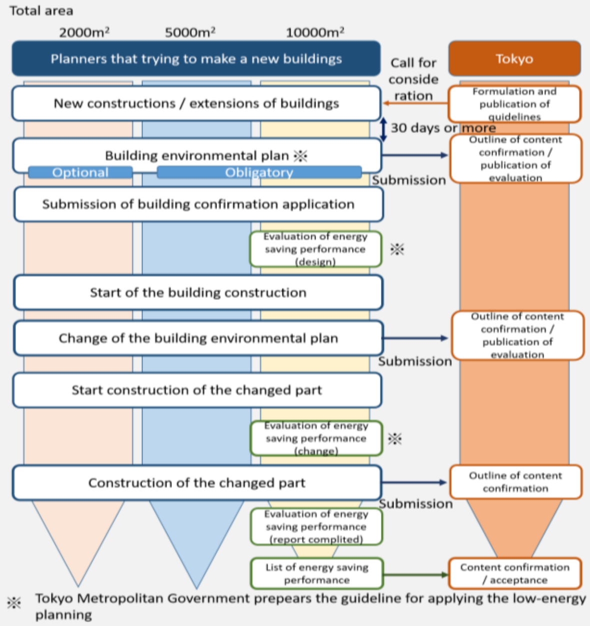


Fig. 0-38. Green Building program system

Source: Tokyo Metropolitan Government

6) Green Lease

There are many office buildings in this districts, and if building owners try to carry out low carbonization, they individually introduce energy saving measures by themselves and their own risk. In this scheme, building owner who has a strong intention of low carbonization contract a “Green Lease” with the public sector. Public sector (local municipality, etc.) provide subsidy to building owner as a part of additional cost for low carbonization.

After building owner improves building equipment, reduction of utility costs caused by the above improvement, is divided by tenants and owner as an incentive of low carbonization for both sides.

It has already been introduced in Tokyo Metropolitan Government to promote low carbonization of private buildings.

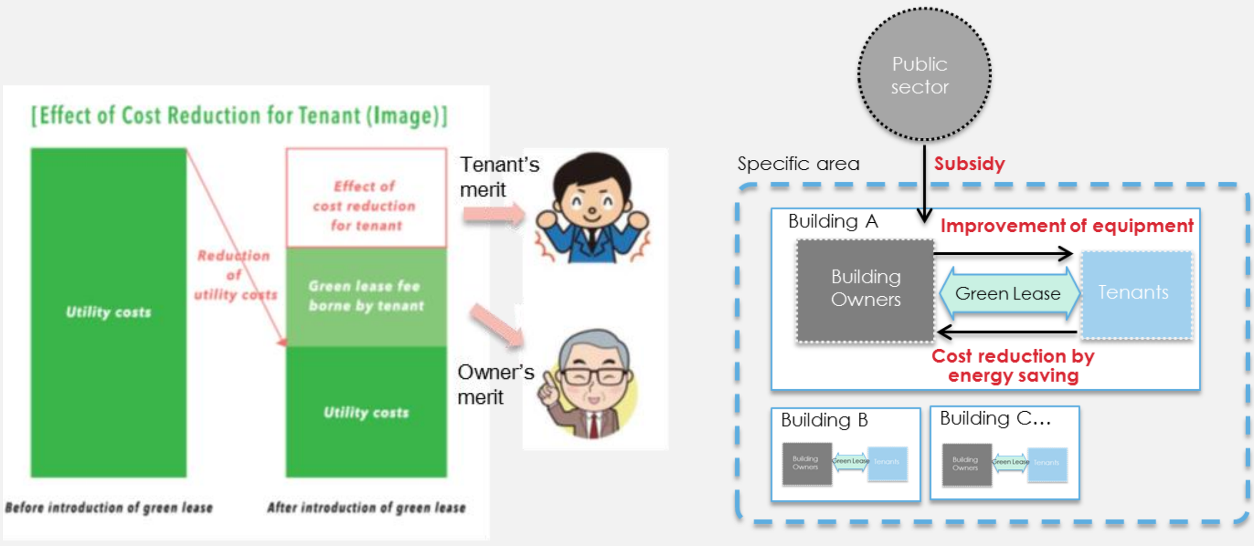


Figure 0-39. Business scheme of Community Green Lease

Source: Project Team (NSRI), Tokyo Metropolitan Government

6-3. Energy

1) Power Purchase Agreements (PPA)

A Power Purchase Agreement (PPA) is an electricity supply agreement between two parties, usually between a power producer and a customer (an electricity consumer or trader).

The PPA defines the conditions of the agreement, such as the amount of electricity to be supplied, negotiated prices, accounting, and penalties for non-compliance. PPAs can be used to reduce market price risks, which is why they are frequently implemented by large electricity consumers to help reduce investment costs associated with planning or operating renewable energy plants.

Local municipality or area management body installs PV panels by utilization of rooftop of the building and unused land / open space within the designated area, and gain an income by selling electricity through the FIT system. In case the FIT system is terminated, Virtual PPA should be considered as an alternative scheme.

Table 0-44. Power Purchase Agreements (PPA) plan

	Self-owned	PPA
Owner of the PV	self-owned	PPA providers
initial investment	Necessary	Unnecessary
maintenance	Necessary	Unnecessary
electric utility charge	Free for self-consumption	Self-consumption also charged
capitalization	on-balance sheet	off-balance sheet
Project period	Return on investment in about 10 years	Contracts of 10 years or more

Source: Project team (NSRI)

2) Energy Service Company (ESCO)

The ESCO business is a business that covers all expenses related to energy-saving repairs with the reduction of utility costs. ESCO companies provide all services related to energy-saving diagnosis, design/construction, operation/maintenance, financing, etc. In addition, it has the feature that the profits of local governments can be maximized by taking a contract form (performance contract) that includes a guarantee of energy-saving effect.

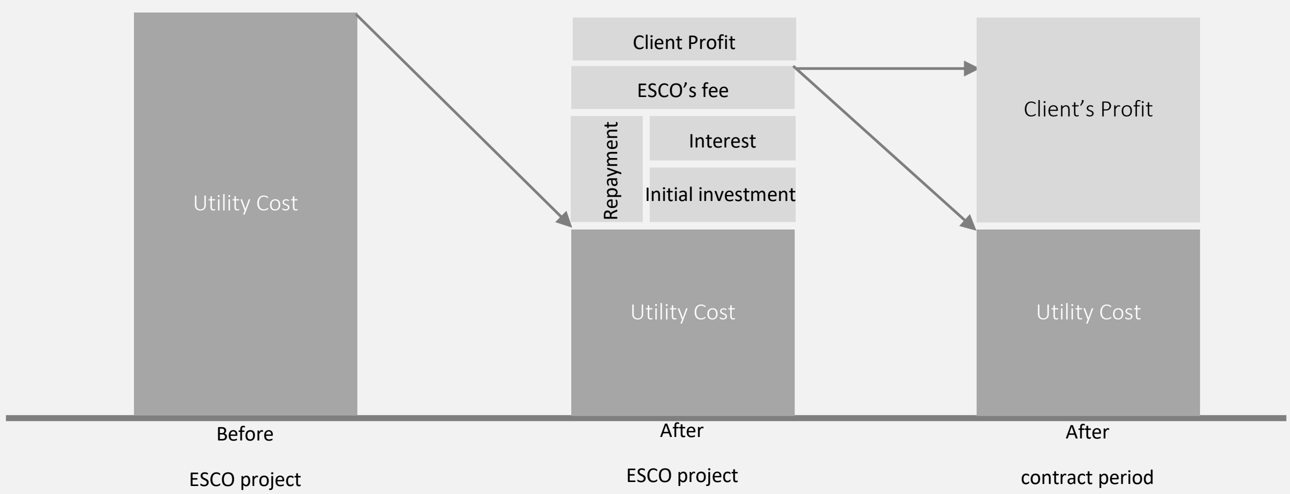


Fig. 0-40. Reduction of utility cost and allocation of profit
Source: Project Team (NSRI)

3) Energy Performance Contracting (EPC)

Energy efficiency investments in buildings and infrastructure are undertaken by specialised companies, EPC providers, with performance guarantee during the time of the contract. EPC providers are paid from achieved savings.

Energy performance contracting offers a number of advantages for clients:

- One partner, one contract for different types of deliveries and services.
- Guaranteed energy savings and greenhouse gas emissions.
- Energy efficiency investments financed directly from cost savings.
- EPC providers takes on the performance risks of works and technology.
- Energy management by EPC provider.
- EPC helps the client arranging the financing of the project.
- Additional savings measures and increase of achieved savings during contract.

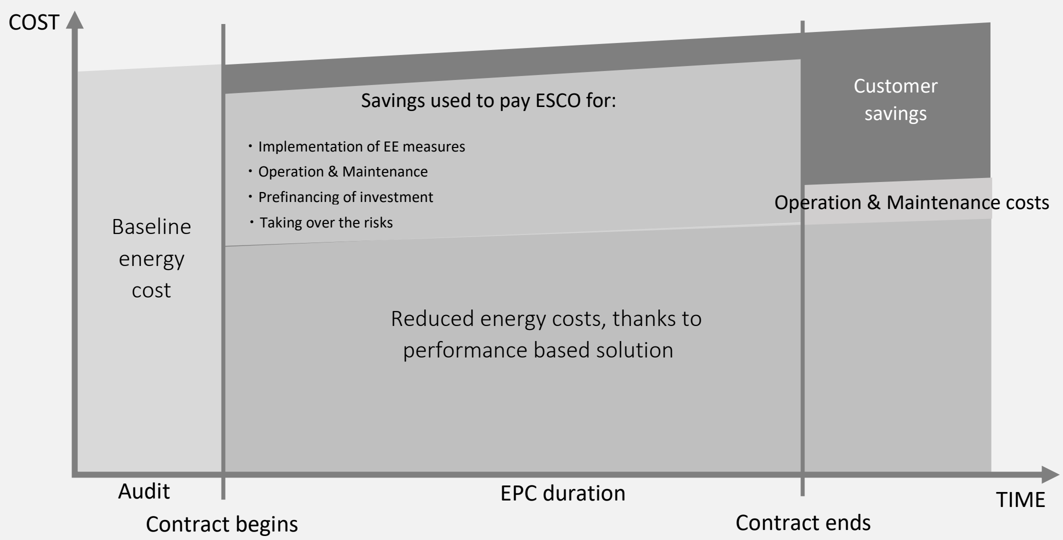


Fig. 0-41. Image of EPC profit
Source: Project Team (NSRI)

4) District Cooling company

In many cases, developers or building owners establish SPC and SPC establishes DC company. Priority is given to areas with high heat demand as heat supply areas, and make a heat supply contract with the building owners. If DC company own renewable energy (such as solar power) at a heat supply facility, DC company can sell the generated electricity to an electric power company.

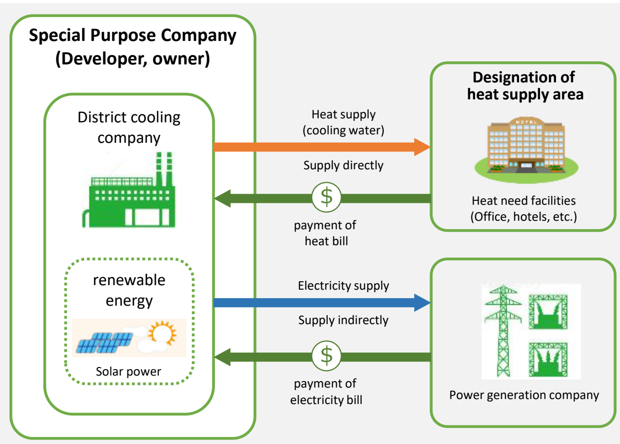


Fig. 0-42. Business scheme of District cooling system
Source: Project Team (NSRI)

5) Waste heat use form incineration plants

Conclude a heat supply contract to supply the waste heat of the incineration plant to heat consumers. It is conceivable to directly supply heat to a building with a large heat demand or to supply heat to a district heating facility with a large heat demand. When the demand for hot water is low, it is conceivable to use the exhaust heat of the incineration plant to produce chilled water. However, in the case of an absorption chiller, the equipment with a large capacity is required, so chilled water is produced from a district cooling company. In many cases, the electricity generated from the incineration plant is sold to the electric power company and indirectly supplied to the development area.

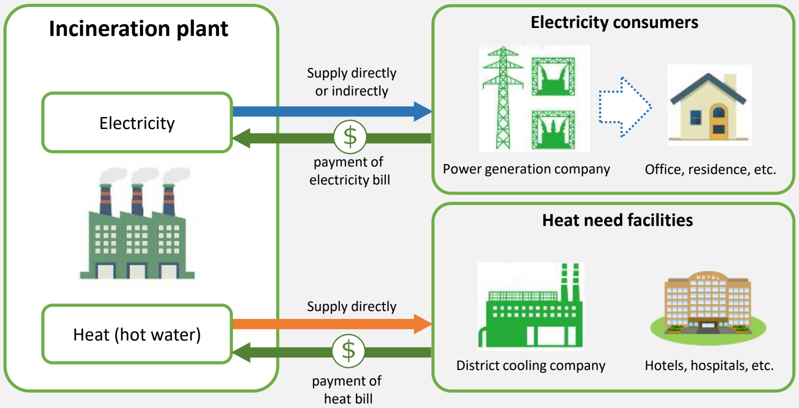


Fig. 0-43. Business scheme of Waste heat use from incineration plants
Source: Project Team (NSRI)

6) Community solar farm

Local municipality or area management body installs PV panels by utilization of rooftop of building and unused land / open space within the designated area, and gain an income by selling electricity through the FIT system.

In case the FIT system is terminated, Virtual PPA should be considered as an alternative scheme.

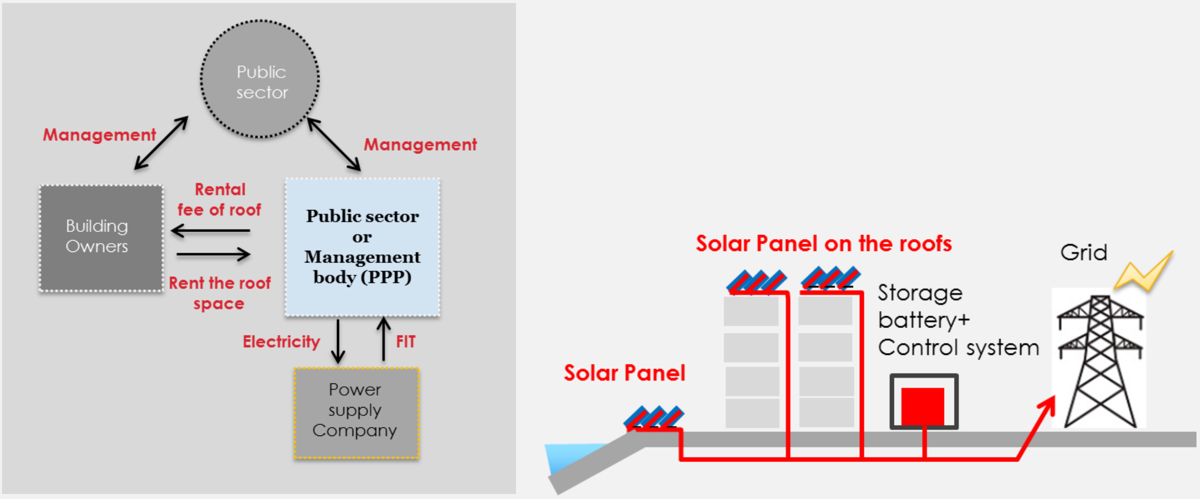


Fig. 0-44. Business scheme of Community Solar Farm
Source: Project Team (NSRI)

7) Urban photovoltaics

Electricity generated from renewable energy is characterized by instability. Therefore, it is desirable that the electric power company purchases the electricity generated from the renewable energy company and supplies the stabilized electric power from the electric power company to a wide area. Electric power company can also sell the purchased electricity derived from renewable energy to consumers as green electricity.

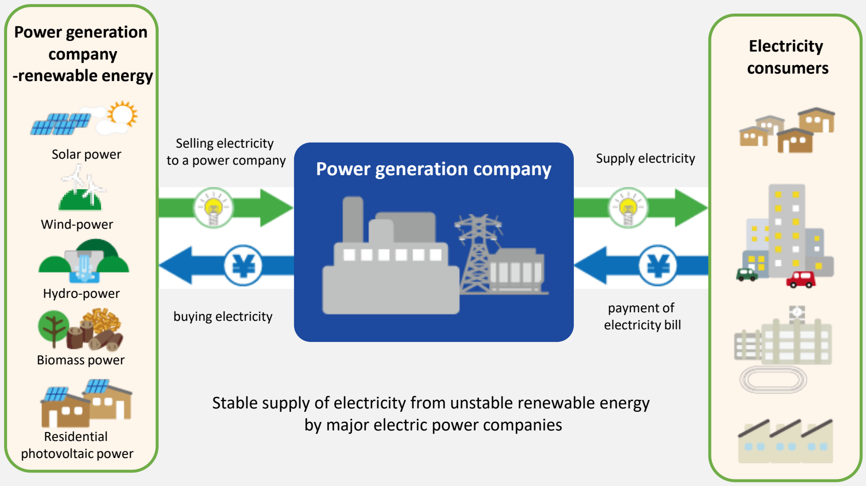


Fig. 0-45. Business scheme of Urban photovoltaics
Source: Project Team (NSRI)

8) Co-generation system

Facilities or buildings with high heat demand will install Co-Generation System (CGS) and use produced electricity and heat. The electricity and heat produced will be preferentially supplied to the area supplied by the District Cooling area (or building) for self-consumption. It is conceivable that the surplus electricity will be sold to the electric power company in reverse. The efficiency of exhaust heat from CGS is high when the exhaust heat is supplied as hot water, but when the demand for hot water is small, the high temperature exhaust heat is converted into chilled water and supplied by using an absorption type facility.

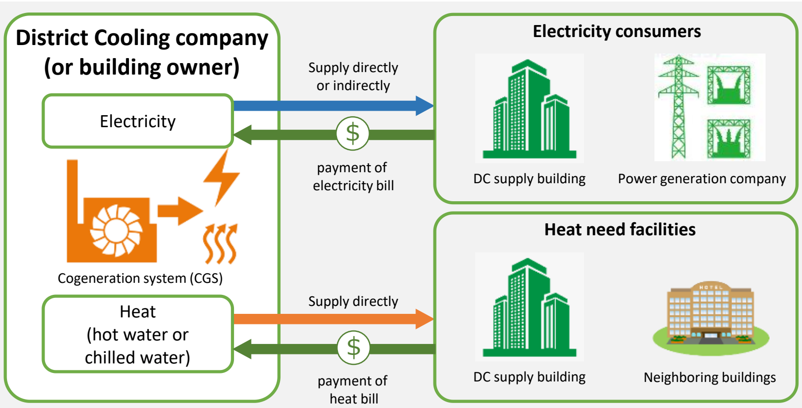


Fig. 0-46. Business scheme of Waste heat use from incineration plants
Source: Project Team (NSRI)

6-4. Transportation

1) Improvement Bus business

Improving the convenience of buses, which are an important means of transportation in the daily lives of local residents, will lead to further reduction of CO_2 emissions.

It is important to optimize the operation of bus routes by continuously reviewing and improving the routes and schedules. As a means to achieve this, efforts to visualize the operation status should be promoted.

While local governments are responsible for the development of bus infrastructure, bus operators will be obliged to provide data on their operations. This will make it possible to build a sustainable transportation system.

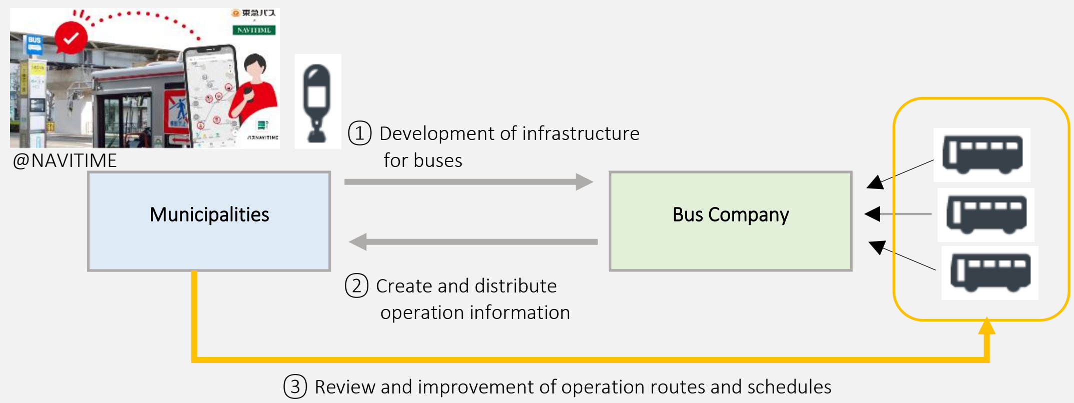


Fig. 0-47. Image of Bus business scheme
Source: Project Team (NSRI)

2) Area management promotion

In TOD, it is important to promote the maintenance and management of the urban space that has been created, and area management will play a major role. In TOD, it is important to promote the maintenance and management of the formed urban space, and area management initiatives will play a major role.

The key point in area management is to secure adequate financial resources to support the activities of the organizations. By introducing a public-private partnership system in which the municipality collects the costs of area management activities from the beneficiaries (businesses) and delivers them to the area management organization, it will be possible to promote appropriate maintenance and management in the future.

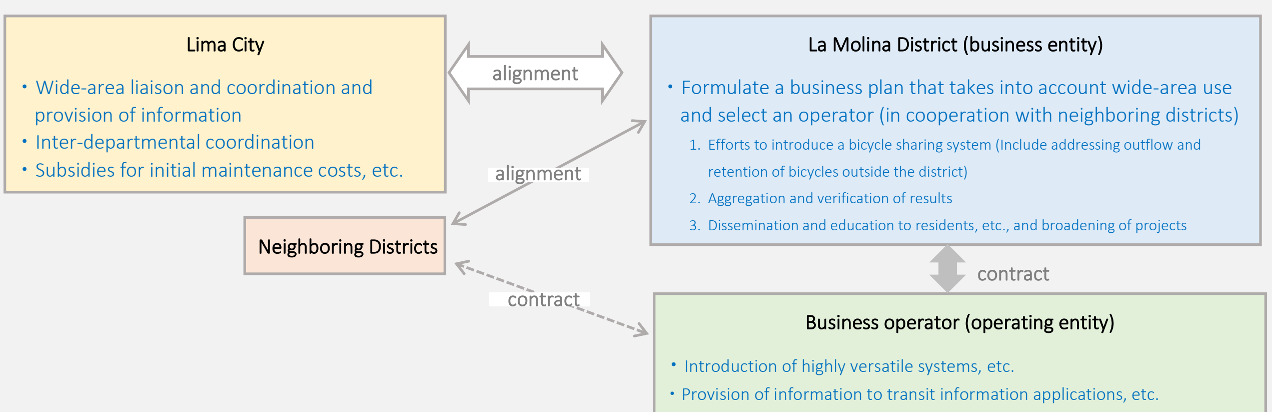


Fig. 0-48. Image of area management contribution system
Source: Project Team (NSRI)

3) Establishment of traffic storage facilities

In urban development, the contribution to the development and improvement of the traffic environment in the area and surrounding urban areas will be evaluated, and the standard floor-area-ratio limits will be relaxed, and specific rules for the contribution and relaxation of the floor-area-ratio will be set according to the actual conditions of the district. In this way, the project will promote the development of projects by landowners and private businesses, and the formation of a traffic environment.

*Transportation complementary facilities to be evaluated: public parking lots, public bicycle parking lots, transportation plazas, bus terminals, cab bays, etc.

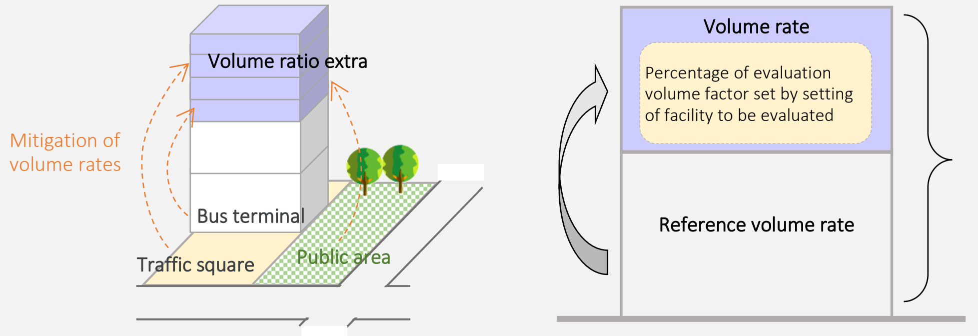


Fig. 0-49. Image that mitigates the volume
Source: Project Team (NSRI)

4) Community based Mobility service

Public sector or management body runs traffic information platform at the designated area. Management body effectively collaborates the existing business such as Grab, etc. It is forecasted that more incubator business happens by utilizing the platform.

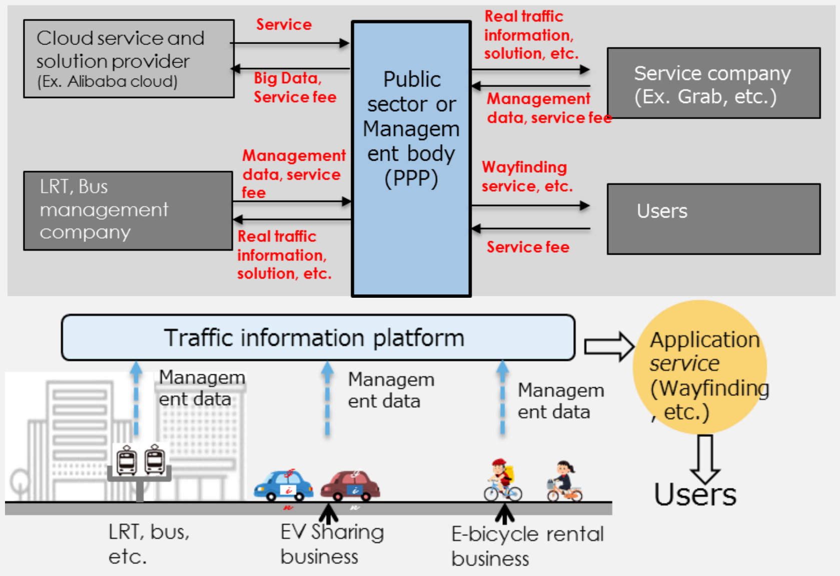


Fig. 0-50. Business scheme of Community based MaaS
Source: Project Team (NSRI)

01

CHAPTER 1. Introduction

1. What is the APEC LCMT Project Dissemination

The APEC Low-Carbon Model Town (LCMT) Project Dissemination Phase 3, which succeeds LCMT Project Phases 1-7, seeks to accelerate the dissemination of low-carbon towns in order to manage rapidly growing energy consumption in the APEC region.

The key activities are: 1) to hold the 2nd LCMT Symposium for the dissemination of the “Concept of the Low-Carbon Town in the APEC Region (Concept)” through utilizing APEC Low-Carbon Town Indicator (LCT-I) System; and 2) to conduct Feasibility Studies for a specific area of three towns participated as the LCT-I volunteer towns in the 1st LCMT Symposium in the LCMT Project Phase 7. The nominations of the LCT-I volunteer towns are on a voluntary basis and three LCT-I volunteer towns are planned to be selected through the EWG.

Relevance

This project directly responds to the declaration at the 9th APEC Energy Ministers Meeting (EMM9), held in Fukui, Japan on 19 June 2010, where ministers discussed low-carbon paths to energy security which also provide cooperative energy solutions for a sustainable APEC as well as growth strategies.

Among several messages, they noted that the introduction of low-carbon technologies in city planning to boost energy efficiency and reduce fossil energy use is vital to manage rapidly growing energy consumption in urban areas of the Asia-Pacific region. In this context, APEC Energy Ministers have agreed to launch an “APEC Low-Carbon Model Town (LCMT) Project” with a view to presenting successful models for coordinated usage of advanced low-carbon technologies. This project is considered as one of the priority projects for APEC.

While local government and municipal officials are getting interested in making their town low-carbon, their urgent concerns tackling now are to alleviate urban problems such as traffic congestion, air/water pollution, waste management, recycling of used water and so on. However, the main objective of the APEC LCMT Project focuses on CO2 emissions reduction. One element of realizing a low-carbon town is to increase energy efficiency while to reduce unnecessary energy consumption.

The investments required for them pay for themselves in a short/medium perspective. The other element is to introduce renewable energy sources such as solar photovoltaic power generation, advanced technology which include building energy management system (BEMS), electric vehicles, smart grid systems and so on.

These technologies are still expensive and some of them may need demonstration tests before putting into commercial applications. However, all these technologies have a huge potential to substantially reduce CO2 emissions in towns. As such, the APEC LCMT Project provides towns with opportunities to obtain financial benefit and a future economic development.

This project is directly linked to "building sustainable and resilient communities" (Rank 1) and "energy efficiency, energy security and energy resiliency including the development of low-carbon technology and alternative energy sources" (Rank 2), which is because it aims to identify successful models for sustainable communities through coordinated usage of advanced low-carbon technologies.

Objective

The key objectives of the project are:

1) To disseminate the basic ideas and effective approaches of the Concept through utilizing the LCT-I System, which helps evaluate the progress and status of low-carbon development of various areas in the APEC region;

2) To provide Feasibility Studies of a specified area of low-carbon development projects selected as the LCT-I volunteer towns in the LCMT Project Phase 3 and identify how to improve the low-carbon development plans through the Feasibility Studies; and.

3) To share best practices and real-world experiences of low-carbon town design with planners and policymakers throughout the APEC region.

Source: APEC Homepage

The Concept of the Low-Carbon Town in the APEC Region

The concept provides a basic idea of what is a low-carbon town and an effective approach to its development. The concept aims to promote the development of low-carbon towns in the APEC region by providing a basic principle that can assist the central and local government officials of the member economies in planning effective low-carbon policies and in formulating an appropriate combination of low-carbon measures while taking socio-economic conditions and city-specific characteristics into consideration.

Source: The Concept of the Low-Carbon Town in the APEC Region, Six Edition, Executive Summary

LCT-I System

The objective of the LCT-I System is to further promote low-carbon efforts at the town level and control CO2 emissions. It was designed to be as simple as possible in consideration of user friendliness. In addition, the LCT-I System is expected to be used as an indicator that reflects the circumstances of each economy and the characteristics of the project.

Source: APEC Low-Carbon Town Indicator System Guideline, First Edition, November 2016

2. Scope of Work

This project will be undertaken according to the following procedure.

Prepare Low-Carbon Development (LCD) Strategy for the three volunteer towns' Low-Carbon Town development projects.

1. Background research and data collection

2. Develop a high-level Low-Carbon vision

3. Define the CO_2 emission baseline as BAU (Business As Usual) Scenario

4. Define comprehensive, specific and feasible Low-Carbon measures
   - Define the CO2 emission reduction and environment target of the town
   - Prepare a low carbon guideline for categories of low carbon town design challenges
   - Select CO2 emissions reduction measures in each design

Analyze CO2 emission reduction and costs for selected design measures

5. Perform scenario analysis of implementation alternatives and Analyze CO2 reduction efficiency

Study the implementation methodology and action plans of proposed CO2 reduction measures

6. Identify regulatory agencies and approval process and Develop the business model required for Low Carbon Methodologies in three volunteer towns

7. Governance Development
   - Governance vision
   - Training / Education

8. Analysis financial efficiency of Low Carbon Business Model in three volunteer towns

Fig. 1-1. Scope of work outline

Source: Project Team (NSRI)

APEC LCMT DISSEMINATION 3

02

CHAPTER 2. Overview of Three Volunteer Town

2.1. La Molina District, Lima, Peru

2.1.1. Geographic Data

Lima is the capital of the Republic of Peru. It is the center of politics, culture, finance, commerce and industry, with a population of about 10 million and 43 districts.

La Molina is a district of the Lima Province in Peru. It is located, geographically, in a boundary area, between what constitutes the upper part of the Chala region and the lower part of the Yunga region, which is between Chala Hanan and Yunga Hurin.

Officially, the district is established on February 6, 1962. The district has a total land area of 65.75 km². Its administrative center is located 241 m above sea level. The location of the district is between 12° 00' 07" S, 76° 57' 00" and 76° 51' 00" W. Furthermore, the district has been divided into 7 sectors for better administration in the municipal service.

Fig. 2.1-1. Location of La Molina District
Source: Project team (NSRI)

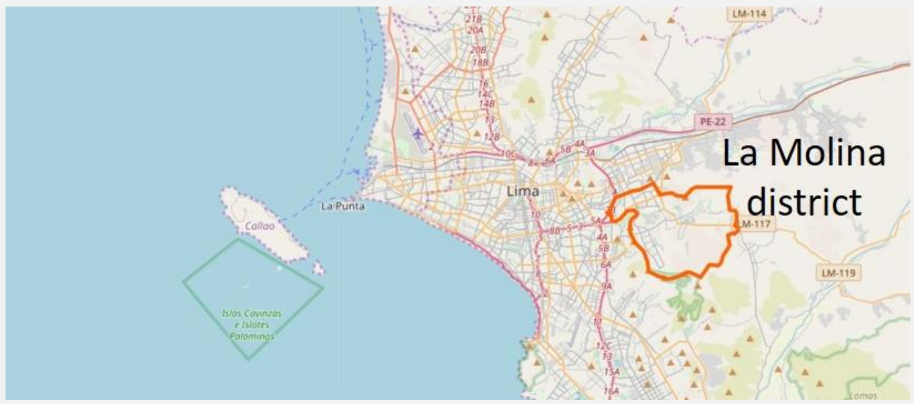


Fig. 2.1-2. Location of La Molina District
Source: Open Street Map

2.1.2. Demography

According to the 2018 census by the INEI, the district has 183,930 inhabitants, with a population density of 2139,6 person/km². Figure 2.1-3 shows that the population in the La Molina district increased from 2009 to 2018 by around 3.0% each year.

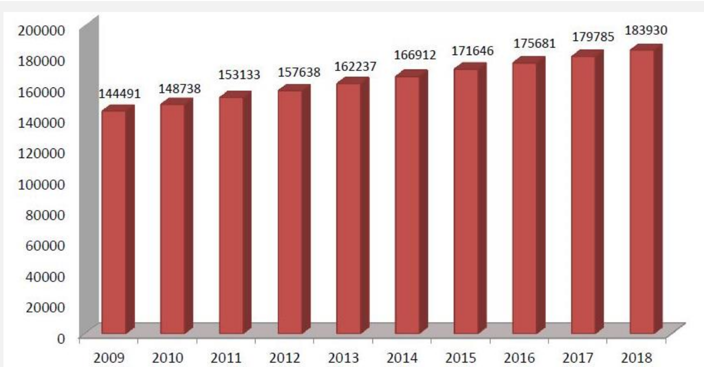


Fig. 2.1-3. The total projected population in La Molina district
Source: Municipal Statistical Compendium, La Molina, 2018

Table 2.1-1 shows the estimation of future population and population density in the Lima-Callao metropolitan area. The population of the La Molina area in 2030 is about 240,000 and is expected to increase 1.2 times in 10 years.

Table. 2.1-1. Future Population Projection, 2012-2030

Area	District Name	Area (ha)	2012 Population	2012 Population Density	2020 Population	2020 Population Density	2030 Population	2030 Population Density
	Sub Total [Lima Area]	267,040	8,481,415	31.8	9,609,386	36.0	10,963,461	41.1
Central Lima Area	Lima	2,198	286,849	130.5	250,769	114.1	204,312	93.0
	Barranco	333	31,959	96.0	27,037	81.2	20,677	62.1
	Breña	322	79,456	246.8	71,214	221.2	60,605	188.2
	Jesús Maria	457	71,364	156.2	71,964	157.5	72,714	159.1
	La Victoria	874	182,552	208.9	156,044	178.5	121,838	139.4
	Lince	303	52,961	174.8	46,379	153.1	37,894	125.1
	Magdalena del Mar	361	54,386	150.7	55,111	152.7	56,016	155.2
	Magdalena Vieja	438	77,038	175.9	75,281	171.9	73,025	166.7
	Miraflores	962	84,473	87.8	79,092	82.2	72,168	75.0
	Rimac	1,187	171,921	144.8	155,885	131.3	135,257	113.9
	San Borja	996	111,568	112.0	112,970	113.4	114,595	115.1
	San Isidro	1,110	56,570	51.0	51,124	46.1	44,117	39.7
	San Luis	349	57,368	164.4	58,593	167.9	60,066	172.1
	San Miguel	1,072	135,086	126.0	137,470	128.2	140,124	130.7
	Santiago de Surco	3,475	326,928	94.1	375,355	108.0	434,720	125.1
	Surquillo	346	92,328	266.8	90,386	261.2	87,852	253.9
	Total [Central Lima Area]	14,783	1,872,807	126.7	1,814,674	122.8	1,735,983	117.4
North Lima Area	Ancón	29,864	39,769	1.3	49,178	1.6	60,555	2.0
	Carabayllo	34,688	267,961	7.7	353,520	10.2	455,939	13.1
	Comas	4,875	517,881	106.2	544,326	111.7	576,884	118.3
	Independencia	1,456	216,503	148.7	220,608	151.5	225,398	154.8
	Los Olivos	1,825	355,101	194.6	401,239	219.9	457,906	250.9
	Puente Piedra	7,118	305,537	42.9	423,069	59.4	562,386	79.0
	San Martín de Porres	3,691	659,613	178.7	772,050	209.2	909,235	246.3
	Santa Rosa	2,150	15,399	7.2	23,344	10.9	32,537	15.1
	Total [North Lima Area]	85,667	2,377,764	27.8	2,787,336	32.5	3,280,840	38.3
South Lima Area	Chorrillos	3,894	314,835	80.9	346,955	89.1	386,483	99.3
	Cieneguilla	24,033	38,328	1.6	58,998	2.5	82,870	3.4
	Lurin	18,026	76,874	4.3	98,024	5.4	123,497	6.9
	Pachacamac	16,023	102,691	6.4	165,546	10.3	237,453	14.8
	Pucusana	3,739	14,403	3.9	20,786	5.6	28,273	7.6
	Punta Hermosa	11,950	6,935	0.6	8,681	0.7	10,791	0.9
	Punta Negra	13,050	6,878	0.5	9,478	0.7	12,560	1.0
	San Bartolo	4,501	7,008	1.6	8,792	2.0	10,946	2.4
	San Juan de Miraflores	2,398	393,493	164.1	426,560	177.9	467,313	194.9
	Santa Maria del Mar	981	1,220	1.2	2,108	2.1	3,107	3.2
	Villa El Salvador	3,546	436,289	123.0	509,576	143.7	599,201	169.0
	Villa Maria del Triunfo	7,057	426,462	60.4	488,430	69.2	564,414	80.0
	Total [South Lima Area]	109,198	1,825,416	16.7	2,143,934	19.6	2,526,907	23.1
East Lima Area	Ate	7,772	573,948	73.8	720,347	92.7	897,166	115.4
	Chaclacayo	3,950	43,180	10.9	44,417	11.2	45,897	11.6
	El Agustino	1,254	189,924	151.5	196,726	156.9	205,050	163.5
	La Molina	6,575	157,638	24.0	194,308	29.6	238,757	36.3
	Lurigancho	23,647	201,248	8.5	247,707	10.5	304,039	12.9
	San Juan de Lurigancho	13,125	1,025,929	78.2	1,206,300	91.9	1,426,300	108.7
	Santa Anita	1,069	213,561	199.8	253,639	237.3	302,521	283.0
	Total [East Lima Area]	57,392	2,405,428	41.9	2,863,442	49.9	3,419,731	59.6
Callao Area	Callao	4,565	417,622	91.5	394,834	86.5	339,742	74.4
	Bellavista	456	74,287	162.9	68,485	150.2	57,308	125.7
	Carmen de La Legua-Reynoso	212	42,065	198.4	39,944	188.4	35,092	165.5
	La Perla	275	60,886	221.4	55,966	203.5	46,625	169.5
	La Punta	75	3,793	50.6	2,655	35.4	1,396	18.6
	Ventanilla	7,352	370,517	50.4	519,606	70.7	731,626	99.5
	Total [Callao Area]	12,935	969,170	74.9	1,081,491	83.6	1,211,789	93.7
	Grand Total [Lima and Callao Metropolitan Area]	279,975	9,450,585	33.8	10,690,877	38.2	12,175,250	43.5

Source: DATA COLLECTION SURVEY ON URBAN TRANSPORT FOR LIMA AND CALLAO METROPOLITAN AREA FINAL REPORT（JICA, 2013)

2.1.3. Climate

The climate of the La Molina district is generally mild. This is a subtropical desert, with a warm season from December to April and a cool, humid and cloudy season from June to October, with May and November as transitional months (Figure 2.1-4).

During winter, from June to September, the sky is almost always cloudy, and there is a kind of mist, the garúa, which can deposit a bit of moisture on the ground. Temperatures are mild, but the lack of sunshine and high air humidity increases the feeling of cold, also because houses are not heated. Thermal inversion favours the accumulation of pollutants on the ground, despite the proximity to the sea.

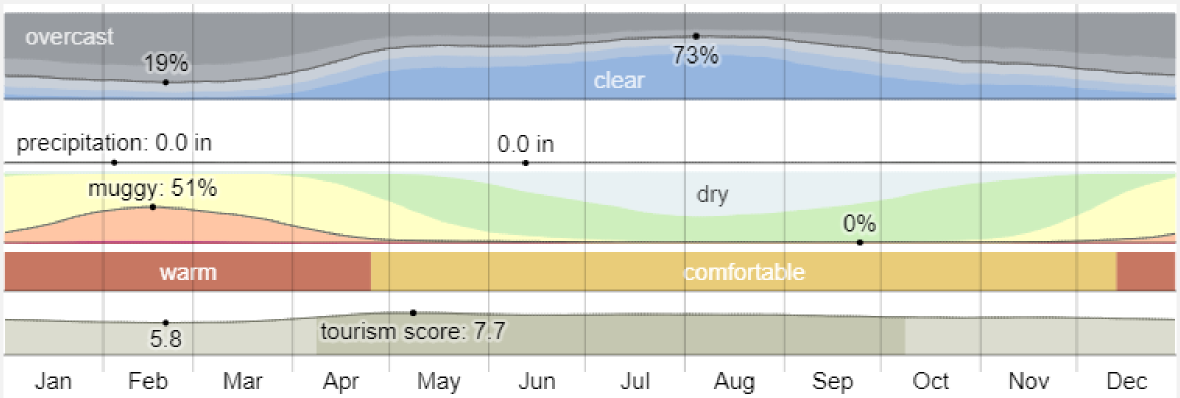


Fig. 2.1-4. The Climate in La Molina
Source: WeatherSpark.com

Rainfall is very small or completely absent. Figure 2.1-5 shows the daily chance of precipitation in La Molina.

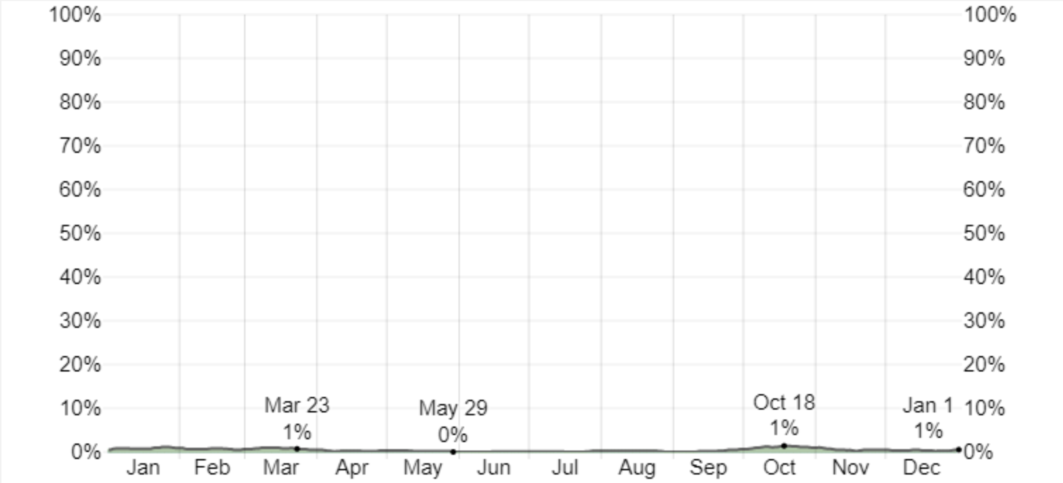


Fig. 2.1-5. The daily chance of the precipitation (%) in La Molina
Source: WeatherSpark.com

2.1.4. Disasters

In Peru, earthquakes are the most recurring natural event. They concentrate on about 85% of the global seismic activity. Another disaster that is common for Peru is frost and cold, mainly in the high Andean areas, in Arequipa, Puno, Cusco, Moquegua and Tacna, from April to September. Floods are another problem in Peru. They occurred between November and April due to the increased flow of the rivers because of heavy rain. Furthermore, the droughts in the southern highlands in Peru, affect agricultural activity, hydroelectric production and the normal supply of drinking water in cities. Proper prevention and implementation of low-carbon interventions are very important to improve the life of people and the surrounding environment.

Table. 2.1-2. Table of the most common natural disasters in Peru (Number of cases per year)

Phenomenon	Y2015	Y2016	Y2017
Cold	26	47	41
Frost	609	952	406
Avalanche	93	83	557
Flood	267	128	385
Drought	25	850	54
Earthquake	28	56	46

Source: INDECI

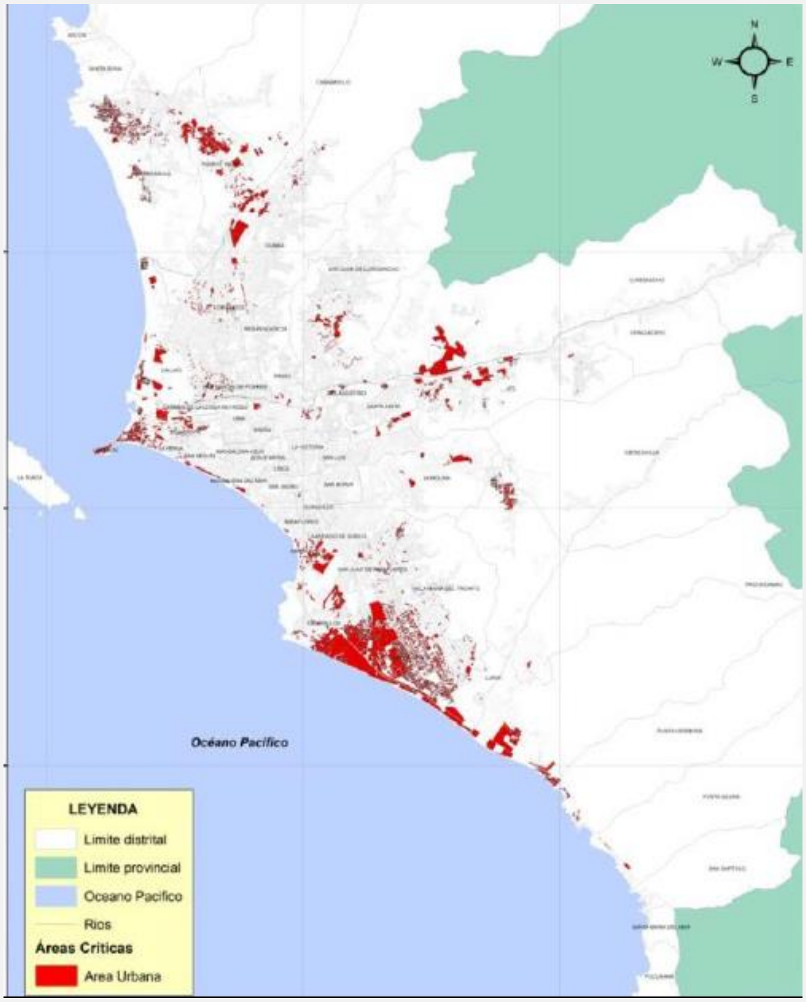


Fig. 2.1-6. Earthquake / tsunami risk in Lima
Source: CENEPRED, JICA

2.1.5. Economy

1) Household income per capita in La Molina District

According to the table below, it can be seen that the district of La Molina currently does not have a poor population, with an income below 575.69 soles. As can be seen, in the district the population with high income predominates 2192.20 or more, representing 57.2%. In conclusion, the majority of the population is medium to high income, representing 91.5%.

Table. Error! No text of specified style in document.-3. Stratified plans La Molina district per capita for household

Layer	Household income per capita (soles)	People (%)	Household (%)	District (%)
High	More than 2192.2	57.2	58.6	54.9
Medium High	1330.1-2192.19	34.3	34.2	34.2
Medium	899.0-1330.09	6.1	5.2	7.2
Medium Low	575.7-898.99	2.3	2.0	3.7
Low	Less than 575.69	0.0	0.0	0.0

Source: Compendio Estadistico Municipal, La Molina, 2018

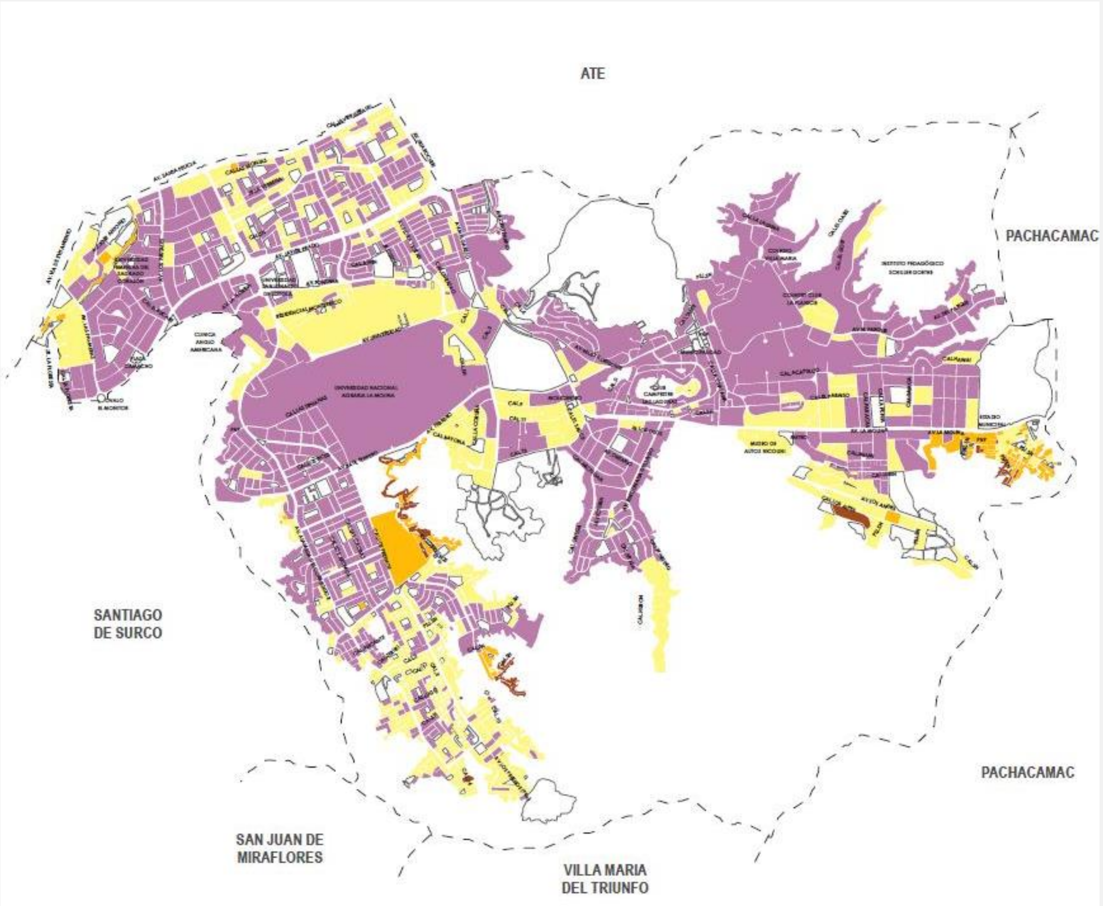


Fig. 2.1-7. Stratified map of La Molina district per capita for household
Source: Segun ingreso per capita del hogar, 2018

Picture. **Error! No text of specified style in document.**.1-1. Stratified map of La Molina district per capita for household
Source: La Molina rumbo a ciudad sostenible

2) Characteristics of the economy in La Molina district

It is observed that from 2619 economic units in the district, the activity of wholesale and retail trade predominates, represented by 45.7%, followed by other service activities and activity of Accommodation and Foodservice with 13.1% and 9.5% respectively. These 3 main activities represented about 68.3% of the total economic activities.

The economic condition of the residents of La Molina shows that the expenditure per capita is 827.1 soles. The main economic activities in the La Molina district are based on numerous wineries and stores, as well as higher education centers, schools, shopping centers, lodgings, and museums, tourist areas, etc. The green area of the district is 4,714,537 m2, which is equivalent to 37.8 m2 / per person. (La Molina, 2011e).

3) Cities in motion index

The Cities in Motion Index (CIMI), has been designed to indicate the completeness, properties, comparability, quality and objectivity of information for the world's leading cities, including Lima city in Peru (Figure 2.1-8). The results above show that almost all dimensions should be improved, especially Mobility and transportation, Governance, Environment, etc. According to the rank of performance for each city, Lima city is placed to 138th position with a CIMI index of 38,14, which means low performance. Such results indicate the need for implementation of interventions regarding low-carbon policy, environment sustainability cities, smart technologies, etc.

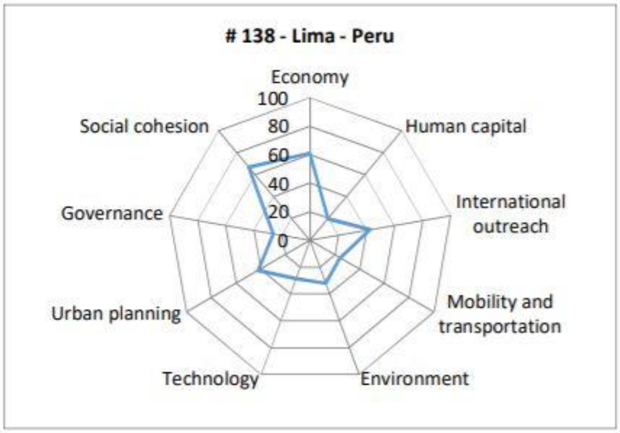


Fig. 2.1-8. Graphical analysis of nine key dimensions in Lima and ranking according to the performance of the city
Source: Cities in Motions index 2019

2.1.6. Energy & Emissions

Figure 2.1-9 shows the composition of Peru's GHG emissions by sector. Notably, forestry and agricultural activities accounted for more than 50% of emissions in the 2000-2009 period, while emissions from other sectors (energy, industrial processes, and waste) have increased by approximately 33% in 2000 to 40% in 2009.

Fig. 2.1-9. Sector composition of the greenhouse gas inventory in Peru, 2000 and 2009 (in percentages)
Source: Elaboration based on data consulted in the Ministry of the Environment of Peru (2010a).

In an unchanged scenario, the total CO2 emissions of Lima-Callao increased by 82% in 2030, compared to 2014. When this is combined with rising prices of real energy, the result is an increase in total energy expenditure of 160%. The mentioned expenses would change from the US $ 4.7 billion in 2014 to a level forecast of $ 12.3 billion in 2030 (previously to consider the impacts of changes due to Line 2 of the metro and the implementation of Euro IV standards) (see Figure 2.1-11 below).

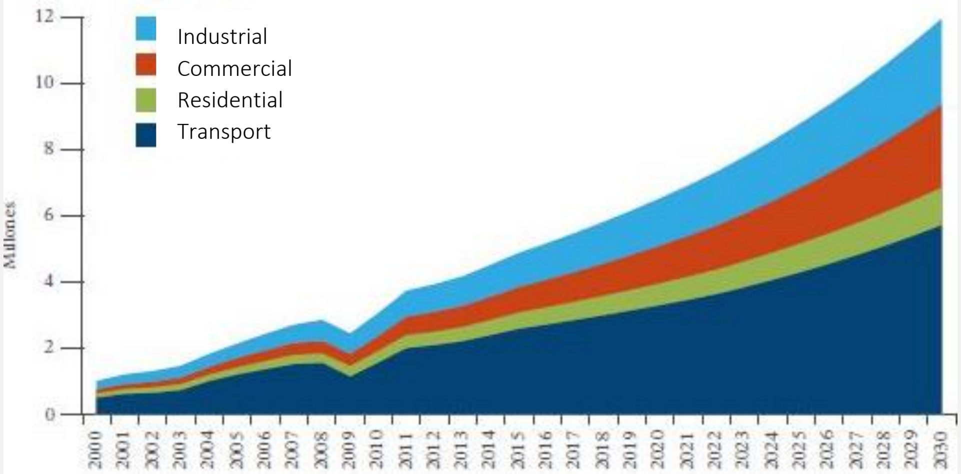


Fig. 2.1-10. Lima-Callao: energy expenditure by sector, 2000-2030 (US $).
Source: Elaboration based on data consulted in the Ministry of the Environment of Peru (2010a).

Instead, when the scenario considered relatively stable levels of CO2emissions per unit of energy consumed, estimates show an increase of 82% of carbon emissions, which would pass from 15.8 MtCO2e in 2014 at a predicted level of 28.7 MtCO2e in 2030 (see Figure 2.1-12).

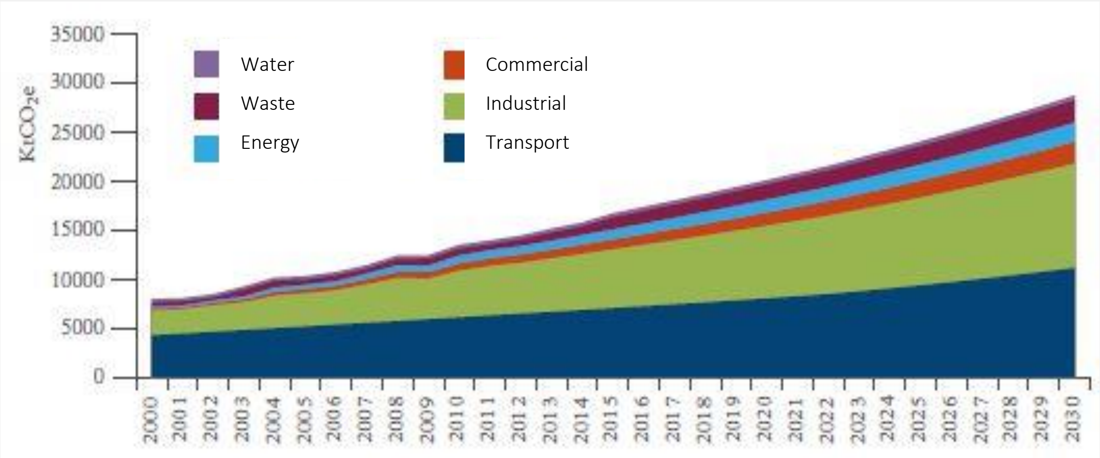


Fig. 2.1-11. Lima-Callao: emissions by final use, 2000-2030 (KtCO2e).
Source: Elaboration based on data consulted in the Ministry of the Environment of Peru (2010a).

1) Electricity in Lima

Per capita, electricity consumption in Metropolitan Lima was calculated to be 7.0 TWh in 2000, rose to 16.3 TWh in 2014 and will reach 29.8 TWh in 2030. Current data (2014) show that the consumption is divided as follows by sector: 49% corresponds to the industrial sector; 16%, to the commercial; 21%, to residential, and the remainder corresponds to public lighting (2%), transmission losses (6%) and own industrial use (7%). The largest increases are projected to correspond to industrial consumption, which is estimated to go from 7.3 TWh in 2014 to 15.1 TWh in 2030, reflecting the great industrial growth that is expected to occur in the city. However, the commercial and residential sectors are also projected to grow significantly. When the increasing levels of carbon emissions per unit of energy consumed are also considered in the estimate, it is projected that carbon emissions from the electricity sector will increase from 3,972 ktCO2e in 2014 to 8,216 ktCO2e in 2030, an increase of 107% compared to 2014 emissions, in a scenario without changes.

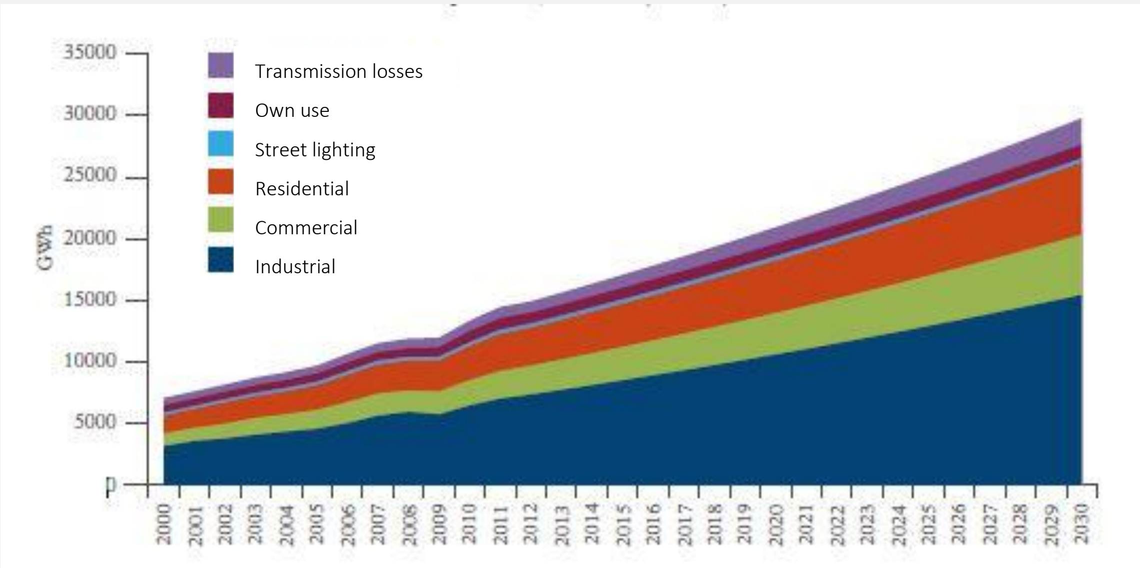


Fig. 2.1-12. Lima-Callao: electricity use by sector, 2000-2030 (in GWh)..
Source: The Economics of Low Carbon and Climate Resilient Cities

2) Energy consumption and emissions in the residential sector

Regarding the residential sector, the trends observed in this area suggest a substantial growth both in the number of households and in the average levels of energy consumption per household. These trends combined lead to an 83% increase in residential sector energy consumption, from 4,035 GWh in 2014 to a projected level of 7,349 GWh in 2030.

When combined with relatively stable levels of carbon emissions per unit of energy consumed, the result is a 101% increase in carbon emissions attributed to residential consumption, from 0.96 MtCO2e in 2014 to a projected level of 1,9 MtCO2e in 2030 (see Figure below).

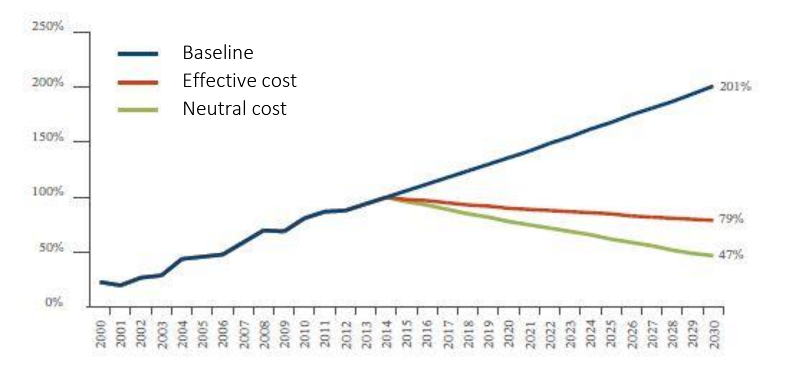


Fig. 2.1-13. Lima-Callao: indexed residential sector emissions corresponding to two scenarios, 2000-2030 (2014 = 100%).
Source: The Economics of Low Carbon and Climate Resilient Cities

3) Energy consumption and emissions in the commercial sector

The commercial sector comprises the use of energy from the commercial sector and the public sector (use of natural gas, gasoline, diesel, liquefied petroleum gas (LPG) and electricity) and therefore includes public sector buildings and the commercial sector, as well as public sector operations, such as street lighting.

In the commercial sector, the trends observed in this area suggest a substantial growth both in the area of the city devoted to commercial activities and in the average levels of energy consumption of each commercial building. These combined trends lead to a 147% rise in the sector's energy consumption, from 5,512 GWh in 2014 to a predicted level of 13,590 GWh in 2030.

When this is combined with relatively stable levels of carbon emissions per unit of energy consumed, a 133% rise in carbon emissions attributed to commercial consumption is obtained, from 0.95 MtCO2e in 2014 to a projected level of 2.2 MtCO2e in 2030 (see Figure below).

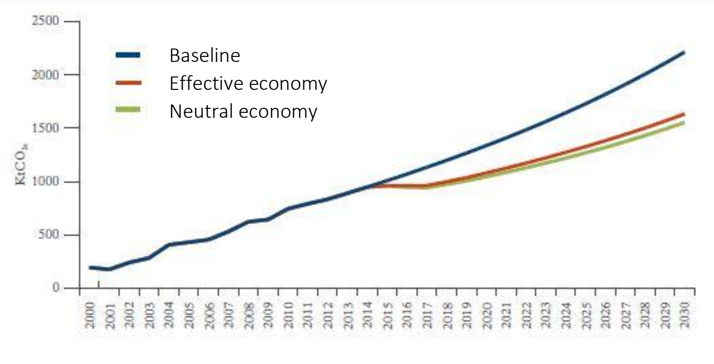


Fig. 2.1-14. Lima-Callao: Lima-Callao: projected emissions of the commercial sector corresponding to two scenarios, 2000-2030 (KtCO2e).
Source: The Economics of Low Carbon and Climate Resilient Cities

4) Energy consumption and emissions in the industrial sector

Regarding the industrial sector, it was considered that the industrial subsectors with potential for carbon mitigation based mainly on the information consulted in the report of the Intergovernmental Group of Experts on Climate Change (IPCC) (Bernstein et al., 2007). The report suggests a large number of mitigation options that are relevant to particular sectors, but we do not analyze specific measures for each subsector in this report due to a lack of information for Lima.

For the industrial sector, the trends observed in this area indicate that the use of industrial energy will increase from 23,800 GWh in 2014 to 44,647 GWh in 2030, which represents an increase of 87%. Likewise, it leads to an 86% increase in carbon emissions attributed to industrial consumption, which would go from 5.67 MtCO2e to 10.6 MtCO2e (see Figure below).

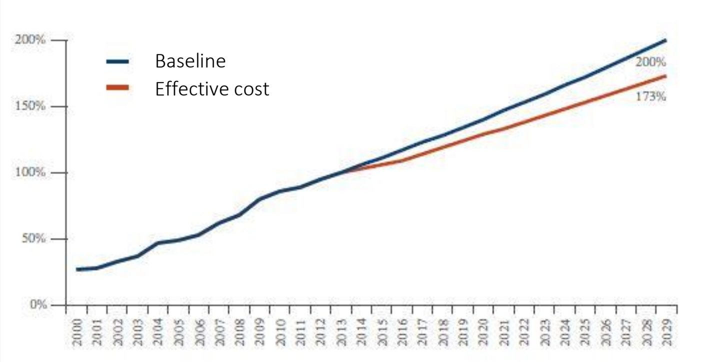


Fig. 2.1-15. Lima-Callao: indexed emissions from the industrial sector corresponding to the unchanged scenario and the cost-effective measures scenario, 2000-2030 (2014 = 100%).
Source: The Economics of Low Carbon and Climate Resilient Cities

5) Solar power activities in La Molina, Lima

The municipality of La Molina inaugurated a neighbourhood alarm system located in various streets of Santa Patricia, which are activated with wireless push buttons and mobile phones. The six installed alarms that will reinforce actions against crime, will be supplied with electricity generated by solar panels that provide autonomy in its operation. The advantage of this sound surveillance system is that its activation in case of emergency not only depends on the person responsible for having the push button (car alarm type), but also that it is programmed to be activated by duly registered cell phones.

In total, 24 neighbours will be able to operate the alarms installed at a height of 9 meters and which can be heard from 100 meters away. After being activated, an alert is immediately transmitted to a computer at the emergency center, which will send the closest patrol to the place and coordinate the intervention of the police. Simultaneously, a text message is sent to the cell phones interconnected with the alarm system, informing the identification of the user who activated it, for better control.

Picture. Error! No text of specified style in document.-2. Electricity generated by solar panels alarms in La Molina(Left), Solar poles in La Molina(Right)
Source: La Molina Municipality

In La Molina in the El Ancla Park, the municipal staff have installed 11 new solar poles that will allow obtaining electricity in an environmentally friendly way.

Strengthening the links between the Peruvian Institute of Mining Engineers (IIMP) and the electricity generation company Engie, the latter implemented a solar energy system, equipped with 52 photovoltaic modules of 400 Wp, in the air of the institution's building located in the district of La Molina.

The Solar Photovoltaic System (SFV) has a total capacity of 20.8 kW and has been designed to be 100% self-consuming. In this way, the building's consumption will have a reduction in CO2 emissions and cost reduction in its electricity tariff.

At present, Engie is one of the main suppliers of electrical energy in the mining sector, for this reason, it works hand in hand with these companies, in new integrated solutions to improve their energy efficiency and decarbonise their activities.

Picture. Error! No text of specified style in document.-3. Solar panels at the Institute of Mining Engineers of Peru.
Source: Courtesy(Photo)., Andina

2.1.7. Transportation

1) Current state of transportation network

Transportation in the Lima metropolitan area consists of walking and private cars, as well as public transportation, mainly buses and micro-buses. In recent years BRT and railroads have been introduced. The road types are shown in the table below.

Table. **Error! No text of specified style in document.**-4. Road type in the Lima metropolitan area

Road type	Basic characteristics	Extension distance(km)
Expressway (Vias Expresas)	Heavy traffic, High speed, Multi-level crossing	140
Highway (Vias Arteriales)	Heavy traffic, Medium speed, At-grade	510
Collector road (Vias Colectoras)	Access to the street, At-grade	750
Access road (Vias Locales)	Residential area, Connection to the block	6600
total	-	8000

Source: Masterplan for Metropolitan area urban transportation in the Republic of Peru (preliminary survey report), JICA, 2003

The peak hour traffic volumes on arterial roads in the Lima metropolitan area are shown in the table below. On Javier Prado, a main road within the La Molina district, 80% of the traffic is private vehicles, and 20% is buses and other transportations.

Table. **Error! No text of specified style in document.**-5. Highway traffic

Road name	Type	Direction	Traffic volume (hour)			
			Car	Bus etc.	Freight	total
Zarymulla	Expressway	South	2,002	856	132	2,990
Tupac Amar	Highway	South	2,195	757	149	3,101
Javier Prado	Expressway	east	2,234	534	-	2,768
Abancay	Highway	South	1,968	605	16	2,589

Source: Masterplan for Metropolitan area urban transportation in the Republic of Peru (preliminary survey report), JICA, 2003

2) Transportation sector

The main transportation system in the Lima metropolitan area is the shared bus, which depends on the road conditions and demand in each city, large buses (commonly known as omnibus), microbuses (commonly known as micro or coaster), and one-box cars (combi) with a capacity of about 50 passengers are used.

Taxis are the main means of transportation in large cities. The main means of transportation in regional cities is the three-wheeled cab (moto-taxi), which is a typical means of transportation in regional cities where the feeder transportation and bus networks of large cities are not well developed.

Minibus

One box car

Moto-taxi

Picture. **Error! No text of specified style in document.**-4. Transportation facilities.

Source: BOP/Volume Zone Business Survey Report（JETRO,2015）

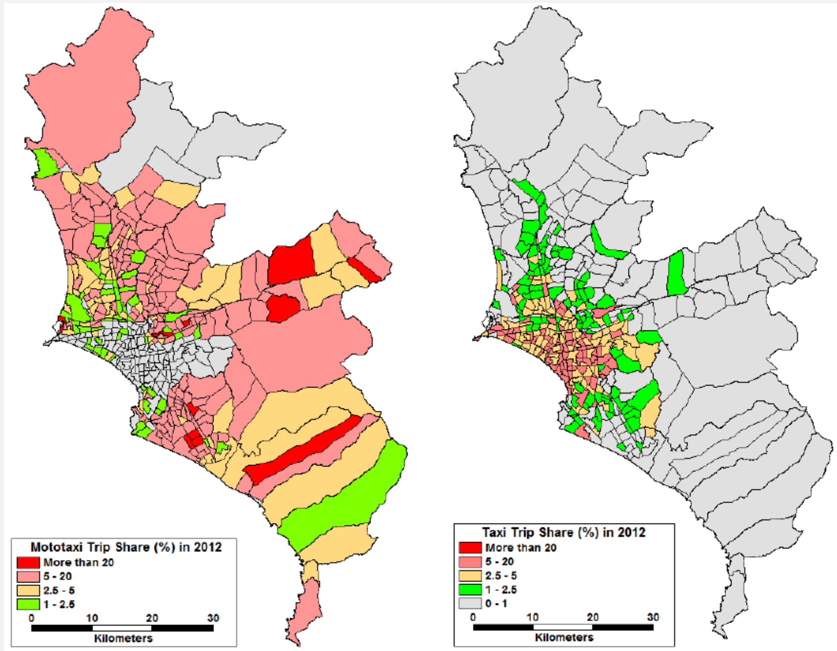


Fig. 2.1-16. Share of Moto-taxi and Taxi by Traffic Zone
Source: JICA Study Team (Person Trip Survey, 2012)

3) Public transport

At the central government level, the Ministry of Transport (Ministerio de Transportes y Comunicaciones: MTC) is responsible for the examination of transportation systems and facilities in the Lima metropolitan area. At the local government level, it is the City of Lima, the City of Callao, and the District Offices (Distrito), but other government agencies and research organizations will also be involved in terms of the master planning.

Table. **Error! No text of specified style in document.**-6. Lima Metropolitan Transportation Project Related Organizations

Major organizations		Main role
Ministries	Ministry of Transport and Communications (Ministerio de Transporte y Comunicaciones-MTC)	Transportation license, National highway maintenance
	Ministry of Economy and Finance (Ministerio de Economía y Finanzas-MEF)	Investment plan
	National Superintendence of Public Registration (Superintendencia Nacional de los Registros Publicos - SUNARP)	Vehicle registration
	National Police of Peru (Policía Nacional del Perú - PNP)	Traffic safety, Traffic control / regulation
The city of Lima	Municipal Direction of Urban Transport (Dirección Municipal de Transporte Urbano –DMTU)	Highway planning, Public transport license, Traffic control / regulation
	Metropolitan Planning Institute (Instituto Metropolitano de Planificación – IMP)	City planning / development license
	SETAME – Metropolitan Taxi Service	Taxi license, Vehicle inspection
	EMAPE – Municipal Toll Administration Company	Road usage fee collection business, Main road maintenance / maintenance
	AATE – Autonomous Authority of the Special Project Electric System of Mass Transport of Lima and Callao	Urban track planning and commercialization
	PROTRANSPORTE – Special Preparation Project of the Investment Plan for the Metropolitan Transport of Lima	Highway bus planning and commercialization
the city of Callao	DGTU – General Direction of Urban Transport	Public transport license, Traffic control / regulation
Ward office (Distrito)		City planning / development planning, Street maintenance and maintenance

Source: Peru: Metropolitan area urban transportation plan preliminary survey report（JICA、2003）

As for the railway in the Lima metropolitan area, Metro Line 1 is currently in operation. Four lines are planned to be developed in the future, and the entire line of Metro Line 2 is planned to open in 2024. Metro Line 4, which runs through the La Molina district, is planned for the route from the Beja Vista district in Callao District to the Ate district. This is a large-scale project that connects the 13 wards of the Lima metropolitan area over 23km from east to west in the form of a subway line, enabling the transportation of more than 1 million passengers a day. It will also be connected to a part of the planned section of Metro Line 2 (toward Lima International Airport).

Fig. 2.1-17. Railroad network map in the Lima metropolitan area
Source: MTC (https://portal.mtc.gob.pe/transportes/concesiones/ferrovias/sistema_electrico_linea1_2.html)

Metropolitano (BRT), which opened in October 2010, connects 12 districts in Lima, from the Comas district (north zone) to the Chorrillos district (south zone). 38 stations are set up in a total length of 26km. At the end point, there is a shuttle bus that connects the surrounding new residential areas. There are 300 vehicles in two types, 120-seater and 160-seater. In addition, there are 300 connecting buses that seat 40 and 80 people (Source: "BOP / Volume Zone Business Survey Report" JETRO, 2015).

Picture. **Error! No text of specified style in document.**-5. BRT route map
Source: metropolitan (http://www.metropolitano.gob.pe/)

Fig. 2.1-18. BRT route map
Source: metropolitan (http://www.metropolitano.gob.pe/)

In 2015, the EcoExpress consortium put into operation a new public transport line on the Javier Prado corridor so that users can be transferred from La Molina to San Isidro and vice versa. This is line 206, which goes from East to West from the La Molina whereabouts to the Petit Thouars whereabouts, and from West to East, from the Javier Prado whereabouts to the whereabouts at Av. La Molina. Moreover, EcoExpress has up to 133 buses that use vehicular natural gas.

Picture. Error! No text of specified style in document.-6. Corridor Javier Prado-La Marina

Fig. 2.1-19. New service corridor in La Molina
Source: Municipalidad de La Molina, webpage in Facebook

Moreover, the new Service 204 of the Red Corridor, which arrives in Musa from San Isidro, is already in operation for the benefit of thousands of Molino residents and the general public.

In 2020, La Molina district signing the agreement with the ATU highlights the joint work to control, supervise and supervise the regular passenger service, the metropolitan taxi service, the service School and tourist transport. This agreement will allow the Transport Inspectors of the Municipality of La Molina to carry out control operations, the allocation of personnel, mobile units, and cranes that are required in joint operations. In this way, the Municipality of La Molina will optimize the work that it has been developing, through the Sustainable Mobility Management.

In addition, the La Molina area is promoting the use of mass transportation to reduce the use of private vehicles.

Picture. 2.1-7. promoting the use of mass transportation
Source: La Molina rumbo a ciudad sostenible

The main public transport routes in La Molina are Javier Prado and Paul Ferrero from east to west, Fresnos, Separadora Insustrial, Huarochiri, Melgarejo and la Molina from north to south. Of these, Separadora Insustrial, Huarochiri, Melgarejo, and la Molina are designated as freight transportation routes. (Figure 2.1-20)

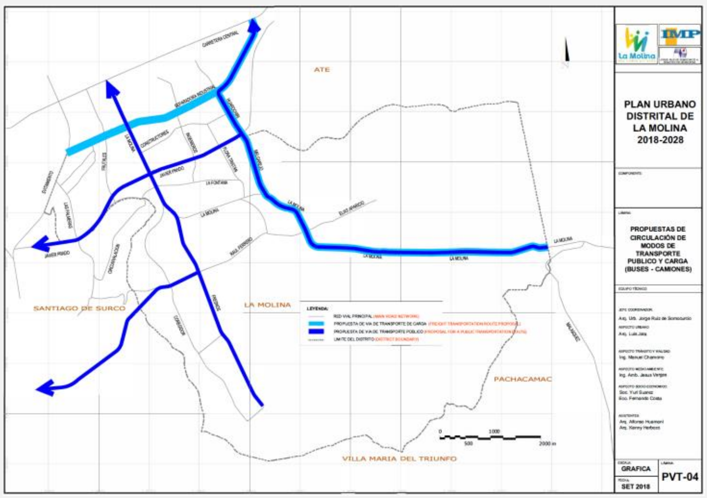


Fig. 2.1-20. PLAN URBANO DISTRITAL DE LA MOLINA 2018-2028
Source: Ordenanza que aprueba el Plan Urbano Distrital de La Molina 2018 – 2028

4) Car

Figure 2.1-21 shows the percentage of car-owning households by district. In the central area of Lima, including the La Molina district, more than 30% of households own one or more cars. In addition, Figure2.1-22 shows the vehicle ownership rate for each income group, showing that car ownership is correlated with income level.

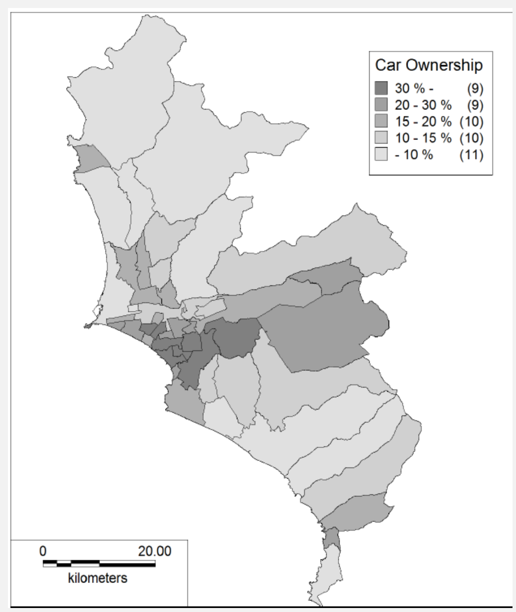


Fig. 2.1-21. Car Ownership (% Households Owning Car)
Source: JICA Study Team (Person Trip Survey, 2012)

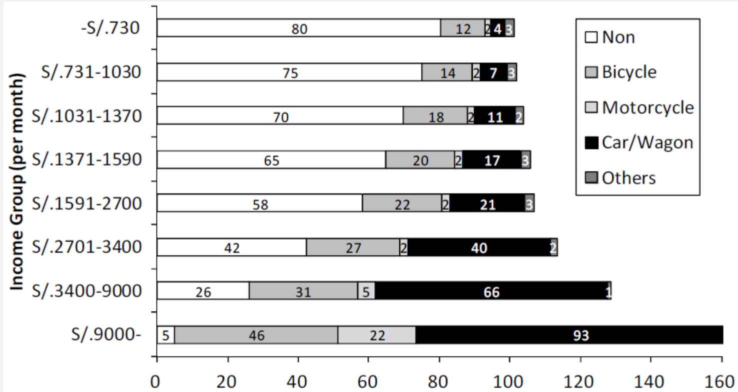


Fig. 2.1-22. Vehicle Ownership by Income Group
Source: JICA Study Team (Person Trip Survey, 2012)

5) Sharing Car

In La Molina district Municipality promotes car sharing for the neighbours to travel more comfortably and collaborate with the environment.

Fig. 2.1-23. Sharing of cars
Source: La Molina rumbo a ciudad sostenible

6) Bicycle

In La Molina, the development of a bicycle priority lane is planned.

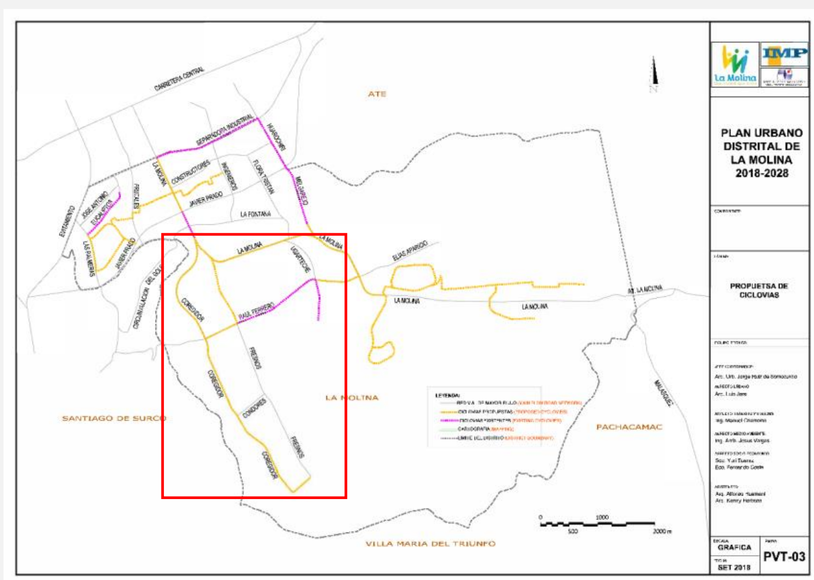


Fig. 2.1-24. bike path plan(2018-2028)
Source: Ordenanza que aprueba el Plan Urbano Distrital de La Molina 2018 – 2028

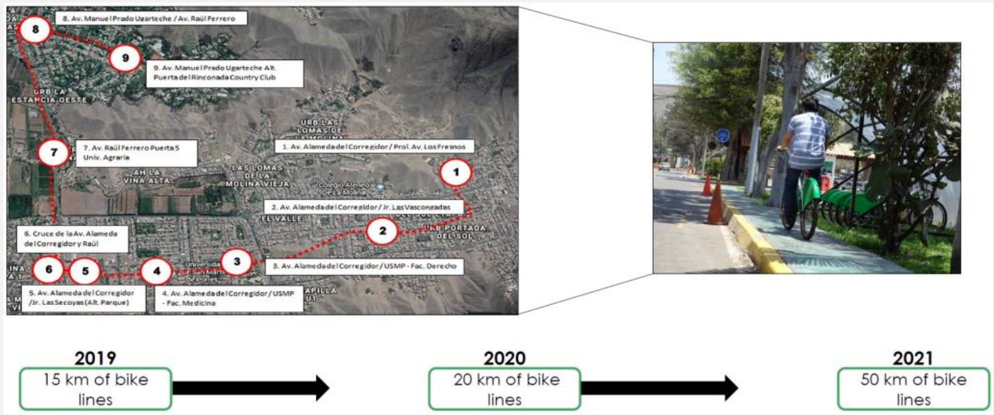


Fig. 2.1-25. bike path
Source: La Molina rumbo a ciudad sostenible

7) Passenger transport

The figure 2.1-26 shows the passenger transport in Lima. 75.6% belong to public transport. Mainly these include combi / custer, and buses. 15.5 % belong to individual transport, mainly the car, and only 7.8% belong to non-motorized transport.

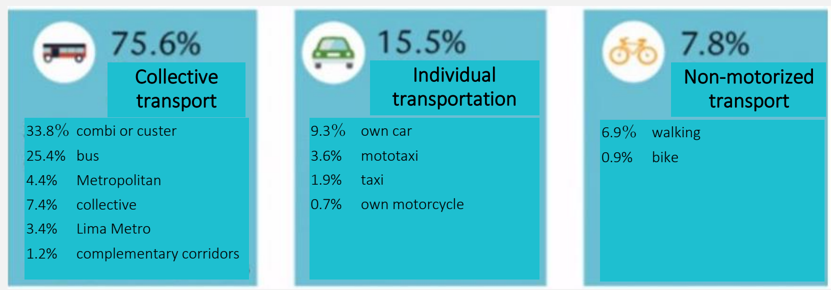


Fig. 2.1-26. Passenger transport in Lima
Source: Lima Cómo Vamos

In the Lima metropolitan area, the BRT was opened in 2010 and the railway was opened in 2012. According to the Person trip survey conducted by JICA, there is no significant change over time in traffic sharing rate, and public transportation accounts for about 50% of the total.

Table. **Error! No text of specified style in document.**-7. Modal Share of All Modes

Mode	2012		2004	
	No. of Trips (000)	Modal Share	No. of Trips(000)	Modal Share
Walk	5,416	24.3%	4,208	25.4%
Bicycle	77	0.3%	84	0.5%
Motorcycle	107	0.5%	30	0.2%
Private car	3,401	15.2%	1,856	11.2%
Mototaxi	1,325	5.9%	600	3.6%
Taxi	591	2.6%	902	5.5%
Aolectivo	333	1.5%	181	1.1%
Combi	3,880	17.4%	3,791	22.9%
Minibus	5,536	24.8%	3,072	18.6%
Bus	1,248	5.6%	1,661	10.0%
BRT	274	1.2%	0	0.0%
Train	74	0.3%	0	0.0%
Truck & Others	44	0.2%	152	0.9%
Total	22,308	100.0%	16,537	100.0%

Source: JICA Study Team (Person Trip Survey, 2012)

Looking at the status of trips between regions, the destinations are concentrated in Zone 1, which is the central city area. Due to the large modal share of public transport, the total number of passengers is shown to be about the same as the number of passengers on public transport. Looking at destinations of the private and paratransit mode, which clarify the difference in volume between zones, we can see that the demand for private mode is high in the city center (between zones 1 and 4, zone 4 and Between 5 etc.).

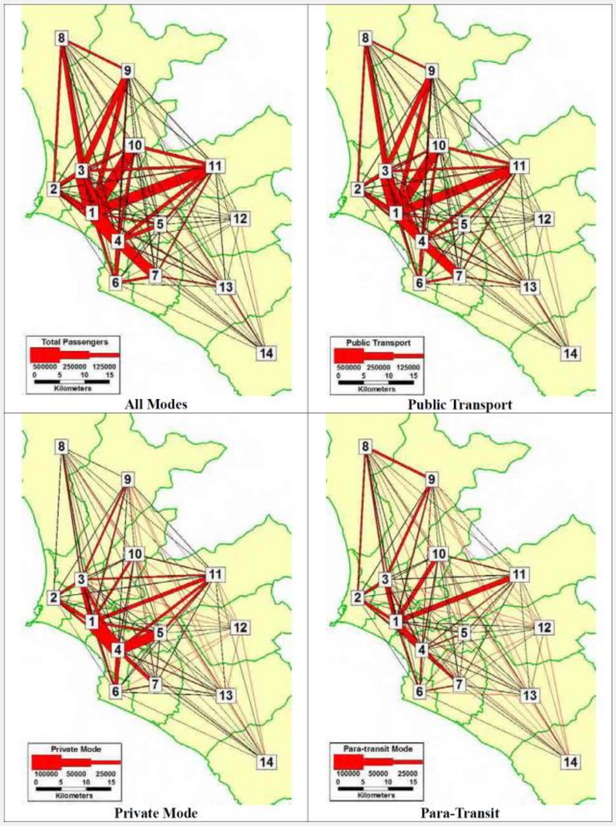


Fig. Error! No text of specified style in document.-27. Desired Line
Source: JICA Study Team (Person Trip Survey, 2012)

8) Ideas for the LCT Development Mobility

La Molina area is promoting the use of EVs and bicycles as measures against air pollution.

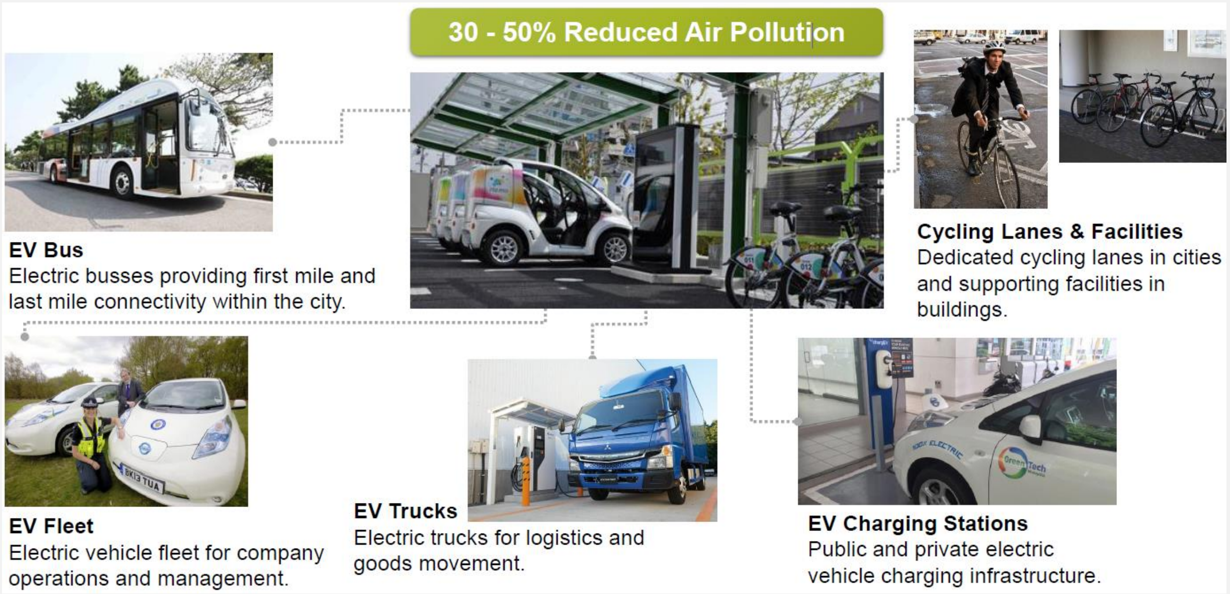


Fig. 2.1-28. Plans in the La Molina area
Source: Review on the LCT Planning of La Molina District

2.1.8. Land use/cover changed

In the district of La Molina, the centralities are presented at the Metropolitan, interdistrict, district and zonal levels. The centralities presented are the following:

- Metropolitan - along the Avenida Javier Prado to Av. La Molina. In this centrality, several shops are specializing in the sale of cars, toilets, financial services and services such as the Panorama building. Complementary to them are universities, colleges, and clinics, of metropolitan attention.
- Interdistrict - located on Av. La Molina at the intersection with Av. J. Prado to the Oval La Fontana. In this area, there are shops and services, such as supermarkets, bank agencies, shopping centers, colleges, universities, churches, clinics, and business centers.
- District - located around the intersection of Av. Ferrero and Av. La Molina. Here, also are located shops and services, supermarkets, schools, churches, etc.
- Sectorial. - One of these is constituted by the section of Av. Ferrero between Av. A. Del Corregidor and Av. Los Fresnos. In this centrality, there are trade and services, such as supermarkets, shopping centers, medical services, and offices, with a medium intensity.
- Zonal - One of these centralities is located on Av. La Molina in the section of MUSA, in which businesses such as markets, car services, schools, sports fields, health centers, minor stores. In this area, there is an intensity of medium to high centrality.

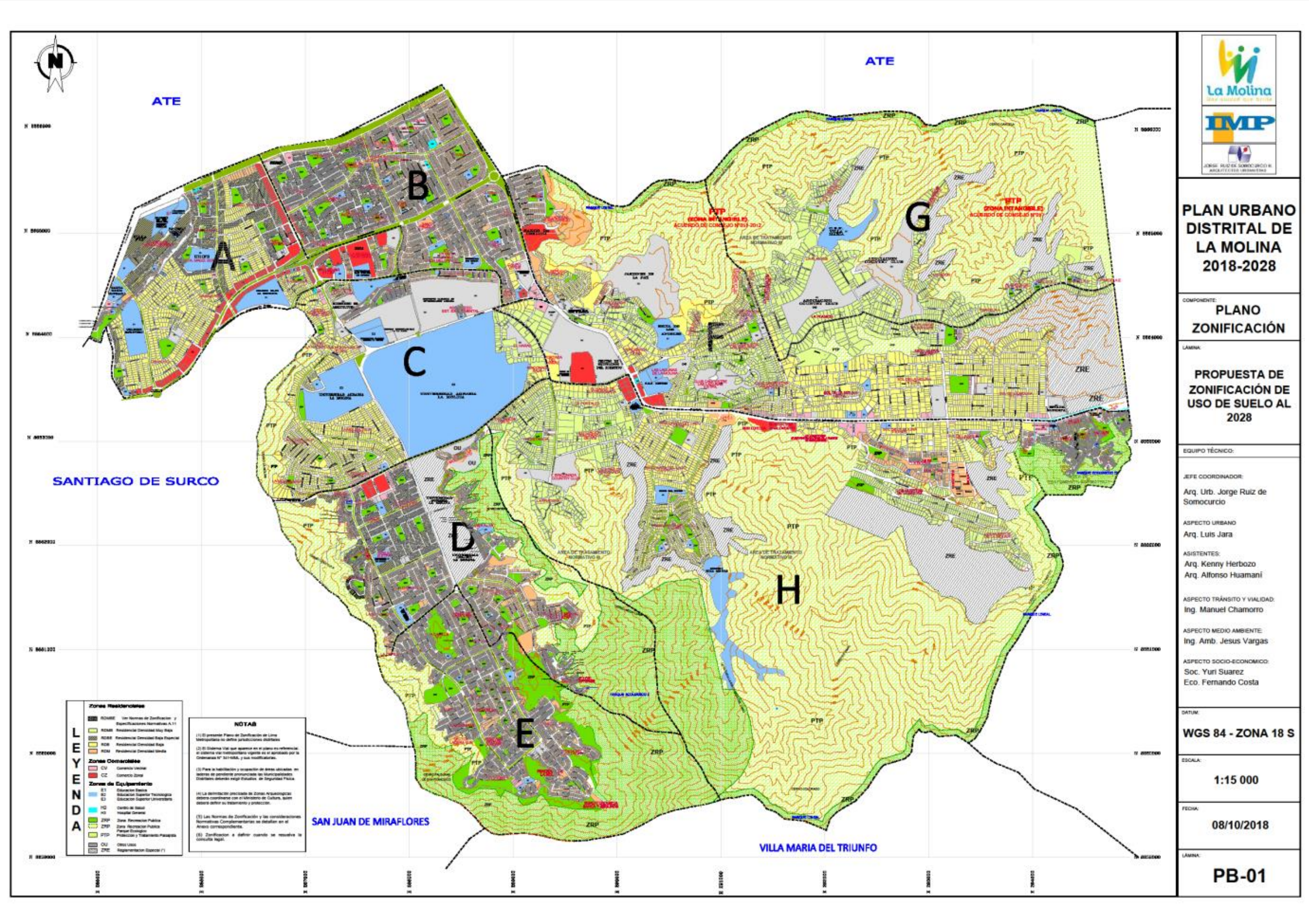


Fig. 2.1-29. Proposal for actualization plan of La Molina, Lima, Peru (2018-2020)
Source: Ordenanza que aprueba el Plan Urbano Distrital de La Molina 2018 – 2028

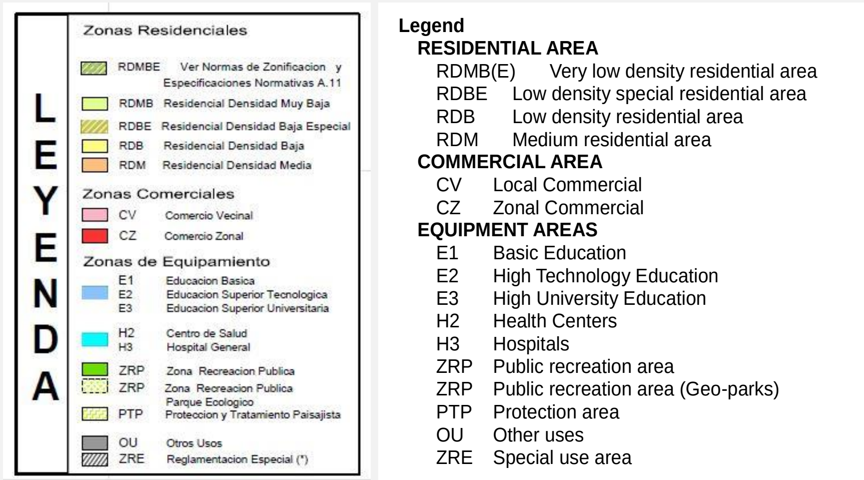


Fig. 2.1-30. Proposal for actualization plan of La Molina, Lima, Peru (2018-2020)
Source: Ordenanza que aprueba el Plan Urbano Distrital de La Molina 2018 – 2028

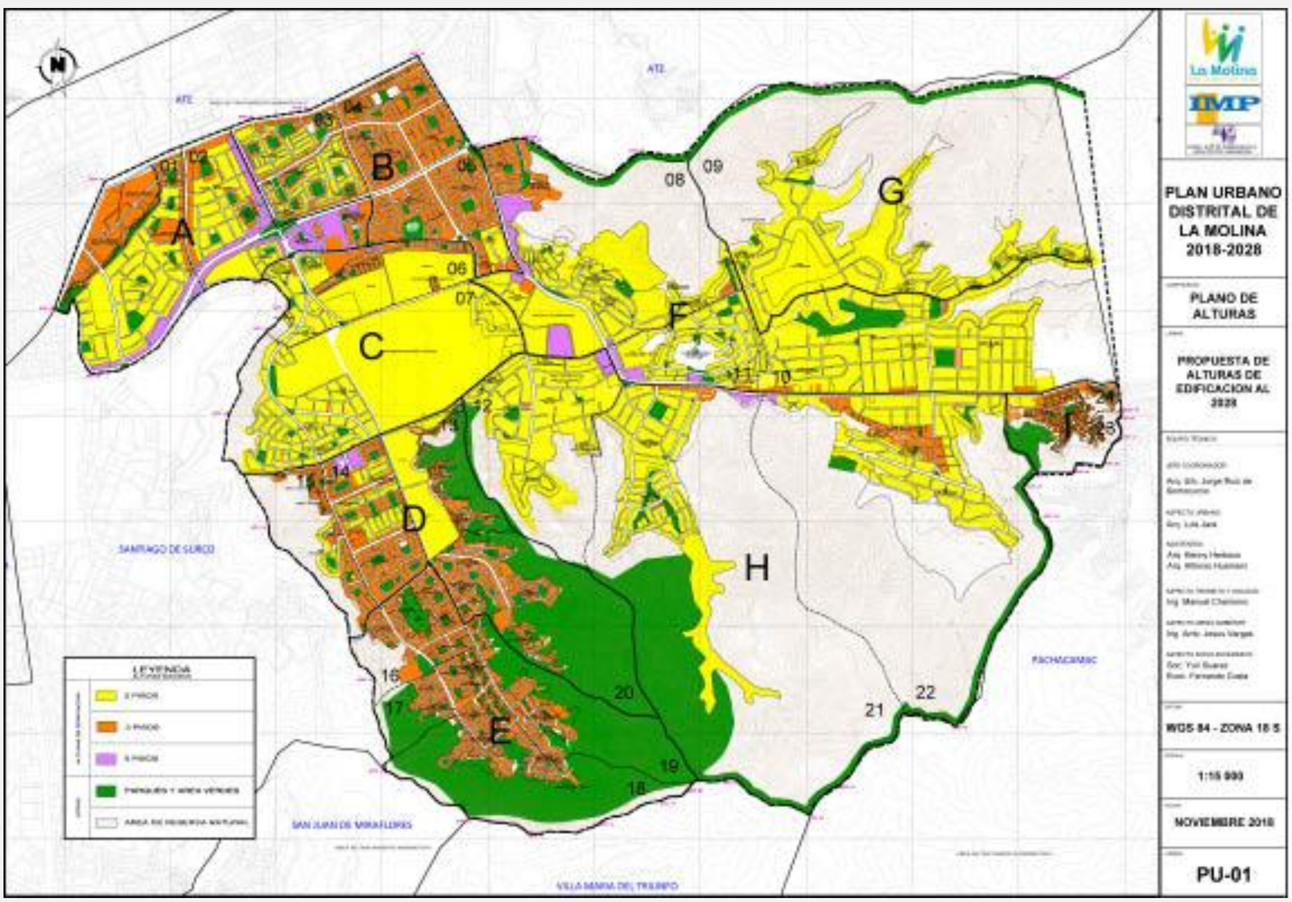


Fig. 2.1-31. Building height plan of La Molina, Lima, Peru
Source: Ordenanza que aprueba el Plan Urbano Distrital de La Molina 2018 – 2028

In La Molina, the main activities are housing, education, health, recreation, commerce, etc. One of the most important commercial activities is Molicentro, Molina Plaza Shopping Center, La Fontana Shopping Center, Plaza Camacho Shopping Center. Moreover, within the district, there are commercial axes that include the following routes: Av. La Molina, Builders Av., Av. Javier Prado, Av. Los Ingenieros, Av. Flora Tristán, Av. Los Fresnos.

Picture. Error! No text of specified style in document.-8. Molina plaza
Source: Plan de desarrollo economico local distrito de la Molina 2018-2020

Picture. Error! No text of specified style in document.-9 Avenue La Molina
Source: Plan de desarrollo economico local distrito de la Molina 2018-2020

Besides, education takes part as the main activity in the La Molina district. Some of the famous universities and colleges are the National Agrarian University of La Molina – UNALM, San Ignacio de Loyola University, Women's University of the Sacred Heart, San Martin de Porres University, Roosevelt College, La Recoleta School.

Picture. Error! No text of specified style in document.-10 National Agrarian University of La Molina – UNALM
Source: Plan de desarrollo economico local distrito de la Molina 2018-2020

2.1.9. Greenery

The activities in La Molina related to urban green

(1) Green Corridor.

This program has a purpose to seek to have more urban trees in some streets and avenues. The figure below shows the proposed green corridors.

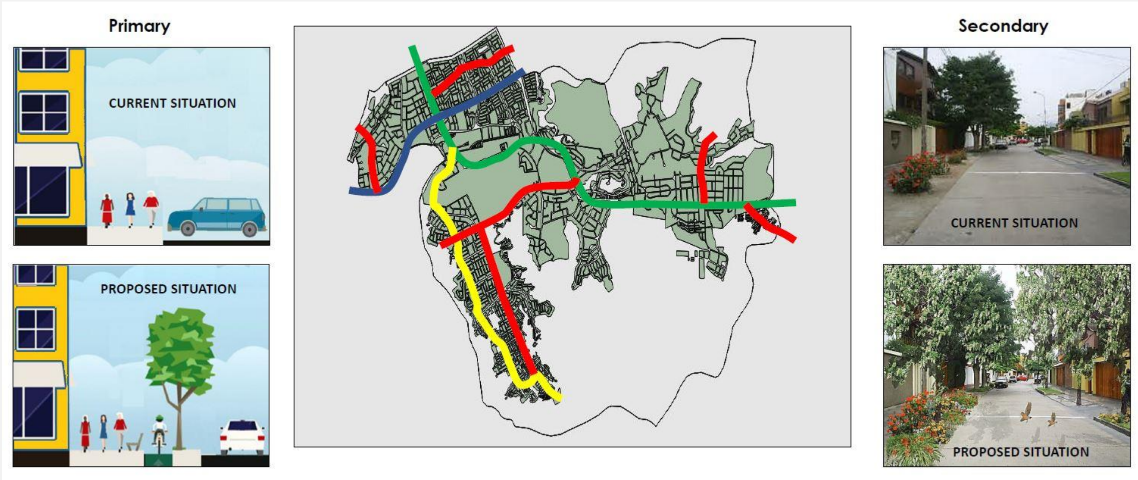


Fig. 2.1-32. Green Corridors in La Molina
Source: La Molina municipality

(2) Urban forest initiatives

Creation of small urban forests distributed throughout the district

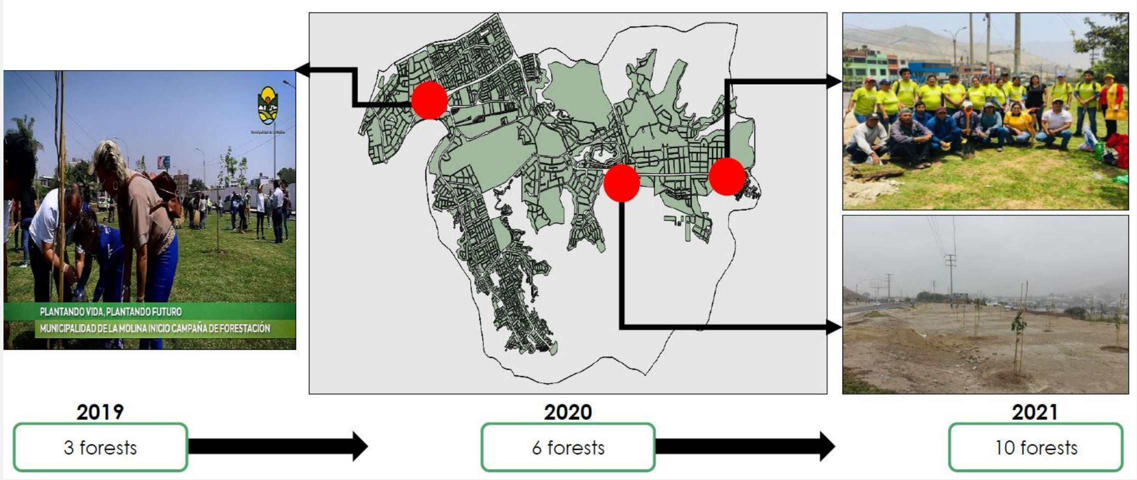


Fig. 2.1-33. Urban forest initiatives in La Molina
Source: La Molina municipality

(3) Green roofs

Green roofs seek to reduce air pollution, add an esthetic value, reduce heat in urban areas and grow food. La Molina Municipality had started the program “Ecotecho Productive” having a purpose to increase the green roofs based on 2019. In 2021 it is planned for the green roofs to be 70.

Fig. 2.1-34. Green Roof initiatives in La Molina
Source: La Molina municipality

(4) Tree phones

In 2019, it has been running for 3 months the program with service for “Tree phones”, and results in 700 trees planted in coordination with neighbours and volunteers. In 2021, it is planned to be planted 10,000 trees.

Fig. 2.1-35. Tree phones services in La Molina
Source: La Molina municipality

2.1.10. Waste Management

(1) Solid Waste

They are of domestic origin (food scraps, paper, bottles, cans, disposable diapers, among others); commercial (paper, packaging, remains of personal hygiene, and the like); urban cleaning (sweeping of streets and roads, brush, among others); and products from activities that generate waste similar to these, which must be disposed of in sanitary landfills.

Fig. Error! No text of specified style in document..1-36. Generation of solid waste in Lima
Source: OEFA, 2014

According to the Environmental Assessment and Enforcement Agency (OEFA), every day at Lima is generated more than 7,400 tonnes of waste, which is around 0.65 kg per person. Moreover, according to the OEFA, 88% of the waste is collected.

La Molina district is located in the East part of Lima. The figure below shows that the East part of Lima generates per person 0.63 kg solid waste. Moreover, it is shown the evolution of solid wastes between 2001 and 2034. In 2034 is predicted that for one day around 16,053 tonnes it will be generated for one day.

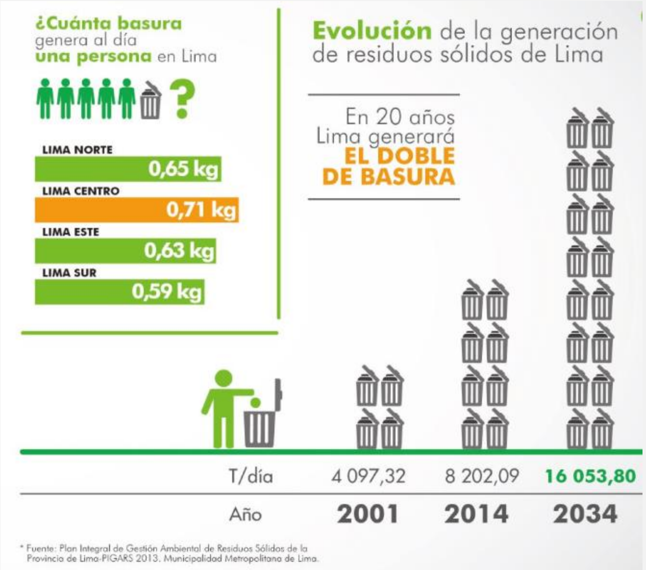


Fig. 2.1-37. Generation of solid waste in Lima between 2001 and 2034
Source: OEFA, 2014

(2) The main problems related to solid waste are:

(2)-1. Lack of landfills and security landfills in Peru

As a direct consequence of the lack of sanitary and security landfills, waste is placed in inappropriate places, commonly called landfills. There are only 9 sanitary landfills and 2 security landfills in Peru. These are not enough for the volume of garbage that is generated in the economy.

(2)-2. Lack of waste heaps for the final disposal of construction and demolition waste

Dumps are facilities to house waste from construction and demolition activities. Despite the number of buildings that exist in Peru, currently, there are no dumps. The lack of them causes construction waste to be thrown into the sea and riverbanks without prior treatment. The procedure to implement them requires proper zoning, among other requirements.

(2)-3. Landfills

The dumps are places of illegal disposal of waste that negatively impact and generate infectious sources of great magnitude for the health of people and the environment. They have municipal and non-municipal management waste. Regardless of the type of waste they contain, the provincial municipalities have to close them following the provisions of Article 18 of the Regulations of the General Solid Waste Law.

(2)-4. Lack of segregation and minimization of solid waste

Segregation is the process of separating waste to reduce, reuse, and recycle materials. It is important to highlight the relevance of this process, from source to final disposal, as the amount of waste disposed of in a sanitary landfill can be reduced and thus extend its useful life. This treatment must be carried out by natural or legal persons, that is, from homes, offices, industries, shops, etc.

The activities in La Molina related to solid waste

(3) Eco-Recycling program.

The program has collected 227 tons directly, also has 3 associations of recyclers who have collected 115 tons. From 2019 to 2021 it was targeted to increase the eco-recycling places from 20 to 26 in La Molina.

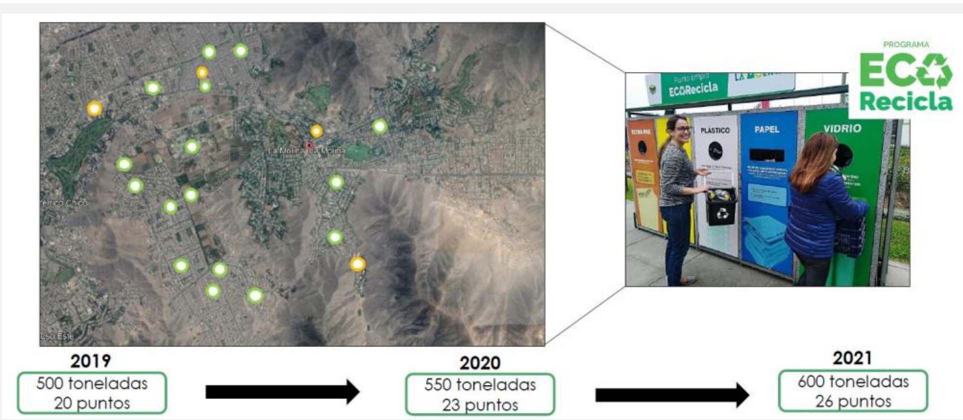


Fig. 2.1-38. Eco-Recycling program
Source: La Molina municipality

Picture 2.1-11. Eco-Recycling program
Source: La Molina municipality

(4) In La Molina has proposed the waste management for green waste

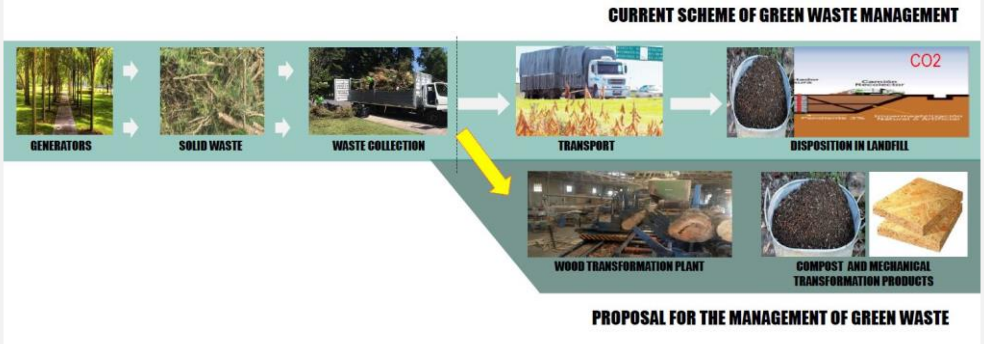


Fig. 2.1-39. Green Waste in La Molina
Source: La Molina municipality

2.1.11. Low carbon policy

1) Lima city Plan

Lima plans to invest US $ 5,100 million in low carbon measures in cost-effective carbon categories that would generate annual savings in energy billing of $ 2.1 billion, which means that investments would be paid in 2.4 years.

Table. **Error! No text of specified style in document.**-8. Plans of Lima city to invest in low-carbon interventions

Sector	Cost-neutral measures sector
Transportation	• Investments in traffic management. • Hybrid scheme: the US $ 2,000 subsidy for 10% of the new cars. • Replacement of diesel taxis with compressed natural gas.
Waste management	• Composting of waste in the closed tank (100,000 t per year). • Burning of gas from the Zapallal sanitary landfill. • Recycling plant: 261 kt of paper, wood, and industrial waste. • Incineration of mud from the Taboada wastewater plant to produce energy.
Residential	• Solar Photovoltaics: the goal of 10 MW per year (scenario without changes). • High-efficiency kitchen appliances (excluding fridge). • High-efficiency air conditioners. • High-efficiency entertainment devices. • High-efficiency washers. • Green roofs in residential apartment buildings (10% of new constructions). Green roofs in semi-detached houses (10% of new constructions).
Electricity	• Coal replace by photovoltaic solar energy (200 MW in 2030). • Best available technology for the use of natural gas (~ 3,500 MW in 2030). • Reconversion of natural gas (1,000 MW in 2030). • Coal conversion (~ 80 MW in 2030).

Source: La economía de las ciudades bajas en carbono y resilientes al clima

Figures 2.1-40 and 2.1-41 below show the projected carbon emissions of electricity and from the commercial sector between 2000 and 2030 respectively.

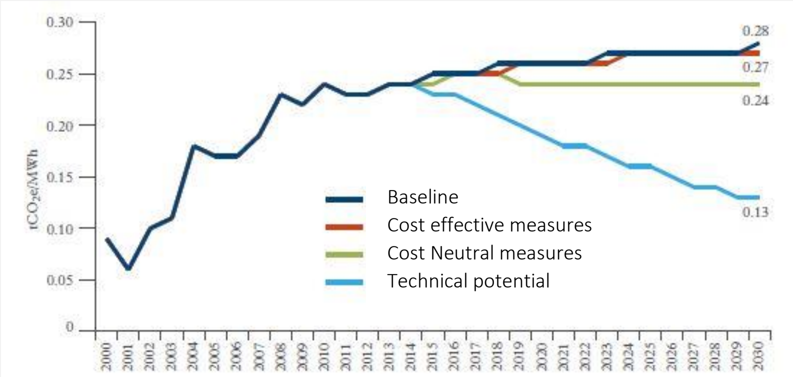


Fig. 2.1-40. Lima-Callao: carbon intensity of electricity from the National Interconnected Electric System, 2000-2030. (Dark blue is the actual condition, red is cost-effective measures, green is cost-neutral measures, and light blue is technical potential (tCO2e per MWh))

Source: La economía de las ciudades bajas en carbono y resilientes al clima

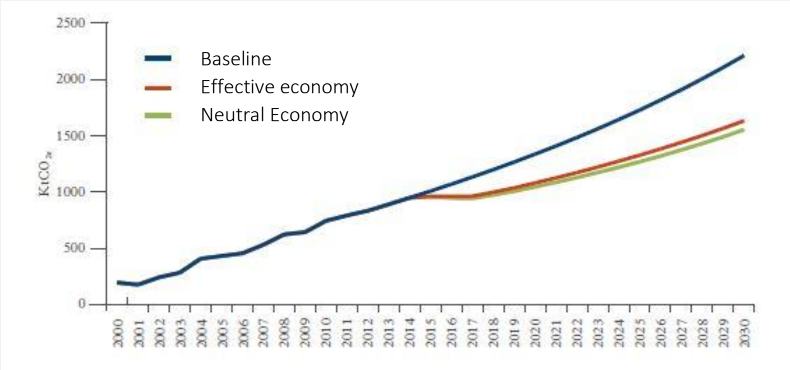


Fig. 2.1-41. Lima-Callao: projected emissions from the commercial sector corresponding to two scenarios (red line is effective economic, the green line is economically neutral), 2000-2030 (KtCO2e).
Source: La economía de las ciudades bajas en carbono y resilientes al clima

2.2. Khon Kaen Municipality, Thailand

2.2.1. Geographic Data

Khon Kaen Municipality is the largest city of Khon Kaen province located in the northeastern part of Thailand. The location of the Municipality is approximately 450 km northeast of Bangkok. Neighbouring provinces of Khon Kaen from the north-clockwise direction are Nongbualampoo, Udornthani, Kalasin, Mahasarakham, Buriram, Nakornratchasima, Chaiyapoom, and Petchchaboon provinces. Access from other cities such as Bangkok is convenient via road, rail, and air.

Geographically, Khon Kaen is located in the middle part of the Khorat Plateau at a longitude of 102° 50′ E and latitude of 16° 26′ N. Covering an area of 46 km2, the city lies at an altitude of approximately 155–160 m above sea level.

Fig. 2.2-1. Location of Khon Kaen
Source: https://oneweirdglobe.com/

Administrative Division

Khon Kaen is divided into 26 districts (called Amphoe) as demonstrated. The district is subdivided into 199 sub-districts (called Tambon) and 2,331 villages.

Fig. 2.2-2. Khon Kaen shown with districts
Source: https://ofomaps.com/

2.2.2. Demography

Figure 2.2.3 shows the projected population in the Khon kaen province. The population in 2030 and 2050 will be 1,822,869 and 1,948,125 people respectively. This means it increases by about 1.01% per year.

The population of the Khon Kaen Municipality grew more than 9 times between 1958 (14,346) to 1990 (131,000) (Ouyyanont, 2017). Based on the 2018 population statistics, there were 118,262 inhabitants in Khon Kaen (Khon Kaen Metropolitan municipality, 2018). Working-age residents represented the largest population segment (71.12%), followed by retirees (15.23%) and people under 15 years of age (13.65%)

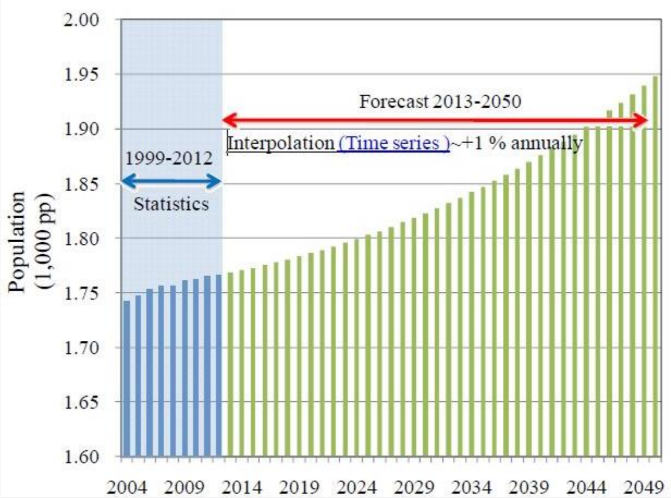


Fig. 2.2-3. Projected number of population in Khon Kaen province from 2004 to 2050
Source: Khon kaen – towards low carbon society

2.2.3. Climate

Khon Kaen has a tropical savanna climate (Köppen climate classification Aw). Winters are dry and very warm, and summers are very hot. The hottest month is April with a monthly average temperature of about 30.0 °C. The monsoon season is from May to October with heavy rain. The average annual rainfall is about 1,214 millimetres. Recently, due to global climate change, dry seasons have become longer and more intense. Heavy rainfall occurs more frequently and causes flooding (Marks, 2019).

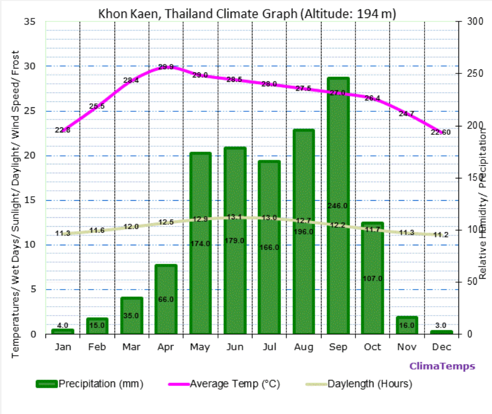


Fig. 2.2-4. Khon Kaen Climate Graph
Source: Clima Temps

2.2.4. Disasters

In the last decades, due to climate change, and the lack of land use control and planning over the urban area in Khon Kaen, heavy rainfall occurs more frequently and causes flooding. Growing flood risks affect Khon Kaen, as well as its nearby municipalities. Recently, floods have become severe.

The south-eastern part of the Khon Kaen metropolitan area and other municipalities have been heavily inundated by a combination of river overflow and rainwater runoff generated in upstream settlements. The picture below shows downpour floods Khon Kaen municipality after strong winds and heavy rain in June 2018.

Fig. 2.2-5. Downpour floods Khon Kaen municipality
Source: Bangkok Post

2.2.5. Economy

The demographic and social characteristics between 2017 and 2020 for Khon Kean City Municipality based on the population size and number of households and gender and age distribution are shown in the below table. Moreover, the Gross Domestic Product, Gross Regional Product and Gross Provincial Product New Series at Current Market Prices by Region and Provinces for 2012 are introduced too.

Table 2.2-1. Demographic and Social Characteristics of Khon Kaen City Municipality

Demographic and Social Characteristics		2017	2018	2019	2020
1) Population Size and Number of Household (Current and Forecast Data)					
	Population	119,265	118,080	114,459	111,607
	Household	52,820	53,185	53,397	53,505
2) Gender Distribution					
	Male	55,065	54,799	53,576	52,666
	Female	64,200	63,281	60,883	58,941
3) Age Distribution					
	7-14 Years		1,429	1,014	1,083
	15-19 Years		2,149	1,740	1,412
	20-24 Years		3,073	1,952	1,256
	25-29 Years		1,619	1,151	955
	30-34 Years		1,238	908	902
	35-39 Years		1,028	842	889
	40-44 Years		934	6,596	846
	45-49 Years		840	632	808
	50-54 Years		772	576	770
	55-59 Years		669	509	707
	60-64 Years		467	359	547
	65-69 Years		265	267	378
	Over 70 Years		679	373	870

Source: Khon Kaen City Municipality

Table 2.2-2. Gross Domestic Product, Gross Regional Product and Gross Provincial Product New Series at Current Market Prices

Gross Domestic Product, Gross Regional Product and Gross Provincial Product New Series at Current Market Prices by Region and Provinces: 2012					
Province	Gross Domestic Product (GDP), Gross Regional Product (GRP) and Gross Provincial (Million Baht)	Per capita GPP (Baht)	Population (1,000 persons)	Per capita GPP, rankings	
				Of the Region	Of the Economy
Northeastern Region					
Khon Kaen	185,595	106,583	1,741	1	33

Source: The 2019 Household Socio-economic Survey, Khon Kaen Province, National Statistical Office

The economy of the Khon Kaen City Municipality is mainly characterized by industrial, commercial, agricultural, and service sectors. The GPP by the manufacturing sector is mainly represented by education, accommodation and food service activities, wholesale and retail trade, repair of motor vehicles and motorcycles and real estate activities with own or leased property. Refer to the amount shown in Million THB.

Table 2.2-3. GDP, main economic sectors and GPP of Khon Kean City Municipality

1) GDP Growth Rate (Current Data and Forecast)	2016 Year
Data from the Khon Kean City Municipality which was conducted on 2016 : GMP (Million THB)	18,956
2) Main Economic Sectors (Manufacturing, Service Industry etc.)	
Data from the Khon Kean City Municipality which was conducted on 2016 : GMP (Million THB)	
Agricultural sector	12
Industrial sector	1,155
Commercial sector	3,207
Service sector	14,582
3) GPP of the Khon Kean City Municipality by the manufacturing sector	
Education	5,596
Accommodation and food service activities	3,756
Wholesale and retail trade; repair of motor vehicles and motorcycles	3,207
Real estate activities with own or leased property	1,652

Source: Khon Kean City Municipality

2.6. Emissions and Efficiency

The information related to energy and emissions is based on the Achieving Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand (LCC) Project. The project aims to strengthen the capacities and processes at the local level for bottom-up integrated low carbon development planning and the implementation and sustainable management of low carbon development projects. The 4-years project (2016-2020) focuses on low carbon urban systems, in particular waste management, energy, and sustainable transport.

City Carbon Footprint (CCF) Evaluation and Low Emission Development Strategies (LEDS) for Khon Kean applied the international standard of Global Protocol for Community-Scale Greenhouse Gas Emission Inventories: GPC (WRI C40 and ICLEI), and 2006 IPCC Guidelines for National Greenhouse Gas Inventories at AR5 level. The forecast GHG emissions to 2030 under the BAU scenario for Khon Kaen City Municipality are shown below:

Table 2.2-4. Forecast to 2030 under BAU scenario

Year	Reduction from measures (tCO2eq)	Emissions under BAU (tCO2eq)	Emissions under smart growth (tCO2eq)	Emission reduction from BAU (%)	Year	Reduction from measures (tCO2eq)	Emissions under BAU (tCO2eq)	Emissions under smart growth (tCO2eq)	Emission reduction from BAU (%)
2019	10,725.81	438,977.15	428,251.35	2.44%	2025	90,636.42	534,282.76	443,646.35	16.96%
2020	21,451.61	452,766.24	431,314.63	4.74%	2026	108,974.54	553,605.83	444,631.29	19.68%
2021	32,177.42	467,311.63	435,134.21	6.89%	2027	127,312.67	574,151.70	446,839.03	22.17%
2022	42,903.22	482,668.77	439,765.55	8.89%	2028	145,650.80	596,038.84	450,388.03	24.44%
2023	58,814.29	498,900.55	440,086.27	11.79%	2029	163,988.93	619,402.02	455,413.09	26.48%
2024	74,725.35	516,078.26	441,352.91	14.48%	2030	182,327.05	644,475.58	462,148.53	28.29%

Source: Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand (LCC) Project

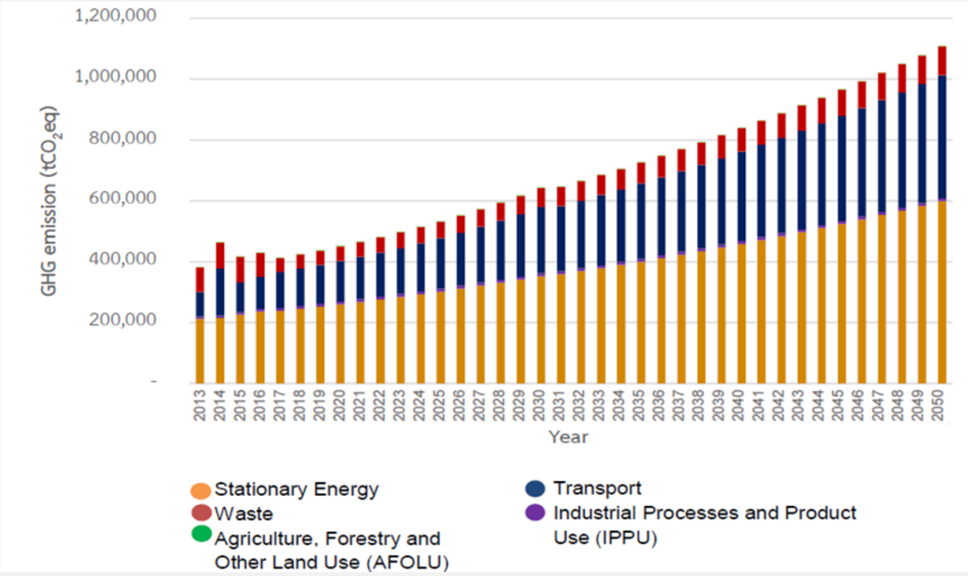


Fig. 2.2-6. Forecast to 2030 under BAU scenario

Source: Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand (LCC) Project

Low emission development strategies (LED) for Khon Kaen City Municipality are shown below:

Table 2.2-5. Low emission development strategies (LED) for Khon Kaen City Municipality

No	Measure *	Q'ty	Units	Implement period (years)	tCO_2 reductions per year
1	LED replacement for residential, commercial and government buildings	2,000	lamps/year	12	7,600
2	Replace low efficiency lamps with high efficiency lamps in public areas	2,000	lamps/year	12	1,000
3	**Replace low efficiency AC with high efficiency for residential, commercial and government buildings**	13,000	units/year	12	18,700
4	**Use high efficiency stoves for residential, commercial and government buildings**	32,500	stoves/year	12	8,400
4.1	LPG stoves	19,500	stoves/year		
4.2	Charcoal stoves	6,500	stoves/year		
4.3	Electric stoves	6,500	stoves/year		
5	**Use high efficiency appliances for residential, commercial and government buildings**			12	2,500
5.1	TV, refrigerators, laudrers appliances	65,000	buildings		
5.2	AC	13,000	buildings		
6	Biodiesel production from used cooking oil	3,000-4,000	liters/day	12	47,500
7	Install streetlight with solar cell in public area			12	860
7.1	LED 124 W	230	poles		
7.2	LED 145 W	479	poles		
8	**Install Solar rooftop 1 kW for residential, commercial and government buildings**			12	9,300
8.1	Residential buildings	65,000	buildings		
8.2	Commercial buildings	13,000	buildings		
9	Establish organic waste treatment stations to produce soil conditioner	120	tons/days	12	19,200
10	Organic waste reduction campaign in households using fermentation bins	6,500	households/year	12	120
11	3R campaign			12	1,170
12	Shfit to EV bus for public transportation	6	buses/year	12	5,000
13	Construct LRT for public transportation	5	bogies	12	16,000
14	Promote the use of biodiesel for vehicles	2	cars/household	12	158000
15	Promote the use of gasohol for vehicles	2	cars/household	12	7,700
16	Promote the use of bicycles or walk	1	kilometers	12	7,500
17	Promote the use of EV cars	100	cars/year	12	7,200
18	Increase green areas	8	hectares	12	1,400
Total					**319,150**

Source: Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand (LCC) Projec

The details of each strategy related to the residential, commercial and government buildings are shown in the table below. The strategies included LED replacement, replacement of low-efficiency lamps with high-efficiency lamps in public areas and promotion of the coordination framework with the private sector and stakeholders to optimize the energy efficiency measures in Khon Kaen City Municipality.

Table 2.2-6. Energy efficiency strategies in Khon Kaen City Municipality

Energy Efficiency (EE)		
LED replacement for residential, commercial and government buildings	The measures to promote LED replacement for residential, commercial and government buildings. The assumption for GHG emission reduction is 2,000 units per year for 12 years of LED replacement which is engaged by the Municipality. The GHG emission reduction is 7,600 tCO2eq.	
Replace low efficiency lamps with high efficiency lamps in public areas	The measures to replace low efficiency lamps (ex. public road, park) with high efficiency lamps or compact fluorescent bulbs or chopsticks tube bulbs. The assumption for GHG emission reduction is 2,000 units per year for 12 years of LED replacement. The GHG emission reduction is 1,000 tCO2eq.	
Promote the coordination framework with private sector and stakeholders to optimize the EE measures	Replace low efficiency AC with high efficiency for residential, commercial and government buildings	The measures to replace low efficiency AC with high efficiency for residential, commercial and government buildings. The assumption for GHG emission reduction is the replacement of COP5 AC for 20 percent of residential, commercial and government buildings (around 65,000 buildings) or replace AC for 13,000 units per year for 12 years. The GHG emission reduction is 18,700 tCO2eq.
	Use high efficiency cooling system for residential, commercial and government buildings	The measures to replace high efficiency cooling system for residential, commercial and government buildings. The assumption for GHG emission reduction is the replacement of high efficiency cooling system for 30 percent of residential, commercial and government buildings (around 65,000 buildings) or replace AC for 13,000 units per year for 12 years. The GHG emission reduction is 1,300 tCO2eq.
	Use high efficiency stoves for residential, commercial and government buildings	The measures to reduce LPG used in residential, commercial and government buildings. The assumption for GHG emission reduction is the apply 3 types of high efficiency stoves include: 1.) high efficiency gas stove for 30 percent per year (19,500 stoves per year), 2.) charcoal stove for 10 percent per year (6,500 stoves per year), and 3.) electric stove 20 percent per year (6,500 stoves per year) for 12 years. The GHG emission reduction is 8,400 tCO2eq.
	Use high efficiency appliances for residential, commercial and government buildings	The measures to replace high efficiency appliances for residential, commercial and government buildings. The assumption for GHG emission reduction is the replacement of high efficiency appliances (ex. television, washing machine) for 20 percent of residential, commercial and government buildings (around 65,000 buildings) or replace AC for 13,000 units per year for 12 years. The GHG emission reduction is 2,500 tCO2eq.
	Use high efficiency appliances for industry.	The measures to replace high efficiency appliances and machines for industry. The assumption for GHG emission reduction is the replacement of high efficiency appliances

Source: Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand (LCC) Project

The details of each strategy related to the Alternative Efficiency (AE) strategies in Khon Kaen City Municipality are shown in the table below. The strategies included biodiesel production, installation of streetlight with solar cell in public area and installation of solar cell for self-consumption.

Table 2.2-7. Alternative Efficiency (AE)strategies in Khon Kaen City Municipality

Alternative Efficiency (AE)	
Biodiesel production	Biodiesel production from used cooking oil in food processing industry and community restaurant. The assumption for GHG emission reduction is 3,000-4,000 liter per day of used cooking oil which used for biodiesel production for 12 years. The GHG emission reduction is 47,500 tCO2eq.
Install streetlight with solar cell in public area	The measures to install streetlight with solar cell in public area which includes 124 Watts for 230 units and 145 Watts for 470 units and operation hours is 12 hours per day for 12 years. The GHG emission reduction is 860 tCO2eq.
Install Solar cell for self-consumption	The measures to produce electricity by solar power in residential, commercial and government buildings. The assumption for GHG emission reduction is the installation of 1,000 MW solar PV rooftop in 20 percent of residential, commercial and government buildings (around 65,000 buildings) or install solar cell at 13,000 buildings for 12 years. The GHG emission reduction is 9,300 tCO2eq.

Source: Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand (LCC) Project

The roadmap of GHG emission reductions for Khon Kaen City Municipality is shown below. The roadmap shows an implementation of the CO2 emission reduction measures that are divided into three terms: Short (up to 2022), medium (up to 2025) and long (up to 2030).

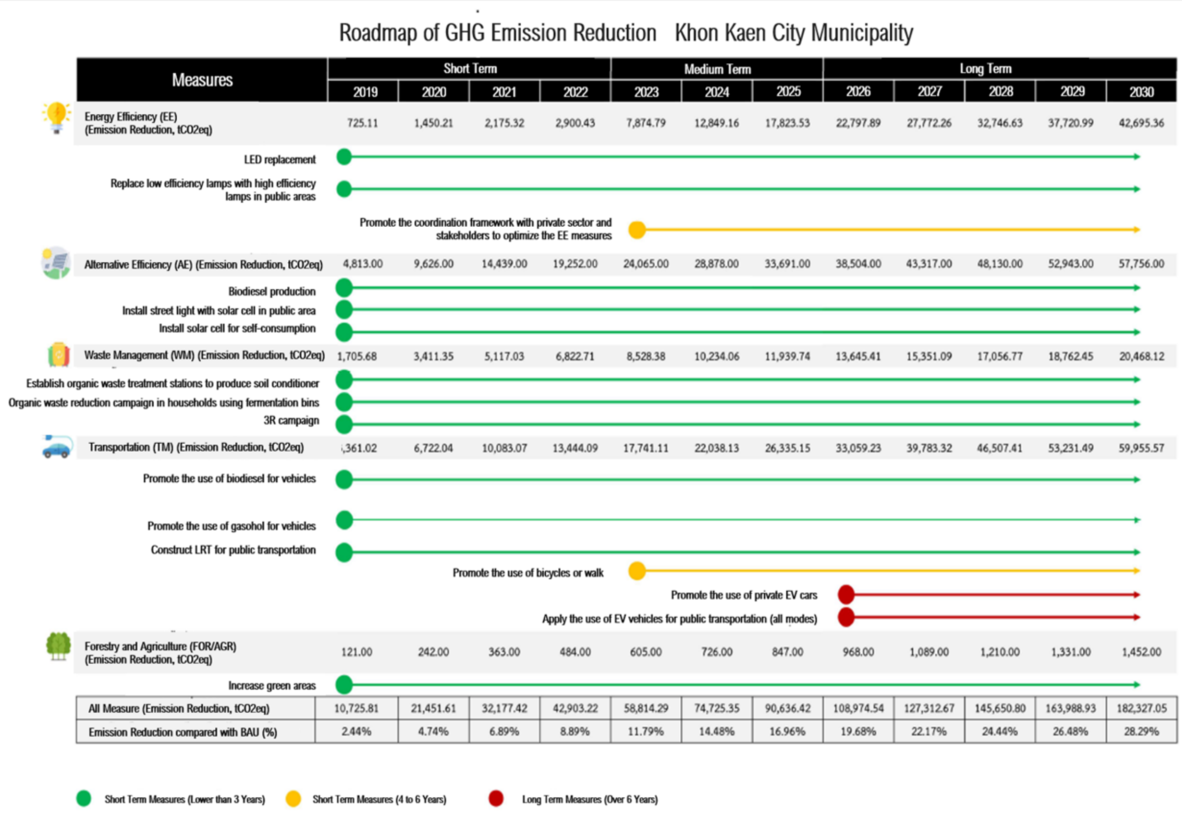


Fig. 2.2-7. Roadmap of GHG emission reductions for Khon Kaen City Municipality

Source: Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand (LCC) Project

2.2.7. Transportation

1) Trip Generation

Khon Kaen's trip generation model was developed by the Office of Transport and Traffic Planning (OTP). The results show that passenger transport demand will increase in 2005 from 18,158 million passenger-km to 71,665 and 73,214 million passenger-km in 2030 and 2050 respectively. For freight transportation demand, it will increase about 2.1 times from 579 million tons km in 2005 to 1,143 and 1,219 million tons km in 2030, and 2050 respectively.

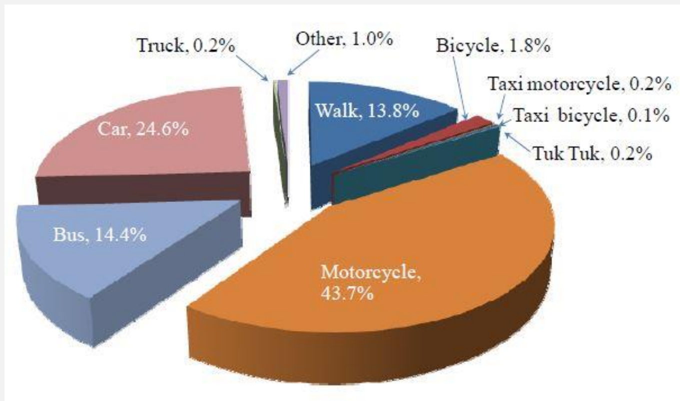


Fig. 2.2-8. Passenger transport in Khon Kaen Municipality
Source: Khon Kaen – towards low carbon society

2) Road Network

Trunk road network in central area is formed with the east-west (No.2), north-south trunk roads (No.12) and the ring road (No.230).

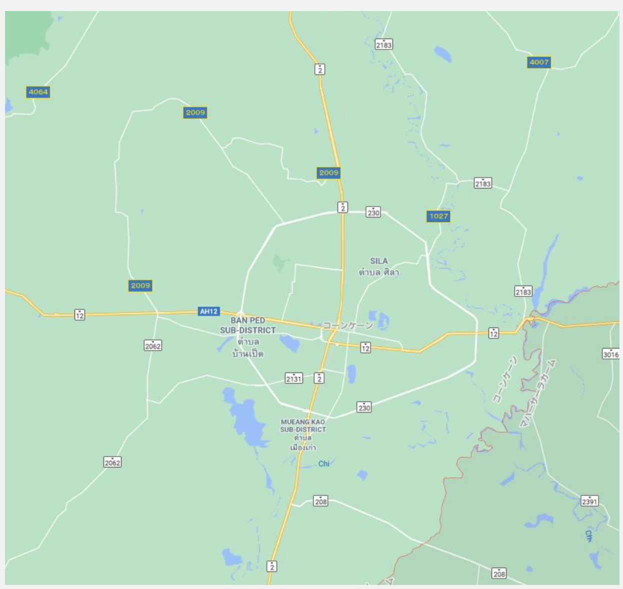


Fig. 2.2-9. Trunk road network in central area in Khon Kaen Municipality
Source: Google map

3) Public Transportation Facilities and Service

(1) Bus Terminal

(1)-1. Kohn Kaen Bus Terminal (No.3)

The Khon Kaen bus terminal (No.3) is located far 7km from the central area. Local bus is operated between the central area and the bus terminal. It takes about 30min. by bus. The bus terminal is connected other big cities in Thailand with bus service routes.

Picture. 2.2-1. View of the Bus Terminal No.3

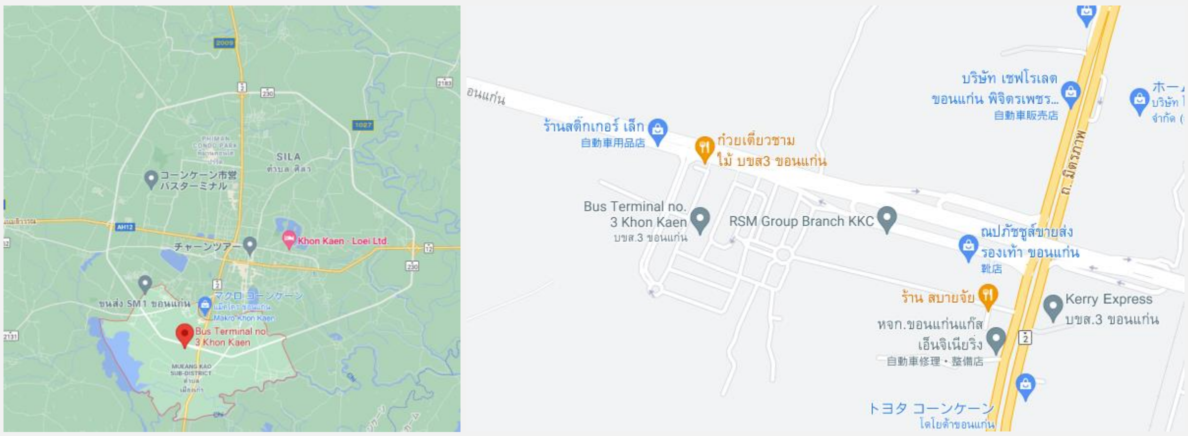


Fig. 2.2-10. Location of the Bus Terminal No.3

Source: Google map

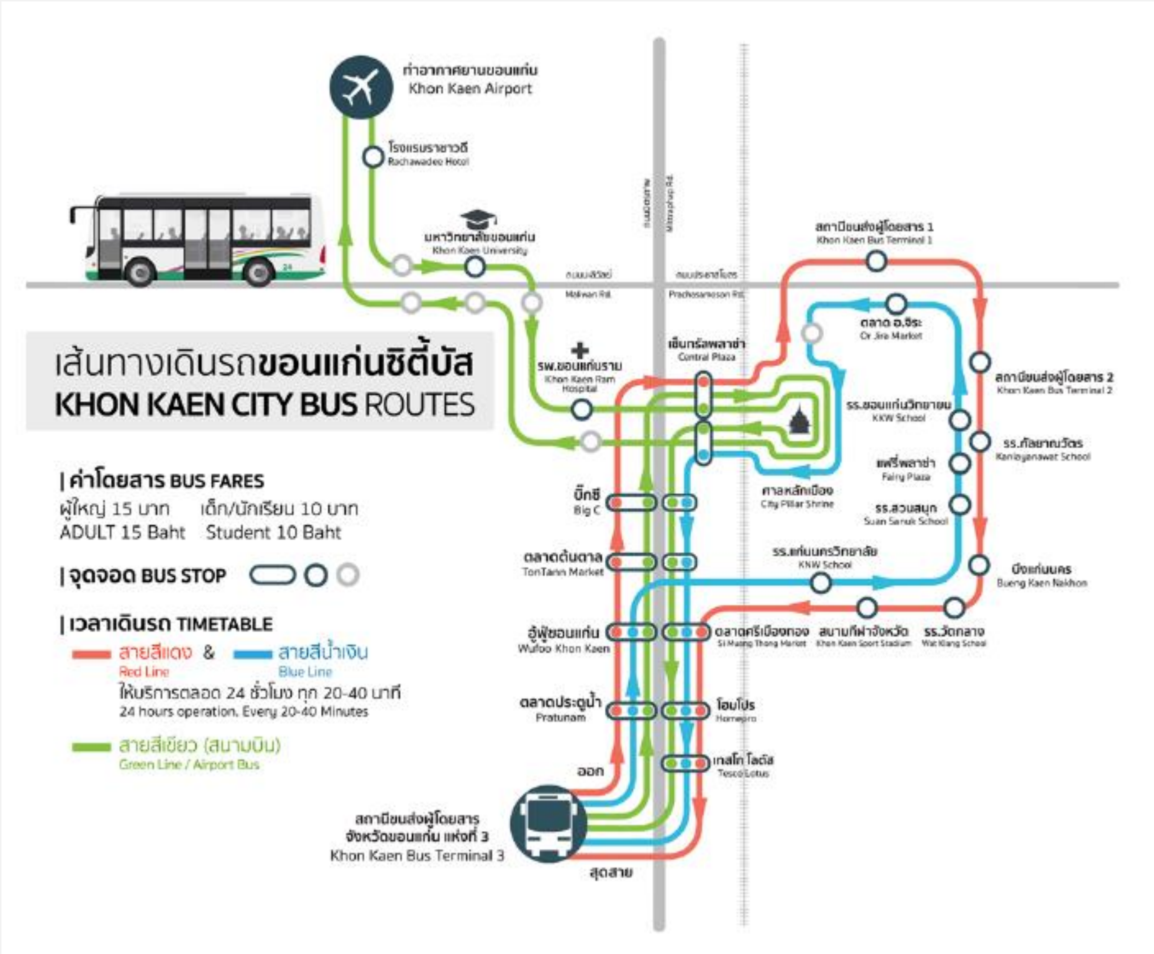


Fig. 2.2-11. City bus routes connected with the Bus Terminal No.3

(1)-2. Khon Kaen Railway Station

Khon Kaen Railway Station is located in central area in the capital city of Muaeng Khon Kaen district. It is far from Bangkok about 450km, 7hour 15min. by express train. Trains are operated in 7 services a day. The Khon Kaen Railway Station was rebuilt to elevate station.

Picture. 2.2-2. View of the Khon Kaen Railway Station
Source:
Left:https://www.google.co.jp/maps/@16.4265685,102.8264276,3a,75y,292.37h,89.19t/data=!3m6!1e1!3m4!1sjQd6CTZf8v6tI9aG7AOx-w!2e0!7i16384!8i8192?hl=ja&authuser=1
Right https://4travel.jp/overseas/area/asia/thailand/khon_kaen/transport

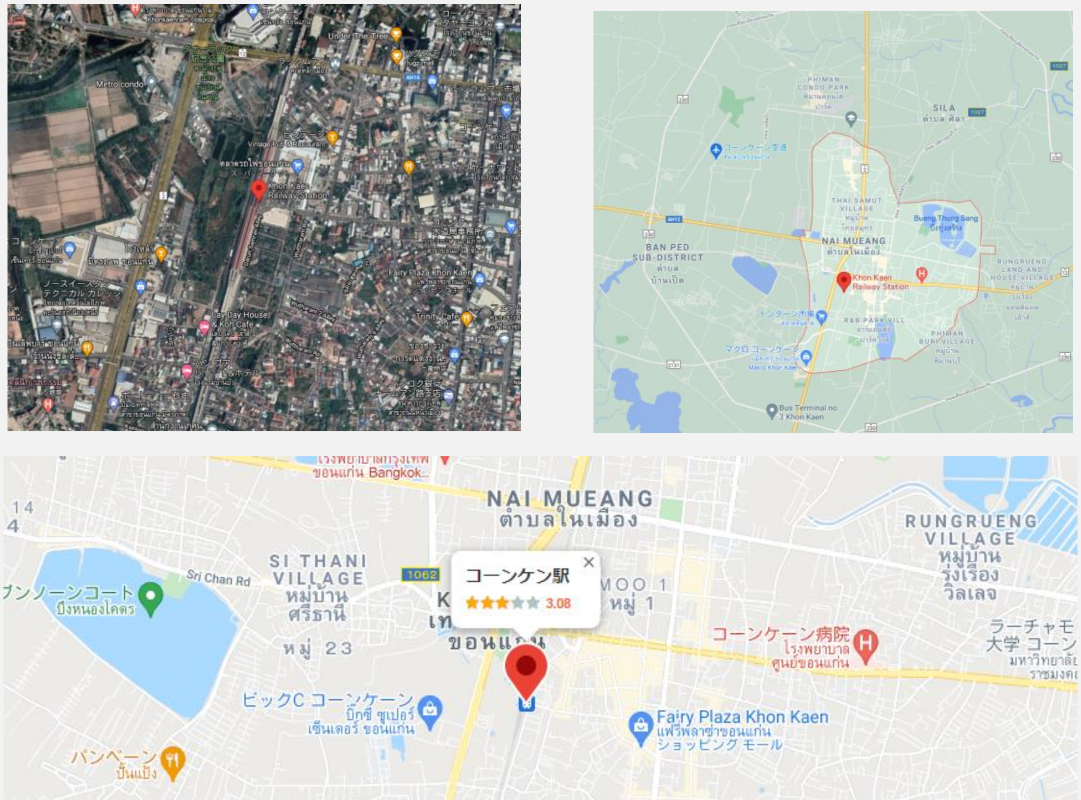


Fig. 2.2-12. Location of the Khon Kaen Station
Source: Google map

2.2.8. Land use/cover changed

Khon Kaen province has a total area of 10,886 km^2. The main area is agricultural (73% of total area), followed by forest, and settlement areas (13% and 6% of total area respectively).

A summary of types of land use in Khon Kaen Province in 2019 is shown in the Figure below. The red color shows the urban area including the road system. Orange and yellow colors are represented by field crops and rice fields, dark green is a forest area respectively.

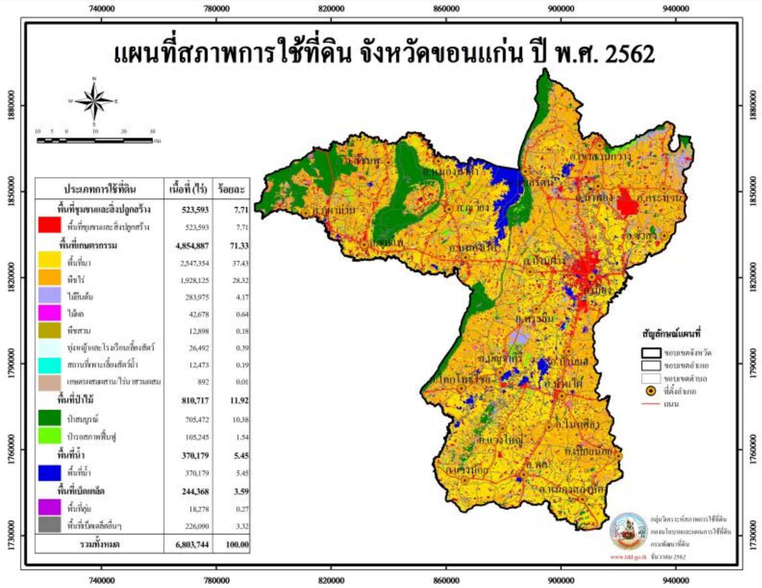


Fig. 2.2-13. Land use map of Kohn Kaen
Source: http://www1.ldd.go.th/web_OLP/Lu_62/Lu62_NE/KKN2562.htm

In the figure below is shown the list of the Comprehensive plan between 2006 and 2017 of the Khon Kaen Province. The plans are divided by forced, under implementation and expired.

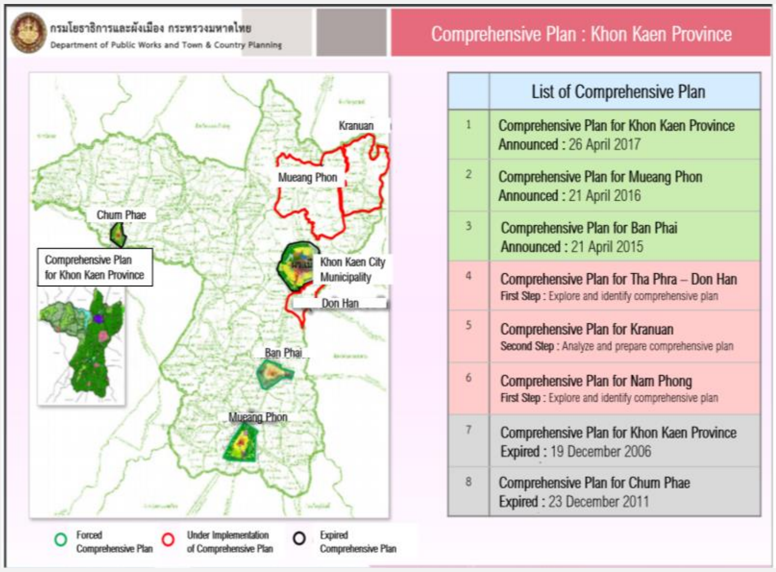


Fig. 2.2-14. Comprehensive plan for Khon Kaen Province
Source: http://subsites.dpt.go.th/edocument/

2.2.9. Waste Management

According to the Strategy Map of Khon Kaen City Municipality, 2017 - 2020, the waste management scheme is shown in the figure below:

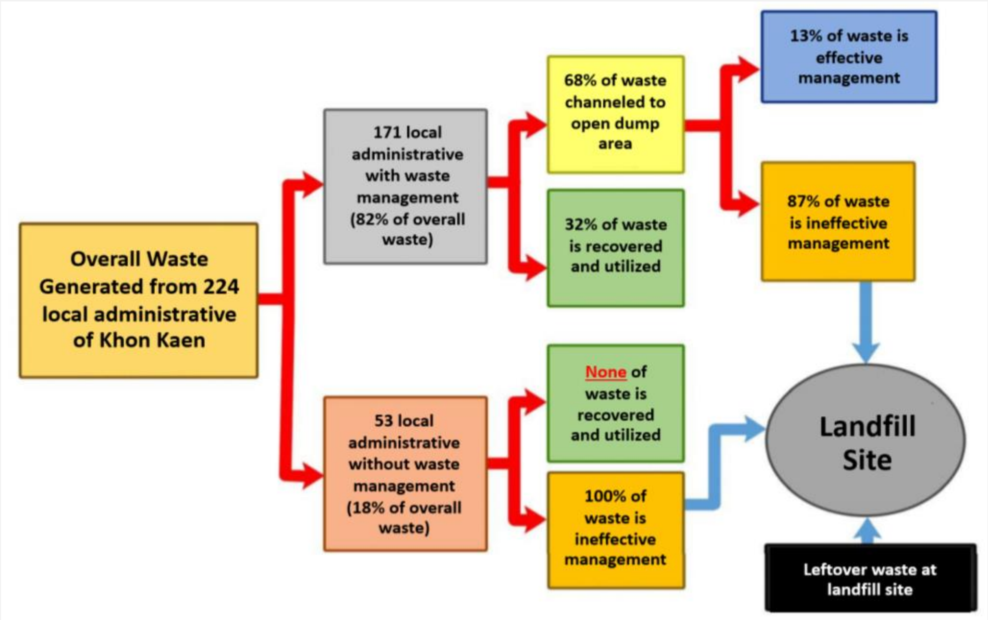


Fig. 2.2-15. Waste Management Scheme for Khon Kaen City Municipality
Source: http://www.kkmuni.go.th/2017/admin/file/files/1486108398_1269816638.pdf

The amount of Waste in Khon Kaen City between 2007 and 2015 is shown in the table below:

Table 2.2-8. Amount of Waste in Khon Kaen City between 2007 and 2015

Year	Amount of Waste (Unit: Tons)	Average (Unit: Tons/day)
2007	55,899.00	153.15
2008	58,385.00	159.96
2009	60,334.00	165.30
2010	61,268.00	167.86
2011	62,050.00	170.00
2012	65,700.00	180.00
2013	75,423.60	205.13
2014	75,190.00	206.61
2015	79,905.50	210.70

Source: Department of Environmental Services / Division of Public Health and Environment

Low emission development strategies (LED) and more especially for the waste management for Khon Kaen City Municipality are shown below with red color:

Table 2.2-9. Low emission development strategies (LED) for waste management for Khon Kaen City Municipality

No	Measure *	Q'ty	Units	Implement period (years)	tCO_2 reductions per year
1	LED replacement for residential, commercial and government buildings	2,000	lamps/year	12	7,600
2	Replace low efficiency lamps with high efficiency lamps in public areas	2,000	lamps/year	12	1,000
3	**Replace low efficiency AC with high efficiency for residential, commercial and government buildings**	13,000	units/year	12	18,700
4	**Use high efficiency stoves for residential, commercial and government buildings**	32,500	stoves/year	12	8,400
4.1	LPG stoves	19,500	stoves/year		
4.2	Charcoal stoves	6,500	stoves/year		
4.3	Electric stoves	6,500	stoves/year		
5	**Use high efficiency appliances for residential, commercial and government buildings**			12	2,500
5.1	TV, refrigerators, laudrers appliances	65,000	buildings		
5.2	AC	13,000	buildings		
6	Biodiesel production from used cooking oil	3,000-4,000	liters/day	12	47,500
7	Install streetlight with solar cell in public area			12	860
7.1	LED 124 W	230	poles		
7.2	LED 145 W	479	poles		
8	**Install Solar rooftop 1 kW for residential, commercial and government buildings**			12	9,300
8.1	Residential buildings	65,000	buildings		
8.2	Commercial buildings	13,000	buildings		
9	Establish organic waste treatment stations to produce soil conditioner	120	tons/days	12	19,200
10	Organic waste reduction campaign in households using fermentation bins	6,500	households/year	12	120
11	3R campaign			12	1,170
12	Shfit to EV bus for public transportation	6	buses/year	12	5,000
13	Construct LRT for public transportation	5	bogies	12	16,000
14	Promote the use of biodiesel for vehicles	2	cars/household	12	158000
15	Promote the use of gasohol for vehicles	2	cars/household	12	7,700
16	Promote the use of bicycles or walk	1	kilometers	12	7,500
17	Promote the use of EV cars	100	cars/year	12	7,200
18	Increase green areas	8	hectares	12	1,400
Total					**319,150**

Source: Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand (LCC) Project

The details of each strategy related to waste management are shown in the table below. The strategies included the establishment of organic waste treatment stations to produce soil conditioner, an organic waste reduction campaign in households using fermentation bins and a 3Rs campaign in Khon Kaen City Municipality.

Table 2.2-10. Waste management efficiency strategies in Khon Kaen City Municipality

Measures	Details
Waste Management (WE)	
Establish organic waste treatment stations to produce soil conditioner	The measures to produce soil conditioner from organic waste. The assumption for GHG emission reduction is 120 tons of organic waste that transformed into soil conditioner (avoid landfill method). The GHG emission reduction is 19,200 tCO2eq.
Organic waste reduction campaign in households using fermentation bins	The measures to promote soil conditioner production by using fermentation bins in household sector. The assumption for GHG emission reduction is 6,500 households where applied the fermentation bins for 12 years. The GHG emission reduction is 120 tCO2eq.
3Rs campaign	The measures to create people's awareness and consciousness on environment. The GHG emission reduction is 1,700 tCO2eq under the assumption of 50 percent of population are adopt 3Rs.

Source: Low Carbon Growth in Cities through Sustainable Urban Systems Management in Thailand (LCC) Project

2.2.10. Low carbon policy

Khon Kaen Municipality and the Khon Kaen province are recognized as one of the "smartest" in Thailand. The local business, government, and educational institutes made a team to develop the Khon Kaen Smart City master plan for better future development. Such a master plan could help the city to be global, and internationally recognized as the most advanced and innovative city in Thailand.

The master plan would cover five years until 2022. It will be included smart mobility, smart living, smart citizens, smart economy, smart environment, and smart governance. The short-term focus would be on three main missions: a medical hub, transportation, and different kind of meetings, incentives, conventions, etc.

The Digital Economy Promotion Agency (DEPA) has signed a deal with Mastercard to bring 27 Thailand candidate smart cities into the "City Possible" program, initiated by the global payments company to accelerate urban development. The figure below introduces 7 pilot cities including Khon Kaen.

Fig. 2.2-16. Smart city development plan
Source: Digital Economy Promotion Agency (DEPA)

2.3. Phu Quoc District, Kien Giang Province, Viet Nam

2.3.1. Geographic Data

Phu Quoc Island is located in the Gulf of Thailand forms part of the Vietnamese province of Kien Giang, with the closest Vietnamese town of Ha Tien being 46 km away, Rach Gia the capital of Kien Giang Province is 115 km away and Laem Chabang (Thailand) is 540 km away. The island covers an area of 567 km² and is about 50 km long north to south, between 3kms wide in the south and 28 km at its wide point (west to east) in the north. Phu Quoc is situated at 10°01'-10°27' north latitude and 103°51'-104°50' east longitude.

Phu Quoc is both the largest of all Vietnamese islands as well as the largest island in the Gulf of Thailand. The island forms an archipelago of 22 islands of all sizes. Phu Quoc is called both the Emerald Island because of its triangular shape as well as the island of "99 mountains" because of its many sandstone chains gradually descending from the north to the south.

Fig. 2.3-1. Location of Phu Quoc
Source: https://dulichdaophuquoc.org/cam-nang-du-lich/ban-do-huong-dan-du-lich-dao-phu-quoc/

2.3.2. Demography

The GDP of Kien Giang province increased slightly over the years, from 2000 to 2011. Although the growth rate was not stable, in the past 8 years, the growth rate has always reached over 10%. In recent years, the GDP of trade, service and industry and construction sectors gradually accounts for a higher proportion while agriculture, forestry, and fishery groups tend to decrease significantly.

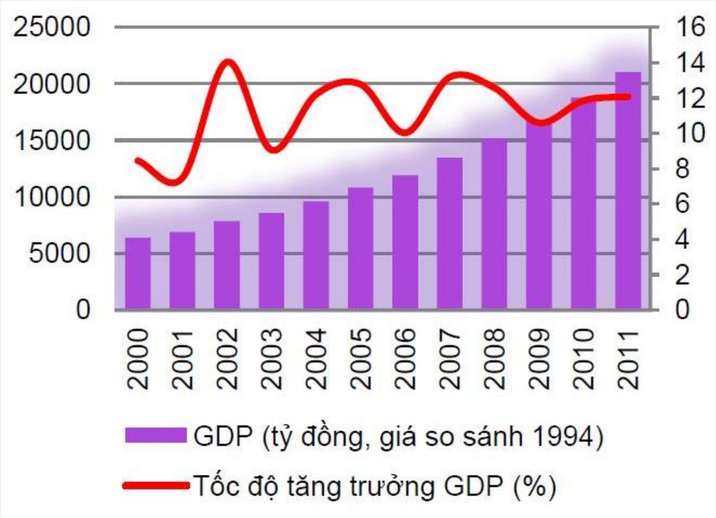


Fig. 2.3-2. GDP in Kien Giang Province
Source: PHU QUOC RESEARCH REPORT Overview of Kien Giang

In Phu Quoc district, before 1975, the population was just over 5000 people. After 1975, the population on the island increased rapidly due to migration. By 2015, according to the statistics of Kien Giang province, the population of the island was over 101,407 people, with a population density of 172 people / km².

As of April 1, 2019, the population of Phu Quoc district was 146,028 people, the population density was 247 people / km² with 75,862 people being urban residents.

Currently, the Phu Quoc district has been forming several new urban areas, InterContinental Phu Quoc urban area, Bac Duong Dong urban area. The average annual GDP growth is 22% and the income per capita is 70,000,000VND per year.

2.3.3. Climate

The climate in Phu Quoc is divided into two distinct seasons: rainy and dry seasons. The rainy season lasts from May to October, the dry season lasts from November to April next year. The island has a consistent average temperature of 27.7 °C, with an average a maximum daytime temperature of 31.2 °C, and an average minimum of 24.6 °C.

With a tropical monsoon climate, the island's average annual precipitation is 2,879 mm. Phu Quoc weather changes throughout the year, the rainy season on Phu Quoc Island falls between July and September. Expect heavy rainfall in the late afternoon. Its average monthly rainfall ranges between 190mm and 361mm. The average temperature is 27°C. January is the month with the coldest seawater, with an average sea temperature of 27°C. Water temperature between 25°C and 29°C is regarded as very warm.

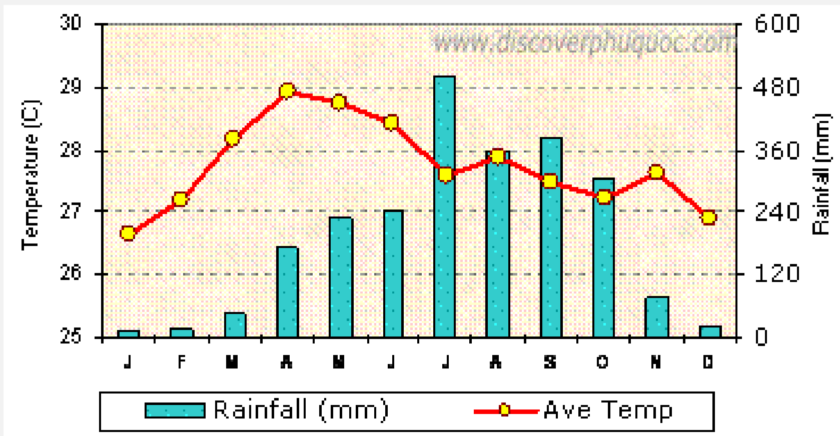


Fig. 2.3-3. Rainfall and the average temperature in Phu Quoc.
Source: Discover Phu Quoc

The driest months on the island are from November through to March when the average rainfall is about 43mm/month. The wettest months occur during the monsoon, from July to October, with an average rainfall of 361mm/month.

Phu Quoc island's calmest months of the year are from late October to April when the average wind speed is 7.2km/h, and the maximum daily wind speed averages 16km/h. The island has the greatest wind speeds during the monsoonal months from July to Early October. Moreover, the island has a consistent humidity, averaging nearly 80%. Humidity starts to increase from March when the monsoon approaches and decreases after the last of the heavy rains in October.

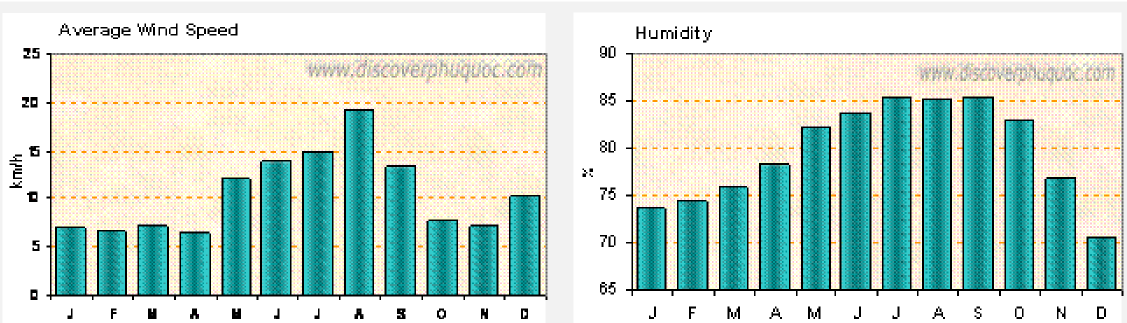


Fig. 2.3-4. Average wind speed and humidity in Phu Quoc.
Source: Discover Phu Quoc

2.3.4. Disasters

According to Phu Quoc district's Steering Committee for Disaster Prevention and Rescue, heavy rainfall in 2019 has left around 8,424 houses flooded, 24 others destroyed or without roofs and a large area of crop devastated. The total damage was estimated at over 107 billion VND (4.6 million USD). 63 km of roads were under 0.7-2 m of water. Fortunately, no casualties were reported in the district. The district authority has mobilized local rescue teams and soldiers to evacuate nearly 2,000 people.

Picture. 2.3-1. People are evacuated from a flooded area in Phu Quoc Island on August 9, 2019
Source: https://kiwiinsaigon.com/ and https://e.vnexpress.net/

The Kien Giang provincial Department of Construction has proposed building open concrete-made canals and fishbone roads from the main road to the sea, to create a nice landscape and help drain rainwater, while reducing infrastructure investment costs.

Recently, Phu Quoc is facing climate change, especially high tides like HCM City.

When re-planning, it is necessary to keep close watch over the high tide situation to come up with the most effective solutions to settle the problem. The table below shows the vulnerability of the settlements and transportation in Kien Giang province due to climate change impact.

Table. 2.3-1. Kiang Giang urban settlements and transportation vulnerability

Climate Change Impact	Settlements			Transportation		
	Building	Water Supply	Waste & Sanitation	Road Transport	Waterway Transport	Ports & Harbors
Temperature	Negligible Risk	Negligible Risk	Negligible Risk	Minor Risk	Negligible Risk	Negligible Risk
Sea Level Rise	Definite Risk	Minor Risk	Minor Risk	Minor Risk	Minor Risk	Definite Risk
Flooding & Inundation	Definite Risk	Minor Risk	Minor Risk	Minor Risk	Minor Risk	Negligible Risk
Salinity	Minor Risk	Minor Risk	Negligible Risk	Minor Risk	Negligible Risk	Negligible Risk
Storm Surge	Definite Risk	Negligible Risk	Negligible Risk	Minor Risk	Minor Risk	Definite Risk
Typhoons	Definite Risk	Minor Risk	Minor Risk	Minor Risk	Definite Risk	Definite Risk

Source: Socialist Republic of Viet Nam: Climate change impact and Adaptation study in the Mekong Delta

Figure 2.3-5 shows the land use and wave heights during the typhoon. The modeled significant wave height in the sea surrounding Phu Quoc is during typhoon Linda that passed over the district in September 1997 causing considerable damage. Some improvements to infrastructure will be required in the long term to deal with localized flooding and saline intrusion into the estuaries particularly Duong Dong town. The island has very high exposure to storm surges and immediate improvements are required for the control measures for the industry, transport and urban infrastructure.

These are in the form of protection from; wind damage, inundation due to storm surges and damage by waves. Structures at risk include urban and tourist facilities, the power generating and distribution system, and the ferry and fishing ports.

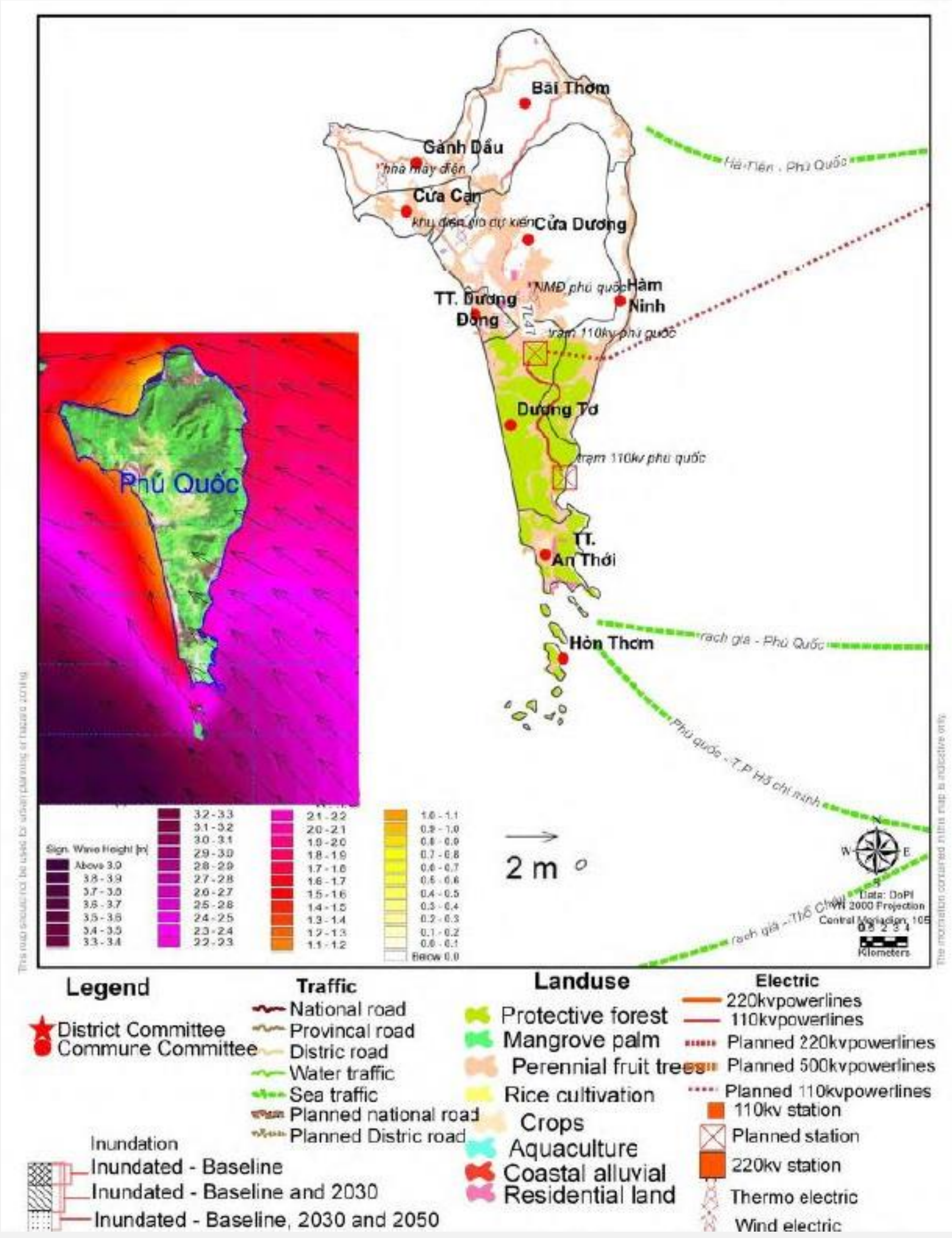


Fig. 2.3-5. Phu Quoc land use and wave heights during typhoon
Source: Socialist Republic of Viet Nam: Climate change impact and Adaptation study in the Mekong Delta

2.3.5. Economy and Tourism

1) Economy

Tourism is the biggest industry it continues to grow annually in Phú Quốc. Fishing and fish related products are the second sources of income. In recent years, the structure of production value also shows a shift towards service. In the 2011-2015 period, Phú Quốc's restructuring was spurred by key industries including information and communication; accommodation and meals; Commerce; finance, banking, and insurance. These industries have an average production scale, around VND 1,000 billion in 2015, with the average growth rate in the period of 2011-2015, information and communication (about 52% / year), accommodation and dining (45% / year), commerce (42% / year), finance, banking and insurance (40.6% / year). The total proportion of these sectors in production value increased from 8.55% in 2011 to 15.52% in 2015.

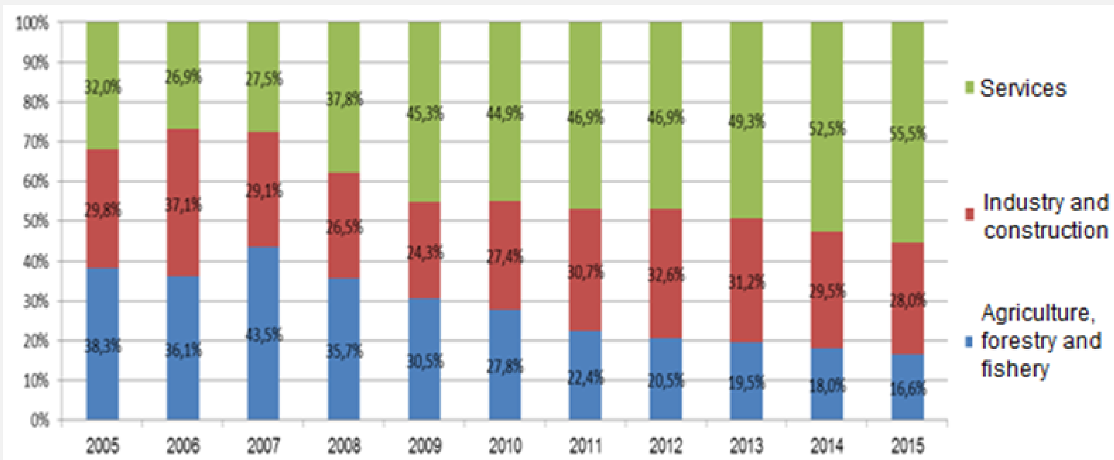


Fig. 2.3-6. The economic restructuring of Phu Quoc island in the period of 2005-2015
Source: GSO 2003-2006, 2009-2011; annual social-economic report of Phú Quốc island People Committee

Phu Quoc has so far attracted 265 projects with a total investment of 377,000 billion VND, equivalent to 16.7 billion USD. In particular, there are 200 projects implemented with a total investment of 220,000 billion, mainly tourism, tourism services, entertainment.

The number of tourists coming to Phu Quoc is increasing, an average increase of 30% per year. Figure 2.3.31 below shows the number of local and international tourists between 2006 and 2013 in Phu Quoc.

2) Tourism

Phu Quoc has seen a continuous increase in tourist arrivals, averaging around 24% in the last seven years. In 2013 the island attracted 622,479 arrivals, of which domestic tourists accounted for 80%. The number of domestic arrivals to Phu Quoc in 2013 was almost double that in 2012 thanks to the opening of the new airport. The number of international arrivals however saw a slight drop as there is no scheduled international flight operating to Phu Quoc.

The average length of stay of foreign tourists in Phu Quoc has not improved for a long time and is currently around 2-3 days. The number of repeat visitors is also very small, accounting for only 5% of total visitors to Phu Quoc every year. If the island does not have a proper plan to diversify its tourism services, a target of 2-3 million tourist arrivals per year in 2020 and 7 million in 2030 seems a long way to go for Phu Quoc even with a 30-day visa exemption.

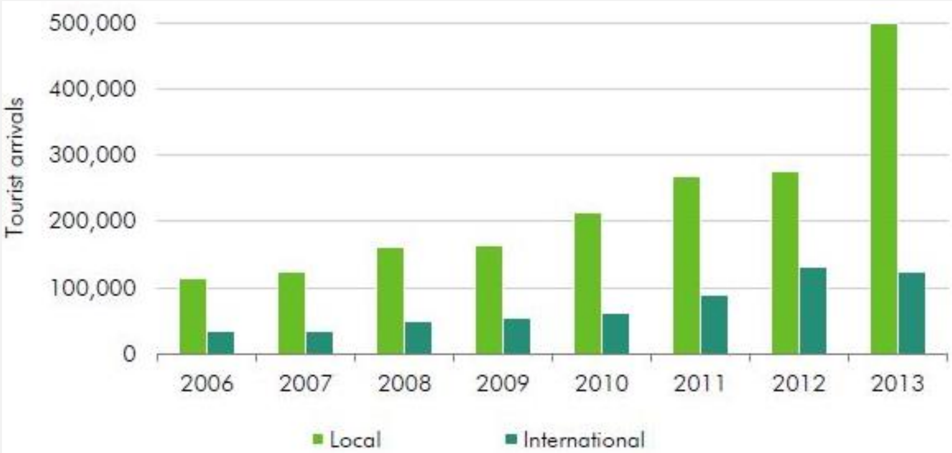


Fig. 2.3-7. Number of local and international tourists coming to Phu Quoc
Source: CBRE, Phu Quoc – fighting for identity

All top-tier hotels in Phu Quoc are on the west side of the island, which is where the main beach, Long Beach (Bai Truong) is located. The beach on this side of the island is calm, clear and has white sand with warm water during the dry season (November-April), which is ideal for tourism. The east side of the island does not have any existing hotel developments even though some of the nicest beaches on the island are located on this site, namely Vong Beach, Sao Beach and Khem Beach.

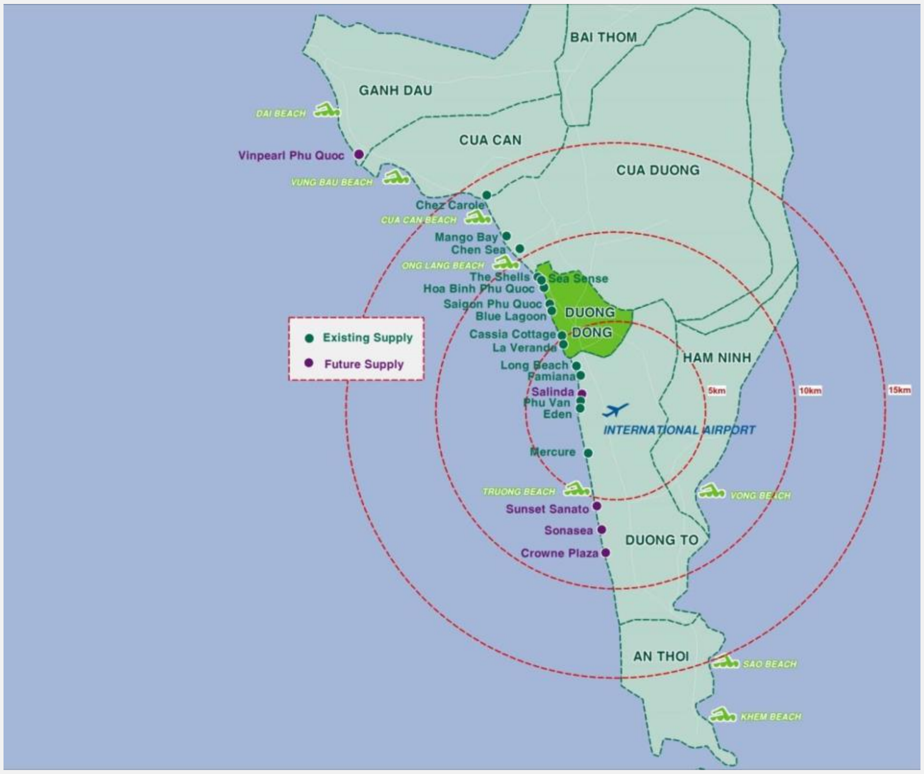


Fig. 2.3-8. Location of top-tier hotels in Phu Quoc
Source: CBRE, Phu Quoc – fighting for identity

2.3.6. Energy & Emissions

Phú Quoc island, nine small islands have their diesel generator powered stand-alone electricity grids funded by Kien Giang province. Since July 2004, Phu Quoc Island's electricity supply has been provided by the new Phu Quoc diesel power plant. This plant is managed by the Kien Giang EVN and is located 5km from (the main Duong Dong town on Phu Quoc.

Additionally, it should be considered that the number of tourists in Phu Quoc will increase in the future according to the data from Section 3.5. This means that the power demand will increase and the possible lack of power supply could be an essential problem for the district in the future.

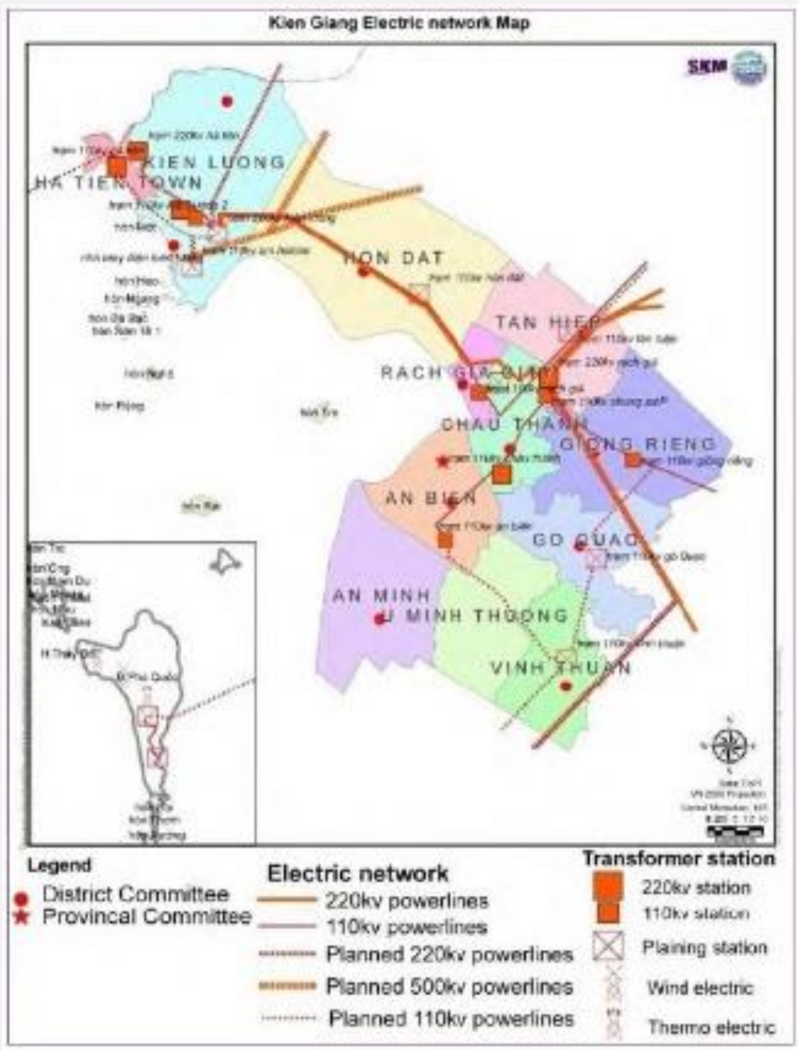
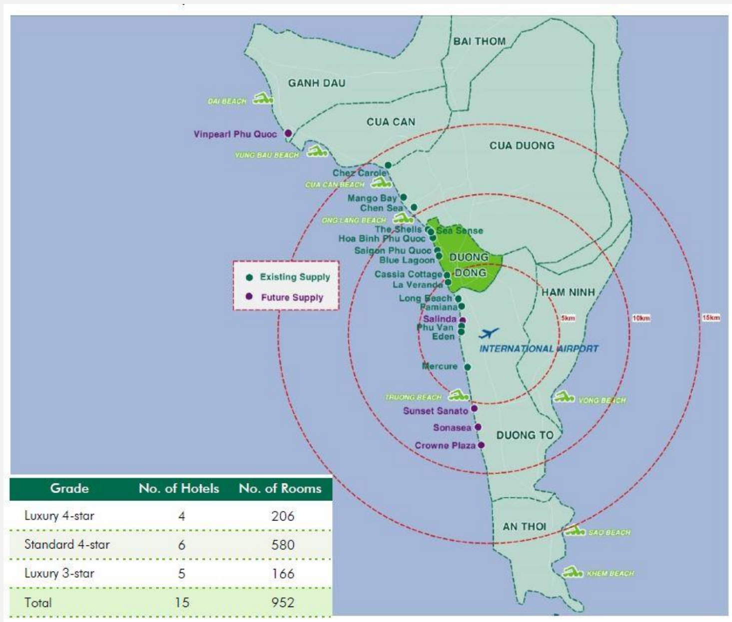


Fig. 2.3-9. The electricity network in Kien Giang and Phu Quoc
Source: Socialist Republic of Viet Nam: Climate change impact and Adaptation study in the Mekong Delta

The majority of accommodation available in Phu Quoc are local guesthouses and small uncertified hotels. Out of 100 establishments offering approximately 2,900 rooms in Phu Quoc, there are only 15 (with 952 rooms in total) that are classified as top-tier hotels. This includes four luxury four-star hotels (206 rooms), six standard four-star hotels (580 rooms) and five luxury three-star hotels (166 rooms). Some hotels like MGallery La Veranda or Chen Sea Resort have room and service quality equal to that of the five-star standard. On average, each top-tier hotel in Phu Quoc has around 47 rooms. In the figure below are shown the top stars rated hotels including the future supply.



Grade	No. of Hotels	No. of Rooms
Luxury 4-star	4	206
Standard 4-star	6	580
Luxury 3-star	5	166
Total	15	952

Fig. 2.3-10. Location of top stars hotels in Phu Quocc
Source: Viet Nam special report Ogu Quoc fighting for identity

1) Air-conditioning facilities

In the Phu Quoc district in the one to two-star ranked and below bungalow and guesthouse types either do not have to air-condition or have only a minimal packaged air-conditioner. Regarding the hotels with three-star and above are equipped with room air-conditioners. For example, in the large-scale five-star multi-room building Vinpearl Phu Quoc, all room has air-conditioners. This hotel’s purported reason for not employing centrally controlled types is that it is not economical throughout the year due to the large decline in the operation rate of guestrooms during the low tourism season.

While there are some examples of hotels that employ centrally controlled air-conditioners in a similar environment in Ho Chi Minh, Viet Nam, one conceivable reason for the lack of employment in Phu Quoc is the small scale of both common-use areas that form the base load for resort hotels and banquet halls that require large-scale cooling.

Also, most room air-conditioners in bungalows are relatively new products that have been installed in the last five to six years due to the enhancement of Phu Quoc Island’s power supply system in recent years and efforts to improve the quality of the island’s hotel industry to become more international.

2) Hot water supply facilities

Hot water supply facilities can also be roughly divided by type of lodging and hotel ranking. Compared to hotels in the mid-range and above that have hot water supply facilities, those at the common level in most cases do not have water-heating equipment in individual rooms. For hotels with water heating facilities, bungalow type rooms have electric storage type water heaters in each room, while comparatively high-ranking hotels with multi-room building guestrooms and common buildings have centralised water-heating equipment. The remaining have individual electric storage water heaters set up in every guest room.

The majority of these electric storage water heaters are made by Italy’s Ariston, a brand popularised in hotels and homes around Viet Nam, not only in Phu Quoc. This manufacturer produces locally in NaNa, and its models are reasonably priced, running from 100 to 300 USD according to scale. Electric storage type water heaters, including those of this company, are very popular in cities around Southeast Asia including Viet Nam where city gas has not yet come into widespread use.

Fig. 2.3-11. Solar water heater installed at Eden Resort on Phu Quoc Island (manufactured by SolarBK)
Source: The Feasibility Study toward Eco-island between Kien Giang Province and Kobe City, Viet Nam

3) Energy source and consumption at Viet Nam's resort hotels

According to the study of energy consumption of hotel buildings in Viet Nam, the data from 32 hotels were gathered from the website on energy efficiency promotion of the Ministry of Construction. The average energy use intensity (EUI) in the whole economy was 151 kWh/m2. At the same time, the structure of end-use energy consumption was estimated, of which 54% for heating, ventilation and air conditioning (HVAC), 10% for lighting, 19% for plug equipment and 17% for lifts.

Table. 2.3-2. The percentage of end-use energy consumptions at hotel buildings in three cities in Viet Nam

Energy end uses	Hanoi		Da Nang		HCMC		Vietnam	
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
Lighting	12	7	7	6	12	7	10	7
Equipment	17	8	23	19	16	7	19	13
HVAC	50	12	53	24	60	18	54	19
Lift	21	10	18	18	11	11	17	14
Total	100		100		100		100	

Source: A study on energy consumption of hotel buildings in Viet Nam, 2018

Table. 2.3-3. Benchmarks for efficient use of resources in Vietnamese hotels

Benchmarks for efficient use of resources in Vietnamese hotels

	Climate-based benchmarks							Overall benchmarks			
Climate category	Coastland			Highland	Inland						
Hotel category	4-star	3-star	2-star	2-star	4-star	3-star	2-star	4-star	3-star	2-star	resort
kW h/room/day (Elec.)	44–77	30–37	25–47	14–17	88–112	38–46	27–37	75–97	37–43	26–37	30–41
kW h/guest/day (Elec.)	24–43	42–62	15–27	15–17	129–178	37–45	26–44	81–127	40–50	27–41	18–24
m^3 water/room/day	2.3–2.6	1.2–1.6	0.9–1.3	1.8–2.6	1.9–2.3	1.2–1.4	1.1–1.5	5.4–20.3	2.6–8.1	0.7–11.5	4.1–16.4
m^3 water/guest/day	1.2–1.5	1.8–2.7	0.5–0.8	2.1–2.6	2.4–3.2	1.3–1.5	1.3–1.8	4.4–38.9	2.2–11	0.6–10.8	6.3–19.6
kg solid waste/guest/day	2.5–7.2	0.4–0.5	n/a	2.2–3.8	9.7–17.5	5.2–9	8.3–13.9	13.5–32.3	8.2–17.9	0.7–5.6	5.7–18.7
m^3 wastewater/guest/day	1–1.3	n/a	n/a	n/a	1.8–3.5	1.2–1.6	1.4–1.7	n/a	2.3–12	1.4–1.9	n/a

Source: The Feasibility Study toward Eco-island between Kien Giang Province and Kobe City, Viet Nam

4) Solar power in Phu Quoc

The demand for economic development and tourism has increased, the price of land and real estate here has increased sharply. Demand for hotels and resorts in Phu Quoc is building very quickly. Although there is a power grid, this is a place far from the mainland and electricity prices are increasing, leading to electricity bills accounting for a significant part of the profit margin of investment businesses as well as households here. With its geographical location and abundant renewable energy from the sun, the solution of installing solar power is one of the most optimal solutions.

Phu Quoc is the southernmost point near the equator of Viet Nam where there is sunshine all year round. And especially, this place was built by investors, so there is a roof area to invest in Phu Quoc solar power in the most optimal and economical way.

Fig. 2.3-12. Solar power in Phu Quoc
Source: ANH DUONG LUXURY CO

The grid power system in Phu Quoc is a system that uses electricity obtained from solar energy and then they are connected to the grid of the economy. The amount of electricity generated from solar energy is always used in advance for daily activities, production until this electricity runs out, the system will automatically take electricity from the economy grid for use. In case the solar power generation system is in excess of the required consumption, the excess energy will be fed into the economy grid.

Fig. 2.3-13. Phu Quoc solar power - grid solar power system
Source: ANH DUONG LUXURY CO

2.3.7. Transportation

At present, means of transportation on the island are limited to motorbikes, taxis and tour buses, with no public transportation such as transit buses. In Phú Quốc, tour buses include shuttle buses that only make stops at a starting point and final point, and rental buses for tourists. Tour buses on Phu Quoc Island are mainly rental buses that cruise around the island leaving Duong Dong town and shuttle buses that connect boat terminals (Bai Bong Harbour) with the towns of Duong Dong and An Thoi.

Fig. 2.3-14. The transport (bus) network in Phu Quoc
Source: www.busphuquoc.com

The distance is only 11 kilometres / 6.8 miles, the city centre can be reached in 20 minutes. Bus line 11 of Bus Phu Quoc runs every 20 minutes between Duong Dong and An Thoi, via Long Beach, Suoi Tranh Waterfall, Phu Quoc Airport and Phu Quoc Prison Museum. The bus departs in both directions, every day of the week between 06:00 hours and 18:00 hours. The first and last stop in Duong Dong can be found at the old airport, the address is 126 Đường Nguyễn Trung Trực. Travel time from the airport to Duong Dong is 30 minutes, the hotels located at Long Beach are accessible in about 15 minutes. It takes 30 minutes from the airport to An Thoi in the south of Phu Quoc. Bus line 11 departs from the parking lot in front of the terminal, you can buy tickets from the bus driver. The price to or from the airport is 20,000 VND, for a bus ride between Duong Dong and Long Beach you only pay 10,000 VND. Please consult the website Bus Phu Quoc for more information. In An Thoi you can travel by cable car to the smaller island of Hòn Thơm, a ride with the Hon Thom Cable Car takes 15 minutes and costs 150,000 VND per person.

2.3.8. Land use/cover changed

The land-use of Phu Quoc is mainly forest and agriculture area (about 70%), followed by unused and urban and residential areas. The Consultative Committee on the UNESCO's Man and the Biosphere Programme has agreed to approve the nomination of the Kien Giang Biosphere Reserve in the deep south of Viet Nam. Phu Quoc National Park is becoming an eco-tourist destination. Regarding the urban and residential area, along with the local houses, there are hotels and resorts scattered on the western side of the Island, near the main town of Duong Dong along Long Beach.

Accommodation ranges from basic bungalows to more recently opened luxury boutique resort and spa types developments like the La Veranda Resort which is owned by the Grand Mercure hotel group or Long Beach Ancient Village for maximum comfort and facilities.

The People's Committee of the Southeastern Kien Giang Province has approved the construction of a casino to a planned resort. According to the plan, 5-star hotels and resorts, restaurants, parks, etc. will be built on a 130-hectare site along the coast of Dachon Beach with 100% foreign ownership (see picture below).

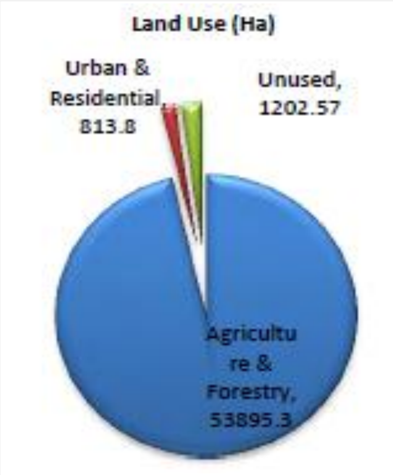


Fig. 2.3-15. The Land-use in Phu Quoc
Source: Socialist Republic of Viet Nam: Climate change impact and Adaptation study in the Mekong Delta

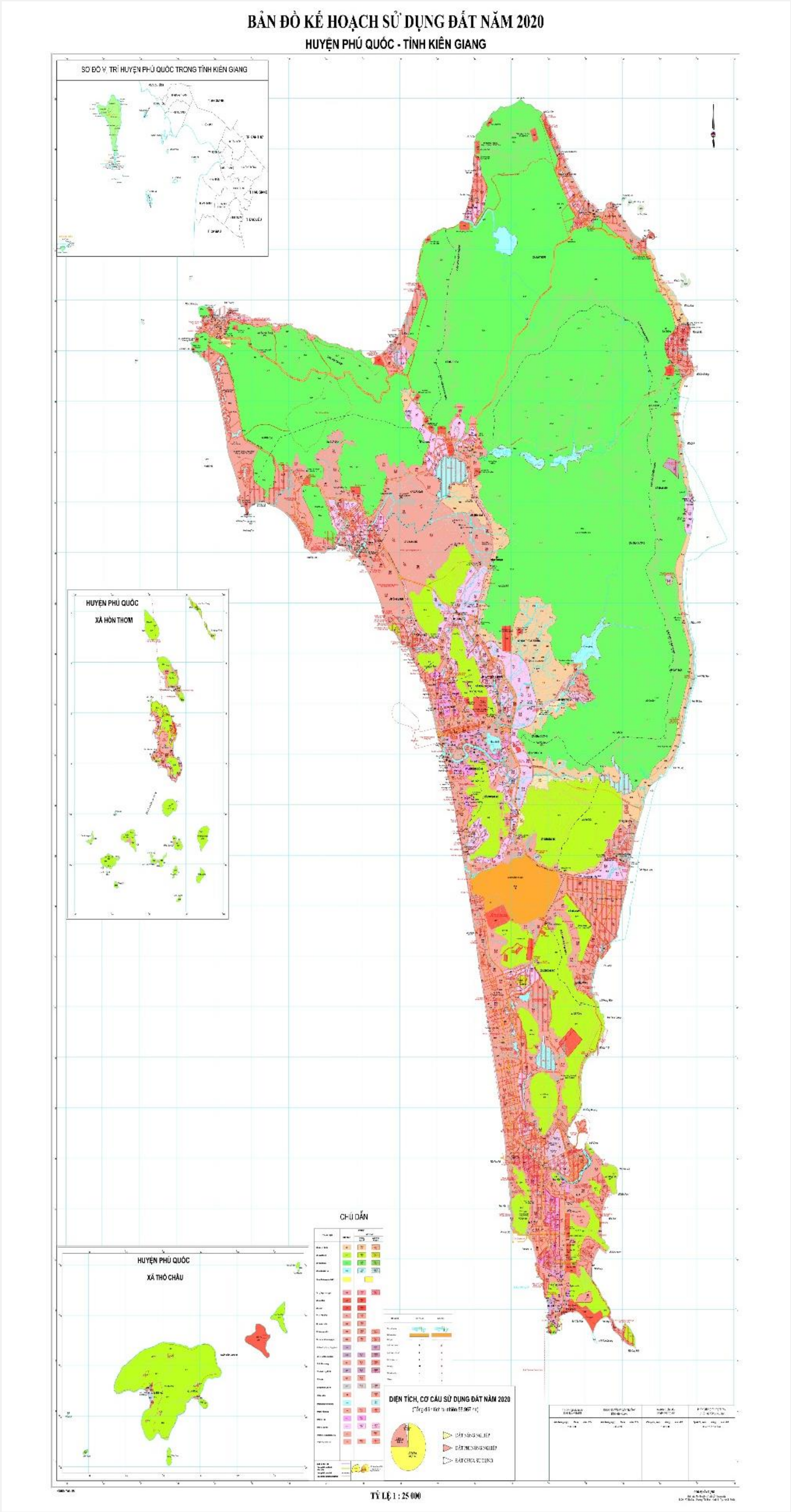


Fig. 2.3-16. The Land-use in Phu Quoc
Source: Kien Giang Province

1) Master Plan for Phu Quoc Island, Kien Giang by 2030

In 2005, Phu Quoc Development Master Plan was formulated focusing on the island's geographical advantages, rich natural environment and tourism potentials. The GDP grew from 16% in 2005 to 23% in 2009. Phu Quoc is expected to contribute to the regional economy as well as play an important role in economic development. Subsequently, the 2005 Master Plan was revised in 2010. The "Amended General Construction Master Plan for Phu Quoc Island, Kien Giang by 2030" was approved as the "Adjusted Master Plan of Construction of Phu Quoc Island, Kien Giang in 2030" by Prime Minister Decision No. 633/QD-TTG in May 2010. (This adjusted master plan is hereinafter referred to as the Master Plan.)

The Master Plan with target years of 2020 and 2030, lays out the step by step approach to sustainably develop the island into an upscale tourist destination and a science and technology hub in the Southeast Asian region, at the same time, carefully preserving its history and natural environment. The projected populations for 2020 and 2030 are shown in Table below.

Table. 2.3-4. Population Forecast by Master Plan

Year	Total Population	Urban Population	Rural Population	Tourist Number equivalent to Population	Number of Tourists
2020	340,000 – 380,000	200,000 - 230,000	80,000 – 90,000	50,000 – 65,000	2 – 3 million
2030	500,000 – 550,000	320,000 – 370,000	90,000 – 100,000	80,000 – 85,000	5 – 7 million

Source: Kien Giang Province

Duong Dong, An Thoi and Cua Can townships are designated as urban development areas, and their development policies are summarized in Table below.

Table. 2.3-5. Development Policies of the Three Designated Urban Areas

Urban Area	Urban Function	Target Population (Y2030)	Development Area (ha)
Duong Dong Urban Center	Government services, publicservices, business center, tourist service center.	240,000	2,502 ha
An Thoi	International port, touristservices, light industry, cultural center.	71,000	1,020 ha
Cua Can	Forest/Marine Protection, Agriculture, Tourist Center	26,500	329 ha

Source: Kien Giang Province

2.3.9. Waste and Water Management

1) Waste

According to Decision No. 633/QĐ-TTg dated May 11, 2010, of the Prime Minister approving the adjustment of construction of Phu Quoc island, Kien Giang province to 2030, Phu Quoc will be a special economic-administrative zone; the international center of eco-tourism of the economy, convalescence and entertainment; the regional financial center is an important hub for international and regional transport and is a center for specialized scientific and technological research, a center for forest biodiversity conservation and sea of the economy and the region. It has a special position on the security and defence of the economy. Up to July 2011, Phu Quoc has had 74 projects granted investment certificates, with a total investment capital of 48,087 billion.

With the current population, Phu Quoc has more than 1,600 operating enterprises, including hundreds of manufacturing establishments and many tourism service enterprises. However, most of these enterprises do not have the wastewater treatment system meeting the standards, leading to untreated wastewater being discharged directly into the natural environment.

At the moment, Phu Quoc exists two large landfill sites over a dozen years, located in An Thoi Town and Cua Duong Commune with more than 140 tons of waste generated each day. However, they are close to the main road causing environmental pollution. At public beaches or estuaries in Phu Quoc residential areas, it is easy to see the scene of waste is rampant.

Table. 2.3-6. Power Demand of Phu Quoc (2018-2025) (kW)

2018	2019	2020	2021	2022	2023	2024	2025
64.5	87.0	117.4	128.6	140.9	154.5	169.3	185.5

Source: Feasibility for Solid Waste Power Generation at Phu Quoc Island, Viet Nam

Phu Quoc was supplied electricity the economy grid via the 110 kV line of Ha Tien - Phu Quoc from February 2014 with a length of 64 km and the Phu Quoc 110 kV transformation station with a capacity of 2x40 MVA. When the Phu Quoc diesel power plant has stopped working, it is only used as a backup source. It can only carry loads of about 76%. In case of an incident of Phu Quoc underground cable, it will be difficult to ensure energy security.

According to statistics from Kien Giang Power Company, the situation of using power registration in Phu Quoc district in the period 2017-2018 is as follows:

- The projects put into operation by the end of 2017, a total of 46.9MW, including Vinpearl Casino: 12 MW; Vinpearl Phu Quoc 3 & 4: 17.8 MW; An Thoi Group: 11.8 MW; Sung Chi Hon: 1.2 MW; BIM Kien Giang Company: 4.1 MW.
- In 2018, additional loads will be added, a total of 36.6 MW, including MIK Group Viet Nam (Movempic Project): 7 MW; An Phuong Group: 12.45 MW; Sung Hong Hon: 5.3 MW; Pulman Resort: 3.2 MW; Novotel: 5 MW; Public transformer substation load: 3.66 MW (about 10% increase).

Fig. 2.3-17. An Thoi's landfills.
Source: Feasibility for Solid Waste Power Generation at Phu Quoc Island, Viet Nam

2) Water

(1) Water Demand

The water demands on the main island of Phu Quoc for 2020 and 2030 are estimated to be 70,000 and 120,000 m3/d respectively. Four new water impounding reservoirs would be required to meet these water demands. The water supply system to be developed would provide 68,000 m3/d by 2020 and 103,000 m3/d by 2030 (equivalent to 65% and 85% of the projected demands), with the balance to be supplemented by rainwater and reclaimed water.

Table. 2.3-7. Storage and Supply Capacities of Water Impounding in Master plan in Phu Quoc

No.	Name of Reservoir	Storage Capacity (m^3)	Supply Capacity in 2020 (m^3/d)	Supply Capacity in 2030 (m^3/d)	Remarks
1	Cua Can	15,000,000	20,000	50,000	The largest capacity on the island
2	Duong Dong	10,000,000	15,000	20,000	Expansion of the existing reservoir
3	Rach Ca	2,000,000	8,000	8,000	
4	Rach Tram	3,000,000	10,000	10,000	
5	Suoi Lon	4,000,000	15,000	15,000	
	Total	34,000,000	68,000	103,000	

Source : Decision No.633/QD-TTg May 11, 2010

Source: PREPARATORY SURVEY ON WATER SUPPLY AND SEWERAGE SYSTEM PROJECT IN PHU QUOC ISLAND

By the year 2020 Master Plan indicates that the entire water supply capacity of the island becomes 68,000 m3/d. Water demand projected in 2030 in Master Plan is 120,000 m3/d, of which 85% (103,000 m3/d) will be secured by the planned water supply systems. It is expected that the balance is fulfilled by the use of rainwater and reclaimed water.

(2) Existing Duong Dong water supply system

The water supply service in Phu Quoc started by KIWACO in 2006 covers only the Duong Dong township area. The raw water source is the Duong Dong impounding reservoir, located approximately 5 km northeast of Duong Dong. The raw water is treated at the Duong Dong water treatment plant (WTP). The supply capacity of the existing system is 5,000 m3/d, and 41% of the population of Duong Dong township is connected to the system. The table below shows general information on the Duong Dong water supply service.

Table. 2.3-8. Existing Water Supply Service in Phu Quoc

	Unit	Values in Year 2010
Water Production	m^3/d	2,640
Water Distributed (billed)	m^3/d	2,194
Domestic Consumption (billed)	m^3/d	1,832
NRW ratio	%	10.8
Capacity of Water Treatment Plant	m^3/d	5,000
Operation Rate	%	53
No. of Connections	connections	3,699
No. of Domestic Connections	connections	3,599
Duong Dong Town Population	persons	32,738
Population Served	persons	16,645
Service Ratio	%	51
Unit consumption by domestic customer	lpcd	113
No. of Employees	persons	20
No. of Employees per 1,000 connections	persons	5.4
Water Tariff (Domestic)	VND/m3	5,500
Annual Bill	VND	4,293,317,649
Average monthly bill per customer	VND/month/customer	96,722
Connection Charge	-	Free up to 5m from the tapping point on distribution pipe. Over 5m customer bears the actual installation cost.

Source: PREPARATORY SURVEY ON WATER SUPPLY AND SEWERAGE SYSTEM PROJECT IN PHU QUOC ISLAND

(3) Other related water supply projects

The “Phu Quoc District Water Supply Project” which will expand the water supply services in Phu Quoc urban center is funded by the World Bank with a target completion by 2020. The 5,000 m3/day Duong Dong WTP would be rehabilitated and expanded to 16,500 m3/day and the distribution networks would be expanded in Duong Dong town and Duong To commune.

The Stage I Duong Dong Dam Upgrading Project funded by the government and implemented in 2012 would provide the water source at the supply capacity of 16,500 m3/day.

Table. 2.3-9. Summary of Phu Quoc District Water Supply Projects

Project name	Vietnam Urban Water Supply and Wastewater Project (VWSWP)
Subproject name	Phu Quoc District Water Supply Project
Project owner	Kien Giang Water Supply & Drainage One Member Limited Company (KIWACO)
Project area	Duong Dong town, Duong To commune and a part of area on the way to Cua Can
Scope of water supply expansion development	1) Modify the raw water intake at Duong Dong Lake 2) Install raw water pipeline φ560 mm, 3.2 km 3) Improve the 3,000 m^3 raw water reservoir and install raw water pumps 4) Rehabilitate and expand Duong Dong WTP (5,000 m^3/day to 16,500 m^3/day) 5) Construct sludge settling ponds on a site 80 m east of the WTP 6) Construct a 500 m^3 reservoir and a new treated water pumping station at WTP 7) Install 16.5 km of treated water transmission mains between Duong Don town and Suoi Lon booster pumping station (BPS) and install 7.5 km to new Phu Quoc airport and residential area toward Cua Can, and construct Suoi Lon BPS 8) Install 44.2 km of distribution pipeline throughout the service area 9) Construct a 500 m^3 reservoir on Provincial road 47 hill 10) Install house connections
Implementation period	2012 to June 2014
Total project cost	US$ 12,872,921

Source: PREPARATORY SURVEY ON WATER SUPPLY AND SEWERAGE SYSTEM PROJECT IN PHU QUOC ISLAND

(4) Existing Sewer in Phu Quoc

There is no sewage treatment plant for domestic wastewater on Phu Quoc Island. Human waste from each household is treated by a septic system with the effluent from the septic tank discharged into water bodies outside the house. Another wastewater is discharged without any treatment

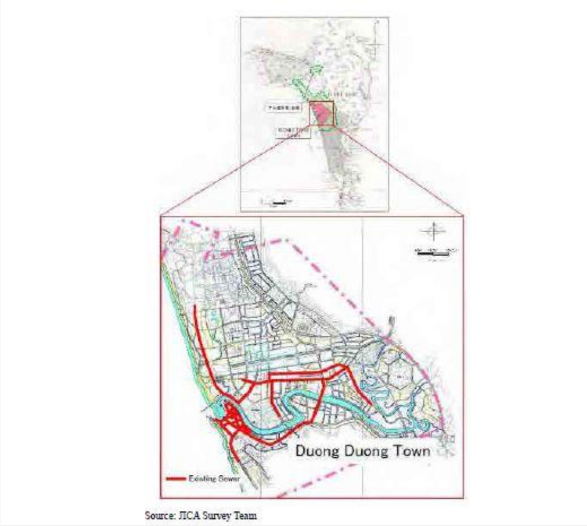


Fig. 2.3-18. Existing sewer system in Duong Dong
Source: PREPARATORY SURVEY ON WATER SUPPLY AND SEWERAGE SYSTEM PROJECT IN PHU QUOC ISLAND

Hotels categorized as shown in Table below, are required to have their sewage treatment facilities to satisfy the effluent water quality standards shown in Table below.

Table. 2.3-10. Categories of hotels in Phu Quoc

Hotel	No. of Rooms	Category
Hotel	<60	III
	60 – 200	II
	>200	I
Bungalow Guest House	10 – 50	IV
	50 – 250	III
	>250	II

Source: PREPARATORY SURVEY ON WATER SUPPLY AND SEWERAGE SYSTEM PROJECT IN PHU QUOC ISLAND

2.3.10. Low carbon policy

1) Economy Strategy on Climate Change

Issued by Prime Minister Nguyen Tan Dung in December 2011, the strategy document acknowledges the threat posed by climate change on Viet Nam and provides the strategic viewpoints, targets and sector-wise missions along with implementation phasing and accountability for the missions. The documents contain two sets of targets. General and Specific targets are envisaged to be realized through interventions in 10 key areas as given below.

Fig. 2.3-19. Key areas of National Climate Change Strategy
Source: Viet Nam Government Portal

A specific target in the document is to develop a low-carbon economy and undertake green growth into main orientations for sustainable development; lower emission and higher absorption of greenhouse gases to become compulsory indicators of socio-economic development.

The sector-specific interventions to achieve this target are provided for sectors like power generation, industry, transportation, agriculture and waste management, details of which are given in Annexure.

2) Low carbon and green growth in Viet Nam

The "National Green Growth Strategy (Prime Minister 1393/QD-TTg 25/9/2012)" approved on 25 September 2012, calls for mitigation of GHG emissions and enhanced capacity for absorption of GHGs, required for green growth policies that realize low-carbon economies and enhance natural capital value. The green growth strategy has become mainstream in the development of sustainable economies and is considered to be a key indicator of socio-economic development.

The following three points are designated as objectives.

- The rebuilding of the economy: to build economic institutions based on the greening of existing sectors, and to promote development in the economic sector to efficiently utilize high added value energy and natural capital.
- Implementation of research: to promote the application of appropriate advanced technologies to efficiently utilize natural capital, reduce the intensity of greenhouse gas emissions and link these actions to effective measures to address climate change.
- Improved standard of living: to create environmentally friendly lifestyles through the creation of employment in green industries, agriculture, and services, investment in natural capital and green infrastructure.

Green production will be advanced as follows.

- Percentage of GDP for the production of high-tech and green technology products: 42-45%
- Percentage of manufacturing facilities that meet environmental standards: 80%
- Percentage of green technology application: 50%
- Promotion of investment to support the environmental protection sector
- Raising the value of natural capital to 3-4% of GDP Major targets for 2020 related to greener lifestyles and the promotion of sustainable consumption is as follows.
- Percentage of Grade III cities (installation of wastewater collection and treatment systems that meet legal standards): 60%, Percentage of Grade IV and Grade V cities and craft villages: 40%
- Environmental improvements in heavily polluted areas: 100%
- Bring rate of collection and treatment of water in forest areas to the same standard as cities
- The usage rate of public transportation in major cities and mid-sized cities: 34-35%
- Applicability of greening standard in major cities and mid-sized cities: 50%

Source: Prime Minister, Decision on approval of the National Green Growth Strategy (No: 1393/QĐTTg)

Table. 2.3-11. GHG and energy consumption reduction targets

Particulars	Targets		
	2011-2020	2020-2030	2030-2050
Reduction intensity of GHG emission	8-10% (compared to 2010 level)	1.5%-2%	1.5%-2%
Reduction in overall GHG emission	10% -voluntary reduction 10% - through international support	10% -voluntary reduction 10% - through international support	-
Reduction in energy consumption per unit GDP	1%-1.5%	-	-

Source: National Green Growth Strategy

3) Low-carbon policies in Kien Giang

Besides the policies, legal documents issued by the Viet Nam government, Kien Giang province has issued the specific policies in low-carbon are shown below:

- Encourage investments both domestically and from overseas in environmentally-sound technologies and advanced low GHG emissions.
- Gather both central and local government funds to carry out thorough treatment of environmentally polluted sites in the province.
- Aim to chronologically replace old conventional technologies being used in various projects with advanced environmentally-sound technologies and low GHG-emitting alternatives.
- Implement research on and application of economic tools and production processes that effectively make practical use of GHG emission reductions from agricultural production, including seedlings, feed, agricultural materials, soil, and water.

4) Low-carbon policies in Phu Quoc

Initiatives on Phú Quốc Island are very similar to the above-mentioned policies of Kiên Giang Province. Meanwhile, the four items shown below are policies executed specifically on Phú Quốc Island.

- Treat sewage and waste collected from factories and workplaces on Phú Quốc Island in conformity with environmental standards and emissions standards.
- Encourage local industries to adopt advanced technologies and conserve fossil fuels.
- Endeavour to maintain existing forests on the island of Phú Quốc.
- Actively bid for local and foreign investment to support projects in sewage and waste treatment.

5) Phu Quoc as a smart city

The Kiên Giang Province People's Committee has approved making Phú Quốc a smart city by 2020. The project will be based on the Việt Nam Post and Telecommunications Corporation (VNPT)'s information communications technology infrastructure and the province's e-governance. It seeks to develop Phú Quốc island into a smart, hospitable and safe city that attracts tourists, improves the quality of services available to residents and tourists and urban management. The most important factor in making Phú Quốc a "smart" city is information and telecommunications infrastructure, which must be capable of supporting all functions of e-government and smart services in tourism, transport, environment, healthcare, education, and finance.

The project will invest in the following points:

- an optic-fibre network
- develop and expand 4G services on the island
- provide free wi-fi, usher in e-governance
- set up online management of visitors
- and offer online management of healthcare and education
- For monitoring the environment, VNPT has collected information to monitor water bodies, air, and noise, and carried out studies to build stations to monitor household wastewater treatment, air, and seawater.
- VNPT has already installed 20 cameras and wifi equipment in six places around Dương Đông town and two others in An Thới town.

Additionally, as an action plan in 2015, it was conducted Feasibility Study between Kien Giang Province and Kobe City aimed to: introduce advanced technologies that contribute to the reduction of CO2 emissions; the possibility of introducing low-carbon technologies, such as waste incineration power generation, in the waste sector; conducting local needs in the field of urban facilities such as transportation, production facilities, hotels, and extract the applicable domestic technology seeds.

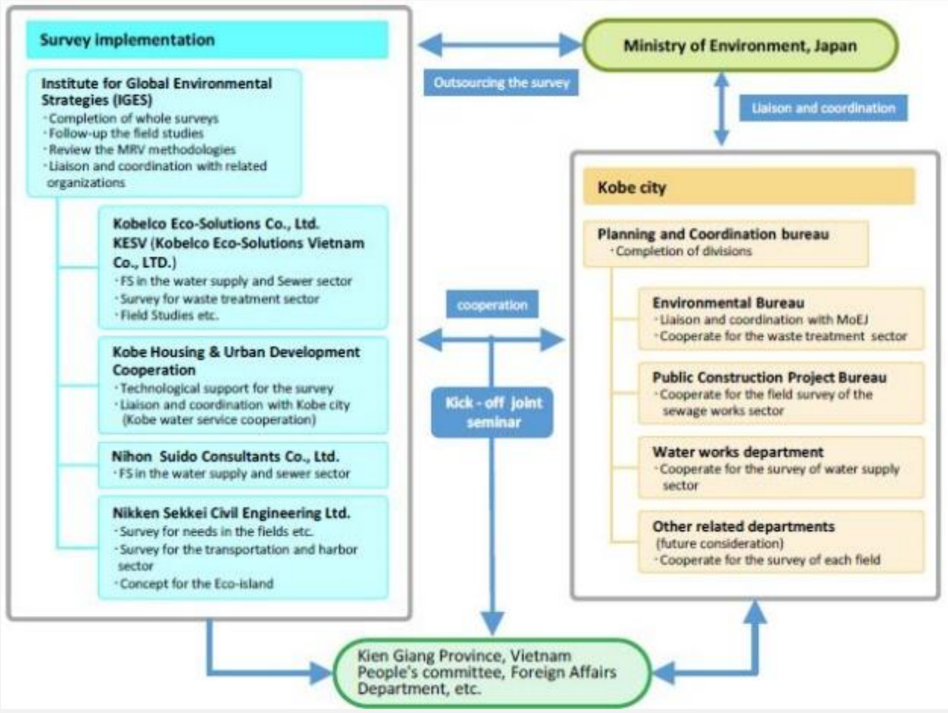


Fig. 2.3-20. Responsibilities of the organizations that took part in the feasibility study.
Source: Feasibility study on Joint Crediting Mechanism Projects towards Environmentally Sustainable Cities in Asia

METHODOLOGIES AND APPROACHES

03

CHAPTER 3. Principles and Methodologies of FS

3.1. Background research and Define baseline in BAU Scenario

3.1.1. Background research and Data collection

The background and data collection for low carbon decisions in the environmental aspect includes the factors that affect town energy consumption and carbon emission both on the demand-side and supply-side.

1) The background research and data collection method in energy and environmental aspect

(1) Factors in supply-side

The factors on the supply-side refer to the current situation of energy supply, energy resource structure and related town infrastructure. Generally, the existing condition analysis is based on the town data.

(2) Factors in demand-side

The factors on demand-side include economic condition, lifestyle and existing building conditions and energy system. The survey covers the following items:

Table. **Error! No text of specified style in document.**.1. The survey items for energy and environment

Related factors	Survey items
Economics	GDP. Income
Life style	Non-residential: ▪ Working time, energy system operation schedule Residential: ▪ Daily Life style
Building condition	Non-residential ▪ Existing Energy Conservation efforts ▪ Energy consumption condition Residential ▪ Building condition and usual layout ▪ End-use energy consumption ▪ Indoor thermal comfort
Building energy system	Non-residential ▪ Heat resource ▪ Main building energy system and facilities Residential ▪ The appliance in residential for high-income, middle income and Low income ▪ The general schedule for electronic appliance

Source: Project Team (NSRI)

2) Survey approach

The shortage of energy-related data is a common issue for most of the research in South Asia economies. The following approaches are applied for data collection according to the existing situation.

(1) Estimate based on limited energy consumption data

As the development and implementation of building management systems (BEMS) in some of the cities of South Asia economies, some data of the non-residential and residential buildings are available.

For these buildings, the existing energy consumption is estimated based on the existing data analysis.

(2) Estimate based on field survey

Most of the buildings, especially residential buildings are lack of data. For these buildings, we conduct a lifestyle hearing survey and onsite measurement survey.

The energy consumption of these buildings is estimated based on a field survey.

(3) Estimated by site other existing research

For the buildings that are still under the plan, the energy consumption for BAU is estimated with a review for other existing research.

3.1.2. Develop a high-level low-carbon vision

The study conducted by NSRI suggests that all the 3 volunteer towns have been selected as the pilot projects in their economies and have already implemented low carbon measurements in their development.

This study will develop based on the existing low carbon initiatives, but also take advantage of NSRI’s experiences.

The basic concepts for 3 volunteer towns are including:

1) Environmental, social and economic aspects should be comprehensively stressed in the study

The existing low carbon innovation in the 3 volunteer towns and their evaluation is mostly put stress on the environmental aspect. However, to make a successful and sustainable development, not only the environment but also their social benefits and economic benefits should be comprehensively discussed.

2) The plan and business model that considers all the stakeholders are vital

The existing projects in 3 volunteer towns mostly focused on technical issues. However, for implementation, a business model and development plan are considered for the benefit of all the stakeholders.

3) The vision should both consider the local features and their expansion

The existing projects in 3 volunteer towns only developed the concept for the district. As a low carbon model town, this study will make the 3 volunteer towns a typical model, including the technical model, business model, implementation model and management model, that can be used for other areas in the economies.

4) Design, implementation and operation

The existing projects focused on the concepts and design phase, but for a successful project, the implementation, operation and maintenance phases are also important.

The vision for low carbon development in the three volunteer towns will be developed in the following chart, based on their common issues and features.

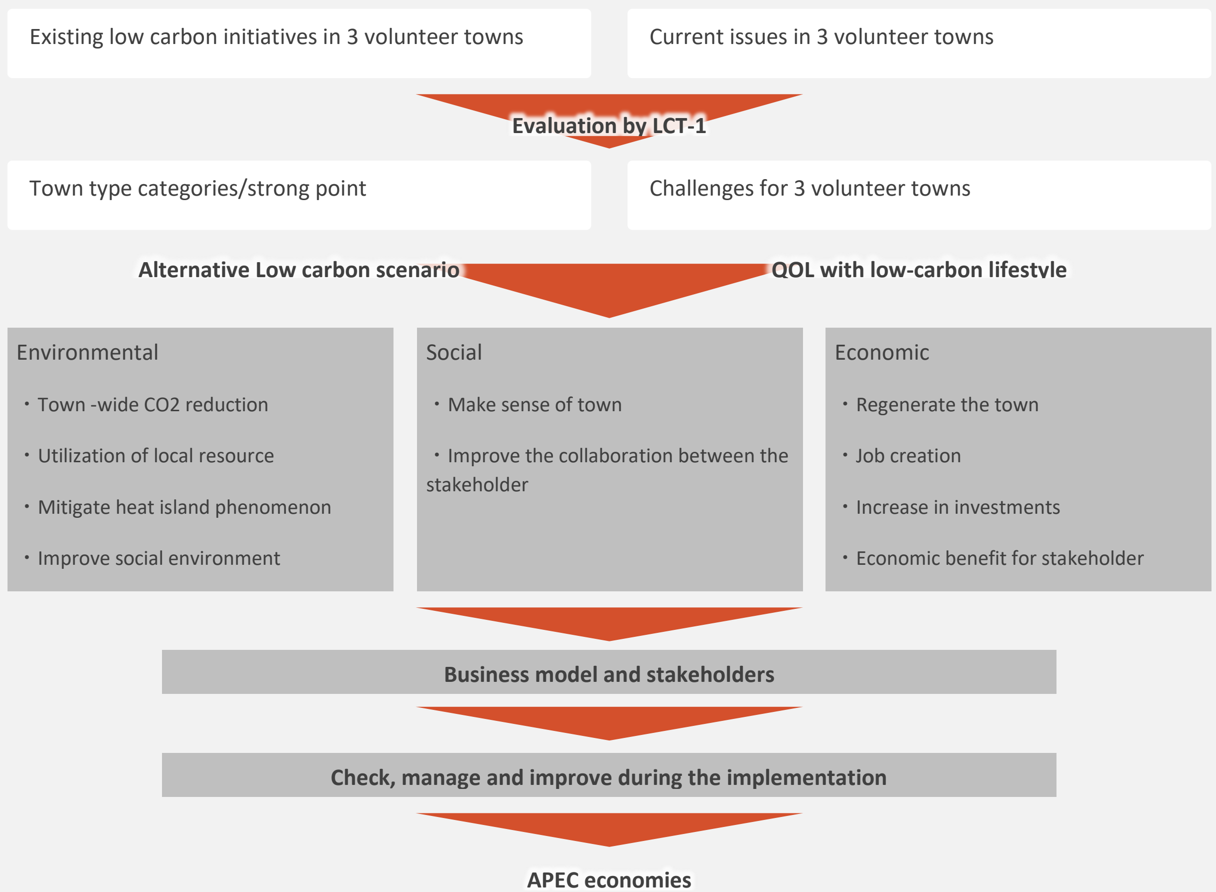


Fig. 3.1.1. Vision of this study

Source: Project Team (NSRI)

3.1.3. Define CO2 emission baseline in BAU Scenario

1) The approach to defining the baseline in BAU

The approach to defining the baseline in the BAU scenario is conducted by the following steps:

- Data collection and define the baseline in BAU;

  The base year and target year in BAU will be decided according to the low carbon action plan in the economies or states of the three volunteer towns and existing low carbon that has already been planned by the government or stakeholders.

- Data collection and define the baseline in BAU;

  Though the detailed information is different according to the different features, targets and scale of the three volunteer towns, the following parameters will be collected for defining the baseline:

  - Existing population, economic factors;
  - Infrastructure information, facility information,
  - Energy consumption in building sectors and traffic sectors;

- Make projections of carbon emission in the target year

  The study will predict the future carbon emission in the target year according to the changing economic factors and populations. The target year includes mid-term and long-term.

- Review and estimate the existing low carbon technologies (EXT)

  All three volunteer towns have their own low carbon action plan which has already been planned or partially implemented by the government. Therefore, the EXT is the special BAU condition that should be evaluated and predicted. The study will estimate and predict their effect in the target year.

- Set target domain as alternative planning scenario (APS)

  The analysis for BAU and EXT will be used to set a target for alternative planning scenarios, which means additional measures which are possible to be implemented in the target year.

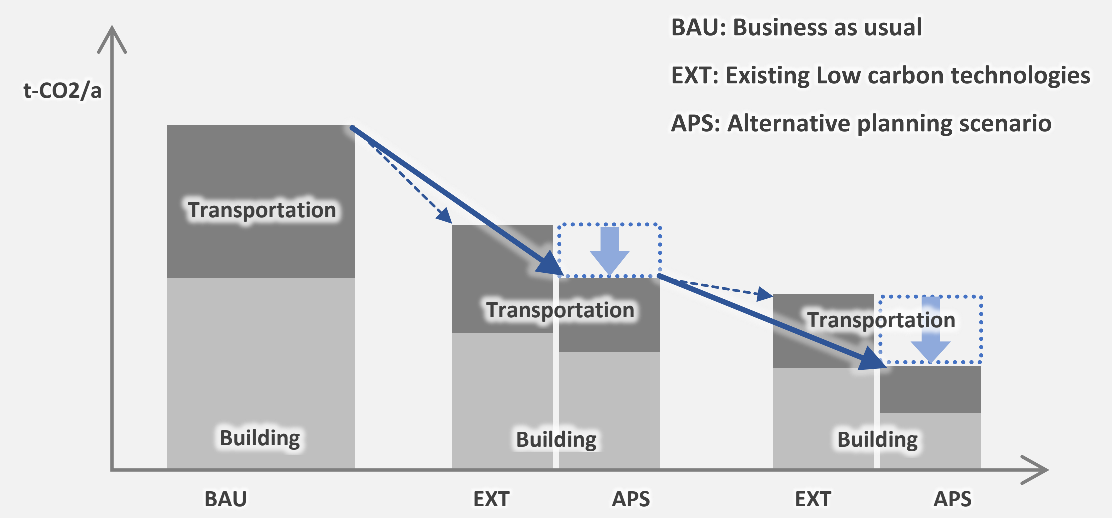


Fig. 3.1.2. Output example for CO2 reduction targets
Source: Project Team (NSRI)

2) The method for BAU setting in building sectors

The Existing carbon emission from the energy sector refers to the carbon emission from building energy consumption

(1) The existing building energy consumption
Building energy consumption is estimated as

$$\Sigma \text{Building energy consumption} = \Sigma(\text{Building energy consumption unit}^{1)} \text{ for different type} \times \text{ building area})$$

※building energy consumption unit is refer to the energy consumption density, the energy consumption per area.

Table. **Error! No text of specified style in document.**.2. Building Energy Consumption

Building Type	La Molina (Peru)	Khon Kaen (Thailand)	Phu Quoc (Viet Nam)
Office	150.0 kWh/(m² year)	133.8 kWh/(m² year)	Estimated based on results of electricity demand on Phu Quoc in the period 2010
Commercial		289.6 kWh/(m² year)	
Hospital	512.0 kWh/(m² year)	64.8 kWh/(m² year)	
Hotel	Same as Commercial	139.7 kWh/(m² year)	
Educational	119.0 kWh/(m² year)	—	
Residential Low	90.6 kWh/(m² year)	16.2 GJ/(year household)	
Residential Medium	121.5 kWh/(m² year)		
Reference	Refer to Table 4.1.10	Refer to Table 5.1.3/ 5.1.4	Refer to Table 6.1.1

Source: Project Team (NSRI)

(2) The Method for an estimate the BAU in short-term and long-term
There are two methods to decide the BAU

- The relationship with GDP growth rate
  Energy consumption has a firm relationship with GDP. For example, in residential buildings, the household appliance increases with the GDP growth and causes an increase in energy consumption. For the office and the commercial buildings, the increasing GDP growth rate also cause longer Business hours and an increase in energy consumption. The factor that can represent the relationship between GDP growth rate and the energy consumption growth rate is Energy-GDP elasticity. It can be calculated as below'

$$\text{Energy Growth rate} = \text{GDP Growth rate} \times \text{Energy-GDP elasticity}$$

  While using this method, the BAU is predicated with the existing energy consumption that is set in (1) and the energy growth rate predicted by GDP growth rate and the Energy-GDP elasticity value for each economy.
  This method is especially fit for the area with less development.

- The relationship with urban development
  The other method, which is used in the area that is still not been developed decides BAU by the increasing of building floor area.

3) The principles for setting low carbon targets

The principles for setting low carbon targets is generally as follows.

- Low carbon targets must be realistic (they must be both appealing and realistic)
- Low carbon targets and indexes will comprise "Low Carbon Targets," "other Indexes"
- Targets and indexes will be composed of quantifiable and visible categories.
- Stakeholders in the 3 volunteer towns will jointly aim at reaching the low carbon targets and indexes and will also share data
- Targets and indexes will require ongoing efforts throughout the life cycle of the project

Table. Error! No text of specified style in document..3. Base year and target year setting for three volunteer towns

Volunteer towns	Baseline	Short & Mid-term	Long-term
La Molina	2021	Energy conservation, PV power generation, etc.: 32% CO_2 reduction (Refer to tables 4.2.7 and 4.2.8)	Energy conservation, PV power generation, etc.: 52% CO_2 reduction (Refer to tables 4.2.7 and 4.2.8)
	2020	Conversion to EV: 5% CO_2 reduction Conversion from cars to public transportation and bicycles: 10% CO_2 reduction	Conversion to EV: 18% CO_2 reduction Conversion from cars to public transportation and bicycles: 20% CO_2 reduction
Khon Kaen	2020	Energy conservation, PV on pond/ roof top, EV etc.: 24% CO_2 reduction (Refer to tables 5.2.1)	Energy conservation (e.g., heat pump hot water equipment), New LRT : 45% CO_2 reduction (Refer to tables 5.2.1)
Phu Quoc	2020	Energy conservation, District cooling, PV power generation, CGS, etc.: 25% CO_2 reduction (Refer to tables 6.3.1)	Energy conservation, District cooling, PV power generation, CGS, etc.: 54% CO_2 reduction (Refer to tables 6.3.1 and 6.3.2)

Source: Project Team (NSRI)

3.2. CO2 reduction scenario

3.2.1 Define comprehensive, specific and feasible low carbon measure

The study for step4 includes the three main parts

A) Define the CO2 emission reduction and environmental target of the town

Based on step3, our study will define CO2 emission reduction and environmental target of three volunteer towns according to the existing condition (BAU) and the low carbon measures that have already been implemented by the government or stakeholders (EXT).

B) Prepare a Low carbon guideline for categories of low carbon town design challenges.

Based on the analysis of LCT-I, and prediction for BAU, a comprehensive and interactive low carbon design guideline will be provided for three volunteer towns with the technologies in demand, supply, demand and supply, governance aspects.

C) Select CO2 emission reduction measures in each design

With our experience in LCMT development, NSRI has low carbon technologies packages that are developed based on LCT-I. Therefore, in this section, we will propose a package of low carbon solutions suitable for 3 volunteer towns while considering the actual situation of each town and propose a system that is balanced from both technology level and cost.

The following show 5 design categories that can help 3 volunteer towns realize their low-carbon development vision, provided that the development of each is in full alignment with the on-the-ground realities and institutional context of each town.

The guidelines and feasibility assessment for each of the 5 design categories and the specific CO_2 avoidance/reduction measures it identifies as promising for 3 volunteer towns will include the following information:

Directly Related	DEMAND Side	Buildings Transportation (Urban Structure)
	SUPPLY Side	Area Energy System Untapped Energy Renewable Energy
	DEMAND & SUPPLY Side	Energy Management System
Indirectly Related	GVERNANCE	Policy Framework Education & Management
	ENVIRONMENT & RESOURCE	Greenery Water Management Waste Management Pollution Control

Fig. 3.2.1. CO2 Reduction Categories

Source: Project Team (NSRI)

- Assessment of potential CO_2 avoidance and reductions of specific measures
- Identification of an appropriate and effective implementation methodology
- Estimates of implementation timeline and costs for each measure
- Ideas for implementers funding sources and funding mechanisms
- How quality of life, quality of the environment and the quality of natural resource usage will be impro

1) Demand Side

(1) Low-carbon buildings

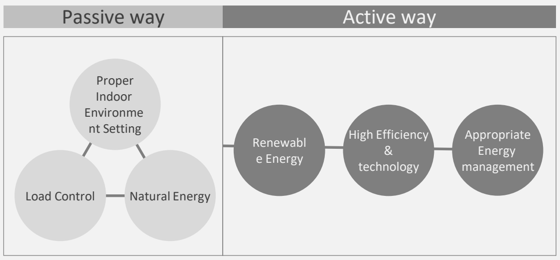


Fig. 3.2.2. Passive way and Active way
Source: Project Team (NSRI)

Since buildings contribute over 30% of total primary energy all over the world (Data source: International Energy Agency. Key World Energy Statics. 2010), low-carbonization in the building sector is considered to be the most important approach to realize a low-carbon society. Two are two effective ways in lowering the CO_2 emissions of a building: the passive way and the active way.

The guidelines for the building will not be limited to the Low-Carbon aspect; both measures from energy and sustainable aspects of buildings, especially office and commercial buildings with high energy intensity, will be considered. In addition, policy and market instruments will be studied to provide recommendations for the promotion of sustainable building practices in 3 volunteer towns for the long run. The overall process of establishing guidelines and policies for the 3 volunteer towns is shown in Fig.3.2.3

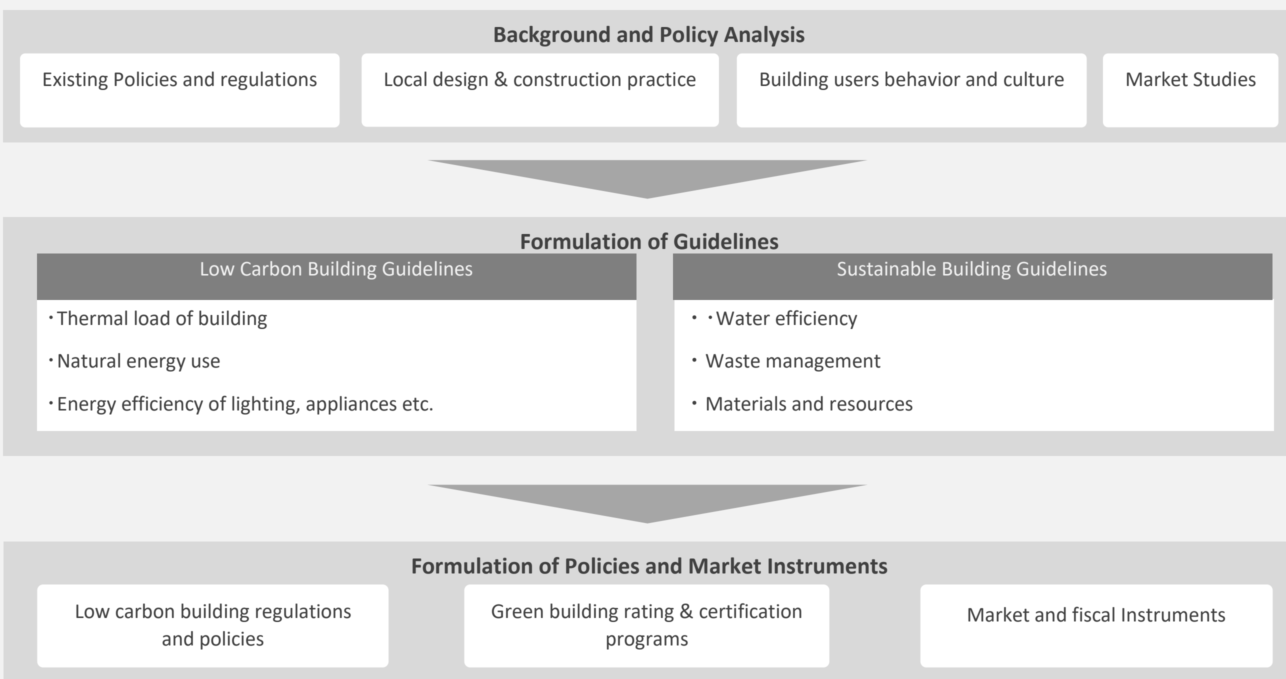


Fig. 3.2.3. Flow of Establishing Low-Carbon and Sustainable Building Guidelines
Source: Project Team (NSRI)

The Low carbon technologies in building sectors are mainly referred to the building energy conservation technology, as Table3.2.1. It includes passive technologies like façade engineering technologies and other active technologies. The energy conservation ratio of every technology is set based on the experience.

Table.3.2.1. Building energy conservation technologies and energy conservation effect

Items	Menu	energy conservation ratio
Heat source	COP improvement	0.282
	Reduction of internal heat generation	0.05
Heat source accessories	Inverter	0.13
Water transport	Inverter	0.18
Air conveyance	High efficiency fan	0.165
	Inverter	0.26
Hot water supply	Device performance improvement	0.292
lighting	Human Sensor	0.03
	Illuminance correction	0.105
	High efficiency of lighting equipment	0.376
Outlet	Reduced power consumption	0.02
ventilation	Total heat exchanger	0.072
	CO2 control	0.057
	High efficiency fan	0.131
	Introduction of CO concentration control of parking fans	0.2
Water supply and drainage	Improve pump performance	0.15
Elevator	Smart operation	0.1
Other	Introduction of high efficiency transformer	0.085
facade	Glass performance improvement	0.1

Source: Project Team (NSRI)

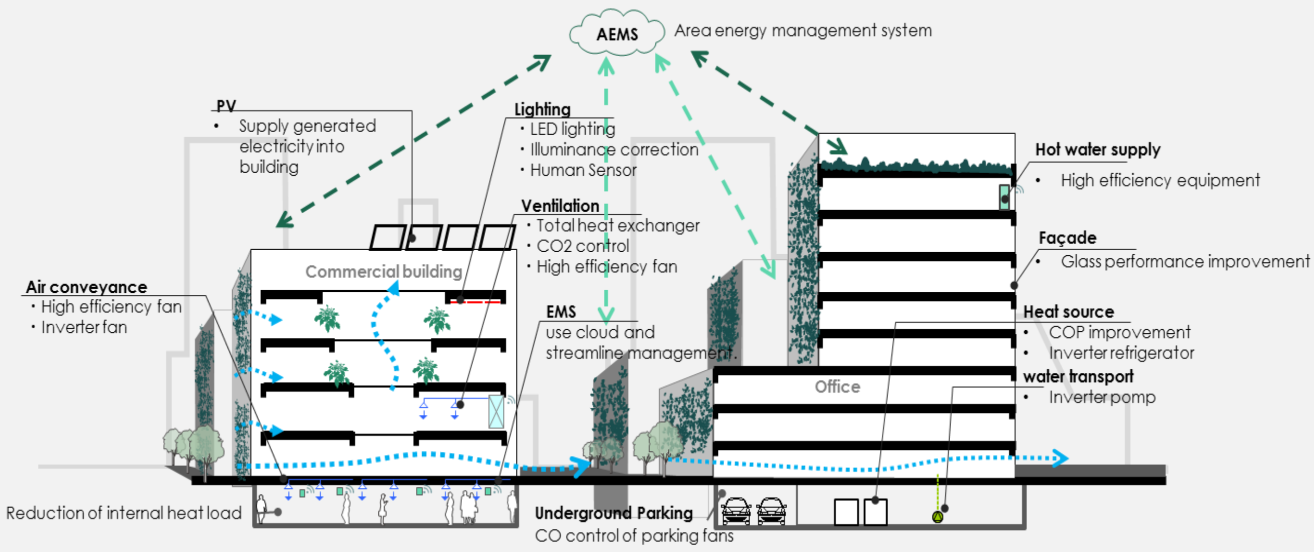


Fig. 3.2.4. Image of low carbon building technologies

Source: Project Team (NSRI)

(2) Low-carbon transportation

In this section, we will prepare the public transport network plan for 3 volunteer towns. Since car traffic, as well as motorbike traffic, will increase with the economic growth, it is important to establish the overall transport network in which special emphasis is placed upon public transport, such as bus and Tram services.

Meanwhile, a “low-carbon transport plan” that varies according to the real land use will also be proposed. That plan will comprise a public transport plan, a bicycle network plan and a pedestrian network plan each of which reflects traffic features varying with land use of residential area or commercial area.

The use of low-carbon vehicles is considered to effect to improve energy efficiency. It is necessary to promote electrification of motorbikes and conversion of cars and buses to PHV, EV and other low-carbon vehicles, as well as the construction of peripheral infrastructure needed for EVs such as charging stations.

Moreover, we will propose that the central area be developed with more walkable areas that are friendly for pedestrians and bicycles. Such walkable areas, allowing “carbon-less transport modes”, will greatly improve the quality of the environment in the city.

CO2 emissions emitted by cars account for a large portion of CO2 emissions produced in transportation. This is partly because the amount of CO2 emissions generated by a car carrying one person is large compared to public transportation such as subways and buses. CO2 emissions emitted by cars can be calculated by the multiplication of three parameters: traffic volume, distance travelled and emission intensity.

Accordingly, controlling traffic volume, modal shift to public transportation emitting less greenhouse gas, shortening of travel distance and the use of fuel-efficient vehicles are effective in reducing CO2 emissions in transportation.

CO2 Emissions = Traffic Volume × Distance Traveled × Emission Intensity

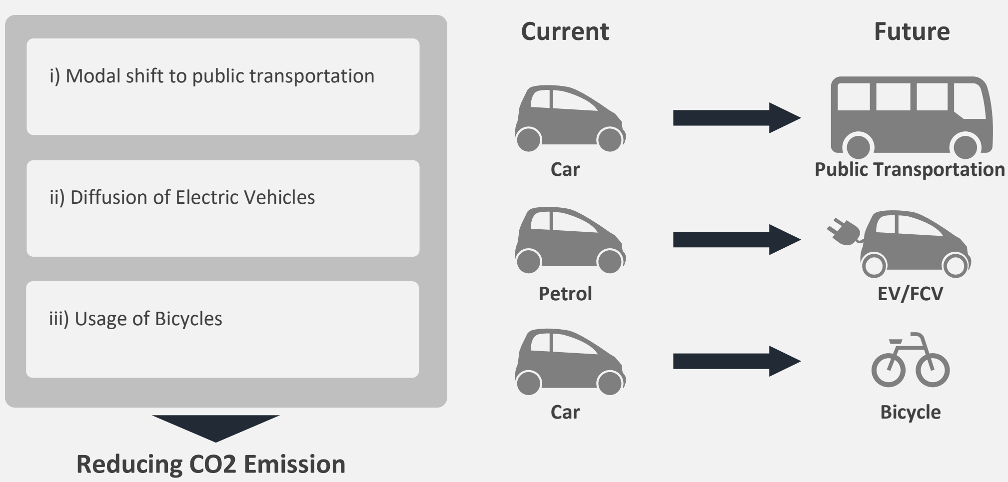


Fig. 3.2.5. Basic policy for Reducing CO2 Emission in Transportation
Source: Project Team (NSRI)

i) Reducing CO2 emissions by Mode Shifting to Public Transportation

Within urban public transportation, there are different modes such as heavy rail, subways, light rail transit (LRT) and buses. The different modes could be further classified in terms of capacity. High capacity transit systems include heavy rail and subways while medium and low capacity transit systems include LRT and buses. CO2 emissions per passenger-km of these public transportation modes are about one-sixth when compared to the emissions from cars. CO2 emissions could be reduced by aiming to build city-centred public transportation with more use of public transportation available.

ii) Diffusion of Electric Vehicles

Electric vehicles are assumed not to directly emit CO2 emissions because they do not use fossil fuels, globally, the adoption rate for commercial usage is growing steadily. The experience already shows that when you compare the CO2 emissions from gasoline-powered vehicles with electric vehicles, electric vehicles emit about 1/2 less CO2 emissions per passenger-km than gasoline-powered vehicles.

iii) Encouraging the Usage of Bicycles

Bicycles have many advantages such as short-distance travel, flexibility, low cost and no CO2 emissions. Improving convenience to move around a city by making use of bicycles could cut down CO2 emissions. To achieve this, the following is necessary: providing adequate physical space for safe bicycle travel, establishing the infrastructure necessary to enable the usage of bicycles anywhere in a city and reserving space for bicycle parking at public transportation.

2) Supply Side

(1) Area energy system

The area energy system differs from the traditional centralized energy system. It refers to the system that has its grid or heat network and can share the energy in the district among different types of buildings. It usually has its power generation system, heat resource, and is widely connected with the onsite renewable energy system.

District energy helps communities reduce their operating costs and keep more energy dollars local by reducing their need to import fuel for heating and cooling. Environmental impacts from heating and cooling are significantly reduced because of the greatly improved efficiency of these systems and developing district energy/CHP systems can help ease the transition of the power sector as older, polluting coal plants are shut down and removed from the grid. District cooling can cut peak electrical demand that typically occurs in the late afternoon – reducing strain on the grid and avoiding expensive peak power costs.

Usually, the district energy system is more efficiently in the city center, with have higher energy consumption density. In the three target towns, Shah Alam and Han Tang Jaya is a high-density urban district, which District Cooling (DC) is the most effective method to be adopted under area energy planning. Providing cooling from a central plant requires less fuel and displaces the need to install separate space cooling in each building.

Further than the low carbon effect, it also can work as a backup in the disaster, providing energy to the people in the surrounding area.

(2) Untapped energy

Untapped energy is, despite the possibility of effective use such as waste heat from the factory, exhaust heat from a subway or underground shopping center, potential heat energy from the river, sewage, snow, etc., which have a large temperature difference between outside temperature, however, has not been effectively utilized yet. Generally, untapped energy utilization technology can be combined with various other environmental and energy technologies to help create a low carbon society.

Presently in all 3 volunteer towns, a large amount of solid waste is being generated daily but there is no systematic waste sorting or recycling system. We, therefore, propose the following strategy to promote energy utilization from waste.

Therefore, the geographical features make it possible to fully utilize waste heat from sewage water and use of potential energy from river water.

- Waste transportation causes traffic jams and order problems.
- A minimum amount of waste is required to achieve efficient waste disposal and power generation.
- The construction of waste treatment facilities is required.

- Systematic waste separation: Separate waste into burnable, non-burnable waste, recyclable waste, and used cooking oil.
- Medium term: Implement systematic waste separation
- Long term: Introduce a business scheme. (Build an incineration plant and a BDF plant outside the Area)

- Waste separation is not generally practiced. Waste is disposed of without being separated properly.
- there is a low level of awareness for waste reduction or recycling. This causes a large amount of waste to be introduced

- The 3R initiative (Reduce, Reuse, Recycle) needs to be introduced throughout the Area.
- A system to support the 3R initiative is needed.
- A feasible business mechanism needs to be introduced.

- Low Carbon Community Council in each town needs to lead the formulation of the Area Recycling Guidelines for general waste from house and commercial facility.

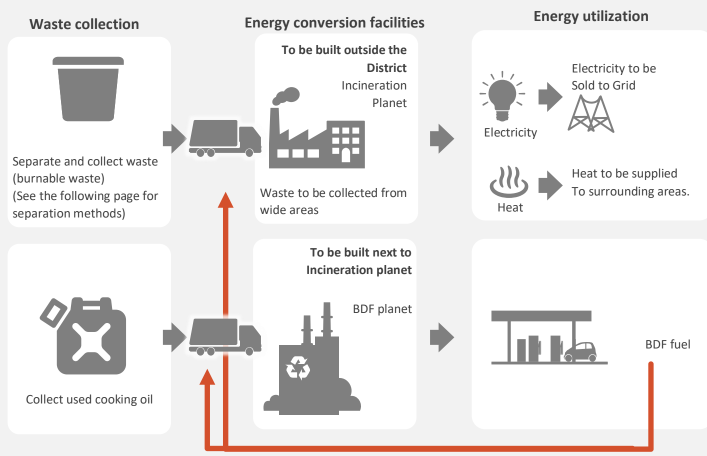
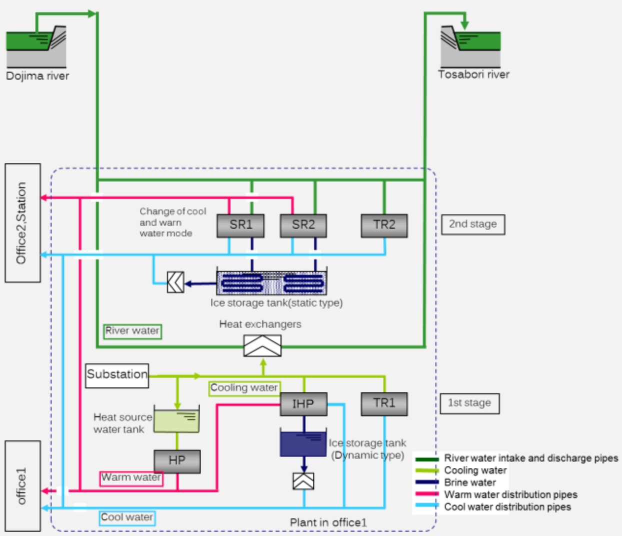


Fig. 3.2.6. Concept Diagram of Energy Utilization from solid waste
Source: Project Team (NSRI)

Project Team (NSRI) experiences of high efficient DHC with untapped energy use from the river will be supportive to propose the same kind of district heating system in 3 volunteer towns.



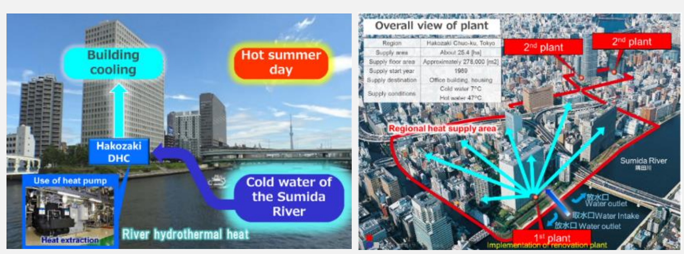


Fig. 3.2.7. High Efficient DHC system Using Thermal Energy of River Water in Hakozaki, Japan
Source: Project Team (NSRI)

(3) Renewable energy

Generally, in 3 volunteers, solar radiation of approximately 1,700 to 1,900 kWh/m2 per year can be obtained, the introduction of photovoltaic power generation is considered effective. When planning an introduction, consideration of both economic and environmental aspects is necessary.

- Step-1. Short-term development target: rooftop PV panels installation.

As a model project in the short-term, the installation of PV panels on the roof of houses and the canopies in parking lots and gas stations is proposed at a small scale.

- Step-2. Mid-term development target: PV panels installation

In the 2020s, with a continuous price reduction of PV modules and the development of PV technology, PV power generation is expected to be widely adopted, besides building roofs, PV panels could be placed along the road and the sidewalk.

- Step-3. Long-term development target: large-scale PV farm construction

In the large-scale PV Farm, PV layout can be designed as a landscape

In South Asia, solar energy is almost the most popular renewable energy. Its power generation potential are estimated according to the weather condition and capacity. The method is as below.

(1) Figure out the potential area where has the potential to set the solar penal

(2) Estimate the area of solar penal with the potential penal ratio

(3) Estimated the capacity of the PV (P) by capacity per area (0.0667 kW/m2 by the value from Japanese product)

(4) Estimate the Yearly power generation(Ep) as below:

$Ep = H \times K \times P \times 365 \div 1$
Ep: yearly power generation (kWh/year)
H: Daily solar radiation (kWh/m2/day)
K: Efficiency(0.73 use in the research by the experience in Japan)
P: Capacity of the PV

3) Demand & Supply Side

(1) Area energy management system

We will make differentiation in the Low Carbon development scenario for three volunteer towns, by taking into account each local characteristic and need.

- La Molina
  Based on the Request for Proposal (RFP), a set of actions in the energy sector will be developed. The countermeasures are grouped into the following actions.

Table.3.2.2. Specific area for La Molina

Area	Tier 1	Tier 2	Possible Low-carbon solutions
Whole city	Demand	Building	Implementation of ZEB and consideration for reduction of office size by 10~20% ; Implementation of ZEH and consideration of local construction and traditional materials
		Transportation※	Sharing Service; Elimination of traffic blank areas; Improving the convenience of public transportation; Promoting EV; Upgrading of bicycle lane
	Supply	Untapped Energy	Introducing geothermal Heat pump; Retrofitting an existing landfill for biogas
		Renewable Energy	Urban photovoltaics (UPV); Solar Rooftop (PV); Solar water heating system; Efficient (instantaneous) heaters; Offshore wind power
	Environment and Resources	Greenery	Green roof as public space and garden; Green corridors
		Waste Management	Solid waste management, bio-waste recycling system and Zero Waste concept and Eco recycling points
	Governance	Policy Framework	Policies to Reduce Greenhouse Gas Emissions from the transportation sector; Policies tor share the Renewable Energy; Policies tor improvement in energy efficiency; Policy Framework in Building Environmental Plan System; Policy Framework in Waste Management
		Education and Management ※	Collaborative program for low-carbon interventions; Trainings, etc.

※Additionally added to the FS after discussion with the volunteer town

Source: Project Team (NSRI)

- Khon Kaen
  Based on the Request for Proposal (RFP), a set of actions in the energy sector will be developed. The countermeasures are grouped into the following actions.

Table.3.2.3. Specific area for Khon Kaen

Area	Tier 1	Tier 2	Possible Low-carbon solutions
Whole city	Demand	Building	Implementation of various energy conservation methods for commercial and residential buildings
		Transportation	EV, new personal mobility, LRT lines
		Untapped Energy	Geothermal heat pump,
		Renewable Energy	PV on pond / roof top
		Multi Energy System	Co-generation system in hospital and hotel
	Governance	Policy Framework	Policies to Reduce Greenhouse Gas Emissions from the transportation sector; Policies to share the Renewable Energy; Policies tor improvement in energy efficiency; Policy Framework in Building Environmental Plan System; Policy Framework in Waste Management

Source: Project Team (NSRI)

- Phu Quoc
  Based on the Request for Proposal (RFP), a set of actions in the energy sector will be developed. The countermeasures are grouped into the following actions.

Table.3.2.4. Specific area for Phu Quoc

Area	Tier 1	Tier 2	Possible Low-carbon solutions
Whole city	Supply	Area Energy System	District Cooling (DC) system for areas with high heat demand area
		Untapped Energy	Use of waste heat from incineration plants, and seawater heat pumps
		Renewable Energy	PV on buildings; PV on the pond and MEGA PV system; Solar water heating system
		Multi Energy System	Co-Generation System
	Environment and Resources	Water Management	Rainwater harvesting; Sewage facilities
		Waste Management	Waste recycling system and Implementation of an advanced waste incineration facility; A solution to poisonous gas and dioxin emissions; Technology to efficiently recover electricity and fuel biomass waste

Source: Project Team (NSRI)

3.2.2 Perform scenario analysis of implementation alternatives and analyze CO2 reduction efficiency

For 3 volunteer towns, energy conservation effect, energy creation effect and low carbon effect of all the low carbon measures proposed in step4, as the example of analysis in Fig. 3.2.8 will be evaluated in step5.

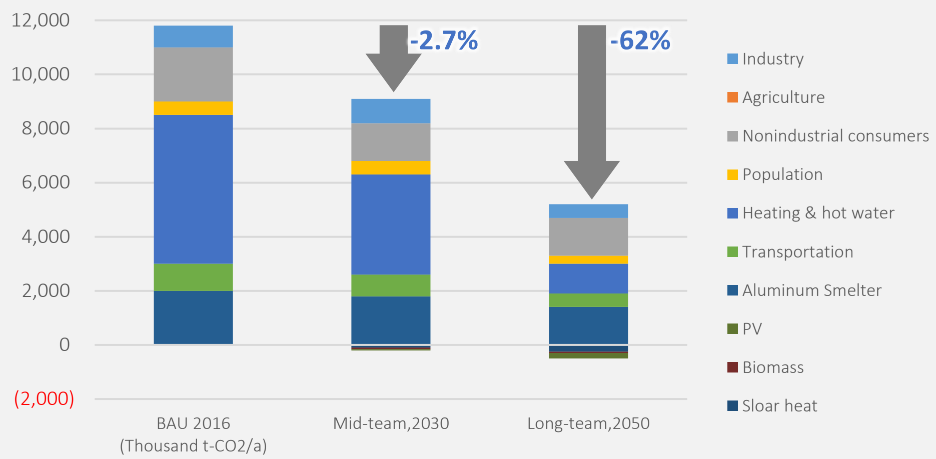


Fig. 3.2.8. Evaluation for various low carbon measures
Source: Project Team (NSRI)

Further, from the view of implementation, We will propose a roadmap towards achieving CO2 targets in the mid and long term. The low carbon measures will be selected according to the target and reduction amount of CO2 reduction.

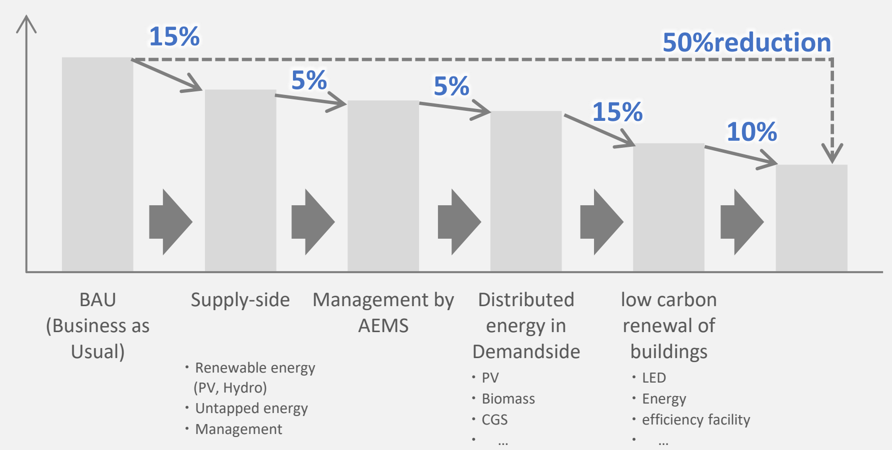


Fig. 3.2.9. Roadmap for achieving CO2 target example
Source: Project Team (NSRI)

As the 3 volunteer town have different features and scales, the project team will adopt different simulation and visualization method evaluations.

Combined Low Carbon Management with Energy Density and Volume

Low carbon management for the buildings at the city level varies with buildings according to their features. NSRI have the experience and tool to categorise the low carbon method for all the buildings according to energy density and volume in the city scale and estimate its energy conservation effect, as Fig.3.2.10

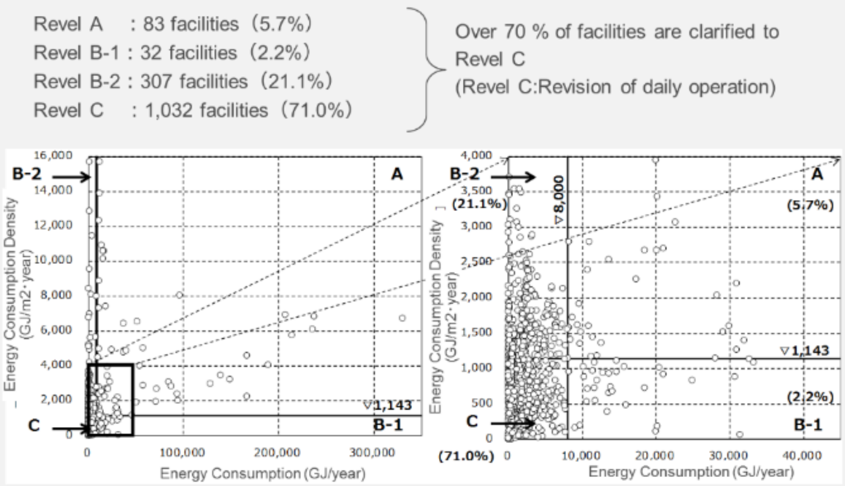
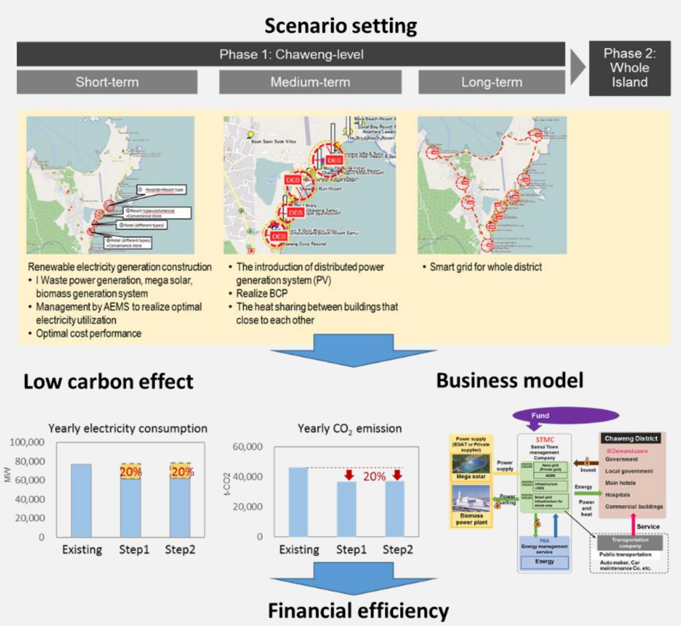


Fig. 3.2.10. Priority setting of low carbon action plan for all of buildings in a area, Yokohama, Japan
Source: Project Team (NSRI)

The scenario for implementation set in this step will both consider the technical possibility and be economically realistic. Therefore, both the low carbon effect and basic economic factors will be discussed, which is the basis for the business model and financial efficiency analysis.



		CaseA-1	CaseB-1
Content of cases	Business body	Demand side	Demand side＋PEA
	Power generation	Energy supply +power generation	
	Remarks	The fee for using commercial line is assumed	The fee for using commercial line is not assumed
①	Without fund	revenue and expenditure is minus	More than 16 years
②	With1/2 fund	minus	13.2years
③	With2/3 fund	minus	8.8 years

Fig. 3.2.11. Example for scenario analysis
Source: Project Team (NSRI)

3.3. Priorities for implementation and roadmap for the realization

The above-mentioned low-carbon scenario is based on the characteristics and needs of each district, but to increase its feasibility, it is necessary to clarify what should be preferentially advanced among them and to draw a road map for their implementation.

3.3.1 Evaluation of Priority

The following two points are raised to clarify their priorities.

1) Analysis of importance and feasibility in each district

It is necessary to determine the importance and urgency of how a low carbon scenario is useful for solving each district's problems. At the same time, it is also an issue whether those scenarios' feasibility is higher or not. For example, clarification of the players (administrative office, private real estate developers, etc.), and the objective and scope of the project to be analyzed to evaluate their priorities.

2) cost performance analysis

If several low carbon scenarios have similar priorities as described above, it is necessary to pick up the priority measures by analyzing the cost performance of each low carbon scenario.

3.3.2 Organization of roadmap consistent with development scenario

Based on the above analysis, consistency with development scenarios will be considered to organize a roadmap for low carbon scenarios implementation.

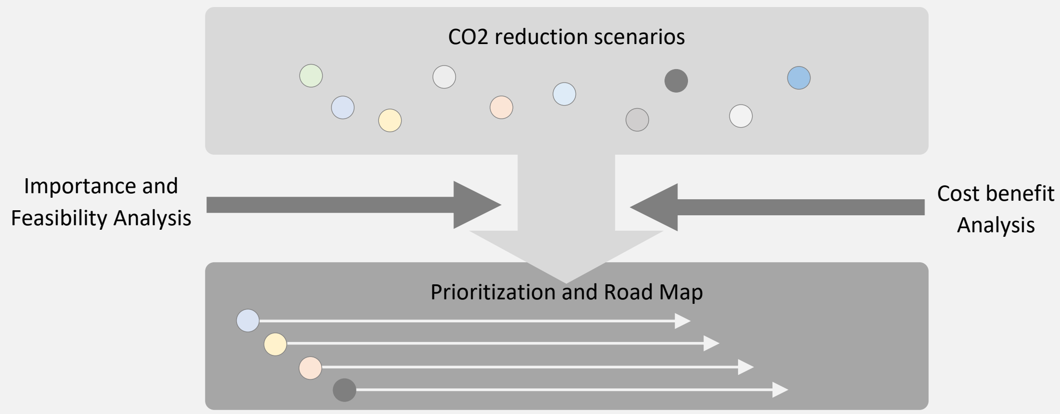


Fig. 3.3.1. Priorities for implementation and roadmap for realization
Source: Project Team (NSRI)

3.4. Business Scheme

The CO2 reduction methods in each region are described previously. In this chapter, we would like to study to implement these methods. Specifically, it is necessary to clarify the leadership and to be able to self-sustain as a sustainable mechanism in the region with the methods established as a business to some extent.

1. Basic concepts

In promoting the mechanism for low carbon in each area, the following are examples of current issues.

- Lack of implementation body

- Lack of legal institutional framework

- Lack of cooperation among multiple entities

For tackling these issues, the basic concepts for building a business model in this study is as follows.

1) Setting an administrator or management body (PPP) as a Low Carbon methods promoter

Maximizing regional Quality of Life is a major objective by promoting low carbonization in the region as an official position. It is necessary to construct an ecosystem to continue sustainably in the future, such as entity involved establishing as business to some extent rather than raising profit.

2) Combination of multiple businesses

In considering the business feasibility as described above, even if it is not always possible to establish in individual methods, it may be possible to establish a business by combining multiple methods. With public entities managing at the top, it is easier to collaborate with multiple companies.

3) Collaboration with existing businesses

In considering the above, some of the contents proposed here have already been entered by other companies and established as a business. It is not favourable that the public sector manages a similar business and interfere with them. In other words, it is necessary to work cooperatively with companies that are likely to collaborate flexibly.

2. Examples of business model

After considering the potential players and feasibility of each method in each district, we would like to propose a possible business model. The following examples are our initial ideas and should be examined in detail later. In any case, while considering the possibility as a player and the possibility of business feasibility, several business models will be proposed by taking advantage of the characteristics of the area further.

Example A: Local grid network + Sharing EV & E-bicycle + Advertisement

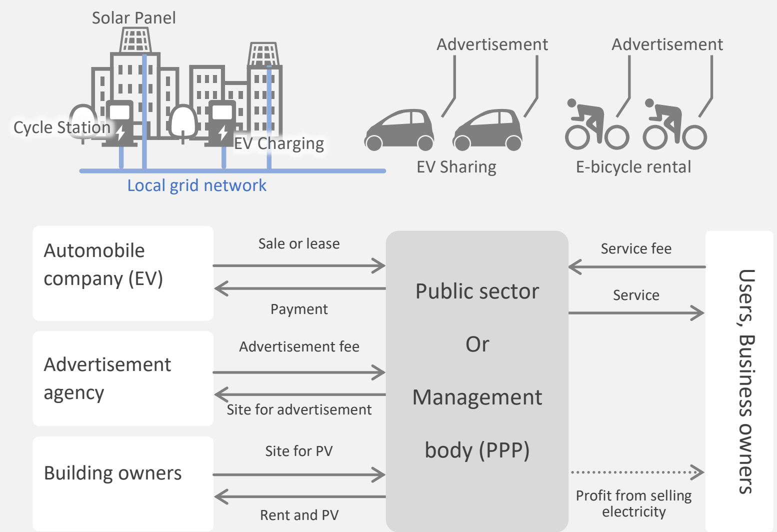


Fig. 3.4.1. Business Scheme A
Source: Project Team (NSRI)

Example B: Area circulation EV + Advertisement

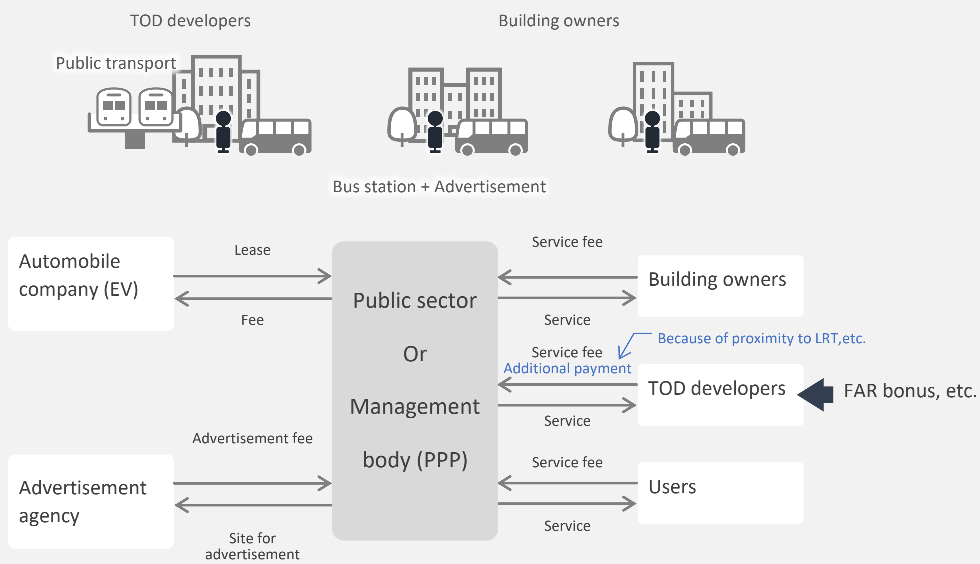


Fig. 3.4.2. Business Scheme B
Source: Project Team (NSRI)

3.4.1 Identify regulatory agencies and approval process and develop the business model in 3 volunteer towns

1) Identify regulatory agencies

(1) Proposal of the agencies based on the scale and their features:

For example, a town on the community scale suggested having the building owners as the main player for the project.

(2) Proposal of the agencies based on low carbon measures

As the CO2 reduction potential analysis, the low carbon measures with high initial cost but low reduction potential as renewable and untapped energy should be initiated by the government. On the other hand, the low carbon measures with low investment but high CO2 reduction potential as building energy conservation, multi-energy system and AEMS have the potential that invested by building owners.

The method for deciding the priority in building conservation technologies are considered as the relationship between reduction rate and cumulative cost.

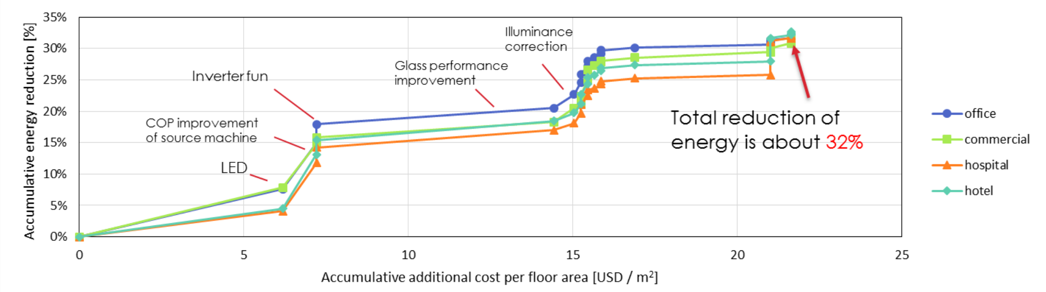


Fig. 3.4.3. Measures automatically introduced at the time of updating equipment are supposed to be free of additional cost
Source: Project Team (NSRI)

2) Business model

The potential agency needs to coordinate with the related stake owners and set up the business model. NSRI has experience as a consultant for providing various business models in Japan and overseas projects.

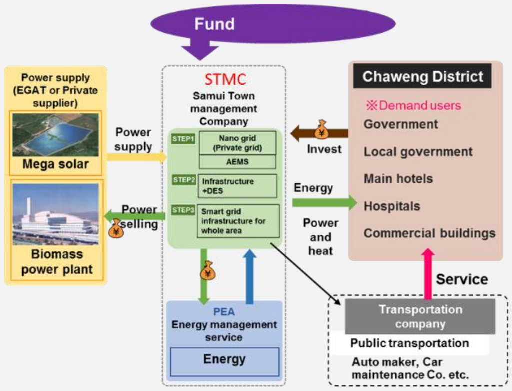


Fig. 3.4.4. Business model for investment and management in Samui, Thailand
Source: Project Team (NSRI)

PROPOSALS FOR LOW CARBON SCENARIO

04

CHAPTER 4. Low carbon scenario for La Molina District, Lima, Peru

4.1. Background research and Define baseline in BAU scenario

4.1.1. Background research and existing analysis for target areas

Electricity consumption in Metropolitan Lima was calculated to be 7.0 TWh in 2000, rose to 16.3 TWh in 2014 and will reach 29.8 TWh in 2030. Current data (2014) show that the consumption is divided as follows by sector: 49% corresponds to the industrial sector; 16%, to the commercial; 21%, to residential, and the remainder corresponds to public lighting (2%), transmission losses (6%) and own industrial use (7%). The largest increases are projected to correspond to industrial consumption, which is estimated to go from 7.3 TWh in 2014 to 15.1 TWh in 2030, reflecting the great industrial growth that is expected to occur in the city. However, the commercial and residential sectors are also projected to grow significantly. When the increasing levels of carbon emissions per unit of energy consumed are also considered in the estimate, it is projected that carbon emissions from the electricity sector will increase from 3,972 ktCO2e in 2014 to 8,216 ktCO2e in 2030, an increase of 107% compared to 2014 emissions, in a scenario without changes.

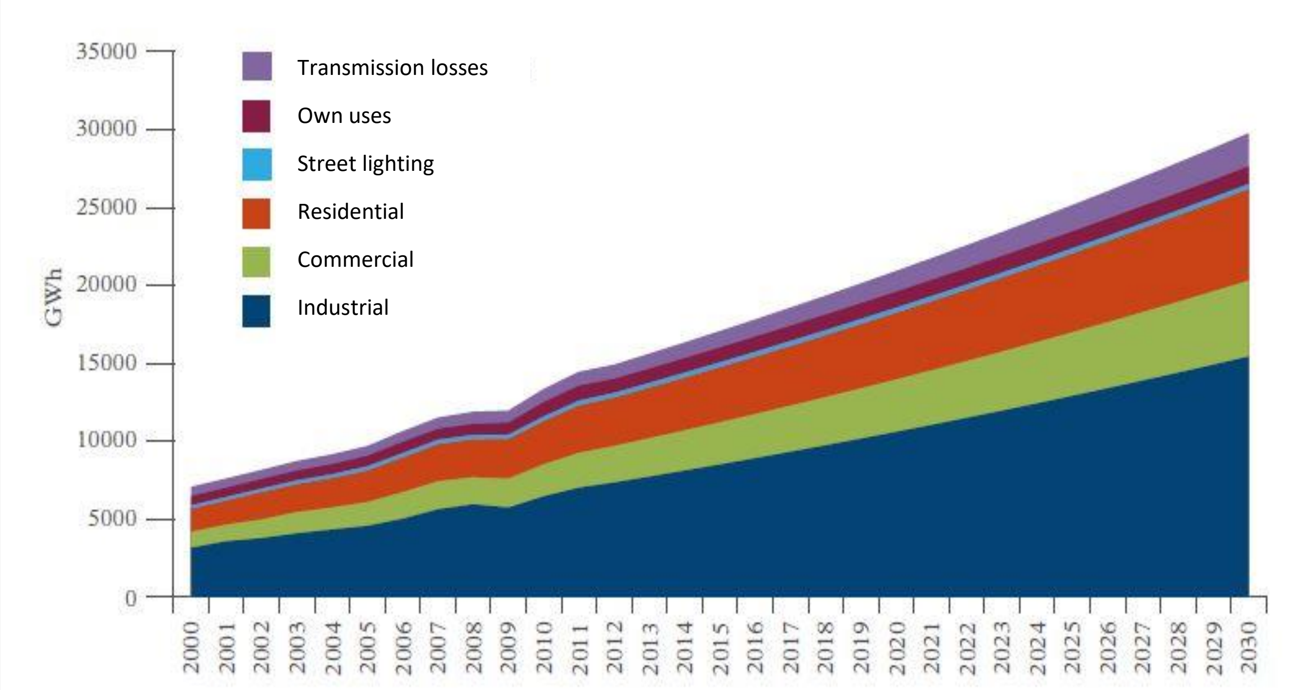


Fig.4.1.1. Lima-Callao: electricity uses by sector, 2000-2030 (GWh).
Source: The Economics of Low Carbon and Climate Resilient Cities Lima-Callao, Peru

The projected emissions are shown in Figure 4.1.2., in which it can be seen that cost-effective measures represent an increase in emissions of 104%, cost-neutral measures represent an increase of 81%, and Implementation of all technically possible mitigation measures implies an overall reduction of 3% compared to 2014 levels. Figure 4.1.3. Represents the carbon intensity of electricity from the National Interconnected Electric System, 2000-2030 (tCO2e per MWh).

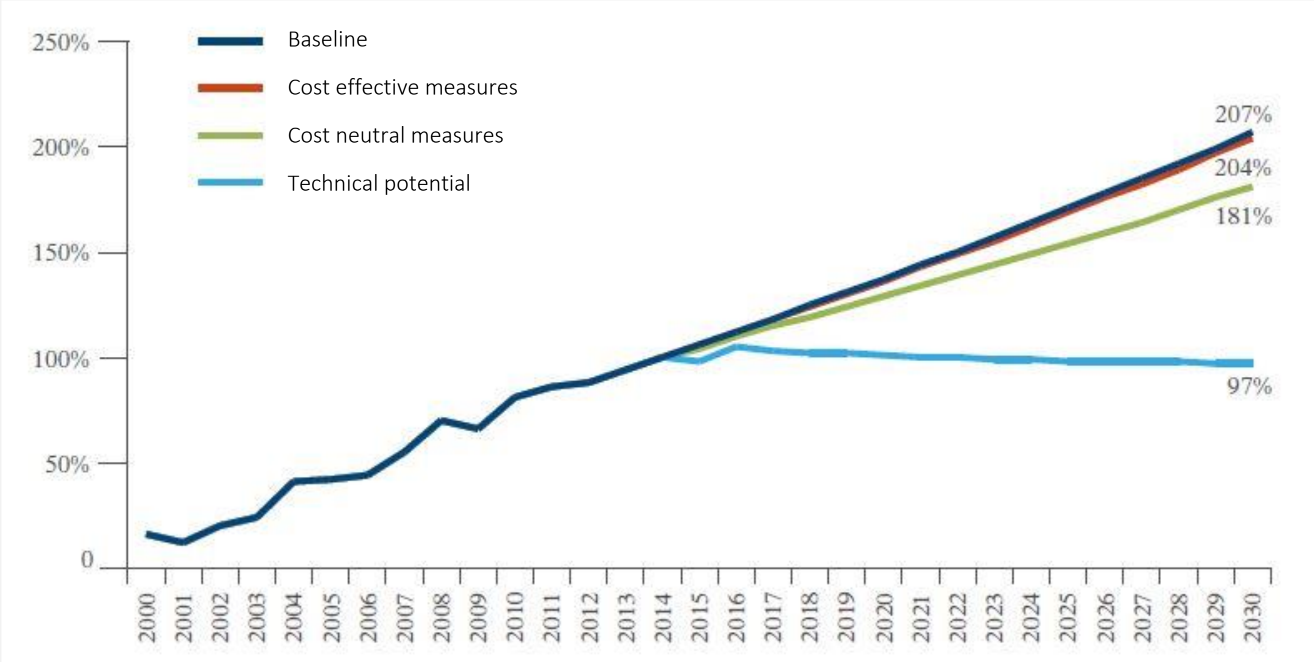


Fig.4.1.2. Lima-Callao: indexed emissions from the electricity sector, 2000-2030 (2014 = 100%)
Source: The Economics of Low Carbon and Climate Resilient Cities Lima-Callao, Peru

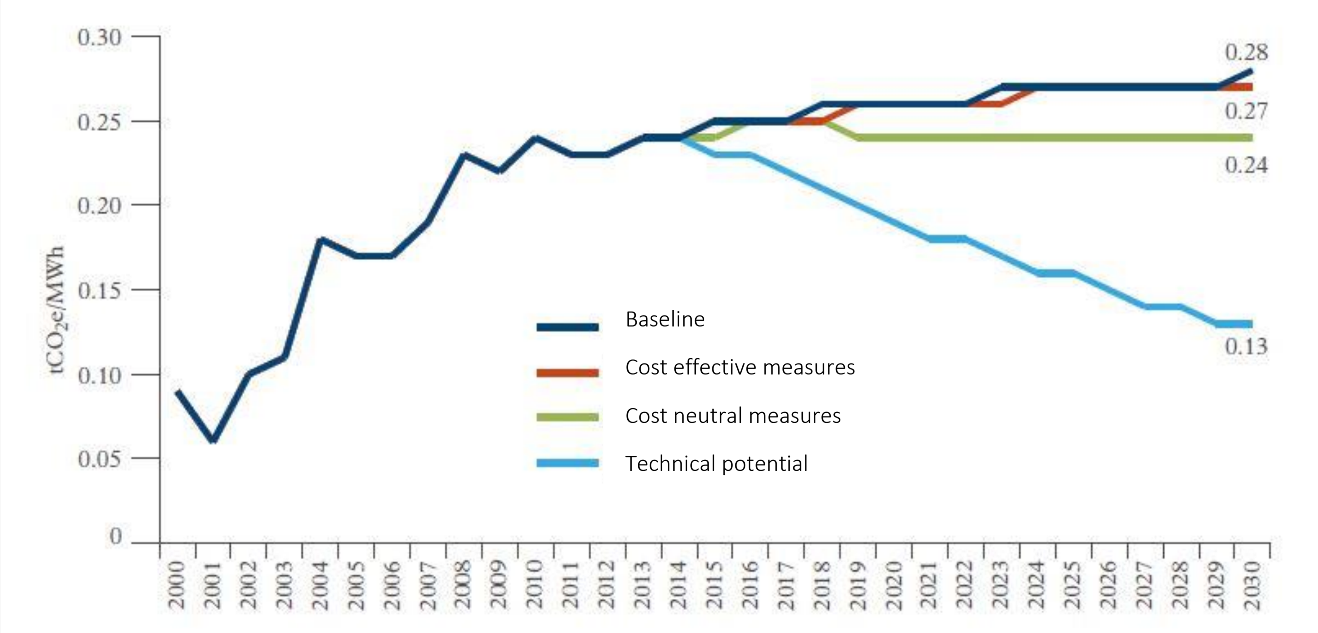


Fig.4.1.3. Lima-Callao: carbon intensity of electricity from the National Interconnected Electric System, 2000-2030 (tCO2e per MWh)
Source: The Economics of Low Carbon and Climate Resilient Cities Lima-Callao, Peru

1) Building Sector

To calculate the total floor area and BAU scenario respectively, the FS uses data of area [m^2] of actual Zoning and Land Use Plan of La Molina and the Normative Heights Plan by the type of building uses.

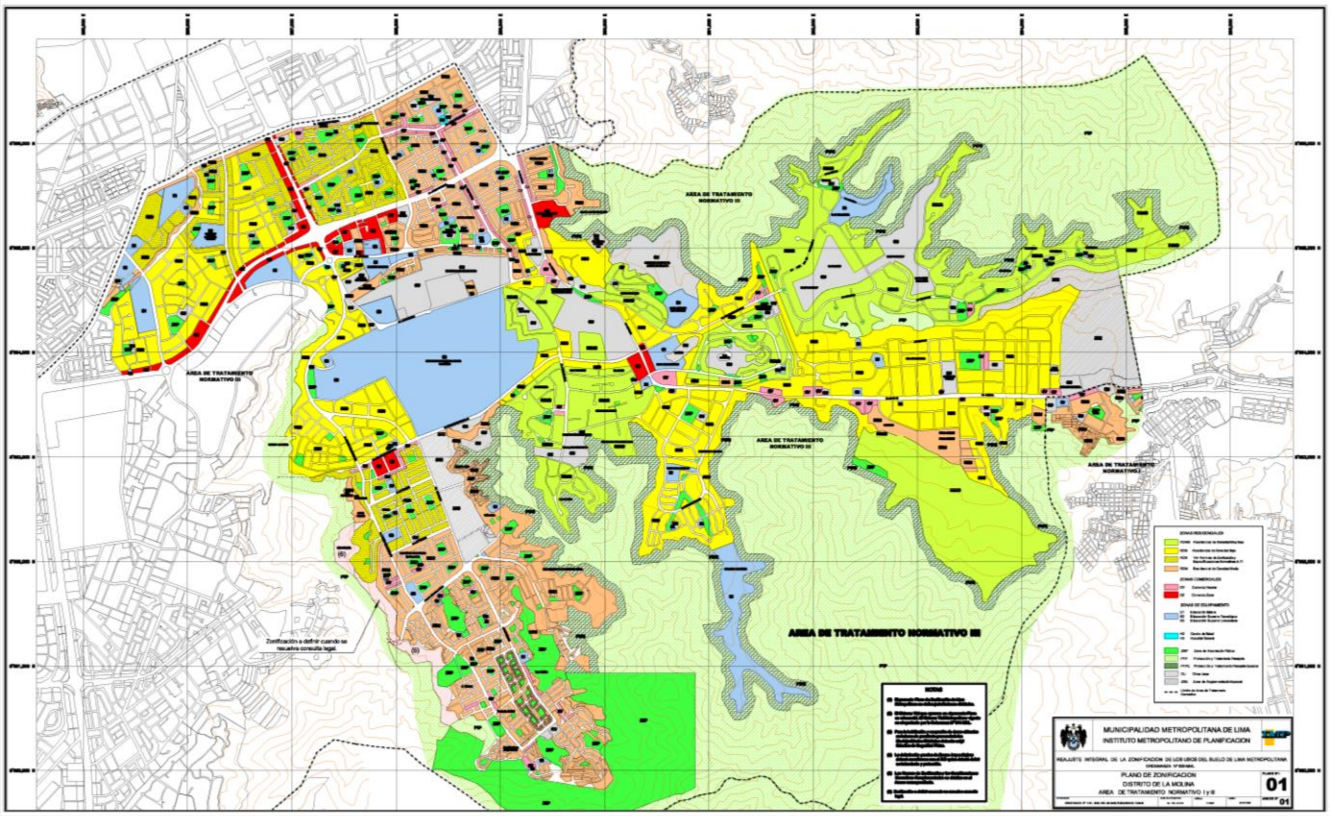


Fig.4.1.4. Zoning and Land Use Plan of La Molina
Source: La Molina Municipality

The Zoning Plan in La Molins is characterized by the following areas:

a) Residential Areas - These are the urban areas primarily intended for the use of housing

- Very Low, Low and Medium Density Residential (RDMB) and (RDB). These are those residential areas that allow the construction of Single-Family Housing, Multifamily (only two housing units).
- Residential of Medium Density (RDM) They are those residential areas that allow the construction of single-family, multifamily and Residential Complex housing units with minimum exclusive housing of 100 m2.

b) Commercial Areas - These are the urban areas primarily intended for the location and operation of commercial establishments and services; depending on the radius of action and intensity of uses, the Zoning Plan of La Molina provides Trade Zones.

c) Education – areas including basic, technological higher and university higher education

d) Hospitals – areas including health centers and hospitals

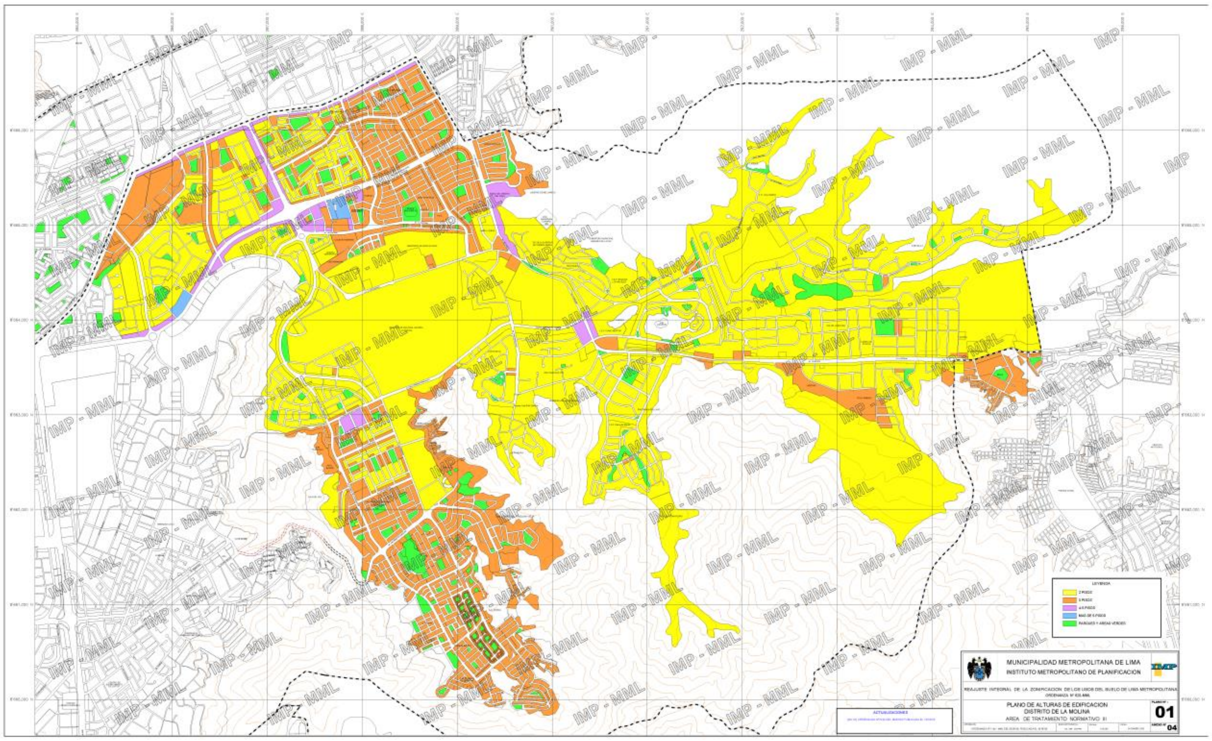


Fig.4.1.5. Normative Heights Plan of La Molina
Source: La Molina Municipality

In this regard, a table of areas of each category described in the legend of the zoning plan and land use has been prepared, as well as the plan of normative heights of the District of La Molina.

Table. 4.1.1. Area [m2] of actual Zoning and Land Use Plan of La Molina

Zone	Area (km²)
Very low-residential	4566.99
Low-residential	7963.58
Medium-residential	3776.41
Commercial zone 1	386.29
Commercial zone 2	494.24
Education	1987.15
Hospitals	12.17
Total urban area	19186.83

Source: La Molina Municipality

Table. 4.1.2. Area [m2] of Normative Heights Plan of La Molina

Height of floor	Area (km²)
2F	13370.6
3F	4712.43
4-5F	480.91
More than 5F	69.26
Total urban area	18633.2

Source: La Molina Municipality

The pictures and plan above show the graphic proposal for zoning in La Molina and the potential zoning plan for 2018-2028 in La Molina.

Fig.4.1.6. Graphic proposals for Zoning in La Molina
Source: DISTRICT URBAN PLAN OF LA MOLINA 2018-2028

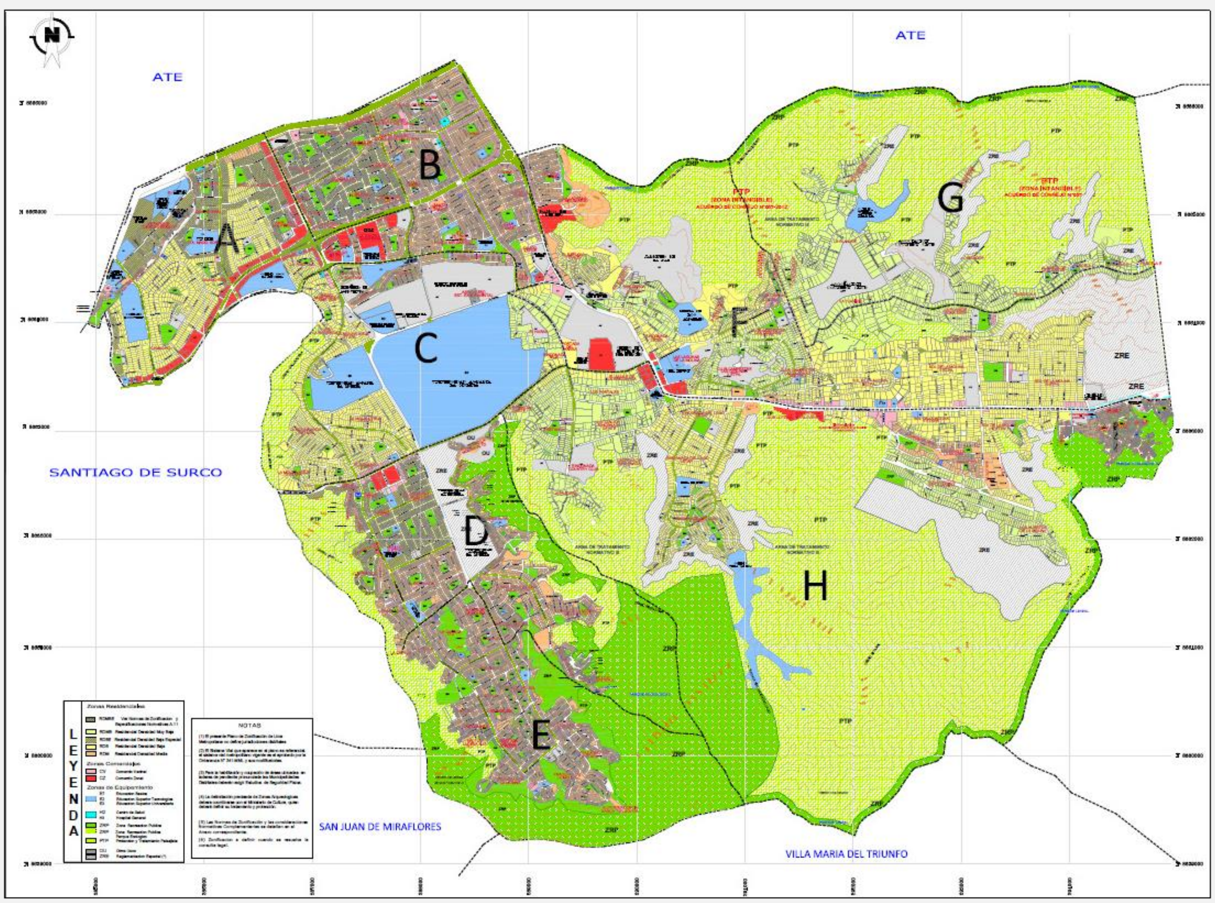


Fig.4.1.7. Zoning plan in La Molina for 2018-2028
Source: DISTRICT URBAN PLAN OF LA MOLINA 2018-2028

According to the zoning plan, in La Molina, the very low residential area and low residential area are dominant compared to other ones, and the building with 2F covers more than 50% of the total area of La Molina.

(1) Estimation of the total floor area

To estimate the CO2 emission in La Molina and to propose the reduction measures respectively, it is very important to obtain the energy consumption per m^2 for each type of building. Such analysis and investigation until now are lacking.

For the reason above, in this FS, to calculate the energy consumption, it is necessary the calculation of the total floor area in La Molina. For the calculation of the building area are used the following sources:

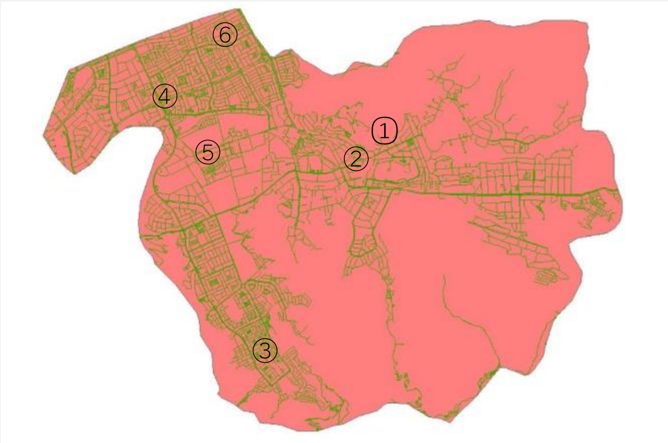
- Geofabric data: shape data of the building. The data does not cover all areas of the district. Moreover, the data are missing the information of the single and total area of the buildings.
- Google Earth: the data of Google Earth are used for verification of Geofabric data and Zoning data.
- Zoning plan provided by La Molina Municipality: in this data, there is information on the number of floors of the buildings in La Molina District as well as the classification of the area by building type.

According to the above data, the Project team has selected six representative areas in La Molina District shown in Figure 4.1.8. The six representative areas are located in very low, low and medium residential areas; commercial areas including educational and hospital areas following the zoning plan provided by La Molina Municipality.

The calculation of the total building and floor area in La Molina is as follows:

- The total building area of the sample area [A],
- Number of buildings in the sample area [B],
- An average area occupied per building [C],
- Site area [G]
- The average floor [D] is obtained by the Normative Heights Plan of La Molina,
- The total building area of the urban zone [I] is based on the Zoning and Land Use Plan of La Molina.
- Based on the mentioned data above, it is calculated the floor ratio area (FAR) [H] and
- The total floor area of the representative area [G]

For more information, refer to the Table 4.1.3~4.1.8 for the calculation of the total building and floor area for each representative sample area.



No	Name of sample area
1	Very Low Residential (Jiron las Redes)
2	Low residential (Isla Terranova)
3	Medium residential (Portada del Sol)
4	Commercial (Commercial Center La Rotonda; University San Ignacio de Loyola - Campus I)
5	Educational (National Agrarian University)
6	Hospital (Hospital Carlos Alcantara Butterfield)

Fig. 4.1.8. Selected sample areas in La Molina
Source: Project Team (NSRI)

The sample area No1 represented a very low residential area near the street Jiron las Redes in La Molina. The average floor area of the buildings is 2F with a total floor area per building of 294.92 m^2.

1. La Molina (Very Low residential)

Fig. 4.1.9. Sample area 1: Very Low residential area in La Molina
Source: Project Team (NSRI), Geofabric data and Google Earth map

Table 4.1.3. Sample area 1: calculation of the total building and floor area in La Molina

Sample area No1 (Very Low residential)	Area (m^2)
A. Total building area of sample area	884.81 m^2
B. Number of buildings in the sample area	6
C. Average area occupied per building [A/B]	147.46 m^2
D. Average floor	2
E. Total floor area of sample area [AxD]	1768.82 m^2
F. Total floor area per building [CxD]	294.92 m^2
G. Site area (shown with yellow lines)	11200 m^2
H. Floor Area Ratio (FAR) FAR%=[E/G]x100	15.8 %
I. Total building area of residential zone [master plan]	4566985.74 m^2
G. Total floor area of residential zone [IxH%]	721583.74 m^2

Source: Project Team (NSRI)

The sample area No2 represented a low residential area near the street Terranova in La Molina. The average floor area of the buildings is 2F with a total floor area per building of 451.54 m^2. The floor rate ratio is estimated to be 28%. The total floor area of the representative area is shown in the below table.

2. La Molina (Low residential)

Fig. 4.1.10. Sample area 2: Low residential area in La Molina
Source: Project Team (NSRI), Geofabric data and Google Earth map

Table 4.1.4. Sample area 2: calculation of the total building and floor area in La Molina

Sample area No2 (Low residential)	Area (m^2)
A. Total building area of sample area	1580.39 m^2
B. Number of buildings in the sample area	7
C. Average area occupied per building [A/B]	225.77 m^2
D. Average floor	2
E. Total floor area of sample area [AxD]	3160.78 m^2
F. Total floor area per building [CxD]	451.54 m^2
G. Site area (shown with yellow lines)	11234 m^2
H. Floor Area Ratio (FAR) FAR%=[E/G]x100	28 %
I. Total building area of representative zone [master plan]	7963584.43 m^2
G. Total floor area of representative zone [IxH%]	2229803.64 m^2

Source: Project Team (NSRI)

The sample area No3 represented a low residential area near the Portada del Sol in La Molina. The average floor area of the buildings is 3F with a total floor area per building of 525,00 m^2. The floor rate ratio is estimated to be 102%. The total floor area of the representative area is shown in the below table.

3. La Molina (Medium residential)

Fig. 4.1.11. Sample area 3: medium residential area in La Molina
Source: Project Team (NSRI), Geofabric data and Google Earth map

Table 4.1.5 Sample area 3: calculation of the total building and floor area in La Molina

Sample area No3 (Medium residential)	Area (m^2)
A. Total building area of sample area	4550.37 m^2
B. Number of buildings in the sample area	26
C. Average area occupied per building [A/B]	175.00 m^2
D. Average floor	3
E. Total floor area of sample area [AxD]	13651.11 m^2
F. Total floor area per building [CxD]	525.00 m^2
G. Site area (shown with yellow lines)	13362.00 m^2
H. Floor Area Ratio (FAR) FAR%=[E/G]x100	102 %
I. Total building area of representative zone [master plan]	3776412.78 m^2
G. Total floor area of representative zone [IxH]	3851941.00 m^2

Source: Project Team (NSRI)

The sample area No4 represented the commercial area in La Molina. This is Commercial Center La Rotonda, University San Ignacio de Loyola – Campus, and other administrative and shopping centers. The average floor area of the buildings is 5F with a total floor area per building of 4739.20 m^2.

4. La Molina (Commercial)

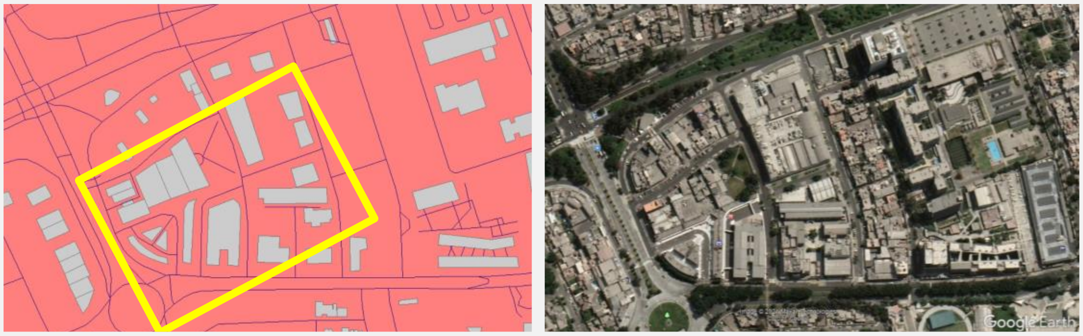


Fig. 4.1.12. Sample area 4: commercial area in La Molina
Source: Project Team (NSRI), Geofabric data and Google Earth map

Table 4.1.6. Sample area 4: calculation of the total building and floor area in La Molina

Sample area No4 (Commercial)	Area (m^2)
A. Total building area of sample area	17061.16 m^2
B. Number of buildings in the sample area	18
C. Average area occupied per building [A/B]	947.84 m^2
D. Average floor	5
E. Total floor area of sample area [AxD]	85305.80 m^2
F. Total floor area per building [CxD]	4739.20 m^2
G. Site area (shown with yellow lines)	67298.00 m^2
H. Floor Area Ratio (FAR) FAR%=[E/G]x100	127 %
I. Total building area of representative zone [master plan]	880538.52 m^2
G. Total floor area of representative zone [IxH]	1118283.92 m^2

Source: Project Team (NSRI)

Sample area No5 represented the education area in La Molina. This is the National Agrarian University. The average floor area of the buildings is 2F with a total floor area per building of 2780.00 m^2.

5. La Molina (Education)

Fig. 4.1.13. Sample area 5: education area in La Molina
Source: Project Team (NSRI), Geofabric data and Google Earth map

Table 4.1.7. Sample area 5: calculation of the total building and floor area in La Molina

Sample area No5 (Educational)	Area (m^2)
A. Total building area of sample area	15291 m^2
B. Number of buildings in the sample area	11
C. Average area occupied per building [A/B]	1390.00 m^2
D. Average floor	2
E. Total floor area of sample area [AxD]	30587.00 m^2
F. Total floor area per building [CxD]	2780 m^2
G. Site area (shown with yellow lines)	172360.00 m^2
H. Floor Area Ratio (FAR) (FAR%=[E/G]x100)	17 %
I. Total building area of representative zone [master plan]	1987150.66 m^2
G. Total floor area of representative zone [IxH]	337815.61 m^2

Source: Project Team (NSRI)

The last sample area selected for this FS is No6 and represented the hospital area and more especially the Hospital Carlos Alcantara Butterfield. The average floor area of the buildings is 3F with a total floor area per building of 7920.60 m^2.

6. La Molina (Hospital)

Fig. 4.1.14. Sample area 6: hospital area in La Molina
Source: Project Team (NSRI), Geofabric data and Google Earth map

Fig. 4.1.8. Sample area 6: calculation of the total building and floor area in La Molina

Sample area No6 (Hospital)	Area (m^2)
A. Total building area of sample area	2640.20 m^2
B. Number of buildings in the sample area	2
C. Average area occupied per building [A/B]	1320.10 m^2
D. Average floor	3
E. Total floor area of sample area [AxD]	7920.60 m^2
F. Total floor area per building [CxD]	3960.30 m^2
G. Site area (shown with yellow lines)	8050.00 m^2
H. Floor Area Ratio (FAR) (FAR%=[E/G]x100)	98 %
I. Total building area of representative zone [master plan]	12175.64 m^2
G. Total floor area of representative zone [IxH]	11932.13 m^2

Source: Project Team (NSRI)

Based on the calculation on the six representative areas and based on the total building area of Zoning and Land Use Plan of La Molina, it was calculated the total floor area in La Molina. The results are shown in the table below.

Table. 4.1.9. Total floor area by building type in La Molina

Total floor area by building type	Area (m^2)
Very Low residential	721 583.74
Low residential	2 229 803.64
Medium residential	3 851 941.00
Commercial	1 118 283.92
Education area	337 815.61
Hospitals	11 932.13
Total	8 271 360.04

Source: Project Team (NSRI)

(2) Estimation of the total electricity consumption

The estimation of the total electricity consumption is shown in the table below. The electricity consumption for the very low residential area is calculated based on single-family houses independent of the socio-economic sector of class B in Lima. The data is provided by Guidance for the Efficient Use of Energy and Energy Diagnosis, Ministry of Energy and Mines, Peru, 2017. The electricity consumption for the low and medium residential areas is calculated based on single-family homes located in a condominium of the socio-economic sector of class B in Lima. The data are provided based on Guidance for the Efficient Use of Energy and Energy Diagnosis, Ministry of Energy and Mines, Peru, 2017. Regarding the commercial, education and hospital area, this FS uses data provided by Energy Efficiency in Public Buildings: Standards, related programs and projects, South America (Chile), 2020.

Table. 4.1.10. Electricity consumption by building type in La Molina

Area	[A]	[B]	[C]=[A]x[B]
	Electricity consumption (secondary)	Total floor area by building type	Total electricity consumption (secondary)
	[$kWh/m^2 \cdot year$]	[m^2]	[MWh/year]
Very Low residential	90.6	721583.7	65375.5
Low residential	121.5	2229803.6	270921.1
Medium residential	121.5	3851941.0	468010.8
Commercial	150.0	1118283.9	167742.6
Education area	119.0	337815.6	40200.1
Hospitals	512.0	11932.1	6109.2
Total		8271360.0	1018359.3

Source: Project Team (NSRI)

Based on The Economics of Low Carbon and Climate Resilient Cities Lima-Callao, Peru, the Electricity consumption in Metropolitan Lima was calculated to be 7.0 TWh in 2000, rose to 16.3 TWh in 2014 and will reach 29.8 TWh in 2030. The above estimation is used for calculating the total energy consumption in La Molina for 2030 and 2050. The table below is shown the total energy consumption in 2021, 2030 and 2050 based on the building type in La Molina. The visualization of the results is shown in Table 4.1.11.

Table. 4.1.11. Electricity consumption by building type in La Molina for 2021, 2030 and 2050

Area	2021	2030	2050
	Total electricity consumption (secondary) [MWh/year]		
Very Low residential	65375.5	91525.7	143826.1
Low residential	270921.1	379289.5	596026.4
Medium residential	468010.8	655215.1	1029623.8
Commercial	167742.6	234839.6	369033.7
Education area	40200.1	56280.1	88440.2
Hospitals	6109.2	8552.9	13440.2
Total	1018359.3	1425703.0	2240390.5

Source: Project Team (NSRI)

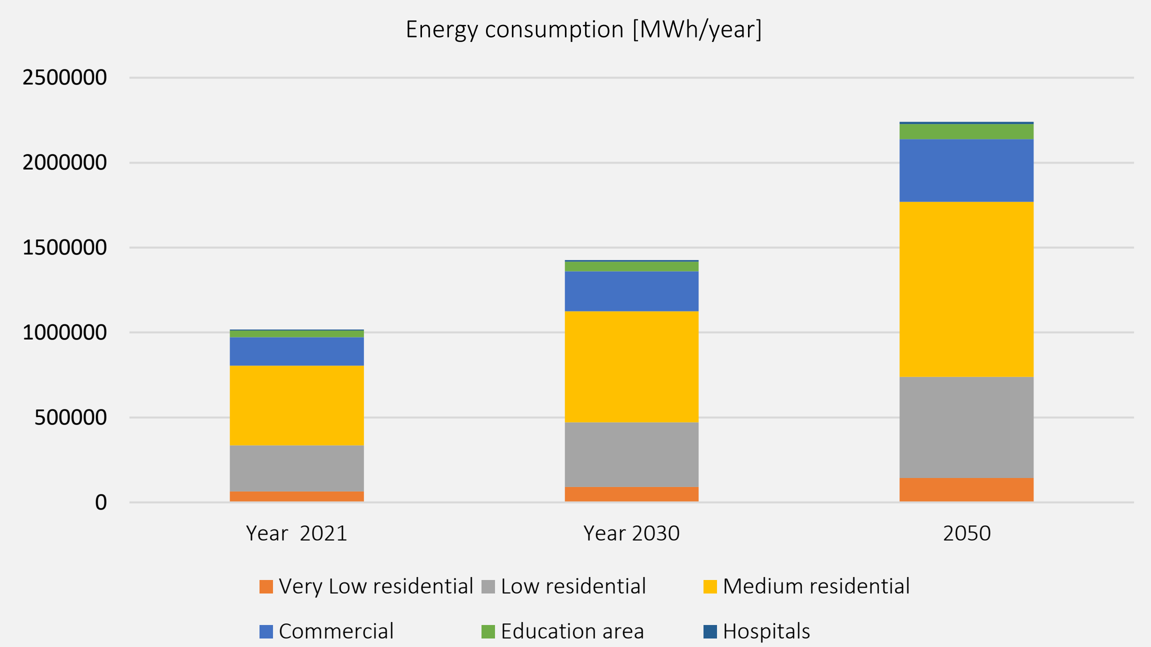


Fig. 4.1.15. Vizualization of the energy consumption by building type in La Molina fot 2021, 2030 and 2050
Source: Projcet Team (NSRI)

(3) Estimation of CO2 emissions in the residential sector by sources and uses (Distribution%)

In this FS, we use the estimation of CO2 emission by sector shown below for reference in order to calculate the Energy consumption ratio in a typical building.

- **Estimation of CO2 emissions in the residential sector by sources and uses (Distribution%)**

The emissions CO2 in the residential sector by source and use are shown in the below figure. According to the results, cooking 66,39%, miscellaneous artifacts 16,66%, refrigerator 7,12%, hot water 4,84 %, other, 4,01%, heating 0,82%, environmental ventilation and refrigeration 0,09%, water pumping 0.07%.

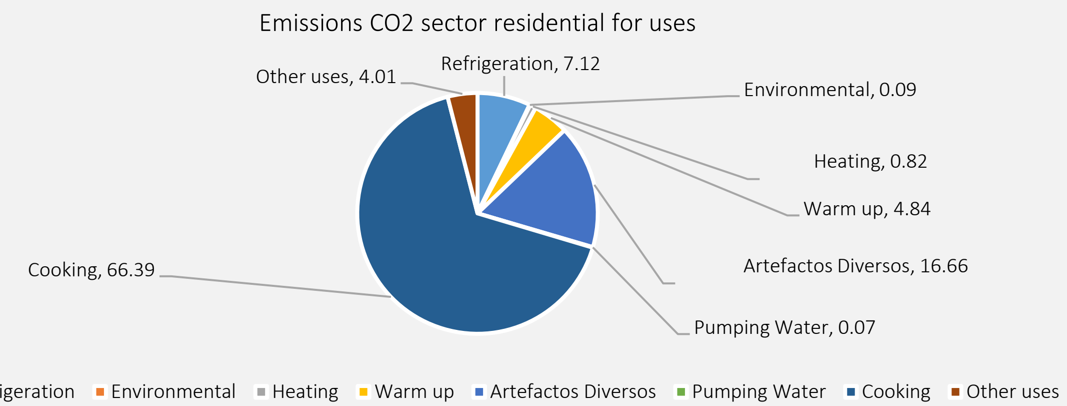


Fig.4.1.16. CO2 emissions in the residential sector by sources and uses

Source: National Balance of Energy of Peru, vol. 1

(4) Estimation of CO2 emissions in the industrial sector by sources and uses (G*g)

Table 4.1.12. CO2 emissions in the industrial sector by sources and uses (G*g)

Uses	CO2
Process Heat	5 902,0
Cold for Industrial Process	342,8
Compressed Air	199,0
Process Driving Force	3 262,2
Lighting	92,9
Cooking	41,4
Food Conservation	9,2
Water Heating	9,1
Environmental Heating	4,9
Air Conditioning	5,2
Environmental Ventilation	4,5
Water Pumping Equipment	12,2
Miscellaneous artifacts	47,5
Whole	**9 932,8**

Source: National Balance of Energy of Peru, vol. 1

(5) Estimation of CO2 emissions in the trade and services sector by sources and uses (G*g)

Table 4.1.13. CO2 emissions in the trade and services sector by sources and uses (G*g)

Uses	CO2
Lighting	155,4
Cooking of food	942,4
Food Conservation	108,3
Water Heating	174,0
Environmental Heating	
Air Conditioning	20,0
Environmental Ventilation	14,0
Water Pumping Equipment	20,6
Process Driving Force	1,7
Miscellaneous artifacts	528,4
Whole	**1 964,6**

Source: National Balance of Energy of Peru, vol. 1

(6) Estimation of CO2 emissions in the health sector by sources and uses (G*g)

Table 4.1.14. CO2 emissions in the health sector by sources and uses (G*g)

Uses	CO2
Lighting	36,20
Cooking of food	22,76
Food Conservation	4,87
Water Heating	11,34
Environmental Heating	39,86
Air Conditioning	21,35
Environmental Ventilation	3,68
Water Pumping Equipment	2,16
Process Driving Force	432,29
Miscellaneous artifacts	112,43
Whole	**686,94**

Source: National Balance of Energy of Peru, vol. 1

According to the Report of the Energy Plan, it is estimated that in 2025 the Greenhouse Gas emissions generated by the final consumption of energy in the different sectors would fluctuate between 81 thousand and 92 thousand Giga Gram of carbon dioxide equivalent (Gg of CO2 eq), lower values between 10~15%, respectively, to what would have resulted without the application of energy efficiency measures in the residential, services, industry and transport sectors

2) Transport Sector

(1) Percentage in the transportation sector

Of the total CO2 emissions in Lima-Callao, emissions in the transportation sector such as automobiles and railways account for about 50% of the total. In addition, if measures against CO2 emissions are not implemented, total CO2 emissions from Lima-Callao are projected to increase by 82% in 2030 compared to 2014, and the impact of the transportation sector on urban activities will be significant.

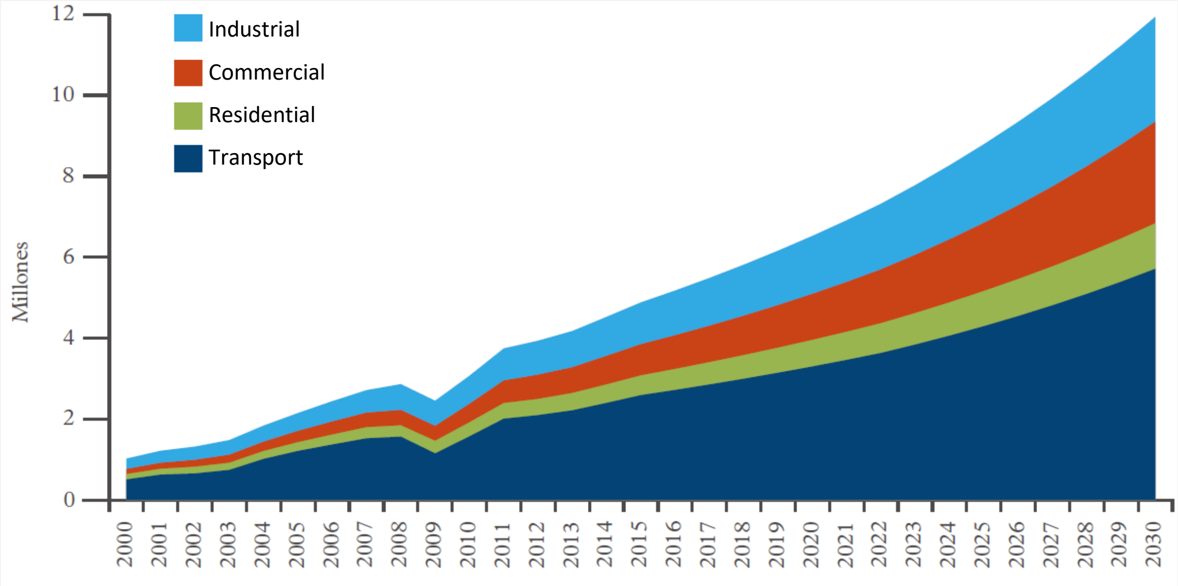


Fig.4.1.17. Lima-Callao: energy expenditure by sector, 2000-2030 (in millions of US $)
Source: The economy of low-carbon and climate-resilient cities Lima-Callao, Peru

(2) CO2 emissions in the transportation sector

By transportation mode, emissions from automobiles account for about 50% of the total. This is followed by microbuses, cabs, and combis. The population of La Molina district has maintained an annual growth rate of over 2% in recent years. Since more than 30% of the households in La Molina own at least one car, it is assumed that the number of registered cars in La Molina will increase with the future population growth, and CO2 emissions will also tend to increase.

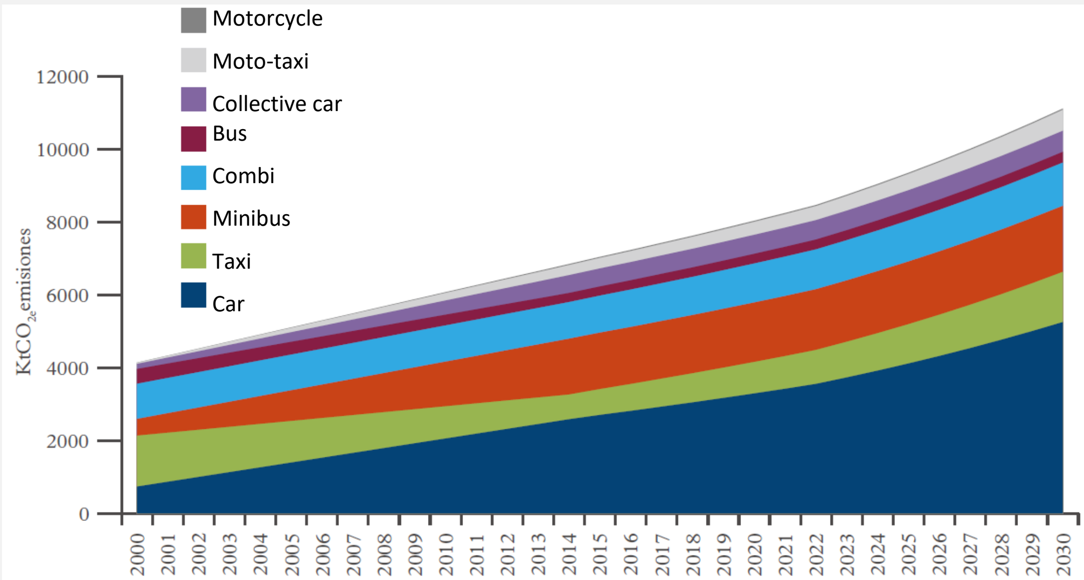
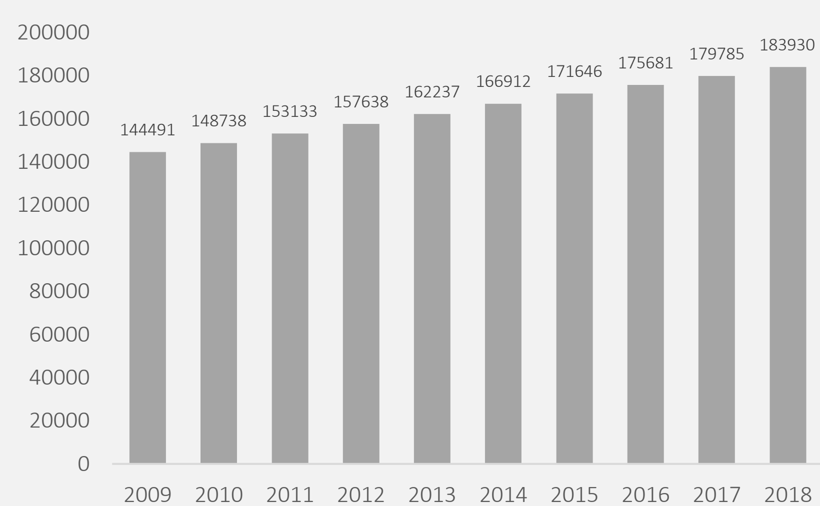


Fig.4.1.18. CO2e emissions from the transport sector by mode of transport, 2000-2030 (in ktCO2e)
Source: The economy of low-carbon and climate-resilient cities Lima-Callao, Peru



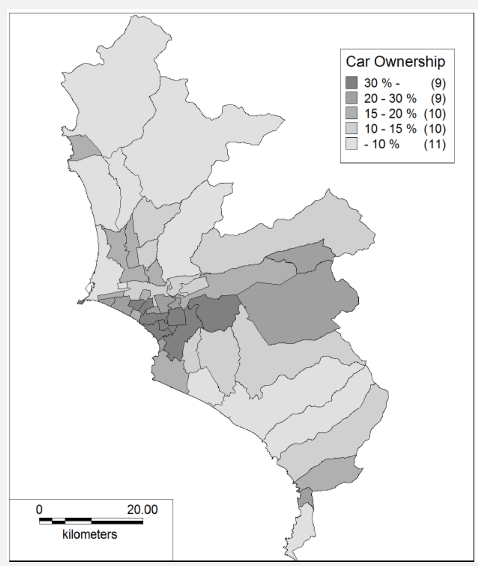


Fig.4.1.19. The total projected population in La Molina district
Source: Municipal Statistical Compendium, La Molina, 2018

Fig.4.1.20. Car Ownership (% Households Owning Car)
Source: JICA Study Team (Person Trip Survey, 2012)

(3) CO2 intensity by traffic mode

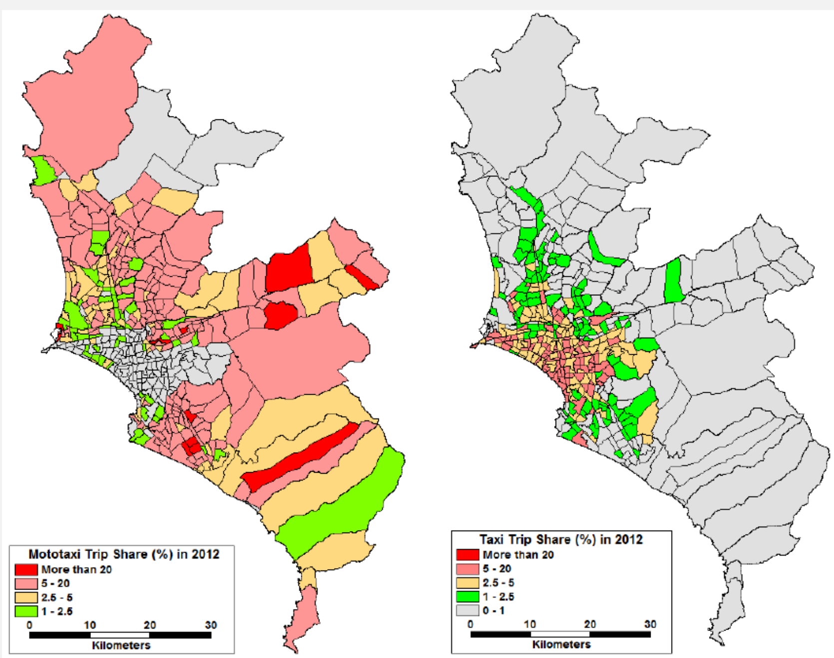
CO2 emissions per passenger are highest for gasoline-fueled cabs, followed by cars. On the other hand, public transportation such as buses, BRT, and railroads emit less CO2 per passenger.

Since cabs and cars are the most common means of transportation from the Lamorina area to the city center, a shift from cabs and cars to public transportation is considered to be effective in reducing CO2 emissions. The number of registered vehicles in Lima is about 2.66 million, of which about half are cars.

Table.4.1.15. Data considered when evaluating different modes of transport in the analysis of the transport sector

Vehicle Type	Used Fuel	Km/l	gCO^2/km	Emissions per passenger km(gCO$^2_{2e}$/km)	Average occupancy rate (people per vehicle)
Taxi	Gasoline	9.50	243	683	1.07
Taxi	Diesel	13.20	202	565	1.07
Taxi	Natural Gas	8.10	58	164	1.07
Combi	Gasoline	2.97	484	25	19.50
Combi	Diesel	2.85	484	25	19.50
Micro bus	Gasoline	3.20	1.400	23	61.75
Micro bus	Diesel	3.34	1.500	25	61.75
Micro bus	Natural Gas	3.71	1.500	24	61.75
New fast transit bus system Euro 6	Natural Gas	1.67	820	8.2	100
Rapid transit bus system	Natural Gas	1.67	393	3.93	100
Metro	Electric	-	63.17	0.05	1200
New Car	Gasoline	15.8	146	77	1.91
Motorcycle and Motor Taxi	Gasoline	26.67	87	76	1.14
Car	Gasoline	10.31	224	117	1.91
Car	Natural Gas	11.01	43	23	1.91
Others private type	Gasoline	10.31	224	145	1.55

Source: The economy of low-carbon and climate-resilient cities Lima-Callao, Peru



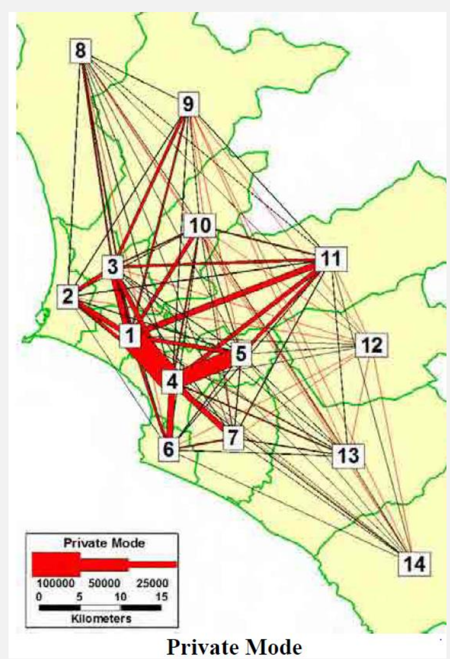


Fig.4.1.21. Share of Moto-taxi and Taxi by Traffic Zone
Source: JICA Study Team (Person Trip Survey, 2012)

Fig.4.1.21. Desired Line

Table.4.1.16. National car fleet estimated by vehicle class according to department : 2016

Departments	WHOLE	Motorcar	Station wagon	Pickup	VEHICLE CLASS Vans Rural	Panel	Bus	Truck	Tug	Tow Semirem.
WHOLE	2'661.719	1'167.041	403.193	283.479	365.316	43.387	80.119	213.155	43.604	62.425
Lima/Callao	1'752.919	807.529	284.251	163.793	236.502	31.006	50.441	116.601	29.520	33.276
Freedom	190.073	77.440	21.459	25.037	18.382	1.372	7.105	21.208	4.548	13.522
Arequipa	187.929	89.335	14.236	21.353	27.142	1.989	5.099	16.853	4.804	7.118
Cusco	73.997	29.313	12.253	9.108	11.300	578	2.938	8.160	281	66
Lambayeque	68.261	30.741	5.908	9.192	9.418	1.034	1.348	8.088	572	1.960
Junín	67.049	22.296	12.308	8.749	9.715	295	2.139	9.231	881	1.435
Piura	55.060	23.771	4.922	10.378	7.915	400	1.280	5.503	518	373
Tacna	49.382	18.040	11.476	4.777	5.580	1.556	1.703	4.727	614	909
Handle	47.696	8.711	8.867	4.740	14.029	3.246	2.562	4.887	297	357
Áncash	33.542	14.484	5.472	4.009	5.555	235	940	2.415	199	233
Others	135.811	45.381	22.041	22.343	19.778	1.676	4.564	15.482	1.370	3.176

Source: MTC *Preparation: ERM*

Source: CONTINUOUS INCREASE IN THE FLEET, AN URGENT PROBLEM TO SOLVE

The table below shows the results of a questionnaire regarding the means of transportation used for commuting to work and school. The use of public transportation is as high as 65%, of which about 50% is used by buses and combi. For combi, the usage rate has decreased significantly. On the other hand, the use of Metropolitano (BRT), which opened in 2010, and Metro, which opened in 2015, is on the rise. The convenience of public transportation is considered to be high.

Table.4.1.17. How do you get around mainly within the city to go to work, office or study center? Metropolitan Lima and Callao, 2010 – 2019

Lima	Collective public transport		Individual public transport		Individual private transportation		Sustainable transport	
	65.3%		6.4%		12.7%		14.2%	
	Bus	**27.9%**	Mototaxi	**4.2%**	Own car	**10.4%**	Hike	**12.7%**
	Combi or custer	**25.4%**	Regular taxi	**1.0%**	Motorcycle	**2.3%**	Bike	**1.5%**
	Metropolitan	**3.9%**	Taxi by app	**1.2%**				
	Collective	**2.9%**						
	Corridors complementary	**2.2%**						
	Lima Metro	**3.0%**						

Source: LIMA AND CALLAO ACCORDING TO THEIR CITIZENS

Table.4.1.18. How do you get around mainly within the city to go to work, office or study center? Metropolitan Lima and Callao, 2010 – 2019

Lima	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Bus	21.8%	22.4%	21.9%	29.9%	24.8%	25.4%	32.5%	37.4%	29.1%	27.9%
Combi or custer	45.9%	42.3%	40.6%	33.6%	33.2%	33.8%	27.9%	28.3%	29.2%	25.4%
I walk or I go on foot	10.0%	7.0%	10.0%	5.8%	8.0%	6.9%	8.7%	8.1%	12.0%	12.7%
Own car	8.7%	9.8%	9.0%	7.6%	9.6%	9.3%	9.4%	10.3%	10.8%	10.4%
Mototaxi	2.6%	3.5%	2.2%	4.8%	3.6%	3.6%	4.2%	2.8%	4.5%	4.2%
Metropolitan	-	4.6%	4.7%	3.0%	5.3%	4.4%	4.9%	2.6%	2.9%	3.9%
Lima Metro	-	-	1.1%	1.7%	2.5%	3.4%	3.1%	1.5%	3.0%	3.0%
Collective	4.3%	4.0%	4.1%	4.1%	5.6%	7.4%	3.3%	2.2%	2.3%	2.9%
Own motorcycle	0.6%	1.1%	1.6%	0.7%	1.0%	0.7%	1.0%	1.7%	1.5%	2.3%
Complementary corridors	-	-	-	-	-	1.2%	1.6%	1.6%	1.7%	2.2%
Bike	1.1%	1.0%	0.8%	0.8%	0.8%	0.9%	0.3%	0.8%	1.1%	1.5%
Other	1.0%	1.0%	1.1%	0.8%	1.0%	1.0%	1.2%	1.3%	0.6%	1.5%
Taxi by app	-	-	-	-	-	-	-	-	-	1.2%
Regular taxi	3.6%	3.2%	2.3%	3.5%	1.7%	1.9%	2.0%	1.4%	1.2%	1.0%

Source: LIMA AND CALLAO ACCORDING TO THEIR CITIZENS

Looking at the evaluation of public transportation, the metro is the highest, followed by taxis and corridors. Buses and combi, which are convenient public transportation methods, have a relatively low rating.

Table. 4.1.19. How would you rate the following public transportation services?

	Qualification	Lima	Callao
Buses	very bad /bad	23.0%	31.3%
	not good not bad	53.0%	53.0%
	very good / good	24.0%	15.7%
Custers or combis	very bad /bad	34.6%	37.3%
	not good not bad	47.1%	49.7%
	very good / good	18.2%	13.0%
Taxis	very bad /bad	7.2%	4.3%
	not good not bad	30.1%	26.1%
	very good / good	62.5%	69.6%
Mototaxis	very bad /bad	22.1%	17.3%
	not good not bad	51.4%	57.6%
	very good / good	26.3%	25.1%

	Qualification	Lima	Callao
Metropolitan	very bad /bad	21.2%	24.3%
	not good not bad	33.2%	32.0%
	very good / good	45.5%	43.7%
Lima Metro	very bad /bad	7.9%	10.5%
	not good not bad	18.5%	21.1%
	very good / good	73.6%	68.4%
Complementary corridors	very bad /bad	10.4%	1.7%
	not good not bad	36.0%	45.0%
	very good / good	53.2%	53.3%

Source: LIMA AND CALLAO ACCORDING TO THEIR CITIZENS

(4) Population density and CO2 emissions

Cities with low population densities tend to have higher CO2 emissions from cars per resident than cities with more concentrated populations. This can be attributed to an increase in the number of vehicle miles travelled per inhabitant due to an increased dependence on cars caused by less convenient public transportation. Since the population density in the Lamorina area is low, it is assumed that the CO2 emissions from cars per resident are high.

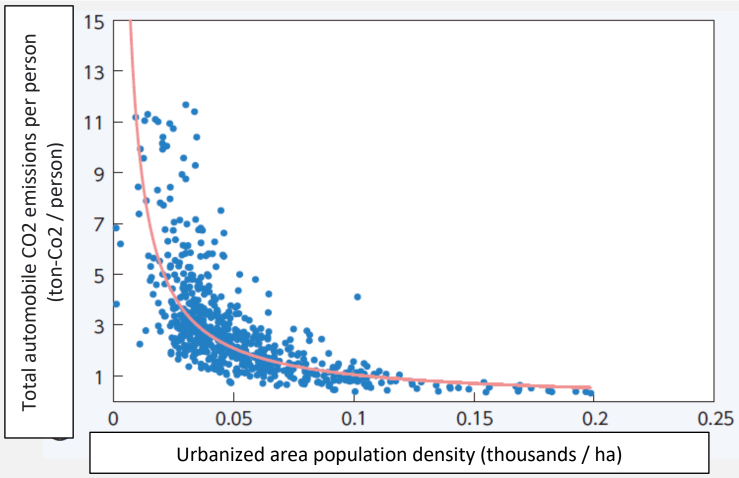


Fig.4.1.22. Relationship between population density in urbanized areas and per capita automobile CO2 emissions
Source: Environmental White Paper (2015, Ministry of the Environment, Japan)

Table.4.1.20. Future Population Projection, 2012-2030

Area	District Name	Area (ha)	2012 Population	2012 Population Density	2020 Population	2020 Population Density	2030 Population	2030 Population Density
	Sub Total [Lima Area]	267,040	8,481,415	31.8	9,609,386	36.0	10,963,461	41.1
Central Lima Area	Lima	2,198	286,849	130.5	250,769	114.1	204,312	93.0
	Barranco	333	31,959	96.0	27,037	81.2	20,677	62.1
	Breña	322	79,456	246.8	71,214	221.2	60,605	188.2
	Jesús Maria	457	71,364	156.2	71,964	157.5	72,714	159.1
	La Victoria	874	182,552	208.9	156,044	178.5	121,838	139.4
	Lince	303	52,961	174.8	46,379	153.1	37,894	125.1
	Magdalena del Mar	361	54,386	150.7	55,111	152.7	56,016	155.2
	Magdalena Vieja	438	77,038	175.9	75,281	171.9	73,025	166.7
	Miraflores	962	84,473	87.8	79,092	82.2	72,168	75.0
	Rimac	1,187	171,921	144.8	155,885	131.3	135,257	113.9
	San Borja	996	111,568	112.0	112,970	113.4	114,595	115.1
	San Isidro	1,110	56,570	51.0	51,124	46.1	44,117	39.7
	San Luis	349	57,368	164.4	58,593	167.9	60,066	172.1
	San Miguel	1,072	135,086	126.0	137,470	128.2	140,124	130.7
	Santiago de Surco	3,475	326,928	94.1	375,355	108.0	434,720	125.1
	Surquillo	346	92,328	266.8	90,386	261.2	87,852	253.9
Total [Central Lima Area]		14,783	1,872,807	126.7	1,814,674	122.8	1,735,983	117.4
North Lima Area	Ancón	29,864	39,769	1.3	49,178	1.6	60,555	2.0
	Carabayllo	34,688	267,961	7.7	353,520	10.2	455,939	13.1
	Comas	4,875	517,881	106.2	544,326	111.7	576,884	118.3
	Independencia	1,456	216,503	148.7	220,608	151.5	225,398	154.8
	Los Olivos	1,825	355,101	194.6	401,239	219.9	457,906	250.9
	Puente Piedra	7,118	305,537	42.9	423,069	59.4	562,386	79.0
	San Martín de Porres	3,691	659,613	178.7	772,050	209.2	909,235	246.3
	Santa Rosa	2,150	15,399	7.2	23,344	10.9	32,537	15.1
Total [North Lima Area]		85,667	2,377,764	27.8	2,787,336	32.5	3,280,840	38.3
South Lima Area	Chorrillos	3,894	314,835	80.9	346,955	89.1	386,483	99.3
	Cieneguilla	24,033	38,328	1.6	58,998	2.5	82,870	3.4
	Lurin	18,026	76,874	4.3	98,024	5.4	123,497	6.9
	Pachacamac	16,023	102,691	6.4	165,546	10.3	237,453	14.8
	Pucusana	3,739	14,403	3.9	20,786	5.6	28,273	7.6
	Punta Hermosa	11,950	6,935	0.6	8,681	0.7	10,791	0.9
	Punta Negra	13,050	6,878	0.5	9,478	0.7	12,560	1.0
	San Bartolo	4,501	7,008	1.6	8,792	2.0	10,946	2.4
	San Juan de Miraflores	2,398	393,493	164.1	426,560	177.9	467,313	194.9
	Santa Maria del Mar	981	1,220	1.2	2,108	2.1	3,107	3.2
	Villa El Salvador	3,546	436,289	123.0	509,576	143.7	599,201	169.0
	Villa Maria del Triunfo	7,057	426,462	60.4	488,430	69.2	564,414	80.0
Total [South Lima Area]		109,198	1,825,416	16.7	2,143,934	19.6	2,526,907	23.1
East Lima Area	Ate	7,772	573,948	73.8	720,347	92.7	897,166	115.4
	Chaclacayo	3,950	43,180	10.9	44,417	11.2	45,897	11.6
	El Agustino	1,254	189,924	151.5	196,726	156.9	205,050	163.5
	La Molina	6,575	157,638	24.0	194,308	29.6	238,757	36.3
	Lurigancho	23,647	201,248	8.5	247,707	10.5	304,039	12.9
	San Juan de Lurigancho	13,125	1,025,929	78.2	1,206,300	91.9	1,426,300	108.7
	Santa Anita	1,069	213,561	199.8	253,639	237.3	302,521	283.0
Total [East Lima Area]		57,392	2,405,428	41.9	2,863,442	49.9	3,419,731	59.6
Callao Area	Callao	4,565	417,622	91.5	394,834	86.5	339,742	74.4
	Bellavista	456	74,287	162.9	68,485	150.2	57,308	125.7
	Carmen de La Legua-Reynoso	212	42,065	198.4	39,944	188.4	35,092	165.5
	La Perla	275	60,886	221.4	55,966	203.5	46,625	169.5
	La Punta	75	3,793	50.6	2,655	35.4	1,396	18.6
	Ventanilla	7,352	370,517	50.4	519,606	70.7	731,626	99.5
Total [Callao Area]		12,935	969,170	74.9	1,081,491	83.6	1,211,789	93.7
Grand Total [Lima and Callao Metropolitan Area]		279,975	9,450,585	33.8	10,690,877	38.2	12,175,250	43.5

Source: DATA COLLECTION SURVEY ON URBAN TRANSPORT FOR LIMA AND CALLAO METROPOLITAN AREA FINAL REPORT（JICA, 2013）

(5) Inaccessible areas

i) Public transport blank area

The low convenience of public transportation leads to an increase in the mileage of automobiles per inhabitant and an increase in CO2 emissions due to an increase in dependence on automobiles. Based on future public transport plans, the central and northeastern parts of the La Molina area are considered to be areas with low public transport convenience.

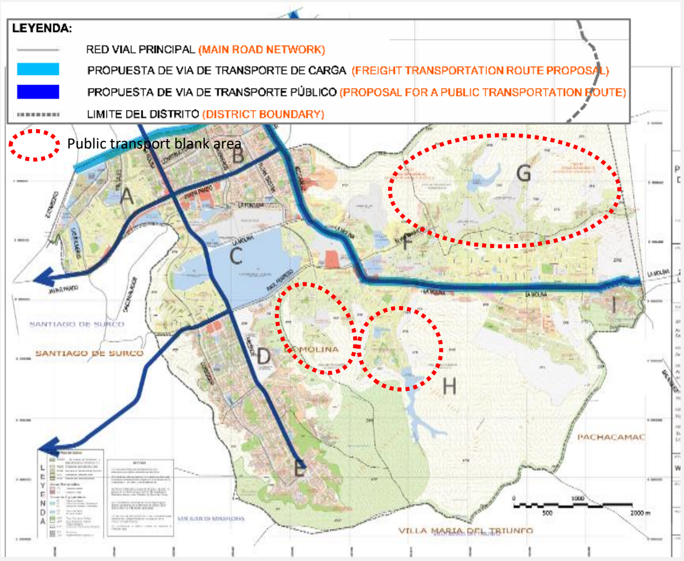


Fig.4.1.23. Public transport planning
Source: Ordenanza que aprueba el Plan Urbano Distrital de La Molina 2018 – 2028

ii) Bicycle Lane planning

Bicycles are environmentally friendly vehicles, and bikeways are being developed in the La Molina municipality. While some sections of the road have been completed, the northeastern part of the Lamorina district has no plans to develop the road, which may prevent the use of bicycles.

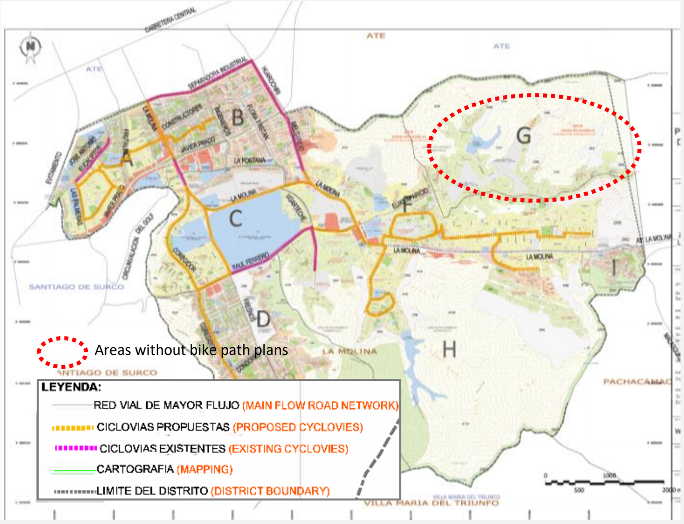


Fig.4.1.24. Public transport planning
Source: Ordinance that approves the La Molina District Urban Plan 2018 - 2028

(6) Issues

To reduce CO2 emissions, it is necessary to reduce emissions in the transportation sector, which currently accounts for about 50%. It is indispensable to switch from transportation means that emit a large amount of energy-derived CO2 such as private cars to low-carbon transportation.
To promote the conversion from automobiles, etc., it is necessary to promote the introduction of low-carbon public transportation such as BRT and metro and improve convenience. By shifting to public transportation, we can expect the effect of reducing CO2 emissions by curbing the use of automobiles and alleviating traffic congestion. The issues are organized below.

- **Promotion of the use of public transportation**

In Lima, the use of public transportation such as BRT and metro is increasing from conventional buses. It is important to select various means of transportation without excessively relying on private cars for transportation from the La Molina area to the city center and for commuting to work or school.

- **Low carbonization of transportation**

In the La Molina area, it is expected that car ownership will increase as the population grows. In addition, the population density is low, and there is a risk of increased dependence on automobiles. It is important to reduce carbon dioxide in transportation means such as automobiles with a large CO2 load.

- **Creating a comfortable user experience**

In the La Molina area, there are plans for bus and bicycle paths, as well as plans for Metro Line 4. On the other hand, there are traffic blank areas in the area where there are no plans for public transportation or bicycle paths. To promote the use of public transportation and reduce the carbon consumption of transportation means, it is important to improve the comfort and convenience of transportation within the La Molina area.

Task	Direction of measures
Promotion of use of public transportation	Improving convenience around stations and bus stops
	Improvement of convenience and operation efficiency by combining a trunk line with improved transportation capacity and speed and a branch line that covers the area in detail.
Low carbonization of transportation	Low carbonization of transportation
	Promotion of CO2 reduction by changing the usage of automobiles, etc.
Creating a comfortable user experience	Creating a safe and comfortable user experience in the transportaion

Specific measures

- Parking lot and bicycle parking lot maintenance (promotion of Park & Ride, cycle & Ride)
- Migratory bus excursion in the city (tour bus, demand bus, etc.)
- Promotion of bicycle path maintenance
- Promotion of sharing (cars, bicycles)
- Promotion of personal mobility (bicycle, electric kickboard, etc.) kickboard, etc.)
- EV conversion of vehicles (cars, buses, etc.)

4.2. Define CO2 emission baseline BAU scenario for target areas

4.2.1 Define BAU of CO2 emission baseline in Building sectors

(1) Calculation of CO2 reduction rate in a typical house in the residential area

In the table below are shown the calculation of CO2 reduction rate based on the countermeasure items for the building in a residential area. In the residential area are included buildings from the low, medium and high residential area. The contribution rate is calculated based on the CO2 emissions in the residential sector by sources and uses provided by the National Balance of Energy of Peru.

Table.4.2.1. Calculation of CO2 reduction rate in a typical house in the residential area

Countermeasure items for the building in residential area	CO2 reduction rate for each item	Contribution for each application	CO2 reduction
Building insulation	10%	10%	1%
Air-conditioning	20%		2%
Lighting	30%	3%	0.9%
Hot water supply	30%	5%	1.5%
Home appliances (electricity)	20%~60%	74%	14.8%~44.4%
Others	20%~50%	8%	1.6%~4.0%

Source: Projcet Team (NSRI)

(2) Calculation of energy consumption ratio in a typical building in the commercial area

Additionally, the CO2 reduction rate base on the countermeasure items for the building in the commercial sector is calculated. In the commercial sector are included commercial buildings, educational and hospitals. The contribution rate is calculated based on the CO2 emissions in the commercial sector by sources and uses provided by the National Balance of Energy of Peru.

Table.4.2.2. Calculation of CO2 reduction rate in a typical building in the commercial area

Countermeasure items for the building in commercial area	CO2 reduction rate for each item	Contribution for each application	CO2 reduction
Building insulation	10%	30%	3%
Air-conditioning	20%		6%
Lighting	30%	3%	0.9%
Hot water supply	30%	5%	1.5%
Home appliances (electricity)	20%~60%	54%	10.8%~32.4%
Others	20%~50%	8%	1.6%~4.0%

Source: Projcet Team (NSRI)

(3) Setting the CO2 reduction rate for each target case (BAU2030 and BAU2050) in the residential area

The table below is shown the CO2 reduction rate for each target case in the residential area. The countermeasure items from energy savings and energy generation from PV are represented for the low, medium and high residential areas.

Table.4.2.3. Setting the CO2 reduction rate for each target case in the residential area

Countermeasure items for residential buildings	2030	2050
Building insulation	1%	1%
Air-conditioning	2%	2%
Lighting	0.9%	0.9%
Hot water supply	1.5%	2.9%
Home appliances (electricity)	14.8%	17.8%
Others	1.6%	1.6%
AEMS	5%	10%
Total(1)	26.8%	36.2%
Energy Generation from PV, etc.	5%	15%
Total(2)	31.8%	51.2%

Source: Projcet Team (NSRI)

(4) Setting the CO2 reduction rate for each target case (BAU2030 and BAU2050) in the commercial area

The CO2 reduction rate for each target case in the commercial rate is calculated using the countermeasure items from energy savings and energy generation from PV for commercial buildings, educational buildings and hospitals.

Table.4.2.4. Setting the CO2 reduction rate for each target case in the commercial area

Countermeasure items for commercial buildings	2030	2050
Building insulation	3%	3%
Air-conditioning	6%	6%
Lighting	0.9%	0.9%
Hot water supply	1.5%	2.9%
Home appliances (electricity)	10.8%	17.8%
Others	1.6%	1.6%
AEMS	5%	10%
Total(1)	28.8%	42.2%
Energy Generation from PV, etc.	5%	15%
Total(2)	33.8%	57.2%

Source: Projcet Team (NSRI)

(5) The estimation of CO2 emissions in BAU scenario in 2021, 2030 and 2050

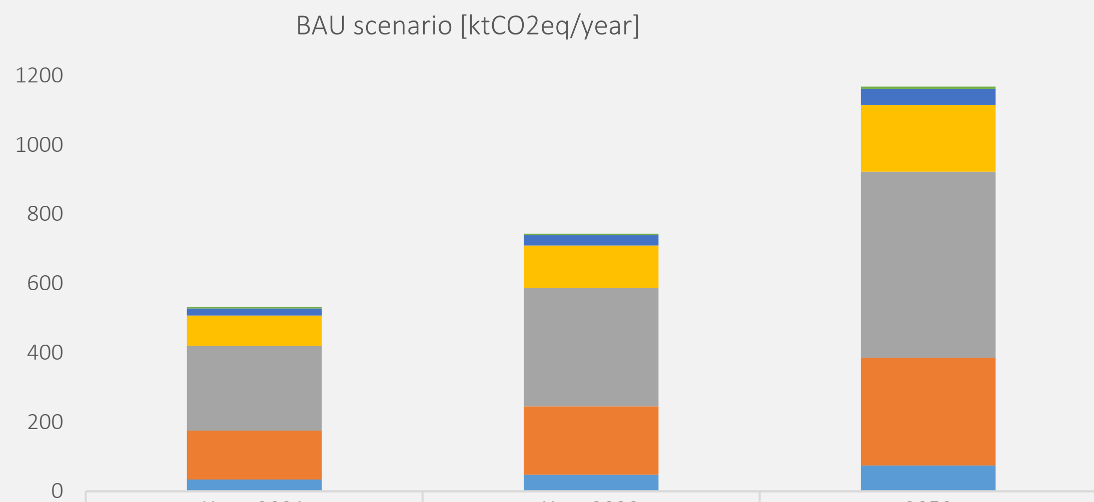
CO2 emission in 2021 in the building ＝
Electricity consumption by type of building × total area by type of building in La Molina × CO_2 emission factor for Peru

CO2 emission in 2030 and 2050 in the building ＝
Electricity consumption by type of building × total area by type of building in La Molina × CO_2 emission factor for Peru[1] × estimated coefficient trend for 2030 and 2050[2]

[1]Emission factor of Peru for 2017 (0.52144 tCO2eq / MWh)

[2] The estimated coefficient are calculate based on the future trend for the electricity consumption in Lima Callao.

The most up-to-date value of the Emission Factor of the Peruvian electricity grid and recommended by MINAM is the one calculated by the developer of the project 'Central Hidroeléctrica Poechos II', for the CDM (Clean Development Mechanism) validation of the same project, corresponding to the year 2017, which is the most updated, whose value is: 0.52144 tCO2eq / MWh.



	Year 2021	Year 2030	2050
Hospitals	3	4	7
Education area	21	29	46
Commercial	87	122	192
Medium residential	244	342	537
Low residential	141	198	311
Very Low residential	34	48	75

Low residential Medium residential Commercial Education area Hospitals

Fig. 4.2.1. The estimation of BAU scenario in 2021, 2030 and 2050
Source: Projcet Team (NSRI)

(6) The estimation of energy savings and CO_2 saving effects

Based on proposed measures in the next chapter 4.3.1, we have estimated the CO2 saving based on the secondary energy consumption, expressing the energy-saving amount as primary energy.

For the residential sector in La Molina, the estimation of the energy reduction rate is considered using the countermeasure items shown in the table below. This includes:

- Use of LED lighting
- Use of heat pumps for hot water supply,
- Improvement of heat insulation performance
- Shielding from solar radiation
- Improvement of home appliance efficiency
- Improvement of cooking appliances (electricity)
- Strengthening insulation of the building envelope and reducing internal heat generation
- Use of natural lighting and ventilation
- Transforms the energy from the sun into electricity using photovoltaics

For the buildings in the commercial, education and health sector the estimation of the energy reduction rate are considered using the countermeasure items shown below:

- Improvement of LED lighting
- Control the heat load through insulation, etc.,
- Actively use natural ventilation and lighting,
- Actively use natural heating
- Improve the efficiency of equipment systems,
- Improvement of energy efficiency
- Improvement of water pumping equipment
- Improvement of cooking appliances (for hospitals and hotels)
- Strengthening insulation of the building envelope and reducing internal heat generation
- Transforms the energy from the sun into electricity using photovoltaics
- Improvement the energy usage status of the target area, solar power generators, storage batteries, power supply facilities, etc., are managed
- Installation of a green roof

The detailed information regarding the implementation measures in La Molina could be found in the next chapter. The contribution for each application was calculated based on the estimation of CO2 emissions for each sector by source and uses in 4.2.5.

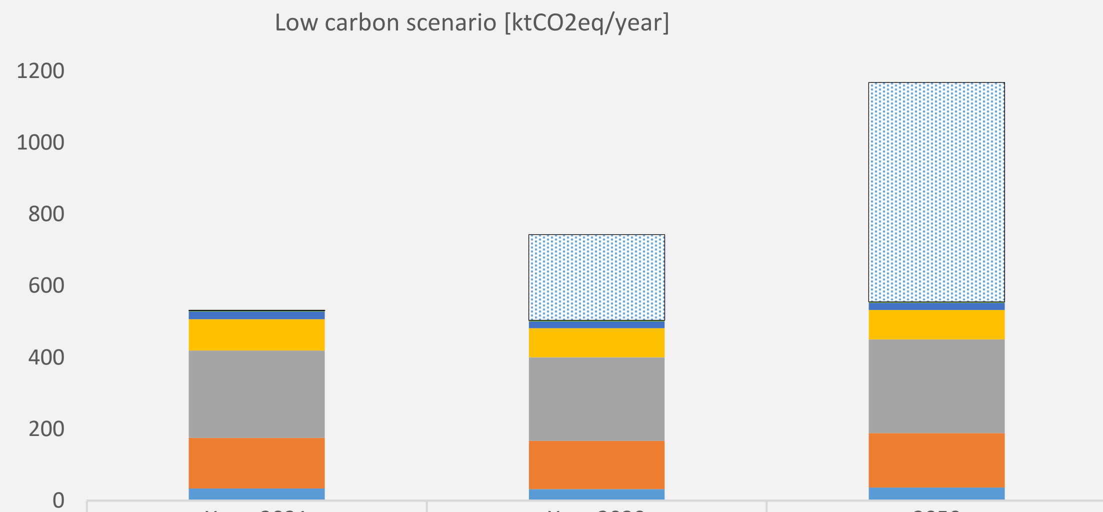
Table. 4.2.5. Countermeasure items in the building sector

Countermeasure items in the building sector	
Residential sector	**Commercial, education and health sector**
1. Promotion of ZEH	1. Promotion of ZEB
2. Passive design: Load control, Use of natural lighting and ventilation, Optimization of indoor environment	2. Passive design: Load control, Use of natural lighting and ventilation, Optimization of indoor environment
3. Active design: Higher efficiency of air conditioning and ventilation equipment, lighting equipment, hot water supply equipment, etc.	3. Active design: Higher efficiency of air conditioning and ventilation equipment, lighting equipment, hot water supply equipment, etc. Introduction of renewable energy: Photovoltaic power generation, wind power generation, etc.
4. Introduction of Home energy management system (HEMS)	4. Introduction of Area energy management system (AEMS)
5. Introducing the Untapped Energy and especially Geothermal cooling	5. Introducing the Untapped Energy and especially Geothermal cooling
6. Renewable Energy and especially solar rooftop and solar heating	6. Renewable Energy and especially solar rooftop, solar heating, urban photovoltaic system, etc.
7. Installation of green roof	7. Installation of green roof
8. Waste management and implementation of recycling program including Zero Waste Program	8. Waste management and implementation of bio-waste recycling system
9. Education program for residents	9. Education program for workers, officers, government, universities, etc.
10. Policy Framework that includes setting up the committee, goals and identify the problems in residential area La Molina District.	10. Policy Framework that includes the development and implementation of the policy for La Molina District.

Source: Project Team (NSRI)

The figure below shows the low carbon scenario in La Molina based on the building type in 2021, 2030 and 2050.

- The CO2 emissions in 2030 through the introduction of low-carbon methods in buildings are estimated to be reduced by around 32% or total up to 239 ktCO2eq/year respectively compared to BAU in 2030.
- In 2050, the CO2 emissions are estimated to be reduced by around 52% or total up to 613 ktCO2eq/year respectively compared to BAU in 2050.



	Year 2021	Year 2030	2050
Down from BAU	0	239	613
Hospitals	3	3	3
Education area	21	19	20
Commercial	87	81	82
Medium residential	244	233	262
Low residential	141	135	152
Very Low residential	34	33	37

Low residential Medium residential Commercial Education area Hospitals Down from BAU

Fig. 4.2.2. The estimation of low-carbon scenario in 2021, 2030 and 2050
Source: Projcet Team (NSRI)

The CO2 emission reduction shown in Figure 4.2.2 is contributed by energy conservation, energy generation from PV and other specific measures shown in Table 4.2.6. Note, in Table 4.2.6, the CO2 reduction volume is shown for 2050 in [tCO2].

Table. 4.2.6. CO2 reduction volume in 2050 [tCO2]

Item	Low carbon methods	CO2 reduction volume in 2050 [tCO2]
1	Others (Waste management and greenery measures)	168,000
2	High efficiency of appliances (residential and commercial)	163,925
3	High efficiency of cooking equipment (residential and commercial)	14,768
4	Lighting equipment (residential and commercial)	8,307
5	PV on residential buildings (50% coverage)	185,990
6	PV on commercial building (50% coverage)	40,133
7	Hot water supply (residential and commercial)	13,845
8	High efficiency of cooling equipment (residential and commercial)	9,230
9	Building insulation: Roof thermal barrier coating (residential and commercial)	4,615
10	Thermal insulation and solar radiation shielding (residential and commercial)	4,615

Source: Project Team (NSRI)

7) The timeframe of implementation for the CO2 reduction measures

To make rational planning of the proposed CO2 reductions methods in La Molina District, this FS proposed plan for the timeframe of implementation and level of achievement of the measures for each sector as shown below.

Table. 4.2.7. Timeframe for implementation in La Molina

Specific Target	CO2 Reduction Measures	Timeframe for the implementation
Buildings	1. Low carbon measure for business building 2. Low carbon measure for residential building	1~2. Short-term （~Y2025） (Home/office appliances and lighting) 2. Mid-term to Long-term （~Y2050） (insulation, etc.)
Transportation	1. Sharing Service 2. Elimination of traffic blank areas 3. Improving the convenience of public transportation 4. Promoting EV 5. Upgrading of bicycle lane	1. Short-term（~Y2025） 2. Short-term to medium-term（~Y2035） 3. Short-term to medium-term（~Y2035） 4. Mid-term to Long-term（~Y2050） 5. Short-term（~Y2025）
Untapped Energy	1. Introducing geothermal Heat pump 2.Retrofitting an existing landfill for biogas	1. Long term (Y2050) 2. Long term (Y2050)
Renewable Energy	1. Urban photovoltaics (UPV) 2.Solar Rooftop (PV) 3.Solar water heating system 4.Efficient (instantaneous) heaters 5. Offshore wind power	1~4. Mid-term to Long-term（~Y2050） 5. Long term (Y2050)
Greenery	1. Green roof as public space and garden 2. Green corridors	1~2. Mid-term to Long-term（~Y2050）
Waste Management	1. Solid waste management and bio-waste recycling system 2.Zero Waste concept and Eco recycling points	1. Mid-term to Long-term（~Y2050） 2. Short-term（~Y2025）
Policy Framework	1. Policies to Reduce Greenhouse Gas Emissions from the transportation sector 2. Policies to share the Renewable Energy 3. Policies tor improvement in energy efficiency 4. Policy Framework in Building Environmental Plan System 5. Policy Framework in Waste Management	1~5. Mid-term to Long-term（~Y2050） (depend on the City Master Plan& Market economy situation)
Education and Management	1. Collaborative program for low-carbon interventions 2. Trainings	1. Mid-term to Long-term（~Y2050） 2. Short-term to medium-term（~Y2030）

Source: Project Team (NSRI)

Table. 4.2.8. The level of achievement of the CO2 reduction measures in La Molina

Specific Target	CO2 Reduction Measures	The level of achievement
Buildings	1. Low carbon measure for business building 2. Low carbon measure for residential building	1. ~25%（Y2030）; ~35%（Y2050） 2. ~27%（Y2030）; ~40%（Y2050）
Transportation	1. Sharing Service 2. Elimination of traffic blank areas 3. Improving the convenience of public transportation 4. Promoting EV 5. Upgrading of bicycle lane	1. 80%（Y2030）; 100%（Y2050） 2. 50%（Y2030）; 70%（Y2050） 3. 50%（Y2030）; 70%（Y2050） 4. 5%（Y2030）; 20%（Y2050） 5. 80%（Y2030）; 100%（Y2050）
Untapped Energy	1. Introducing geothermal Heat pump 2.Retrofitting an existing landfill for biogas	1~2. ~15%（Y2050） The geothermal system could be installed in a several number of buildings.
Renewable Energy	1. Urban photovoltaics (UPV) 2.Solar Rooftop (PV) 3.Solar water heating system 4.Efficient (instantaneous) heaters 5. Offshore wind power	1~4. ~5%（Y2030）; ~15%（Y2050）※ 5. Offshore wind power is optional and depend on the purchase and sale of energy between generators and demanders (municipality of La Molina) that allows for bilateral contracts between both parties.
Greenery	1. Green roof as public space and garden 2. Green corridors	1~2. ~15%（Y2050）※ It depend on the green policy and future Master and eco-green plan of La Molina.
Waste Management	1. Solid waste management and bio-waste recycling system 2.Zero Waste concept and Eco recycling points	1~2. ~15%（Y2050）※ ※The current FS considers reduction in total of ~15%（Y2050）based on greenery, PV and waste management interventions.
Policy Framework	1. Policies to Reduce Greenhouse Gas Emissions from the transportation sector 2. Policies to share the Renewable Energy 3. Policies tor improvement in energy efficiency 4. Policy Framework in Building Environmental Plan System 5. Policy Framework in Waste Management	1~5. The level of the achievement depends on the building and transportation sector, implemented measures of renewable energy and waste management. Refer to the above sectors of each level of the achievement.
Education and Management	1. Collaborative program for low-carbon interventions 2. Trainings	Refer to building, transport, greenery and waste management sector.

Source: Project Team (NSRI)

4.2.2 Define BAU of CO2 emission baseline in Transport sectors

CO2 in the traffic field is mainly emitted by private automobiles. One reason for this is because, as compared with public transportation such as railways and buses, automobiles emit a large amount of CO2 per person. To reduce CO2, it is effective to control the traffic volume of automobiles, use forms of public transportation with less CO2 emissions, reduce travel distance and reduce the amount of CO2 emitted by each car. In addition, it is effective to change bus transportation, which is the main form of public transportation, to vehicles with low CO2 emissions, and to reduce the amount of CO2 emitted by each bus.

To calculate the CO2 emissions for transportation, multiply the person trip in each modal share and Travel distance. To that value, the CO2 emission indicator is integrated to calculate the CO2 emissions of the car.

CO2 emission ＝ Fuel consumption (l/day)×Unit colorimic value factor(GJ/kl)

×CO2 emission factor(tC/GJ)×44/12

Fuel consumption （l/day） =Number of vehicles(unit)×Number of trip per day(trip/day)

× Operation Rate(%)×Number of trip per opereted uite （trip/unit)

×Trip length per trip(km/trip/day)/Fuel Economy(Km/l)

The CO2 emission estimation flow related to cities and transportation are shown below.

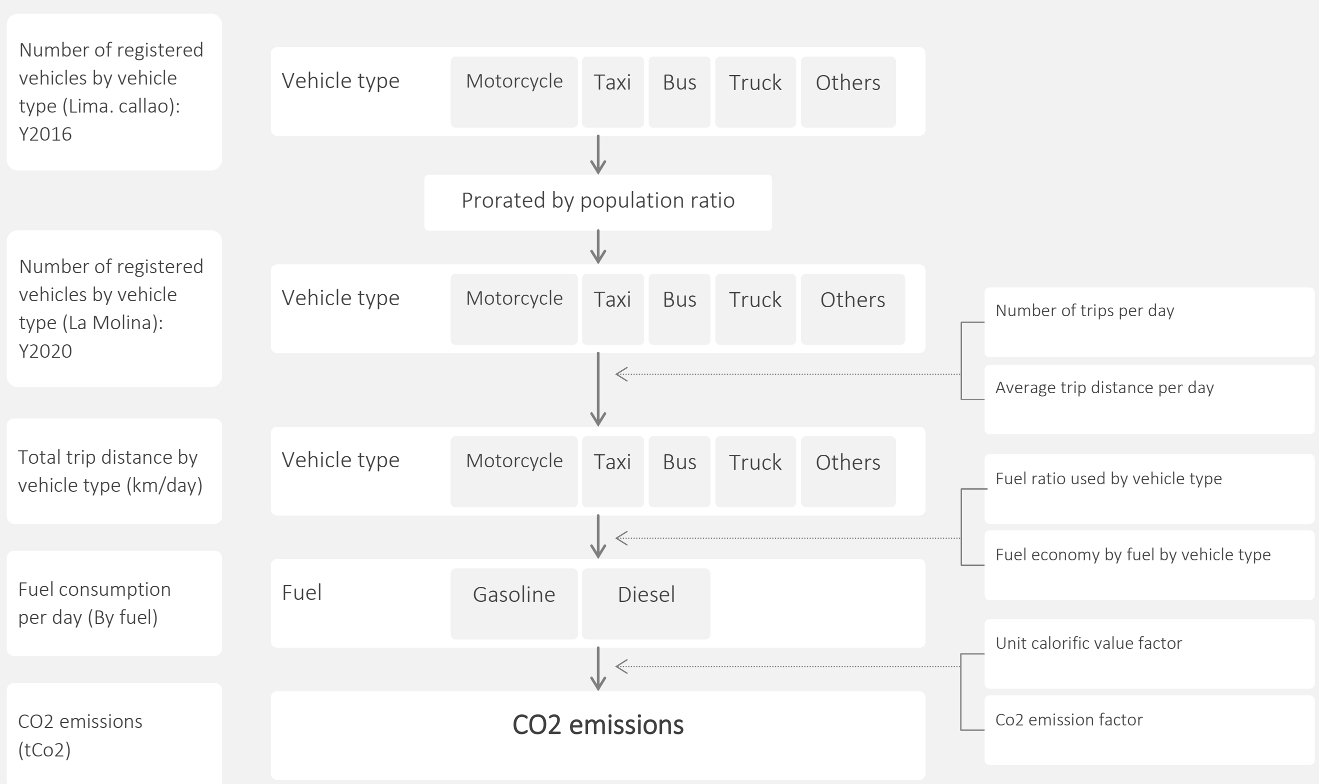


Fig. 4.2.3. City / Transportation-related CO2 Emission Estimate Flow
Source: Project Team (NSRI)

1) Details of future estimates

The number of vehicles by fuel in the base year (2020) in La Molina is shown below. is as follows. The number of vehicles was allocated according to the population ratio from the number of vehicles by vehicle type in Lima and Callao. As for fuel by vehicle type, it is assumed that half of the automobiles and 20% of other vehicles are diesel vehicles.

Table. 4.2.9. Number of vehicles by vehicle type and fuel (2020)

Type of Vehicle	Total	Fuel	
		Gasoline	Diesel
Car	13,294	10,635	2,659
Taxi	2,260	1,130	1,130
Bus	9,147	5,939	3,208
Truck	2,364	1,182	1,182
Others	473	378	95
Total	27,538	19,264	8,274

Source: Project team (NSRI)

The total trip length is shown below. Japanese values have been set for the operation rate, the number of trips per unit of operation, and the distance per trip.

Table. 4.2.10. Total trip length (km/day)

Type of Vehicle	(a) Number of vhicle	In/**Out** from other area ratio	(b)Operation Rate (%)	(c)Number of trip per opereted uite (trip/unit)	(d)Trip length per trip (km/trip/day)	(e)Total trip length (km/day) (Product of (a) to (d))
Car	13,294	2.00	60%	3.21	12.59	644,034
Taxi	2,260	1.20	60%	3.21	12.59	65,692
Bus	9,147	1.20	86%	3.12	11.50	339,437
Truck	2,364	2.00	55%	6.17	14.67	236,857
Others	473	1.00	28%	3.09	7.33	2,962
Total	27,538		—	—	—	1,288,983

Source: Project Team (NSRI)

Table. 4.2.11. Total trip length by Fuel type (km/day)

Type of Vehicle	Total	Fuel	
		Gasoline	Diesel
Car	644,034	515,218	128,817
Taxi	65,692	32,846	32,846
Bus	339,437	220,391	119,046
Truck	236,857	118,429	118,429
Others	2,962	2,367	595
Total	1,288,983	889,251	399,733

Source: Project Team (NSRI)

The daily fuel consumption was calculated from the trip length and fuel consumption by vehicle type, and the CO2 emissions were calculated by multiplying the basic unit. The Unit calorific value factor and Co2 emission factor were set from the Japanese value.

Table. 4.2.12. Fuel Economy (km/ l)

Type of Vehicle	Gasoline	Diesel
Car	15.8	15.8
Taxi	15.8	15.8
Bus	5.7	5.7
Truck	7.24	7.2
Others	2.01	2.01

Source: Project team (NSRI)

Table. 4.2.11. Total Fuel Consumption by Fuel Type Economy (l/ day)

Type of Vehicle	Gasoline	Diesel
Car	32.6	8.2
Taxi	2.1	2.1
Bus	38.7	20.9
Truck	16.4	16.4
Others	1.2	0.3

Source: Project Team (NSRI)

Table. 4.2.13. CO2emission (tCO2/Year)

Fuel Consumption	Gasoline	Diesel	Total
(a)Unit calorific value factor(GJ/kl)	34.6	37.7	-
(b)Co2 emission factor(tC/GJ)	0.0183	0.0187	-
(c)Co2 emission(tCO2/day)	211	124	335
(d)Co2 emission(1000tCO2/Year) (d)=(a)x(b) x(c) x44/12	**77**	**45**	**122**

Source: Project Teams (NSRI)

The calculation result of BAU in the transportation field in La Molina is shown. To calculate the BAU, the number of registered vehicles by vehicle type in 2030 and 2050 was assumed according to the rate of population growth. Annual CO2 emissions in the current situation in La Molina are approximately 183,000t-CO2. It is expected to increase by about 8% by 2030 and by about 18% by 2050.

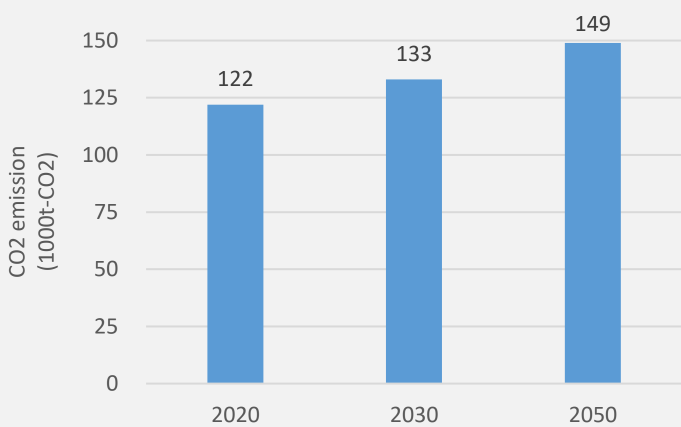


Fig.4.2.4. BAU
Source:Project Team (NSRI)

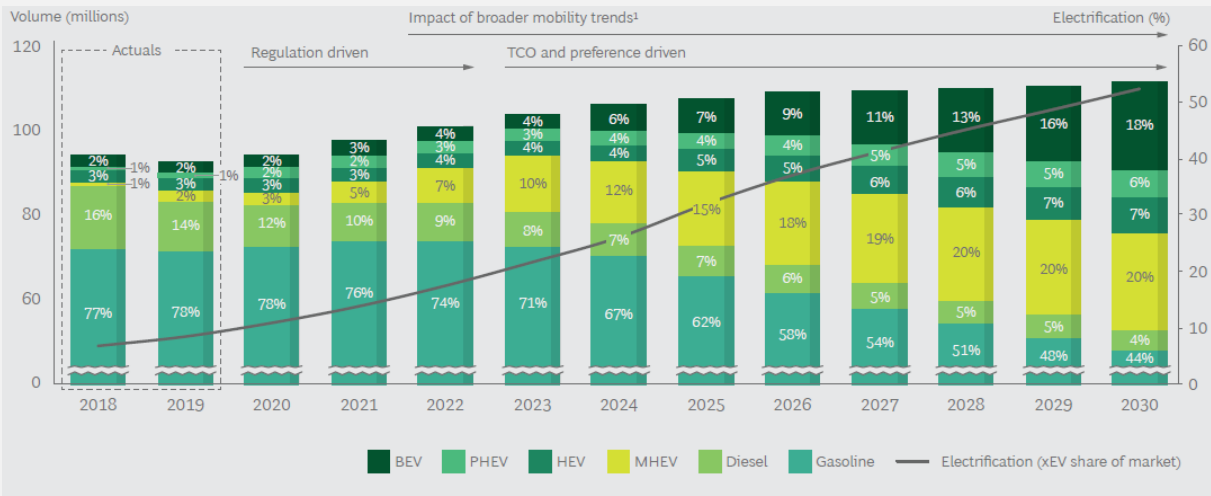
2) CO2 reduction scenario

The CO2 reduction scenario will be based on the promotion of the introduction of EVs, the shift from automobiles to public transportation, and the promotion of bicycle use.

(1) Setting up the introduction of EVs

In Peru, the Ministry of Energy and Mines (MINEM) issued Presidential Decree No. 022-2020-EM in July 2020. This established the rules for the development of domestic infrastructure for the supply and charging of EVs. The Peruvian government has set a goal of increasing the percentage of electric vehicles in the economy's regular passenger cars, buses, and other transportation to 5% by 2030. This regulation is a part of the accompanying legislation. Legislation is currently in place for the widespread use of most electric vehicles (EVs).

On the other hand, the global EV penetration rate has been predicted by various research institutes to be around 20% by 2030. Taking into account the fact that almost no EVs have been introduced at present, we have assumed that the adoption of EVs will be 5% by 2030 and 20% by 2050.



Source: BCG analysis.
Note: BEV = battery electric; PHEV = plug-in hybrid electric; HEV = full hybrid electric; MHEV = mild hybrid electric. Because of rounding, the percentage total for a particular year may not equal 100%.
¹Including such changes in consumer mobility behavior as car and ride sharing.

Fig.4.2.5. Global Car Sales Through 2030 by Powertrain Type
Source: Who Will Drive Electric Cars to the Tipping Point? (Boston Consulting Group)

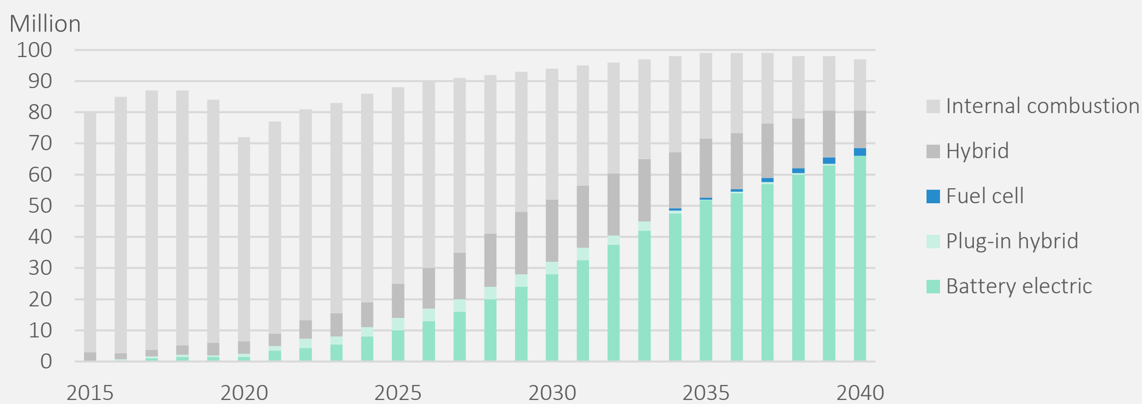


Fig.4.2.6. Global passenger vehicle sales outlook by drivetrain-Economic Transltion Scenario
Source:Electric Vehicle Outlook 2021(Bloomberg NEF)

The emission factor for electric vehicles is set at 0.092 kg-Co2/km, referring to the data for Japanese vehicles.

Typical car	CO2 emissions per unit distance traveled (kg-CO2/km)
Demio EV	0.88
LEAF	0.093～0.095

Fig.4.2.5. CO2 emissions per unit distance traveled
Source: Hiroshima City Government report

(2) Promoting the shift from automobiles to public transportation and the use of bicycles

We have assumed that the conversion from automobiles to public transportation and bicycles will reduce the distance traveled by automobiles and that the trip length of automobiles will be reduced by 10% in 2030 and by 20% in 2050.

(3) Reduction effect

By implementing the reduction effect, it is expected to reduce to 178,000 t-CO 2 (20% reduction) by 2050.

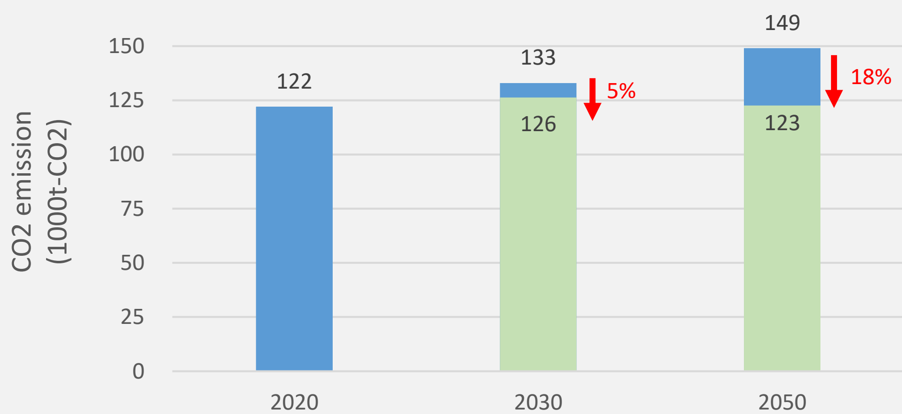


Fig.4.2.7. CO2 reduction scenario
Source:Project Team (NSRI)

4.3. Low Carbon measures for target areas

4.3.1 Concept and basic approach

This section shows the concept of low carbonisation in the La Molina District. This study considers the improvement of the low-carbon development regarding the buildings, transportation, Untapped Energy & Renewable Energy, Greenery, Waste Management, Policy Framework, and Education and management. (Figure 4.3.1).

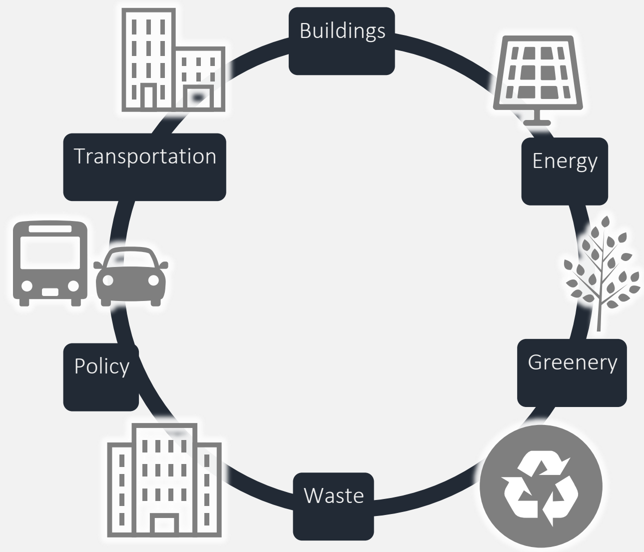


Fig. 4.3.1. Target area and concepts for improvement of low-carbon development in La Molina
Source: Project Team (NSRI)

A more specific explanation regarding the intervention for each sector is shown as below:

- Buildings: Zero Energy Housing (ZEH), passive and active design, energy management, Area energy management system (AEMS), Home Energy Management System (HEMS)
- Transportation: Sharing Service, Elimination of traffic blank areas (Demand traffic system), Improving the convenience of public transportation (extend bus route, Enhancement of transfer base), Promoting EV, Upgrading of bicycle lane
- Untapped Energy & Renewable Energy: promotion of low carbonization in facilities, use of solar urban photovoltaics, solar roofing, wind power generation, Insulation, solar hot water supply equipment, the electricity of hot water supply, etc.
- Greenery: promotion of the green roof, green corridors, and tree planting in La Molina, etc.
- Waste management: here the interventions include solid waste management (organic and non-organic), promoting the bio-waste recycling system, and recycling.
- Governance: A policy framework
- Education and management: including capacity buildings and awareness

4.3.2 Buildings

1)Promotion of ZEH in La Molina

A Zero-emission house (ZEH) is a house with an annual net energy consumption around zero (or less) by saving as much energy as possible while maintaining a comfortable living environment. This can be achieved through better heat insulation, high-efficiency equipment, and creating energy with photovoltaic power generation.

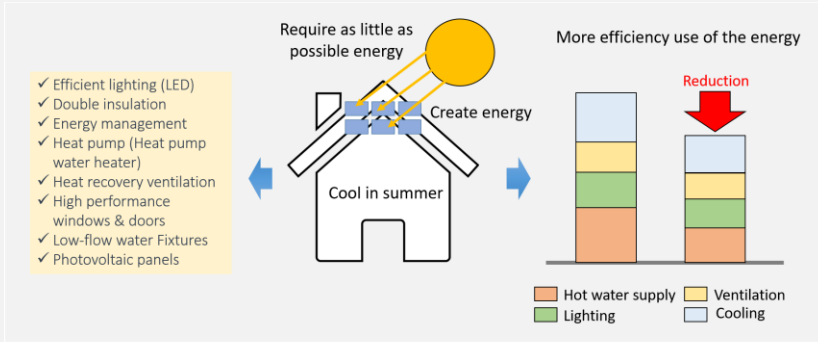


Fig. 4.3.2. ZEH in La Molina
Source: NSRI correction based on the materials of the Agency for Natural Resources and Energy

In La Molina, it is important to improve the efficiency of air-conditioning, ventilation, lighting, and hot water supply equipment to effectively use energy while realizing the "high insulation standard" of the ZEH and maintaining comfortable living spaces. The ZEH standard requires energy savings of more than 20% higher than the Energy Saving Standard via better insulation of the building envelope and higher equipment performance.

(1) Evaluation of ZEH

Using an energy balance of normalized energy supply (G*) and normalized energy demand (C*) which is converted into a non-dimensional numeric as annual primary energy consumption of a reference building. The energy performance evaluation and labeling are as follows;

G* : Normalized Energy Generation = (Energy generation of target building) / (Energy consumption of reference building)

C* : Normalized Energy Consumption = (Energy consumption of target building) / (Energy consumption of reference building)

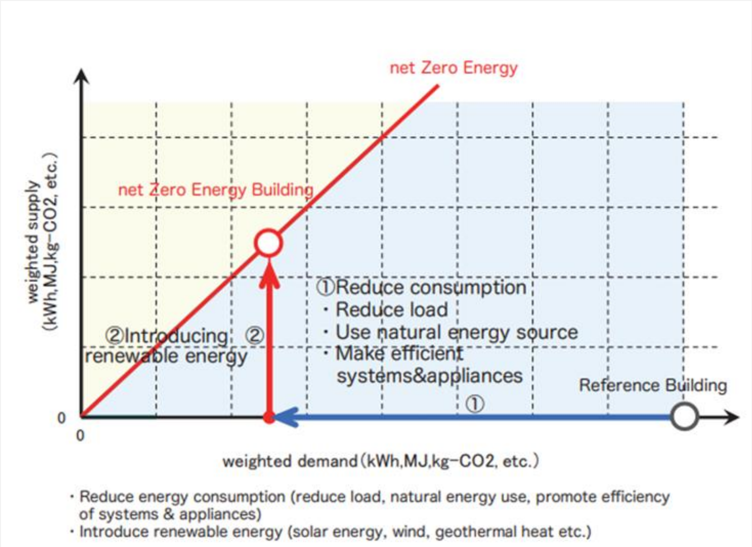


Fig. 4.3.3. Evaluation of ZEH for improvement of low-carbon development in La Molina
Source: METI

(2) Implementation of ZEH

The implementation of ZEH in La Molina is considered for

1. "Newly-constructed detached houses" in La Molina. For example, potential places could be El Sol de la Molina, Las Laderas de la Molina, Los Huertos de la Molina, etc.

2. Evaluation during the "design phase".

3. Although it is important to improve the energy-saving performance of housing complexes (including apartments), achieving the ZEH status is more difficult due to the limited roof area compared to consumption.

2)Promotion of ZEB in La Molina

Zero energy buildings (ZEB) combine energy efficiency and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources over a specific period. That is, reducing the load due to the improvement of 1) skin performance, 2) by performing the high efficiency performing equipment systems that aim to realize energy saving of 50% or more. And 3) introducing renewable energy, will enhance the independence of the building from the outside in La Molina District.

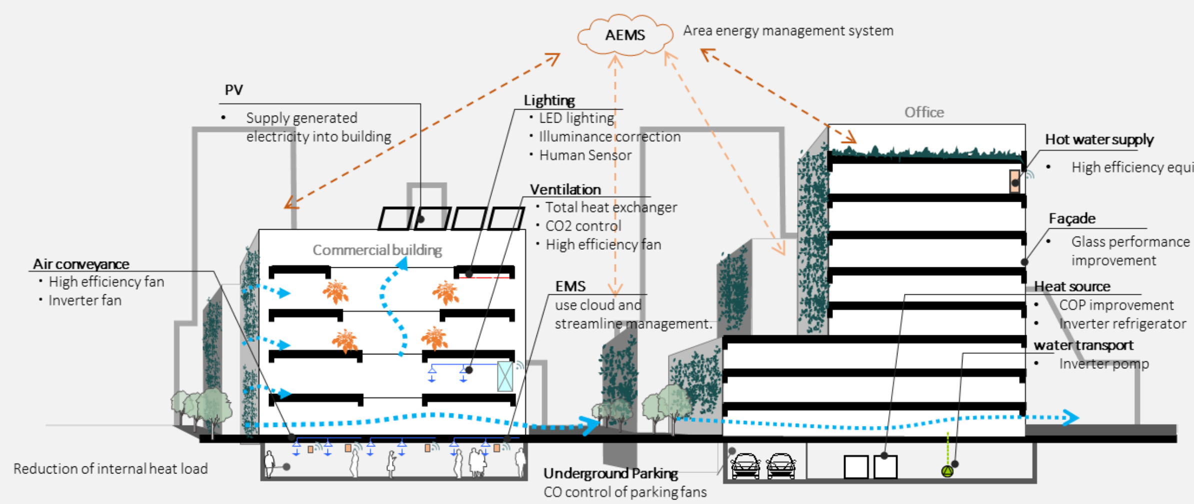


Fig. 4.3.4. ZEB in La Molina
Source: Project Team (NSRI)

3) Passive Design

The passive design utilizes natural sources of heating and cooling, such as the sun and cooling breezes. It is achieved by appropriately orientating the building on its site and carefully designing the building envelope (roof, walls, windows and floors of a home).

Regarding houses and buildings in La Molina should be considered follows:

1. Appropriate surrounding environment: Appropriate building layout and construction planning, and appropriate exterior planning

2. Load control: Strengthening insulation of the building envelope and reducing internal heat generation

3. Use of natural energy: Use of natural lighting and ventilation

4. Optimization of indoor environment: Optimization of thermal environment, air quality environment, and light environment

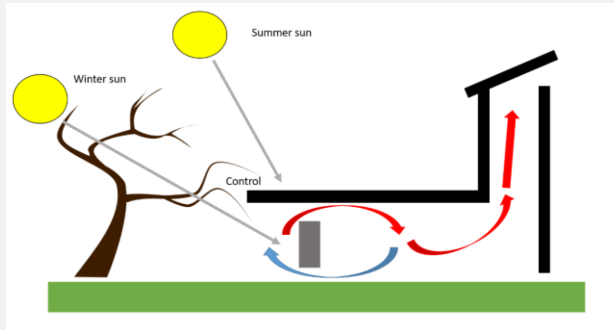


Fig. 4.3.5. Passive design
Source: Project Team and The Designing Buildings

Relatively straightforward design solutions such as brise soleil can be used to allow the low-level sun to enter a building, but to shade higher, summer sun. Other solutions, such as planting deciduous trees in front of windows can be effective as leaf cover in the summer will shade glazing from solar radiation (Figure 4.3.5).

4) Active Design

Active designs use equipment that modifies the state of the building, creating energy and comfort. In addition to introducing high-efficiency equipment systems, consider using untapped energy (e.g., temperature difference energy from groundwater and river water), minimize energy consumption, and introduce renewable energy.

1. Higher efficiency of facilities and systems: Higher efficiency of air conditioning and ventilation equipment, lighting equipment, hot water supply equipment, etc.

2. Introduction of renewable energy: Photovoltaic power generation, wind power generation, etc.

5) Energy management

In addition, lifecycle energy management throughout the life of the building is necessary to ensure that a net-zero energy building can be operated properly for many years. For energy management, it is necessary using of BEMS (Building Energy Management System), implementation of lifecycle energy management, visualization, etc.

(1) Key elements for low carbon residential building

Table. 4.3.1. Key elements for low carbon residential buildings

Environment	Use of natural energy	Thermal insulation of building envelope	Energy-saving equipment
Thermal environment	Solar water heating	Improved thermal insulation & solar radiation shielding	Cooling system planning
Air environment	Natural ventilation		
Light environment	Daylight use & solar power generation		Lighting equipment planning
Others			High-efficiency appliance & heat pump hot water systems

Source: Project Team (NSRI)

(2) Area energy management system (AEMS)

Conventional energy-management was carried out on a facility-by-facility basis, but with AEMS, the energy usage status of the entire area, solar power generators, storage batteries, power supply facilities, etc., are managed in an integrated manner to predict the power demand of each facility and carry out optimal operation and control of the community's energy. The system will achieve power peak shaving by integrating power between facilities with different power demand peaks, such as offices and commercial facilities, and will contribute to lowering electricity rates and lowering the carbon footprint of the entire region by reducing the amount of contracted power.

Solar power generation, which fluctuates depending on weather conditions, will be combined with storage batteries and controlled by AEMS to ensure the stable operation of renewable energy. In the unlikely event of a large-scale power outage, the energy owned by the entire community will be systematically transferred to each facility to maintain lifeline facilities for business continuity and daily life, and at the same time, emergency information such as evacuation guidance will be transmitted to support the safety and security of the town. In the event of a power outage, the electric vehicle batteries will be effectively used as an emergency power source for the town, thus contributing to the community disaster prevention plan.

Fig. 4.3.6. La Molina District Energy Management
Source: Project Team (NSRI)

The figure below shows the Energy management system in by facility, traffic and all. The facility could be included in residential, office, shopping center, hotels in La Molina as well as in the La Molina Municipality Governmental Building. Regarding the traffic are shown private cars, motorcycles, taxis, buses, and others. The system could represent the CO2 emission report of power generation showing also the weather conditions.

(3) Home Energy Management System (HEMS)

HEMS makes it possible to "visualize" energy usage by connecting electrical appliances at home, and to control each device to automatically control energy, making power saving comfortable. For example, it is possible to get a detailed numerical grasp of how many watts of energy are generated by solar power generation and how much energy is stored by storage batteries, and how many watts are consumed by the air conditioner in the bedroom and the lighting in the living room.

The benefits of HEMS are:

1. Understand the waste of electricity
2. Understand the tendency of electricity usage
3. Easy to set numerical targets for power saving
4. Saves on electricity bills
5. A more comfortable living environment can be realized

The figure below shows the HEMS in La Molina. On the TOP screen are shown the consumption, machine control and indoor condition of the system that include Sales, Battery, and PV. The three screens on the bottom show in detail the conditions for the specific room or area of the house or building.

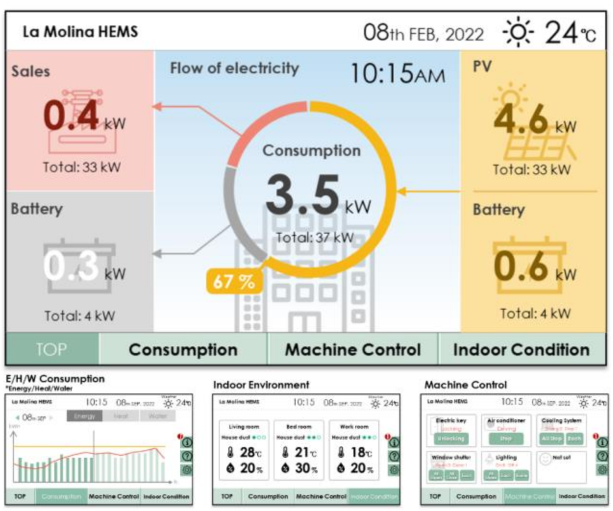


Fig. 4.3.7. La Molina HEMS
Source: Project Team (NSRI)

4.3.3 Transportation

1) Sharing Service

We propose to promote the introduction of sharing services (Shared bus, Car sharing, Share cycle) in order to secure transportation in the La Molina area. In particular, the share cycle is effective in reducing carbon dioxide emissions and can be expected to reduce congestion caused by vehicles. The share cycle is highly convenient because bicycle parking spaces called ports for renting and returning are set up in various places in the area. Another major feature is that it can be returned to a port different from the lending port. It is also effective as a means of transportation that bears the end of public transportation.

Picture. 4.3.8. Bike Shring (Left), Sharing port map (Right)
Source: NTT Docomo

2) Elimination of traffic blank areas (Demand traffic system)

Based on future public transportation plans, the central and northeastern parts of the La Molina area are considered to be areas where public transportation is inconvenient (traffic blank areas). We propose the introduction of a demand-responsive transportation system in order to eliminate this traffic gap area. A demand-responsive transportation system is a form of public transportation that flexibly operates according to the needs of users such as telephone reservations. It is a transportation service that takes you to a designated place at a designated time by making a reservation, instead of going around a fixed stop at a predetermined time zone like a bus or train. It is a means that can be expected to reduce CO2 emissions by reducing the use of automobiles and taxis, and also contributes to the reduction of traffic accidents by reducing the number of vehicles.

There are various types of operation in the demand-responsive transportation system, such as the following, and it is possible to select a type that is easy for residents to use.

・The same method as fixed-diagram type buses and trains with fixed-time fixed-route type
・A method of going around the patrol route with a non-fixed watermark
・The watermark is fixed, but it is a method of going around the free route and stopping at the place where the reservation is made
・Free-route door-to-door type, non-fixed diamond system

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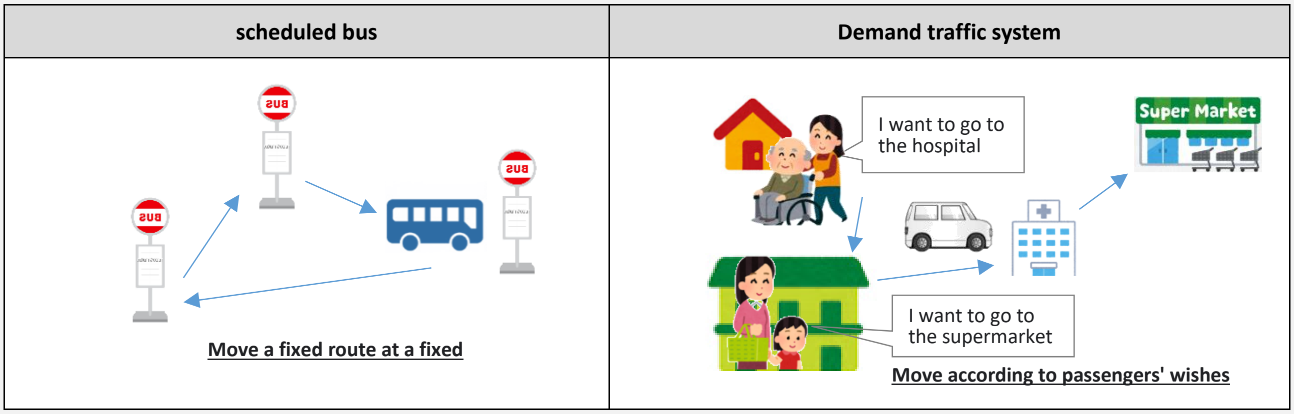
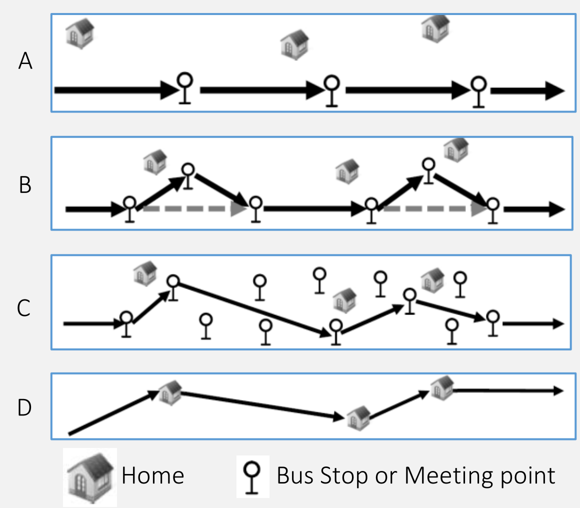


Fig. 4.3.9. On-demand transportation system
Source: NSRI

There are various types of operation in the demand traffic system such as the following, and it would be selected based on the public transportation passengers demand, characteristic of area (population density, location of facilities,etc.) in the target area.



	Type	Ride on/off point	Service route	Number of bus in service
A	Fixed Route Type	Fixed	Fixed	Depend on reservation
B	Area Demand Type	Part of fixed	Part of fixed	Depend on reservation
C	Meeting Point &Free Route Type	Choice a meeting points	Free	Depend on reservation
D	Door to Door Type	In front of a home	Free	Depend on reservation

Fig. 4.3.10. Demand traffic system
Source: Project Team

3) Improving the convenience of public transportation (extend bus route, Enhancement of transfer base)

Creating a comfortable mobile environment by combining personal mobility and public transportation. By developing parking lots and bicycle parking lots at locations that will serve as transportation hubs, we will promote the conversion to public transportation that emits less carbon dioxide. Figure 4.3.11 shows the possible locations of transportation hubs in the La Molina District.

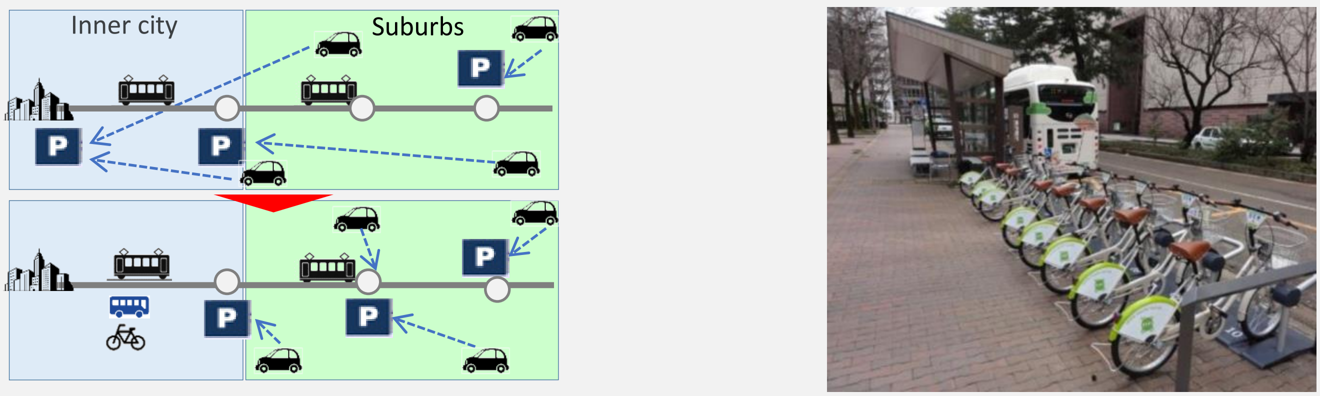


Fig. 4.3.11. park and ride image (Left), cycle and ride (Kanazawa city, Japan)(Right)
Source: Nagoya city, Japan, Ministry of Land, Infrastructure, Transport and Tourism,Japan

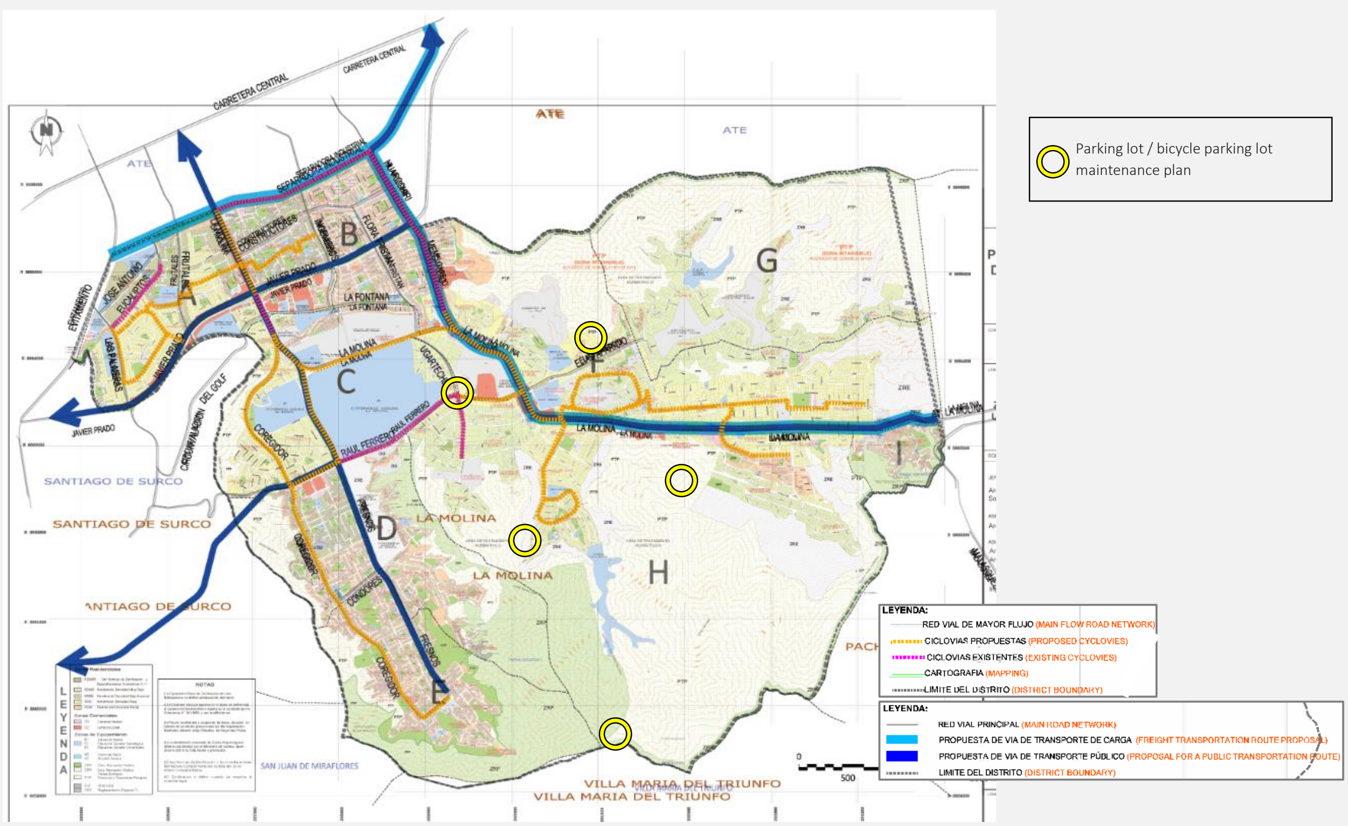


Fig.4.3.12. Parking lot / bicycle parking lot maintenance plan
Source: Order issued in the Urban District Plan of La Molina 2018 - 2028

Carbon emission shall be reduced by replacing private cars, taxis, Bus cars currently in use with EVs and low-carbon vehicles. To popularize eco-friendly vehicles, it is necessary to take various measures such as introducing subsidies.

Picture 4.3.13. EV Car Sharing (Times Car Plus × Ha:mo)
Source: Yualog

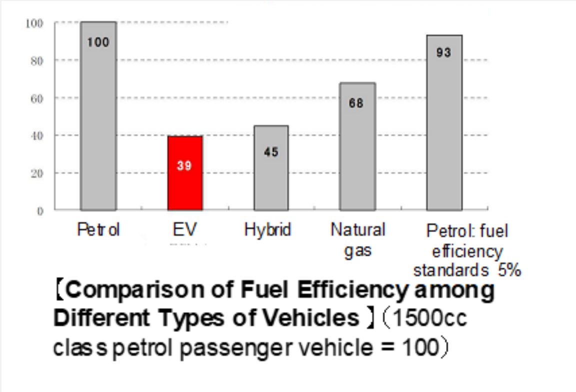


Fig. 4.3.14. Comparison of fuel efficiency by fuel type
Source: MLIT of Japan

5) Upgrading of bicycle lane

Promote the development of bicycle paths on highways in the La Molina area. Promote the use of bicycles by improving the comfort and safety of bicycle paths.

A use of small-size private motilities (PM) shall be introduced for short-distance movements such as from a station to own house, shop.

Picture 4.3.15. Bicycle lane (Lima city) (Left)
Source: Project Team

Picture 4.3.16. .TOYOTA i-ROAD (Left), cycle and ride (Japan)(Right)
Source: TOYOTA (Left),

4.3.4 Untapped Energy

1) Geothermal cooling

Ground source heat pumps (GSHPs) are known as highly efficient systems which transfer the heat between the indoors and subsurface by using a heat exchanger embedded in the subsurface (i.e., ground heat exchanger). For La Molina District is recommended GSHP cooling mode according to the climate and weather condition especially in the residential area. The advantages of geothermal systems can be categorized to their efficiency, reliability, safety, flexibility, convenience, renewable energy advantages, and financial advantages.

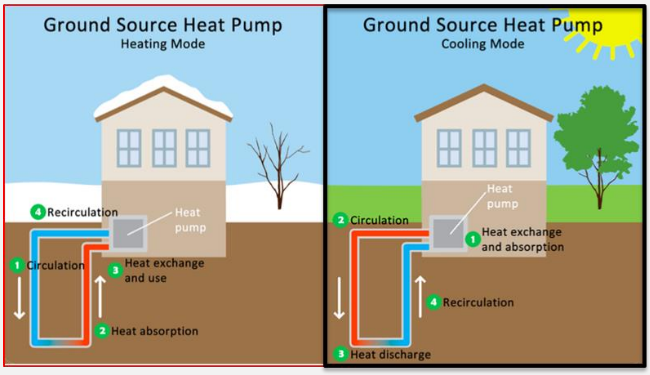


Fig. 4.3.17. Geothermal cooling in La Molina
Source: Electrek

4.3.5 Renewable Energy

1) Urban photovoltaics (UPV)

Urban photovoltaics (UPV) uses sealed areas in cities, towns and villages to generate electricity from renewable sources and to create attractive urban landscapes.

Picture 4.3.18. Charging station
Source: Solar Urban, Delft University of Technology, Netherland

In La Molina UPV could be used in parking lots, public squares, or sport and recreation areas, where photovoltaics is installed in combination with shading elements, light sources, charging infrastructure for electromobility or rain shelters. For example, Cementerio Jardines de La Paz, which is park area in La Molina, Central Plaza, Kasba - Rinconada del Lago Park, etc. This adds value to the spaces for users and allows them to experience the energy transformation positively. A further example is the combination of photovoltaics with lighting, shading and rain protection in a central omnibus station or over the parking areas of trade exhibition grounds. Along the roadside, PV systems can serve as advertising boards or be integrated with WiFi, 5G mobile network or monitoring functions. UPV installations must meet high expectations on design and functionality and thus usually demand individual solutions.

The below picture shows an on-campus charging station at the Delft University of Technology, Netherland. They recently developed and realized an e-bike charging station that solely uses solar energy. The charging station has eight solar panels with a total peak power of 2.3 kilowatts and features a 10-kWh storage unit for cloudy days. During summer, the station will deliver its excess power to the grid. The solar charging station has connections for four e-bikes or e-scooters with three different connections: 48-volt DC, 230-volt AC, or a wireless connection through the e-bike’s kickstand which functions as an antenna. The station also has a weather station to monitor the outside climate as well as temperature sensors to monitor the temperature levels of the solar panels.

2) Solar Rooftop (PV)

Photovoltaic systems (PV systems) are renewable energy technology that transforms the energy from the sun into electricity using photovoltaics. These photovoltaics, also known as solar panels, provide a reliable green energy solution. A solar PV system is a sustainable, low-maintenance option for anyone who wants to contribute to a greener environment, as the system does not cause any pollution or emissions and has numerous advantages.

Photovoltaic systems use photovoltaic cells to collect solar energy from the sunlight and convert it into direct current (DC) electricity. The reflection of the sunlight will create an electric field across photovoltaic systems, causing electricity to flow. The DC electricity will be transported to an inverter, which will convert this DC power into alternating current (AC). This AC power is the type of electricity that is used for the electric appliances in your home, also referred to as AC load.

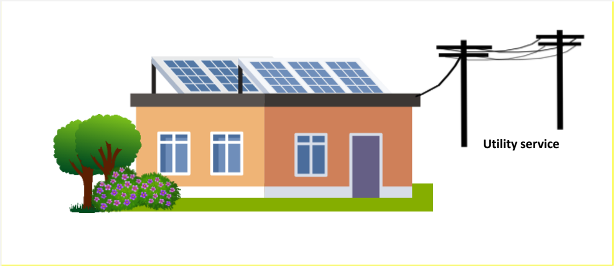


Fig. 4.3.19. Solar Rooftop PV
Source: Project Team

A photovoltaic system, also a PV system or solar power system, is a power system designed to supply usable solar power using photovoltaics. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to convert the output from direct to alternating current, as well as mounting, cabling, and other electrical accessories to set up a working system. It may also use a solar tracking system to improve the system's overall performance and include an integrated battery solution, as prices for storage devices are expected to decline.

The FS is took into consideration the type of roof of the current and future potential buildings and typical architecture in La Molina. It is considered that in the residential area more than 50% of the detached houses and residential buildings are able for installation of the PV system as well as the governmental, hotels, and commercial buildings.

3) Solar water heating system

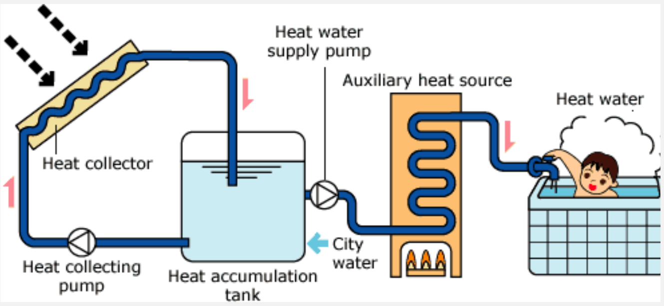


Fig. 4.3.20. Solar water heating system
Source: Global Energy Network Institute

Solar water heating systems can be used to provide space heating in addition to domestic hot water. For example, the Japanese solar thermal program is focused on active solar thermal processes. The active solar thermal program is focused on the development of systems that are capable of using solar energy to provide either heating or cooling applications for use in areas of high insulation (e.g., work is underway on a solar freezing/refrigerating system that would provide cooling to -10 °C for use in desert areas).

Solar heat equipment has a higher energy exchange ratio and has better cost-effectiveness with relatively lower prices among other new Energy sources.

In La Molina, as have mentioned in the PV section, it is taken into consideration the type of roof of the current and future potential buildings and typical architecture. It is considered that in the residential area more than 50% of the detached houses and residential buildings are able for installation of the PV system including the solar water heating system. Moreover, the climate conditions are excellent because of the numerous sunny days with hot wheater during the year.

4) Offshore wind power

Along the Lima coastline, the implementation of offshore wind power could produce the clean and renewable energy obtained by taking advantage of the force of the wind that is produced on the high seas, where it reaches a higher and more constant speed than on land due to the absence of barriers. Offshore wind energy benefits are:

1) provide renewable energy;

2) do not consume water;

3) provide a domestic energy source;

4) create jobs;

5) do not emit environmental pollutants or greenhouse gases.

In order to implement this measure, it is necessary to purchase and sale of energy between generators and demanders (municipality of La Molina) that allow for bilateral contracts between both parties.

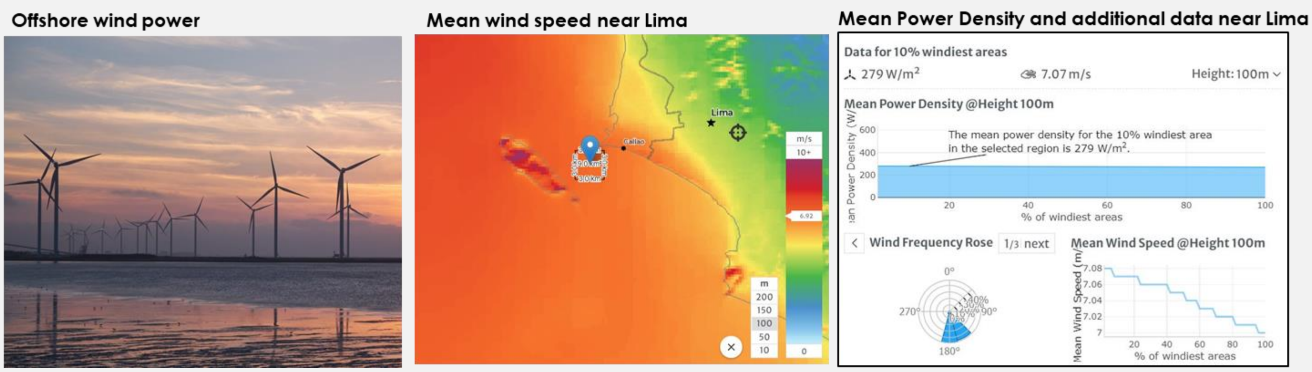


Fig. 4.3.21. Offshore wind power
Source: Energia Estrategica and Global Wind Atlas

4.3.6 Greenery

1) Green roof

Table. 4.3.2. Comparison of various green roofs

CRITERIA	Extensive green roofs	Semi-extensive green roofs	Intensive green roofs (roof garden)
Load-bearing component	CONCRETE WOOD TANBARK	CONCRETE	CONCRETE Maximum pitch 5%
Plant choice	Sedums, mosses, perennials	Perennials, smalll shrubs, lawns	Shrubs, trees, lawns
Thickness of growing medium	4 to 15 cm	12 to 30 cm	30 and over cm
Weight of complete system (kg/m²)	75 to 180	200 to 500	500 to 2000
Irrigation	No*	✓	✓
Maintenance			
Cost of roofling	€	€€€	€€€€
Accesibility	No	Limited	✓

*With the exception of southern areas and sloping roofs

Source: Vegetalid

A vegetated roof, also known as a green roof, living roof, or eco-roof is a planting system where materials and plants are installed on the top of a building. The vegetation is designed to be independent as a result of selecting plants capable of developing into a stable ecosystem.

The extensive green roof should be distinguished from the traditional roof garden. Light and fairly thin, the plant system can be established on any type of support (such as wood or steel). The selected group of plants requires very little maintenance and develops into a stable ecosystem. Finally, the extensive green roof is a system that is generally inaccessible to pedestrians: the movement of people is limited to maintaining a watertight roofing membrane and the health of the plants. Three types of green roofs exist extensive, semi-intensive, and intensive green roofs.

(1) Concept of green roof as public space and share the community in La Molina

One of the examples of the green roof that merges nature and human space weaves its way into the daily life of dwellers through intelligent roof geometrics is the URBAN FARM in Shanghai, China designed by Nikken Sekkei. The urban complex utilizes nature's cooling system to counteract the heat-island effect, refreshing the city's environment as well as the social environment.

In La Molina, a good example for starting the implementation of this measure could be the governmental building of Municipalidad de La Molina as well as the university buildings in the area.

Fig. 4.3.22. Green roof and concept for an urban farm
Source: Nikken Sekkei

(2) Concept of green roof as a garden

The practice of producing vegetables on green roofs has been gaining in recent years as a method to facilitate agricultural sustainability in urban areas. Rooftop gardens are becoming an important part of recent urban agriculture and offer alternative spaces to grow vegetable products for urban markets. Green roofs create spaces for the production of vegetable crops, which then generate opportunities for integrating agriculture into urban communities.

In La Molina, rooftop vegetable crop agriculture can be productive on shallow extensive green roofs using standard green roof substrates, but maximum productivity in these systems will require high nutrient and irrigation inputs. Although there are several challenges to effectively managing green roof vegetable production systems, they provide a unique opportunity to effectively grow food in spaces that are typically unused

The benefits of installing a green roof in the La Molina district are shown below:

- ✓ The installation of a green roof reduces the need to manage any stormwater that accumulates, as well as the stress put on local sewer systems.
- ✓ In urban settings, the inclusion of green roofs reduces the overall heat conducted by the buildings, covering many of the surfaces that would generate the most warmth.
- ✓ The plants prevent the distribution of smog and dust while also catching many of the pollutants found in the air.
- ✓ Green roofs can be public spaces, such as gardens or recreational areas, to be enjoyed by the community.
- ✓ Due to the amount of work and money that goes into the creation and installation of green roofs, the use of them in a neighborhood can result in an increase in jobs and revenue for local businesses.

2) Green corridors and tree planting in La Molina

The intervention includes the follows:

1. Planting trees and plants in areas with less vegetation in the residential part and the Ecological park of La Molina

2. Increase the vegetation in the parks and green areas: park area in La Molina, Central Plaza, Kasba - Rinconada del Lago Park, Ecological park of La Molina, etc.

3. Considering streets corridor by the tree and additional vegetation in the office and residential area: Av. Ricardo Elías Aparicio, Av. Laguna Grande, Av. La Molina, Av. Raul Ferrero (continuing the green corridor)

The FS study is considering several types of corridors depending on the structure and area of the street. The green corridor is considered along the road or in the central part of the road.

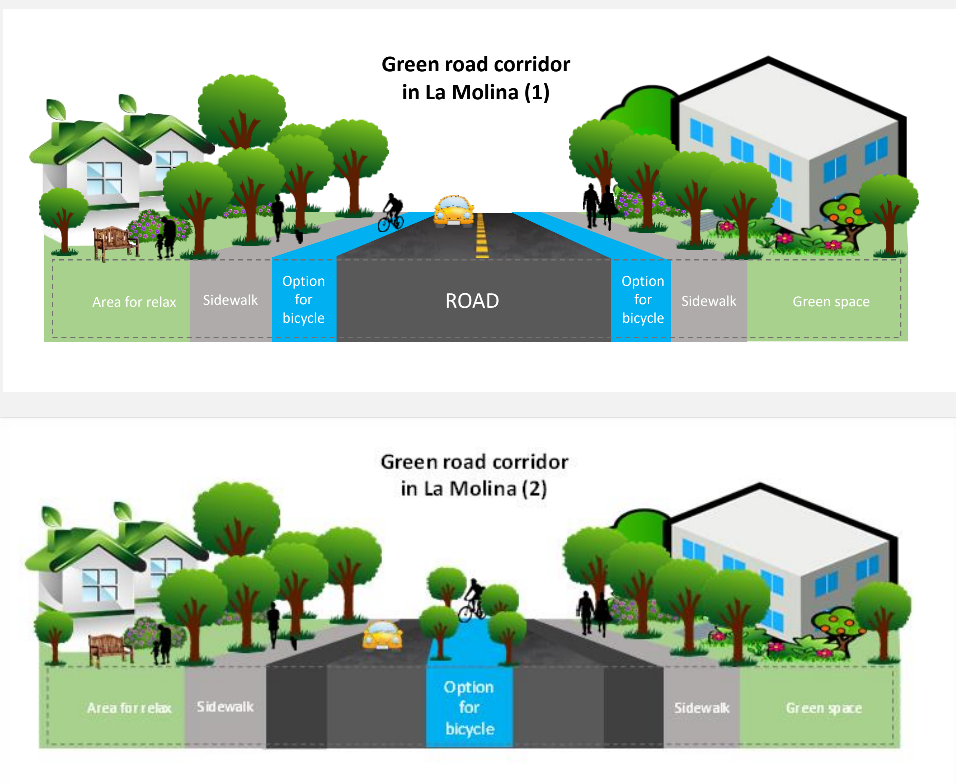


Fig. 4.3.23. Concept for a green corridor in La Molina
Source: Project Team

4.3.7 Waste management

1) Solid waste management and bio-waste recycling system

In Peru, more than seven and a half million tons of solid waste are generated each year, of which 64% comes from households. According to the forecasts of the World Bank, it is estimated that by 2025 up to 36,000 tons of garbage will be generated per day, thus making it necessary to propose immediate solutions such as recycling.

In Lima, about 9,000 tons of garbage is generated daily, whereof, only 4% is recycled. Lima is the city with the highest ecological footprint, exceeding ecologically permissible parameters.

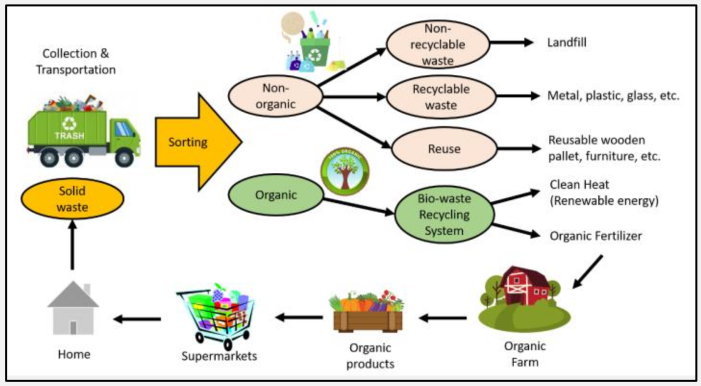


Fig. 4.3.24. Potential Waste Management and Bio-waste recycling system in La Molina District
Source: Project Team

This study proposes intervention for reducing CO2 and improving the quality of life of citizens concerning waste management that includes organic and non-organic waste. Organic waste is any organic waste that can be composted. It is most usually composed of refuse from gardens such as grass clippings or leaves, and domestic or industrial kitchen wastes. Green waste does not include things such as dried leaves, pine straw, or hay. The organic waste is recycled by the Bio-waste recycling system, which is an environment-friendly technology that converts organic waste into commercially useful byproducts. The intense heat generated by the plasma enables it to dispose of all types of waste including municipal solid waste, biomedical waste, hazardous waste, organic fertilizer, or compost safely and reliably. The organic fertilizer could be used in the farms and bio gardens to make bio-organic products which could be easy for consummation from the locals.

Non-organic waste includes non-recycling waste that directly is transported to the landfill, recycled waste, like metal, plastic, glass, and reuse waste, mainly wood and furniture.

The figure below shows the schematic diagram of all processes related to the waste management and bio-waste recycling system proposed in the La Molina District.

2) Recycling

Recently, the municipality of La Molina seeks to encourage recycling in its district. The initiative seeks to promote recycling through the delivery of ecoins, the virtual currency that rewards you for recycling. To be able to claim the reward, it is needed to take a photo of yourself delivering your waste to the district recyclers or leaving it at a Clean Point in La Molina.

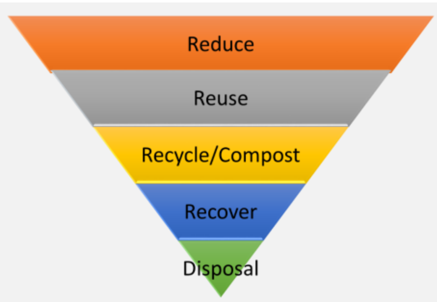


Fig. 4.3.25. Potential program for reducing, reuse, and recycle in La Molina District
Source: Project Team

Along with the numerous recycling activities that have been made in La Molina, this study proposed additional and useful concepts in order to reduce the CO2 emissions in the district and improve the environment and lifestyle of citizens.

1. Zero Waste concept: The main point of this concept is the reduction of GHG emissions in every household. Programs that reduce, reuse and recycle municipal waste are effective and high-impact means of reducing GHG emissions (Figure 4.3.24).

2. Increasing the Eco recycling points in La Molina District. By 2021, the Municipality of La Molina has planned 26 points with a capacity of direct collection of waste 600 tonnes. However, with the support by “Eco Recycling”, should be considered a new actual plan with increasing recycling points throughout La Molina.

4.3.8 Policy Framework

Step 1. Plan. This phase includes setting up the committee, goals and identifying the problems in La Molina District. For example, setting the goals for energy-efficient appliances at homes and offices, planning the implementation of the PV panels, consideration of the implementation of more green corridors, etc.

Step 2. Implementation. This phase includes the development and implementation of the policy for the La Molina District based on Step 1 and setting the potential plan for the implementation of the measures proposed in this FS.

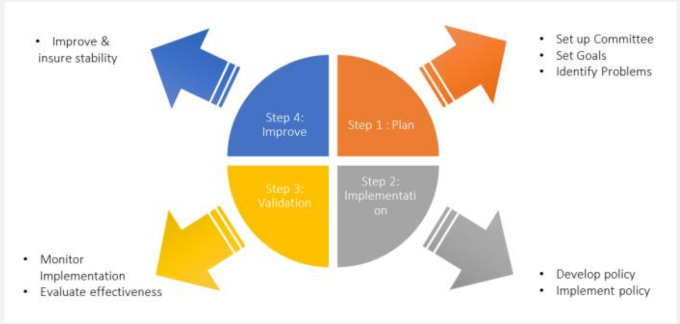


Fig. 4.3.26. Steps regarding policy framework in La Molina
Source: Project Tema (NSRI)

Step 3. Validation. Here are included monitor implementation and evaluation of effectiveness after proposed implementation of the project. Each implementation has a level of achievement which is shown in Table 4.2.6.

Step 4. Improving and ensuring sustainability. After the validation process and setting the timeframe of implementation and level of achievement of the measures (Tables 4.2.6 and 4.2.7), it is needed to prepare a plan for improving for the sectors that have slowing achievements related to the C02 reduction, etc.

1) Buildings

Based on the experience of driving green building codes in other parts of the globe, it is observed that policy push is key to driving changes, coupled with regulatory changes. While regulatory changes define the activities that need to be undertaken for transformation, policy measures help overcome the price barrier for implementation. Both these measures need to be supplemented by market promotion and awareness generation activities to stimulate citizen participation.

Guidance on how to implement regulatory changes can be taken from the case of the Building Environmental Plan System promulgated by the Tokyo Metropolitan Government (Tokyo Metropolitan Government, 2005). In Tokyo, it is required for the buildings that will be newly built or extended and whose total floor area exceeds 5,000 square meters to submit their building environment plans. Moreover, those buildings that will be newly built or extended and whose total floor area exceeds 2,000 square meters may submit their building environment plans voluntarily. Details of plans and

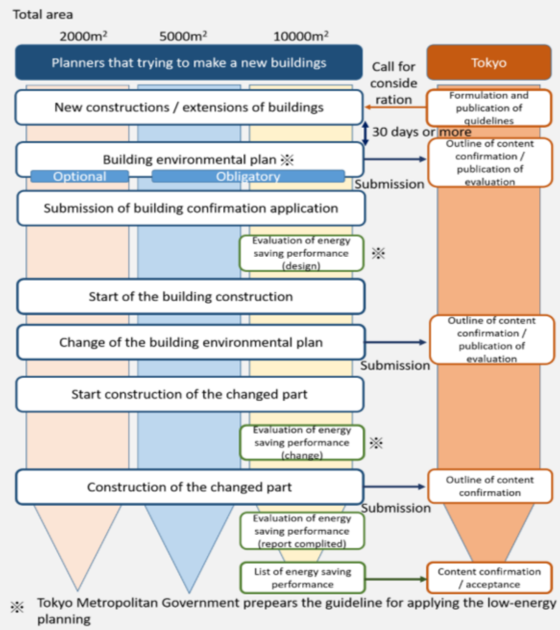


Fig. 4.3.27. Methodology of Building Environmental Plan System in Tokyo
Source: Tokyo Metropolitan Government, 2005

the results of the evaluation of environment-friendly approaches are opened to the public on the official website of the Tokyo Metropolitan Government.

The submission system of the building environment plan has four evaluation points, i.e., "streamlining of energy use," "appropriate utilization of resources," "protection of the natural environment" and "mitigation of heat island phenomenon".

2) Waste management

Promotion of Sorted Collection and Recycling Containers and Packaging in Japan

In Japan, the law establishes a system in which waste plastic containers and packaging, glass and paper containers discarded from homes are collected through the sorted collection by municipalities and retailers, which are then handed over to the Japan Containers and Packaging Recycling Association. The association then consigns reproduction companies to recycle them into new products. There are voluntary recycling activities to collect resources, such as PET bottles, and hand them over to recycling businesses is called Shudan Kaishu (Group Collection).

The figure below shows the structure of the law for the promotion of ported collection and recycling containers and packaging in Japan. This could be a good example for La Molina District in order to improve the recycling system.

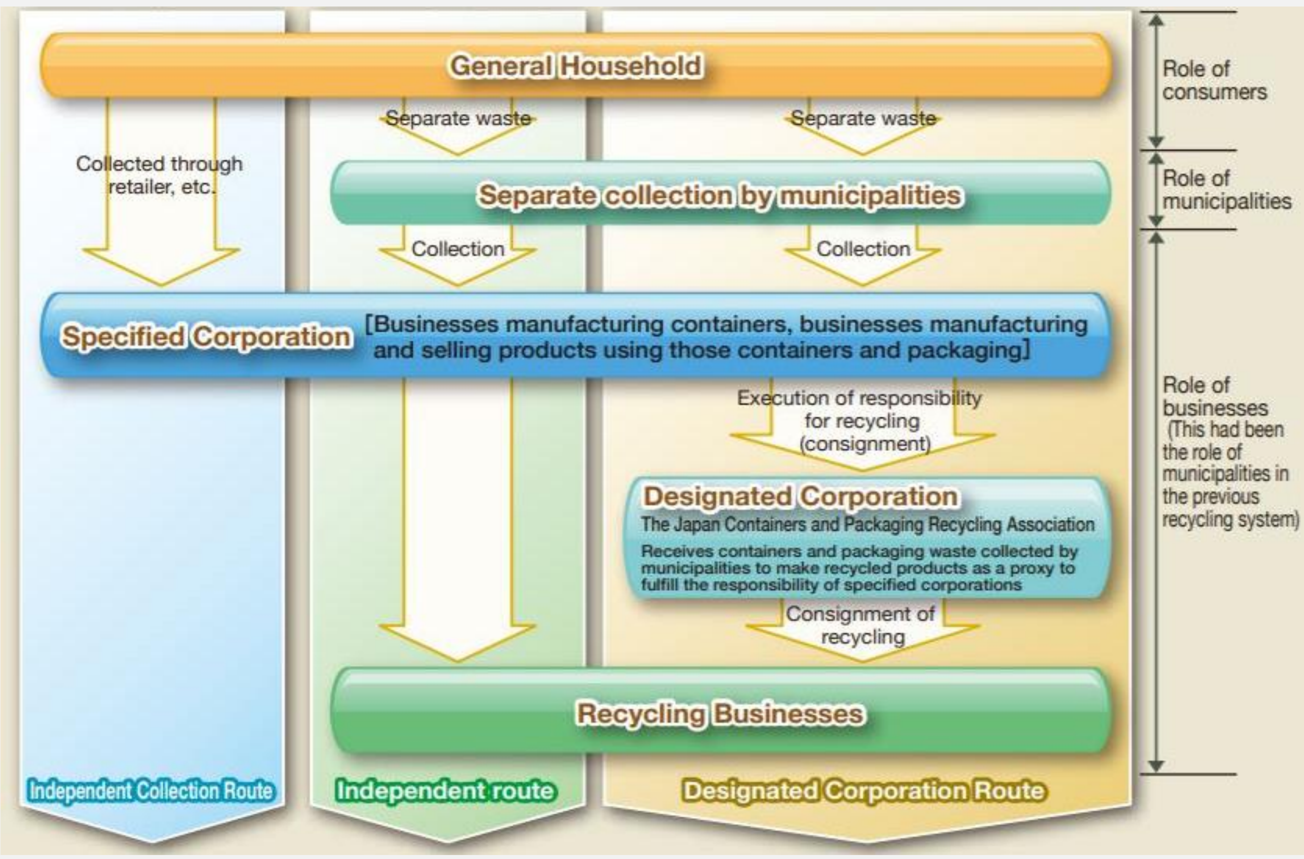


Fig. 4.3.28. The Structure of the Law for the Promotion of Sorted Collection and Recycling Containers and Packaging in Japan
Source: Solid Waste Management and Recycling Technology of Japan

4.3.9 Education

It is important in La Molina District to be implemented the collaborative program between the government in charge of the organizations related to the low-carbon interventions and students/citizens. The impact of the training could contribute to understanding the following:

The conceptual knowledge related to energy

How the energy could be used in daily life

The relationship between energy production, consumption, environment, and society

The impact of the environment of individual decisions and actions that are energy-related

Make the choices that influent the energy and relations between the environment and society

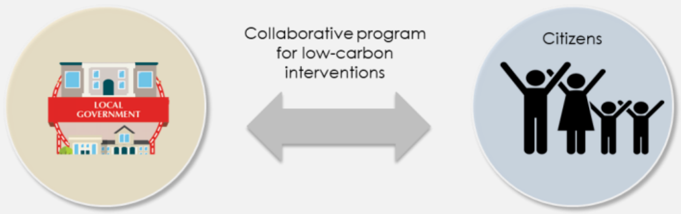


Fig. 4.3.29. Education and Management implementation in La Molina
Source: Project Tema (NSRI)

The FS considering the following programs in La Molina:

1. Training and workshops:
   - Dissemination of benefit and implementation guidelines for recommended interventions across each Government department
   - Guidelines on efficient energy use to be communicated to citizens
   - Training on proposed interventions to support community outreach initiatives for awareness building or supporting implementation activities
   - Seminars and workshops include a wide range of attendees
   - School seminars

   The above training programs are applicable for government, energy and environmental departments, NGOs, students, etc.

2. Media Communication:
   - Benefits of efficient energy use & practices to achieve it through:
     - ✓ Ads in newspapers, billboards, etc.
     - ✓ Flyers with gas and electricity bills
   - Promotion through print media & community outreach programs of proposed interventions communicating key financial benefits and responsibilities of citizens

   The above programs apply to citizens.

3. Events:
   - Organize cultural events "Eco-Festivals" to spread awareness of low-carbon initiatives through innovative means – music, posters, banners, competitions, Latino dance, etc.
   - Planting tree events
   - Waste management and eco recycling volunteer events with competitions
   - School summer vacation events

   The above programs apply to citizens.

PROPOSALS FOR LOW CARBON SCENARIO

05

CHAPTER 5. Low carbon scenario for Khon Kaen Municipality, Thailand

5.1. Define CO2 emission baseline BAU scenario for target areas

5.1.1 Define BAU of CO2 emission baseline in Khon Kaen

The overall carbon dioxide emissions of Khon Kaen were divided into two major categories: emissions from buildings and emissions from transportation. The details of the emissions from buildings are shown in 5.1.2, and the details of the emissions from traffic are shown in 5.1.3.

The year 2020 was set as the base year, and BAU was set assuming that it will increase in proportion to the population growth in 2030 and 2050.

The results of the calculation of BAU for Khon Kaen's CO2 emissions are shown below. Emissions from buildings are categorized and described by use.

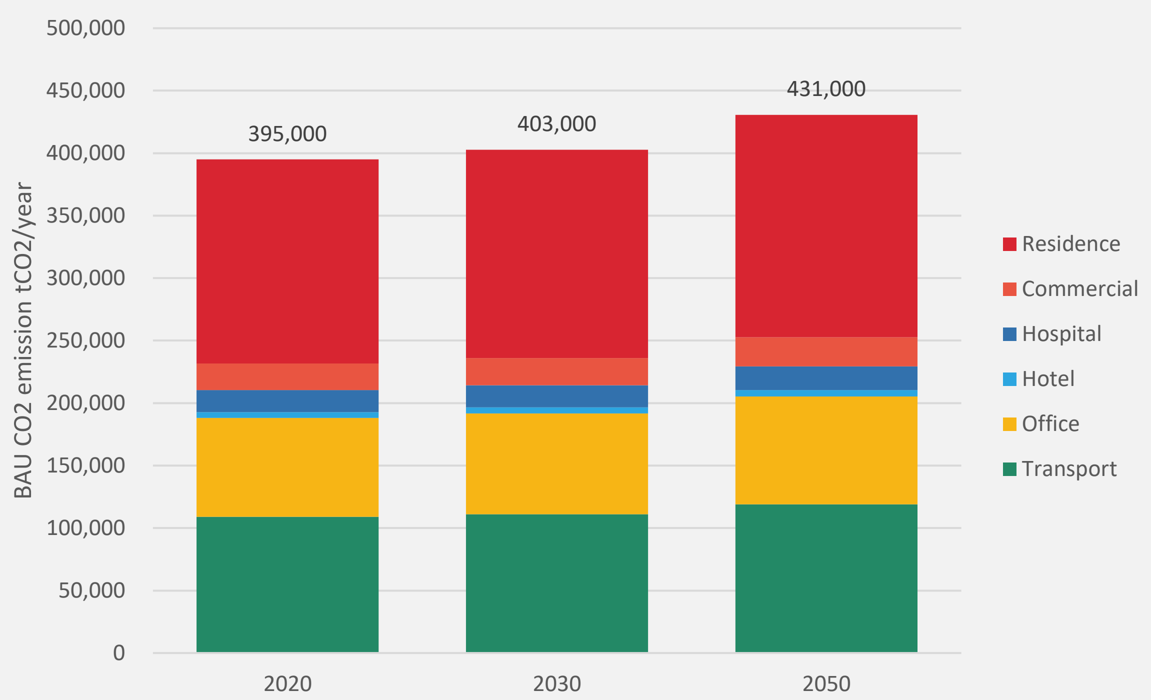


Fig.5.1.1. Define BAU of CO2 emission baseline in Khon Kaen
Source: Project Team (NSRI)

5.1.2 Define BAU of CO2 emission baseline in Building sectors

1) Approach to estimating CO2 emissions

As seen in Section 2, the BAU calculated in "Khon kaen - towards low carbon society" shows that the commercial sector is expected to have the highest growth rate of carbon dioxide emissions. Since the commercial sector mainly emits carbon dioxide from buildings, this project will estimate detailed BAU scenarios for building-related carbon dioxide emissions in an accumulative manner.

The CO_2 emissions from building sectors are estimated by building floor area and energy consumption unit of different types of building.

Building CO2 emissions ＝
Σ ｛Building CO2 emissions unit according to building use(t-CO2/ m2) × Building floor area (m2)｝

Building energy consumption units is decided based on the research of NSRI. To calculate the BAU.

2) Data Collection and existing analysis for target areas

To achieve a low-carbon city as a whole, it is especially important to understand the energy consumption of buildings that emit large amounts of carbon dioxide. By implementing energy conservation measures in the order of buildings that consume the most energy, it is possible to reduce the carbon footprint of the entire city. Figure5.1.3 shows the energy consumption of a typical building in Khon Kaen. The building with the highest energy consumption is the university. Universities have a lot of energy-intensive equipment such as draft chambers and laboratory refrigerators. The second most energy-intensive building was a commercial facility. Commercial facilities use a lot of energy because their total floor area is larger than that of ordinary buildings and they often operate for a long time. Specific low-carbon methods for these buildings will be discussed later.

Data on total floor area by use was not directly available for the city of Khon Kaen. Instead, we obtained the number of buildings by use. The below table shows the number of buildings by use in Khon Kaen City. The typical total floor area and the number of floors for each use were estimated by NSRI from satellite photos and google street view. The total floor area of the entire city of Khon Kaen was estimated by multiplying (1) the number of buildings by use, (2) the total floor area of a typical building by use, and (3) the number of floors of a typical building by use.

Table. 5.1.1. The number of buildings in in Khon Kean City Municipality

The number of building	2017	2018	2019	2020
Detached house	52,820	53,185	53,397	53,505
Apartment	4,685	4,982	5,077	5,082
Flat	2,075	2,076	2,136	2,137
Government agency	1,245	1,246	1,239	1,245
Shop house	779	792	793	794
Educational	783	784	785	785
Other	595	600	602	602
Temporary house	546	549	551	552
Dormitory	374	403	418	450
Civil servant residence	277	339	410	448
Commercial	160	185	206	232
Row house	129	129	136	139
Office	87	94	96	97
Temple	67	69	69	69
Hotel	51	55	58	59
State enterprise	17	17	17	17
Building	11	11	12	15
Company	14	14	14	14
Hospital	11	11	11	11
Non registered house	7	7	7	7
Foundation	3	3	3	3
House of priest	2	2	2	2

Source: Project Team (BMC)

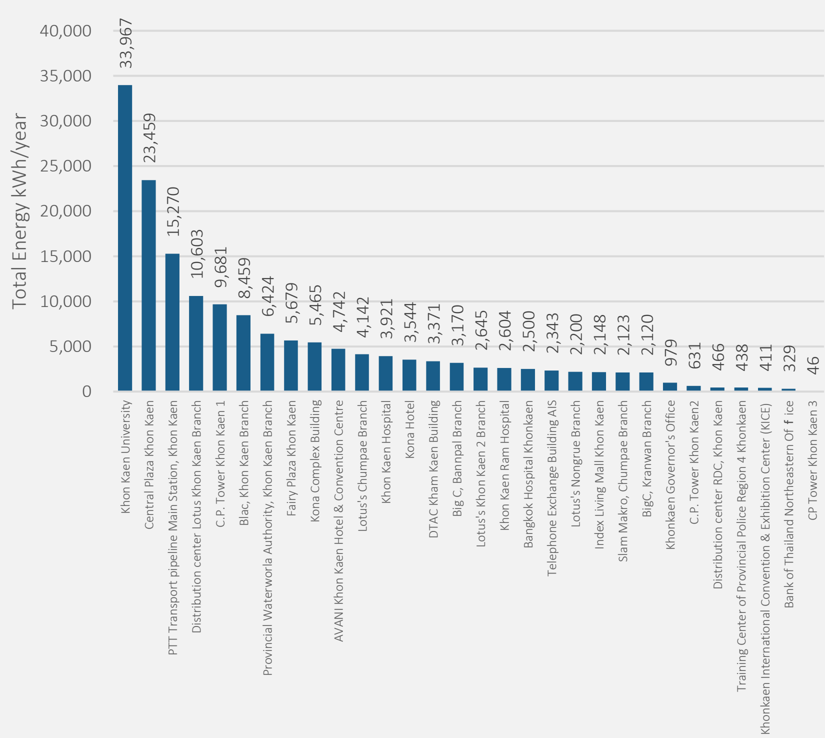


Fig.5.1.2. Annual energy consumption for major buildings in Khon Kaen

Source: Project Team (BMC)

3) Define BAU in Building sectors

The carbon dioxide emissions of commercial buildings were calculated as follows: Based on the consumption of electricity, gas, etc. in representative buildings in Khon Kaen, the CO2 emissions of each building were calculated. The CO2 emission of a building is greatly affected by the total floor area of the building and the building use; the CO2 emission per total floor area was calculated for a typical building in Khon Kaen and averaged for each use to calculate the CO2 emission per total floor area for each use in Khon Kaen.

Table. 5.1.2. CO2 emissions of a typical building in Kohn Kaen

building name	building type	Fuel				CO2				Total CO2 emission	Total Floor Area	CO2 emission per total floor area
		Electricity	Diesel	LPG	Bunker Oil C	Total Electricity	Diesel	LPG	Bunker Oil C			
		kWh	L	kg	L	kg-CO2	kg-CO2	kg-CO2	kg-CO2	kg-CO2	m2	kgCO2/m2/year
Central Plaza Khon Kaen	Commercial	23,459,011				12,847,715				12,847,715	250,000	51
C.P. Tower Khon Kaen 2	Office	630,780				345,457				345,457	7,431	46
Training Center of Provincial Police Region 4 KhonKaen	Office	438,060				239,911				239,911	23,120	10
Khon Kaen Ram Hospital	Hospital	2,604,000				1,426,124				1,426,124	60,242	24
Siam Makro	Commercial	4,534,120				2,483,186				2,483,186	13,703	181
Tesco Lotus Branch 2	Commercial	7,814,502				4,279,741				4,279,741	17,600	243
Kosa Hotel	Hotel	2,503,405	360	38,400		1,371,031	943	226,944		1,598,918	26,667	60
Charoen Thani Hotel	Hotel	7,603,030	780	113,673	270,626	4,163,925	2,043	671,807	811,878	5,649,653	43,608	130
Pullman Hotel	Hotel	5,443,560	2,438			2,981,256	6,385			2,987,641	36,093	83
CP Tower Khon Kaen 2	Office	2,151,390				1,178,244				1,178,244	7,431	159
Training Center of Provincial Police Region 4	Office	2,213,475				1,212,246				1,212,246	23,120	52
Khon Kaen Provincial Agriculture and Cooperatives Office	Office	418,430				229,160				229,160	2,322	99
Rajamangala University of Technology Isan Khon Kaen Campus	Academy	2,722,674				1,491,117				1,491,117	43,210	35
Khon Kaen-Ram Hospital	Hospital	5,197,560				2,846,530				2,846,530	60,242	47

Source: Database of Designated Building, DEDE, 5 March 2019

Table. 5.1.3. CO2 emissions per total floor area

Building Type	CO2 emission per total floor area kgCO2/m2/year
Office	73
Hotel	91
Hospital	35
Commercial	159
Academy	35

Source: Project Team (NSRI)

Carbon dioxide emissions of residential buildings were calculated as follows: Annual carbon dioxide emissions per household were calculated using the statistics of domestic energy consumption for 300 households in Bangkok, Thailand by Shimizu et al. (2020).

Table. 5.1.4. CO2 Emissions from household in Bangkok, Thailand

	Electricity	LPG	total	unit
Annual secondary energy consumption	13.3	2.9	16.2	GJ/year/household
Annual CO2 emission	2.07	0.16	2.23	t-CO2/year/household

Source: Shimizu et al. RESEARCH ON HOUSEHOLD ENERGY CONSUMPTION AND DATABASE DEVELOPMENT IN THAILAND, VIET NAM, AND CAMBODIA (PART 1): THE DEVELOPMENT OF A HOUSEHOLD ENERGY CONSUMPTION DATABASE IN SOUTHEAST ASIA, 2020,https://doi.org/10.3130/aije.85.535

As described above, the carbon dioxide emissions of Khon Kaen were calculated by multiplying the number of buildings by the carbon dioxide emissions by total floor area and use for commercial buildings, and by the carbon dioxide emissions by the household for residential buildings. The future projections for 2030 and 2050 were calculated based on the population growth rate.

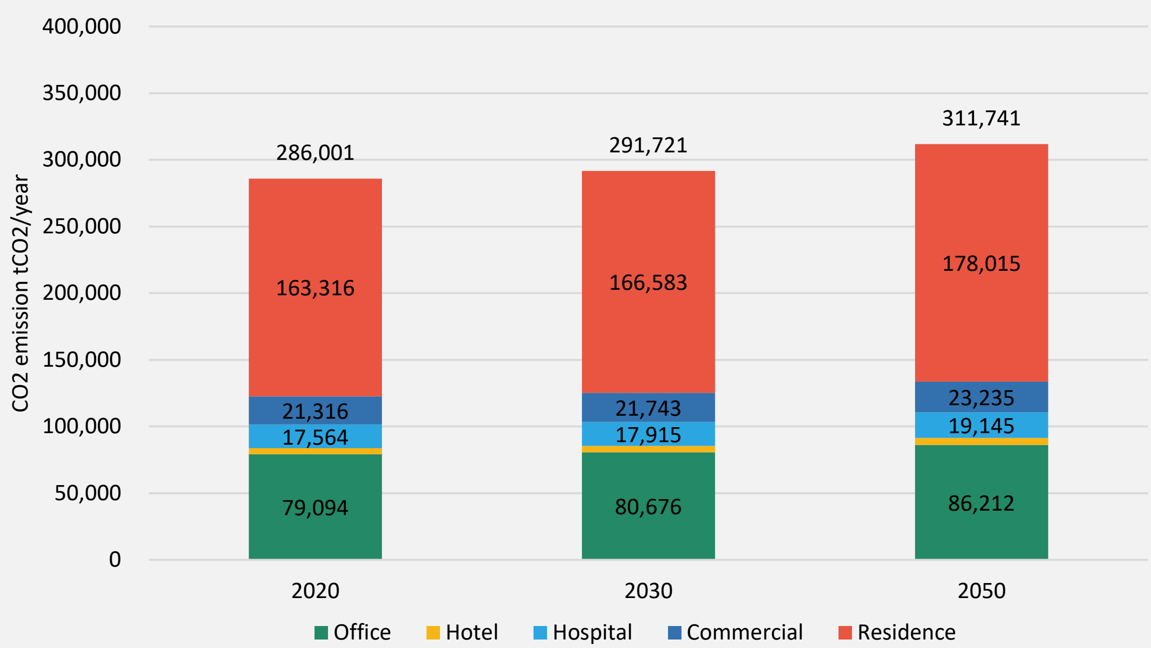


Fig.5.1.3. Define BAU of CO2 emission baseline
Source: Project Team (NSRI)

1) Urban Master Plan

According to the City Plan Map of Khon Kaen, the cross point of trunk road the east-west (No.2) and the north-south trunk roads (No.12) is the central area of Khon Kaen CIty. Central area is planned as commercial and high-residential area (red color), around this area is planned as moderate residential area (orange color), outside of this area is a low-density residential area(yellow color).

Note: The color in city plan refers to.

Color	Type of Land-Use
	Low-Density Residential Area
	Moderate-Density Residential Area
	Commercial and High-Density Residential Area
	Industrial and Warehouse Area
	Special Industrial Area
	Rural and Agricultural Area
//////////	Rural and Agricultural Conservation Area
	Open Space for Recreation and Environmental Preservation Area
	Educational Institution Area
	Environmental and Fishery Preservation Area
	Religion Institution Area
	Government Institution, Public Utility and Amenities Area
	Communication and Transportation Area

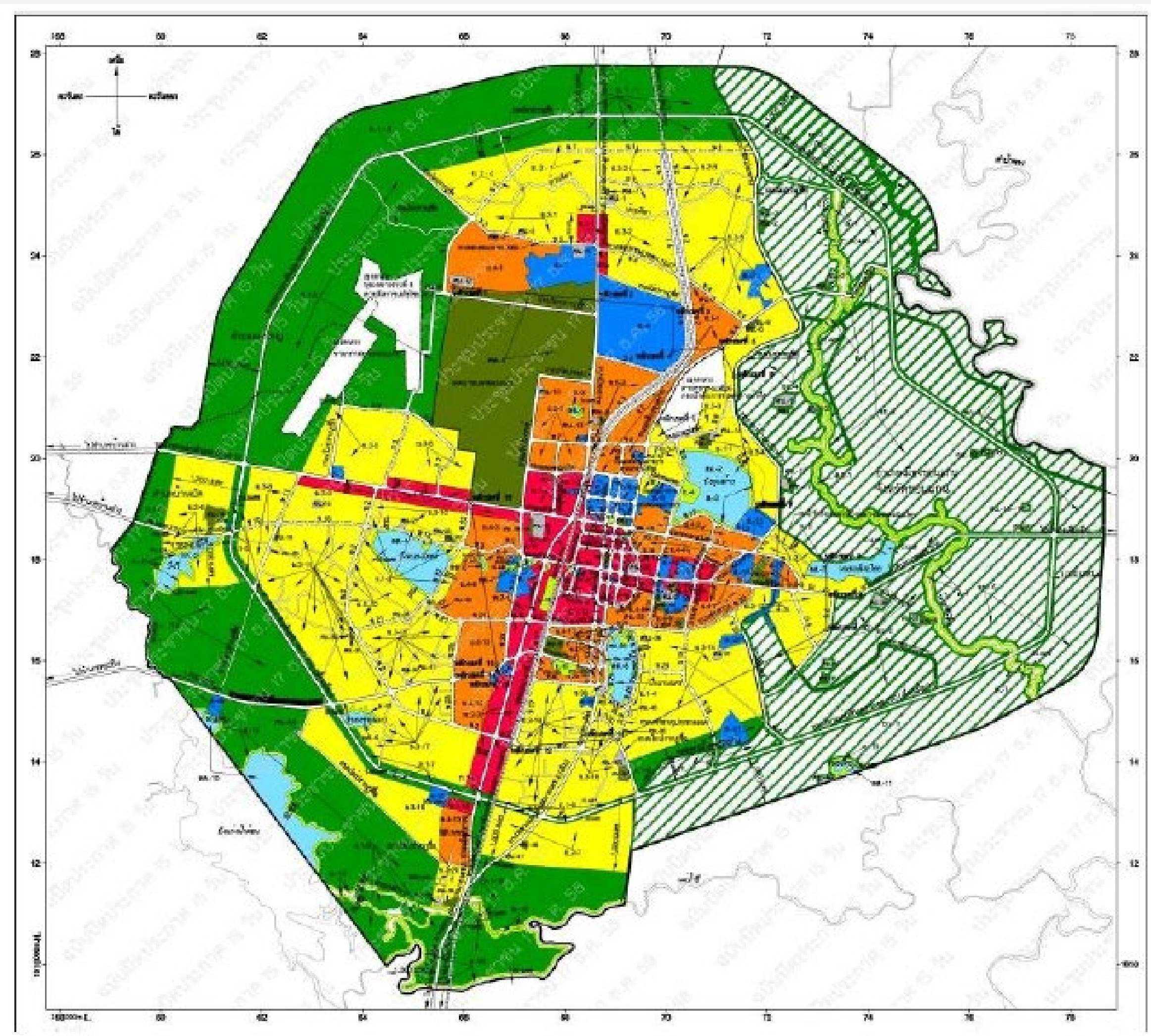


Fig.5.1.4. Urban Masterplan

2) Urban Transport Plan

Khon Kaen municipality has five LRT lines plan as below. These five lines are covering the center of Khon Kaen City. It is expected that the new LRT public network may lead to shifting private car use to public transportation use.

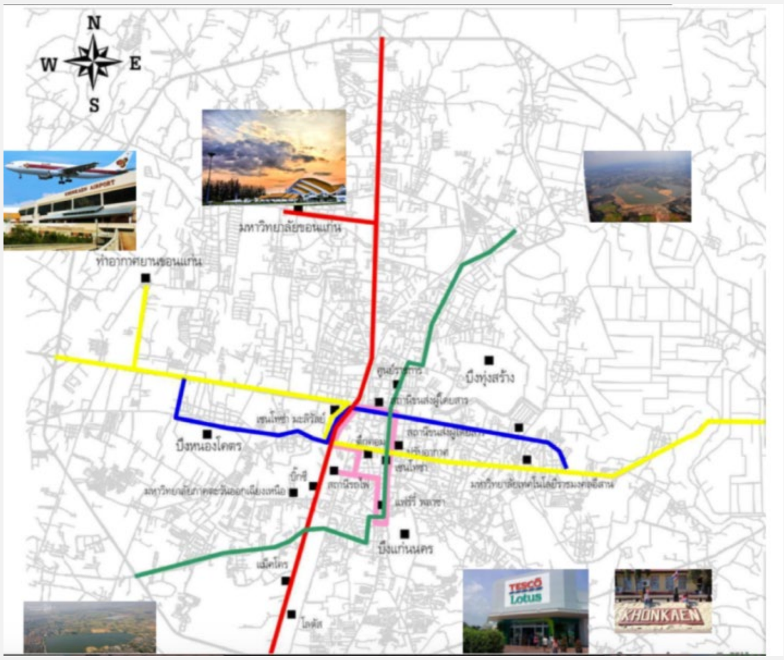


Fig. 5.1.5. LRT lines future plan

Source: JICA

3) Estimated future socio-economic indicator

Regarding the estimated future socio-economic indicator for 2005 and 2050, the population growth rate is 1.11 (2050/2005), total commercial floor area growth rate is 17.4 (2050/2005). From these indicators, it is considered that the central area may be developed larger than current and transportation passengers demand may grow.

Khon Kaen's trip generation model was developed by the Office of Transport and Traffic Planning (OTP). The results show that passenger transport demand will increase in 2005 from 18,158 million passenger-km to 71,665 and 73,214 million passenger-km in 2030 and 2050 respectively.

Table. 5.1.5. Socio-economic indicator for year 2030 and year 2050

	2005	2030	2050	2030 / 2005	2050 / 2005
Population (million pp)	1.75	1.82	1.95	1.04	1.11
No. of household (million hh)	0.47	0.87	0.93	1.85	1.98
GPP (million $US)	2,933	6,619	8,532	2.26	2.91
Floor space for commercial (km2)	17	223	396	13.1	23.3
Passengers transport demand (million p-km)	18,158	71,665	73,214	3.95	4.03

Source: Khon kaen – towards low carbon society

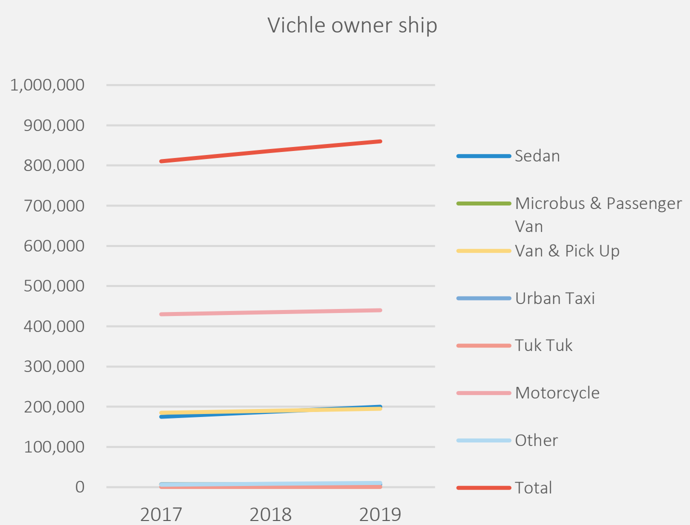
4) Tendency of car ownership

The tendency of a total number of vehicle ownership has increased from 2017 to 2019. The composition of the vehicle is including 51.6 per cent of motorcycles, 22.1 per cent of Van & Pick Up, 23.8 per cent of the van & pick up.

Table. 5.1.6. Vehicle Owner Ship by type

	2017	2018	2019
Sedan	175,341	190,028	204,498
Microbus & Passenger Van	6,279	6,287	6,323
Van & Pick Up	181,109	186,109	190,485
Urban Taxi	412	416	344
Tuk Tuk	502	496	480
Motorcycle	433,054	438,944	443,380
Other	13,763	14,205	14,529
Total	810,460	836,485	860,039

Source: Khon kaen – towards low carbon society



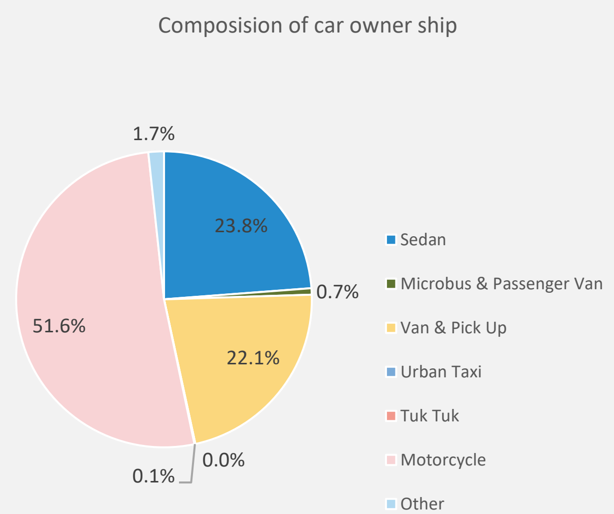


Fig. 5.1.6. Composition of vehicle type (2019)

5) Estimation process for BAU

To calculate the CO_2 emissions for transportation, multiply the person trip in each modal share and Travel distance. To that value, the CO_2 emission indicator is integrated to calculate the CO_2 emissions of the car.

CO_2 emissions are calculated by estimating the gasoline consumption of each vehicle based on the number of registered automobiles (cars, motorcycles, taxis, buses, trucks). The process of CO_2 emission is shown below.

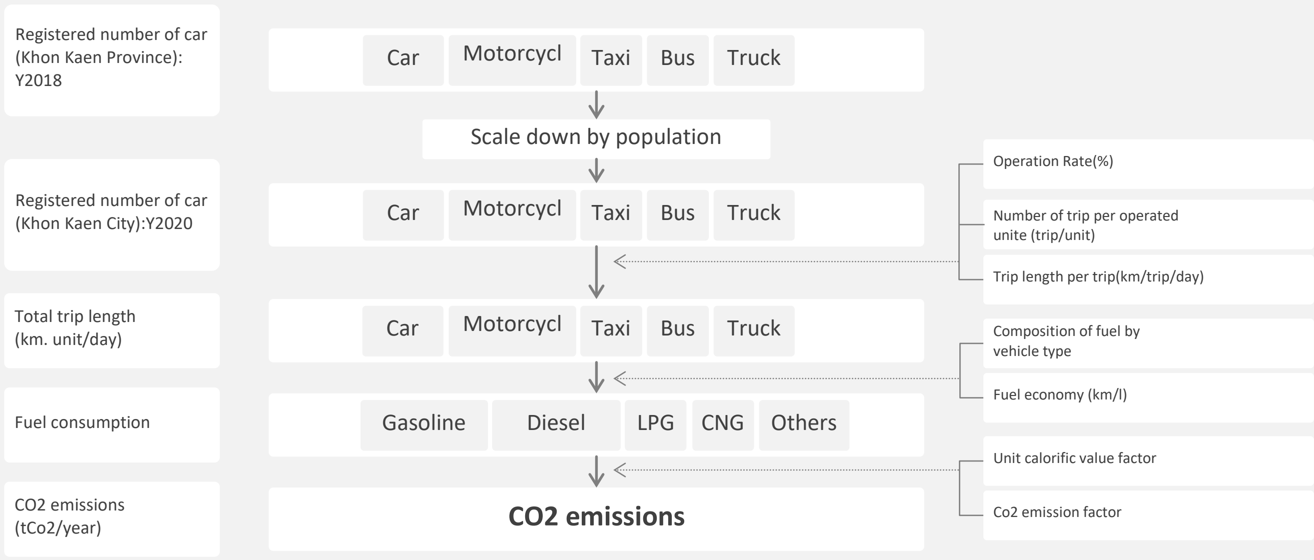


Fig. 5.1.7. The process of estimation of CO_2 emission in transport sector
Source: Project Team (NSRI)

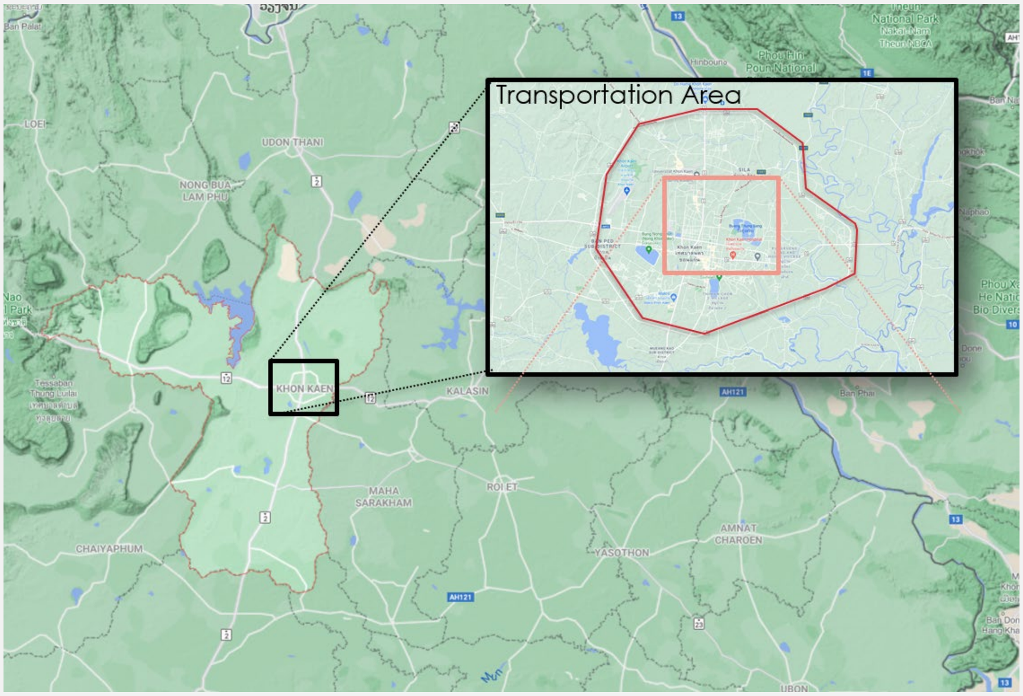


Fig. 5.1.8. Target area for estimation of BAU in transportation field
Map: Google

6) Result of estimation of BAU

Table. 5.1.7. Number of Vehicle of Khon Kaen City

Type of Vehicle	Total	Gasoline	Diesel	LPG	CNG	Others
Car	24,376	7,598	15,611	869	289	9
Motorcycle	28,607	28,605	0	0	0	2
Taxi	88	4	1	81	2	0
Bus	601	16	536	12	36	1
Truck	1,790	1	1,496	2	32	259
Others	908	0	905	0	0	3
Total	56,370	36,224	18,549	964	359	274

Source: NSRI calculated above number from number of vehicle of Khon Kaen Province(2018)

Table. 5.1.8. Total trip length by vehicle type

Type of Vehicle	(a) Number of vhicle	(b) Operation Rate(%)	(c) Number of trip per opereted uite (trip/unit)	(d) Trip length per trip(km/trip/day)	(e) Total trip length(km/day)
Car	24,376	60%	3.21	12.59	590,453.6
Motorcycle	28,607	60%	3.21	8.39	461,960.0
Taxi	88	60%	3.21	12.59	2,131.6
Bus	601	86%	3.12	11.50	18,585.5
Truck	1,790	55%	6.17	14.67	89,673.2
Others	908	28%	3.09	7.33	5,686.0
Total	56,370				1,168,489.8

Source: Project Team (NSRI)

Table. 5.1.9. Total trip length by Fuel type

Type of Vehicle	Total	Gasoline	Diesel	LPG	CNG	Others
Car	1,180,907	368,089	756,282	42,099	14,001	436
Motorcycle	554,352	554,313	0	0	0	39
Taxi	2,558	116	29	2,354	58	0
Bus	22,303	594	19,890	445	1,336	37
Truck	179,346	100	149,889	200	3,206	25,950
Others	5,686	0	5,667	0	0	19

Source: Project Team (NSRI)

Table. 5.1.10. Fuel economy

Type of Vehicle	Gasoline	Diesel	LPG	CNG	Others
Car	15.8	15.8	9.8	9.8	9.8
Mortorcycle	60	60.0	60.0	60.0	60.0
Taxi	15.8	15.8	9.8	9.8	9.8
Bus	5.7	5.7	5.7	5.7	5.7
Truck	7.24	7.2	7.2	7.2	7.2
Others	2.01	2.01	2.01	2.01	2.01

Source: Project Team (NSRI)

Table. 5.1.11. Total Fuel Consumption by Fuel Type(kl/day)

Type of Vehicle	Gasoline	Diesel	LPG	CNG	Others
Car	23.3	47.9	4.3	1.4	0.0
Motorcycle	9.2	0.0	0.0	0.0	0.0
Taxi	0.0	0.0	0.2	0.0	0.0
Bus	0.1	3.5	0.1	0.2	0.0
Truck	0.0	20.7	0.0	0.4	3.6
Others	0.0	2.8	0.0	0.0	0.0
Total	32.7	74.9	4.7	2.1	3.6

Source: Project Team (NSRI)

Table. 5.1.12. Result of CO2 emission

Fuel Consumption	Gasoline	Diesel	LPG	CNG	Others	Total
(a)Unit calorific value factor(GJ/kl)	34.6	37.7	50.8	50.8	34.6	-
(b)Co2 emission factor(tC/GJ)	0.0183	0.0187	0.0161	0.0161	0.0183	-
(c)Co2 emission(tCO2/day)	76	194	14	6	8	298
(d)Co2 emission(000tCO2/Year)	28	71	5	2	3	109

Source: Project Team (NSRI)

Estimation of CO2 emission for transportation in 2030,2050

CO2 emission in 2030,2050 is calculated by the population growth rate in Khon Kaen City based on estimated CO2 emission in 2020

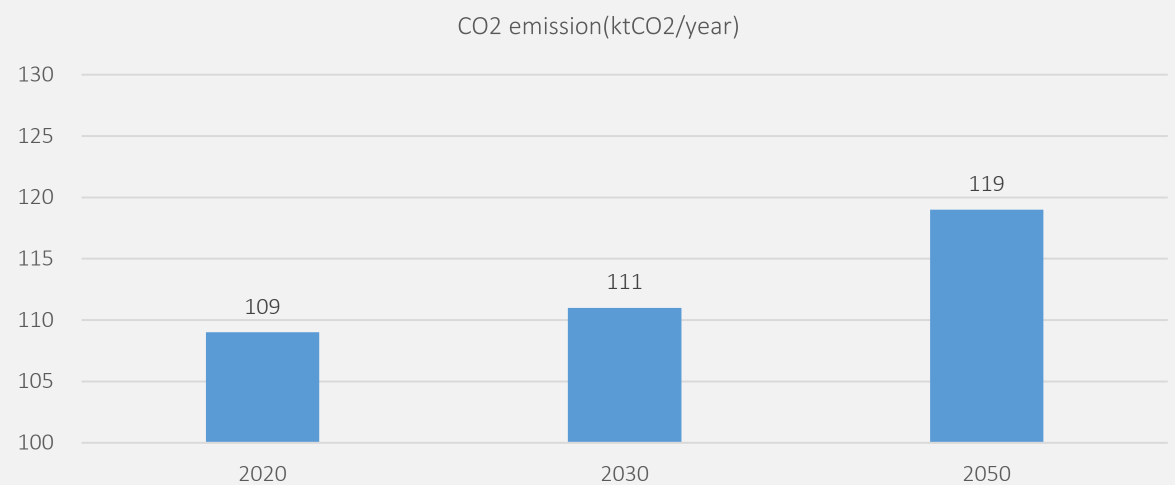


Fig.5.1.9. BAU Scenario for the Transport sector

Source: Project Team (NSRI)

5.2. Low Carbon measures for target areas

5.2.1 Low Carbon Scenario by all measures

Low carbon methods can be divided into several categories. The categories are Buildings, Transportation, Untapped Energy, Renewable Energy, Multi Energy System, Policy Frameworks, Greenery, and Waste Management. The details of each measure are described in detail in Section 5.3.2 onwards.

The following figure shows the low-carbon scenario when all the measures are implemented. Compared to the BAU shown in Section 5.1.1, the Low carbon scenario is for a 24% reduction in 2030 and a 45% reduction in 2050.

The priorities of the low-carbon measures (excluding transportation) were planned based on the period, as discussed in Section 7.2.1. It was assumed that the short-term measures with the highest priority would be introduced by 2030, while the middle and long term measures would be introduced by 2050. The roadmap for transportation is presented in Section 5.2.3.

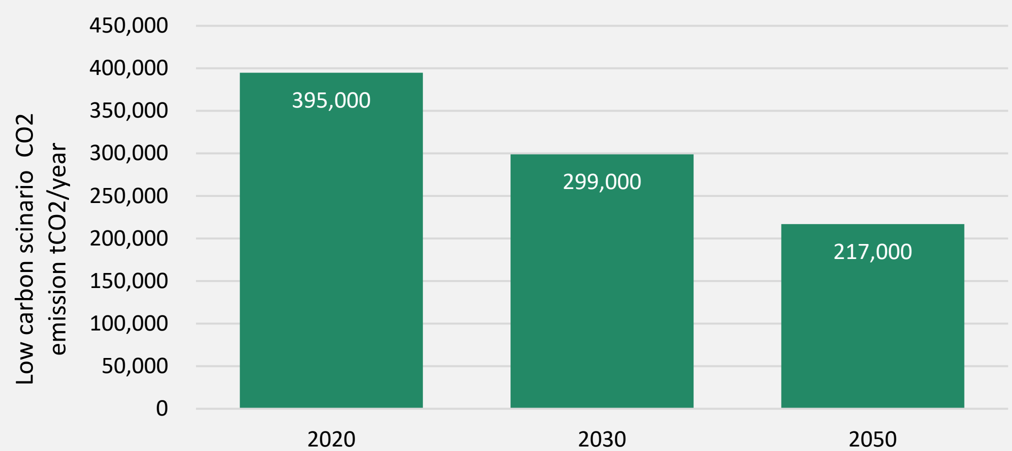


Fig.5.2.1. Low carbon scenario in Khon Kaen by all mesures
Source: Project Team (NSRI)

The reductions for each category are shown in the following figures. The ratio of measures for buildings, transportation, and renewable energy is high, indicating their high importance for Khon Kaen's Low carbonization. Note that Untapped Energy, Policy Flamework, Greenery, and Waste Management are not included in the calculation of the Low Carbon Scenario due to their large uncertainties or small effects.

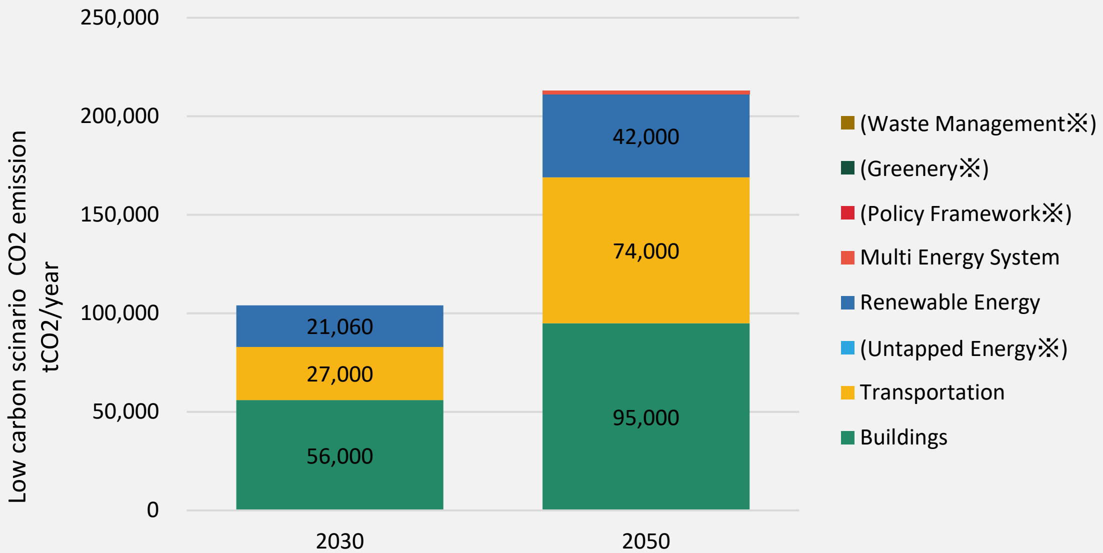


Fig.5.2.2. Total CO2 reduction from BAU in Low carbon scenario in Khon Kaen
※Not included in the low carbon scenario due to large uncertainties or small effects.
Source: Project Team (NSRI)

5.2.2 Low Carbon measures by buildings

Khon Kaen has a warm climate throughout the year. There is a cooling demand throughout the year; thus, air conditioning accounts for a large portion of the energy consumption. Approximately 60% of the power consumption of commercial buildings stems from air conditioning[1].

1) ZEB (Zero Energy Building) approach

ZEB approach is important to reduce the CO2 emissions of buildings. ZEB is a low-carbon approach to buildings that achieves significant energy savings without degrading indoor or outdoor environmental quality. The basic concept of net-zero energy is that the amount of energy consumed within a building or site, such as air conditioning, lighting, ventilation, and hot water supply, is roughly equal to the amount of energy generated within the site by photovoltaic power generation.

(1) Definition of ZEB

A net-zero energy building is defined as a building that has high energy saving through load reduction, natural energy use and high-efficiency systems and appliances without decreasing the environmental quality both indoors and outdoors. With the introduction of on-site renewable energies, the on-site energy supply will be equal to or greater than the energy demand within the building in a year. The amount of energy supply and demand could be replaced by relevant indicators multiplied.

(2) Evaluation of ZEB

Using an energy balance of normalized energy supply (G*) and normalized energy demand (C*) which is converted into a non-dimensional numeric as annual primary energy consumption of a reference building. The energy performance evaluation and labelling are as follows;

G* : Normalized Energy Generation = (Energy generation of target building) / (Energy consumption of reference building)

C* : Normalized Energy Consumption = (Energy consumption of target building) / (Energy consumption of reference building)

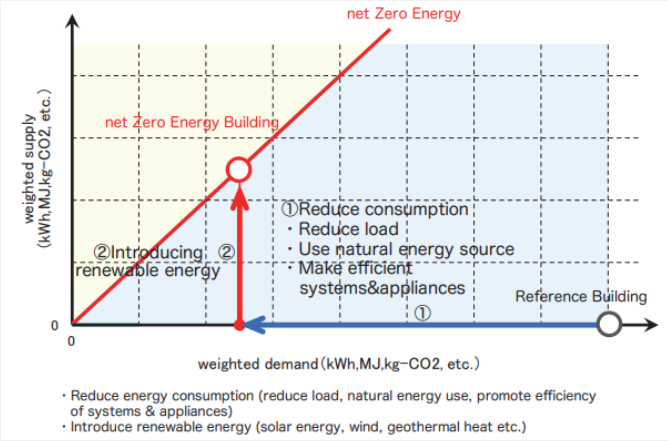


Fig. 5.2.3. Definition of ZEB
Source: The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan. Net Zero Energy Building Advanced Case Collection

[1] Chirarattananon, S.; Taweekun, J. A technical review of energy conservation programs for commercial and government buildings in Thailand. Energy Convers. Manag. 2003, 44, 743–762.

In the design phase of ZEB, it is important to maximize the use of building planning methods (passive methods) such as thermal insulation, solar radiation shielding, use of natural ventilation, and use of daylight, while also upgrading the energy-saving performance of the building envelope, which has a long life and is difficult to retrofit, and then superimposing the upgrading of building facilities. In order to achieve this, first, the load on the building should be controlled through high insulation of the building frame and the use of natural energy. On top of that, energy-saving technologies will be introduced to achieve thorough energy conservation. Finally, it is important to introduce renewable energy sources such as solar energy to get as close to net-zero as possible.

(3) Passive Design

The load of the building is controlled by keeping the surrounding environment and indoor environment appropriate. On top of that, a design method is required to actively utilize natural energy such as light and wind or to control it well.

1. **Appropriate surrounding environment**: Appropriate building layout and construction planning, and appropriate exterior planning
2. **Load control**: Strengthening insulation of the building envelope and reducing internal heat generation
3. **Use of natural energy**: Use of natural lighting and ventilation
4. **Optimization of indoor environment**: Optimization of thermal environment, air quality environment, and light environment

(4) Active design

In addition to introducing high-efficiency equipment systems, consider using untapped energy (e.g., temperature difference energy from groundwater and river water), minimize energy consumption, and introduce renewable energy.

1. **Higher efficiency of facilities and systems**: Higher efficiency of air conditioning and ventilation equipment, heat source equipment, lighting equipment, hot water supply equipment, etc.
2. **Introduction of renewable energy**: Photovoltaic power generation, wind power generation, etc.

(5) Energy management

In addition, lifecycle energy management throughout the life of the building is necessary to ensure that a net-zero energy building can be operated properly for many years.

1. **Energy management**: Use of BEMS (Building Energy Management System), implementation of lifecycle energy management, visualization, etc.

2) Specific measures to achieve ZEB

(1) Non-residential buildings (e.g., office, hotel, commercial etc.)

To calculate the low-carbon scenario, the total floor area of each building use in Khon Kaen was assumed, and the energy consumption of each use was calculated from the breakdown of energy consumption, multiplied by the reduction ratio of each measure. The priorities of the low-carbon measures were planned based on the time span, as discussed in Section 7.2.1. It was assumed that the short-term measures with the highest priority would be introduced by 2030, while the middle and long-term measures would be introduced by 2050.

Table. 5.2.1. Building Energy Conservation Technologies

<table>
<tr><th rowspan="2">Target</th><th rowspan="2">Low carbon measures</th><th rowspan="2">Target Energy Conservation ratio</th><th>Office</th><th>Commercial</th><th>Hospital</th><th>Hotel</th></tr>
<tr><th colspan="4">Introduction rate 2030 / 2050</th></tr>
<tr><td>Heat source</td><td>High-efficiency equipment</td><td>0.28</td><td colspan="4" rowspan="2">100% / 100%</td></tr>
<tr><td>Heat source</td><td>Reduction of internal heat generation</td><td>0.05</td></tr>
<tr><td>Heat source auxiliary</td><td>Inverter</td><td>0.13</td><td colspan="4">0% / 100%</td></tr>
<tr><td>Water conveyance</td><td>Inverter</td><td>0.18</td><td colspan="4">100% / 100%</td></tr>
<tr><td>Air conveyance</td><td>High efficiency fan</td><td>0.10</td><td colspan="4">0% / 100%</td></tr>
<tr><td>Air conveyance</td><td>Inverter</td><td>0.26</td><td colspan="4">100% / 100%</td></tr>
<tr><td>Hot water</td><td>Conversion to heat pumps</td><td>0.29</td><td colspan="2">0% / 0%</td><td colspan="2">100% / 100%</td></tr>
<tr><td>Lighting</td><td>Human Sensor</td><td>0.03</td><td colspan="4" rowspan="2">0% / 100%</td></tr>
<tr><td>Lighting</td><td>Illuminance correction</td><td>0.11</td></tr>
<tr><td>Lighting</td><td>High efficiency of lighting equipment</td><td>0.38</td><td colspan="4" rowspan="2">100% / 100%</td></tr>
<tr><td>Outlet</td><td>Reduced power</td><td>0.02</td></tr>
<tr><td>Ventilation</td><td>Total heat exchanger</td><td>0.07</td><td colspan="4" rowspan="2">0% / 100%</td></tr>
<tr><td>Ventilation</td><td>CO2 control</td><td>0.06</td></tr>
<tr><td>Ventilation</td><td>High efficiency fan</td><td>0.13</td><td colspan="4" rowspan="3">100% / 100%</td></tr>
<tr><td>Water supply and drainage</td><td>Improve pump performance</td><td>0.15</td></tr>
<tr><td>Elevator</td><td>Smart operation</td><td>0.10</td></tr>
<tr><td>Other</td><td>Introduction of high efficiency transformers</td><td>0.09</td><td colspan="4" rowspan="2">0% / 100%</td></tr>
<tr><td>Heat source</td><td>Glass performance improvement</td><td>0.10</td></tr>
</table>

Source: Project Team (NSRI)

Table. 5.2.2. Energy consumption ratio in a typical building

	Heat source	Heat source auxiliary	Water conveyance	Air conveyance	Hot water	Lighting	Outlet	Ventilation	Water supply and drainage	Elevator	Others	Total
office	25.8%	4.5%	3.1%	11.8%	1.4%	20.2%	18.4%	6.2%	0.8%	2.5%	5.3%	100%
commercial	24.7%	4.4%	1.1%	4.0%	0.9%	20.8%	19.2%	12.8%	0.9%	5.4%	5.8%	100%
hospital	27.2%	4.8%	2.5%	9.5%	18.0%	10.9%	10.1%	7.0%	1.0%	3.0%	6.0%	100%
hotel	30.6%	5.4%	2.3%	8.7%	12.0%	12.0%	11.0%	8.3%	1.2%	3.5%	5.0%	100%

Source: Project Team (NSRI)

Table. 5.2.3. Total floor area of buildings in Khon Kaen calculated in 2020

Original Building Type	The number of buildings	Building Type for CO2 calculation	Typical total floor area	Total floor area in Khon Kaen Municipality
			m2	m2
Hospital	11	Hospital	20,000	220,000
Hotel	59	Hotel	1,000	59,000
Shopping Mall & Discount Stores	15	Commercial	10,000	150,000
Building	241	Office	500	120,500
Shop	234	Commercial	500	117,000
Office	97	Office	5,000	485,000
Company	14	Office	300	4,200
Government agency	1245	Office	100	124,500
State enterprise	17	Office	15,000	255,000
Foundation	3	Office	500	1,500
Academy	3	Academy	40,000	120,000

Source: The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan. Net Zero Energy Building Advanced Case Collection

(2) Residential buildings

The low-carbon methods for housing can be summarized as follows

Table. 5.2.4. Key elements for low carbon residential buildings

	thermal environment	Air environment	Light Environment	Others
Use of natural energy	• Solar water heating	• Natural Ventilation	• daylight use • Solar power generation	
Thermal insulation of building envelope	• Improved thermal insulation • Solar radiation shielding			
Energy-saving equipment	• Cooling system planning		• Lighting equipment planning	• High-efficiency appliance • Heat pump hot water systems

Source: National Institute for Land and Infrastructure Management. Design Guideline toward Low Energy Houses with Validated Effectiveness, NSRI

- **Natural Ventilation**

By actively using outside air in the form of ventilation at night and other times, cooling energy can be reduced. It is important to devise a building plan and the shape of openings that will allow natural breezes to flow in. Specific methods include securing openings in the path of ventilation and creating openings according to the prevailing wind direction. A reduction in cooling energy of up to 10% can be expected.

- **daylight use**
  By bringing sunlight into the building, it will ensure the brightness of the residential rooms and reduce lighting energy consumption. A reduction of up to 10% in lighting energy can be expected.

- **Solar power generation**
  See 5.2.5 Renewable Energy.

- **Solar water heating**
  See 5.2.5 Renewable Energy.

- **Improved thermal insulation**
  The insulation performance of houses is effective in reducing the cooling load. If the insulation performance is low, the ceiling surface, in particular, may become hotter than the air temperature due to solar radiation. Due to thermal radiation, people in the room feel uncomfortable and tend to lower the set temperature of the air conditioner. Improving the thermal insulation performance may increase comfort.

- **Solar radiation shielding**
  In hot regions, shielding of solar radiation is of utmost importance in considering cooling loads. In addition to windows and other openings, heat shielding of roofs and walls is also important. The following methods can be used to block solar radiation: external shielding devices (eaves, louvers, external blinds, etc.) and the building frame (ventilation layer, solar reflective paint, etc.).

- **Cooling system planning**
  Installation of high-efficiency air conditioners and fans/ceiling fans are effective. Assuming that the fan can reduce the perceived temperature by 1°C, it may be possible to reduce cooling energy by up to 35%.

- **Lighting equipment planning**
  If fluorescent or incandescent bulbs are used, a significant reduction in lighting energy can be expected by using LEDs. Changing from fluorescent to LED will result in energy savings of about 30%. It is also effective to use motion sensors in entrances and restrooms.

- **High-efficiency appliance**
  For home appliances such as refrigerators and televisions, it is important to use devices with high energy efficiency.

- **Heat pump hot water systems**
  The use of heat pump hot water supply systems for water supply can achieve a lower carbon footprint than gas or electric water heaters. When compared to electric water heaters, a reduction of about 70% can be expected.

The method of calculating the effect of low-carbon methods for residential buildings is shown: the number of households in Khon Kaen is estimated from the number of residential buildings, and the low-carbon scenario is calculated from the breakdown of energy use by household and the effect of low-carbon methods by energy use destination.

Table. 5.2.5. Effectiveness of low-carbon methods for housing

Target	Low carbon measures	Target Energy Conservation ratio	Introduction rate 2030 / 2050
Cooling	External wall insulation + solar radiation shielding	0.25	0% / 100%
Cooling	Roof insulation	0.05	0% / 100%
Cooling	High efficiency of cooling equipment	0.15	0% / 100%
Lighting	High efficiency of lighting equipment	0.30	100% / 100%
Hot water supply	High efficiency of hot water supply equipment	0.30	0% / 100%
Home appliances	High efficiency of home appliances	0.30	100% / 100%
Cooking	High efficiency of cooking appliances	0.05	100% / 100%

Source: Project Team (NSRI)

Table. 5.2.6. Energy consumption ratio in a typical housing

Cooling	Ventilation	Hot water supply	Lighting	Home appliances	Cooking	total
15.5%	4.7%	20.7%	20.4%	32.1%	6.6%	100.0%

Source: Project Team (NSRI)

Table. 5.2.7. Assumptions for calculating the number of households in Khon Kaen

Original housing Type	The number of housing	Number of floors in a typical housing	Floor Area of one floor in a typical housing	Total floor area per household	The number of household per housing	Occupied Floor area per household	vacancy rate
			m2	m2		m2/household	
Houses (detached house, twin house)	53,505	2	50	100	1	100	15%
Dormitory	450	3	50	150	2	75	15%
Row house (fire protection construction materials)	794	4	50	200	2	100	15%
Row house (not fire protection construction materials)	139	4	50	200	2	100	15%
Flat	2,137	2	200	400	4	100	15%
Apartment	5,082	2	200	400	4	100	15%
Temporary house	552	1	50	50	1	50	15%
Boat & raft	5	1	50	50	1	50	15%
Non registred house	7	1	50	50	1	50	15%
Temporary house registration (foriegner)	1	2	50	100	1	100	15%
Civil servant residence	448	2	50	100	1	100	15%

Source: BMC, NSRI estimation

3) Area energy management system (NOT included in the low carbon scenario calculation)

Conventional energy-management was carried out on a facility-by-facility basis, but with AEMS, the energy usage status of the entire area, solar power generators, storage batteries, power supply facilities, etc., are managed in an integrated manner to predict the power demand of each facility and carry out optimal operation and control of the community's energy. In Japan, AEMS has been introduced in the Kashiwa-no-ha area through the development of Mitsui Fudosan, Hitachi, Sharp, and Nikken Sekkei.

The system will achieve power peak shaving by integrating power between facilities with different power demand peaks, such as offices and commercial facilities, and will contribute to lowering electricity rates and lowering the carbon footprint of the entire region by reducing the amount of contracted power.

Solar power generation, which fluctuates depending on weather conditions, will be combined with storage batteries and controlled by AEMS to ensure the stable operation of renewable energy. In the unlikely event of a large-scale power outage, the energy owned by the entire community will be systematically transferred to each facility to maintain lifeline facilities for business continuity and daily life, and at the same time, emergency information such as evacuation guidance will be transmitted to support the safety and security of the town. In the event of a power outage, the electric vehicle batteries will be effectively used as an emergency power source for the town, thus contributing to the community disaster prevention plan.

Since the low-carbon effects of area energy management systems are highly uncertain to quantify, the low-carbon scenario is not shaped for calculation.

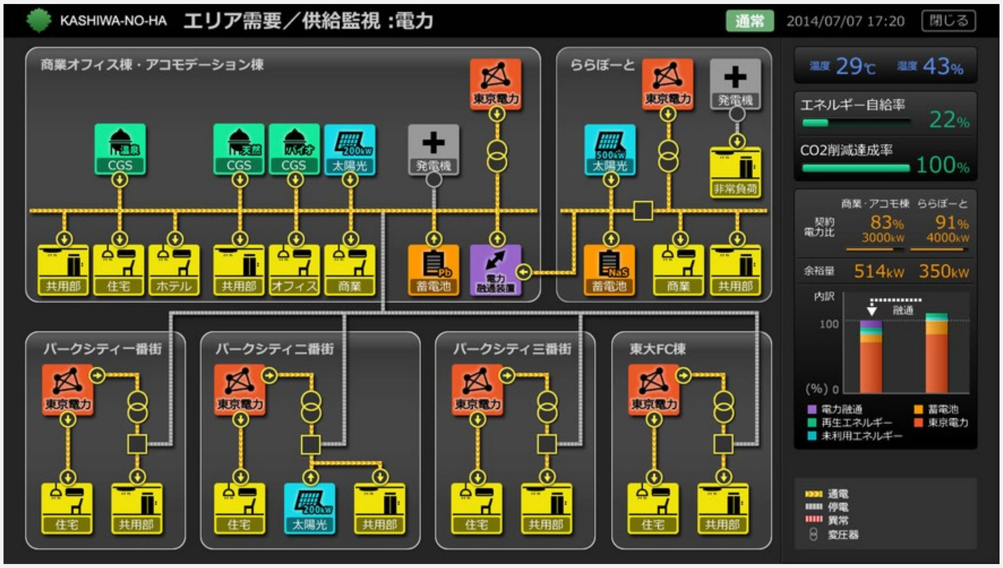


Fig. 5.2.4. Community Energy Management System (Kashiwanoha, Japan)
Source: Good design award (https://www.g-mark.org/award/describe/40423?locale=en)

6) CO2 reduction in buildings

To reduce CO2 emissions in the building sector, the most important things to do are (1) to save energy thoroughly, and (2) to use renewable energy sources such as PV.

Concerning energy efficiency and conservation methods, for residential buildings, (a) use of heat pumps for hot water supply, (b) improvement of heat insulation performance, (c) shielding from solar radiation, and (d) LED lighting are particularly important as energy efficiency and conservation measures. In particular, heat insulation and solar radiation shielding can greatly improve not only CO2 emissions but also occupant performance. For commercial buildings, it is important to (a) electrify, (b) control the heat load through insulation, etc., (c) actively use natural ventilation and lighting, (d) improve the efficiency of equipment systems, and (e) continuously manage energy.

With regard to the use of renewable energy, the most common method is the installation of PV on roofs and rooftops. PV is particularly effective because the demand curve for cooling and the power generation curve for PV often show a similar trend.

A low-carbon scenario for 2030 and 2050 was developed, in which the most effective measures described in Section 5.3.2 and later are implemented systematically, resulting in a reduction of 22% in 2030 compared to BAU, and 44% in 2050 compared to BAU.

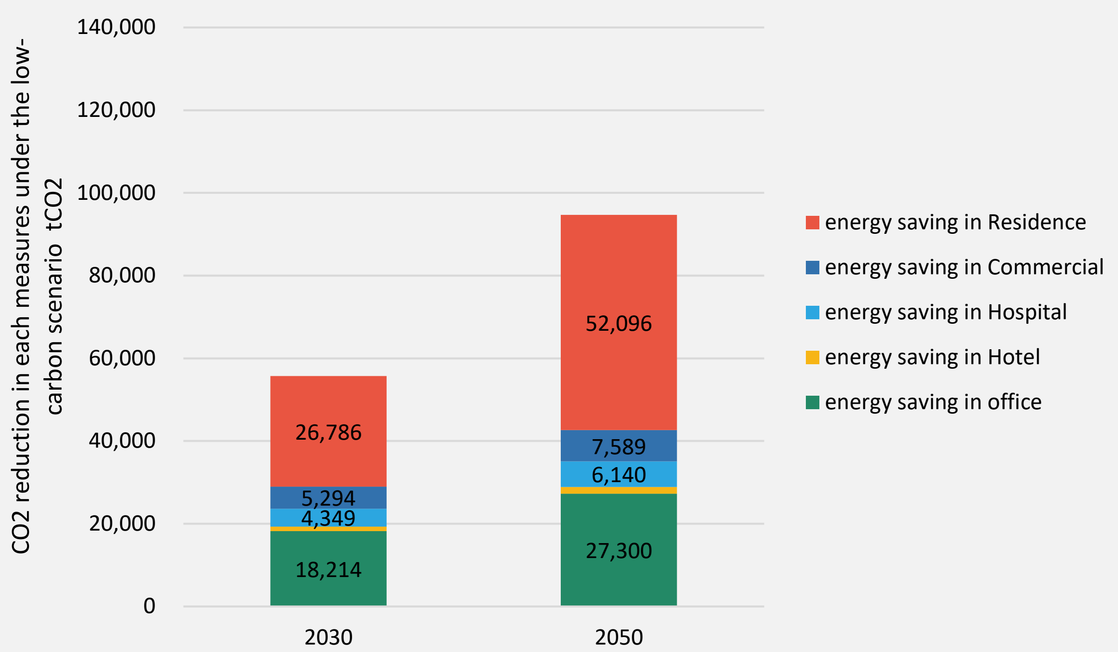


Fig.5.2.5. CO2 reduction for the buildings
Source: Project Team (NSRI)

5.2.3 Low Carbon measures by Transportation

1) Low carbon concept in Urban and Transportation field

In order to achieve the Low Carbon City, the basic concept of the transportation measures is shown below.

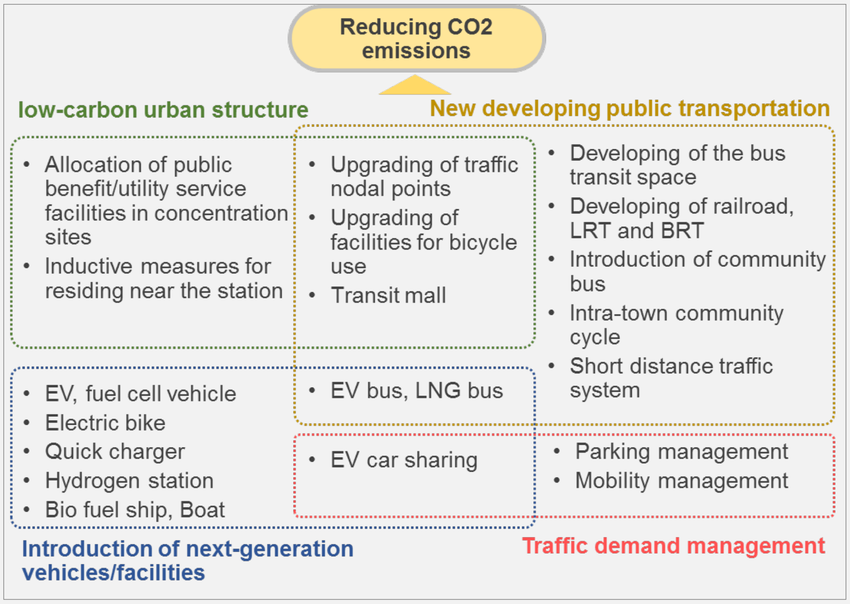


Fig. 5.2.6. Measures to Reduce CO2 Emission in Transportation
Source: Project Team (NSRI)

2) Proposal for CO2 reduction measures

The viewpoints for planning low-carbon transportation in Khon Kaen City are:

- Developing new LRT lines and shifting to public transportation from personal car use.
- Developing a TOD (Transit Oriented Development) City along the LRT lines.
- Diffusion of Low carbon vehicles.
- Introducing a new personal mobility’s as electric kick-board, sharing bicycle, etc.

Fig. 5.2.7. Concept
Source: Project Team (NSRI)

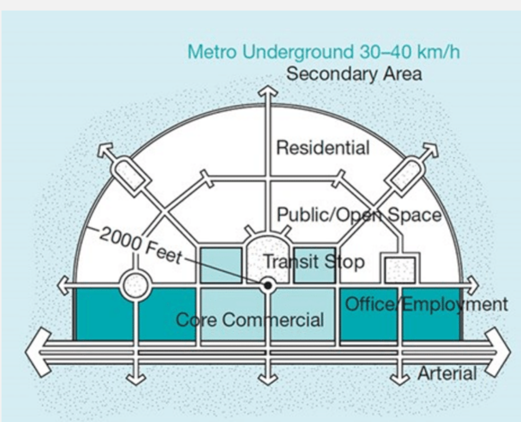
(1) Shifting public transportation with developing the LRT network

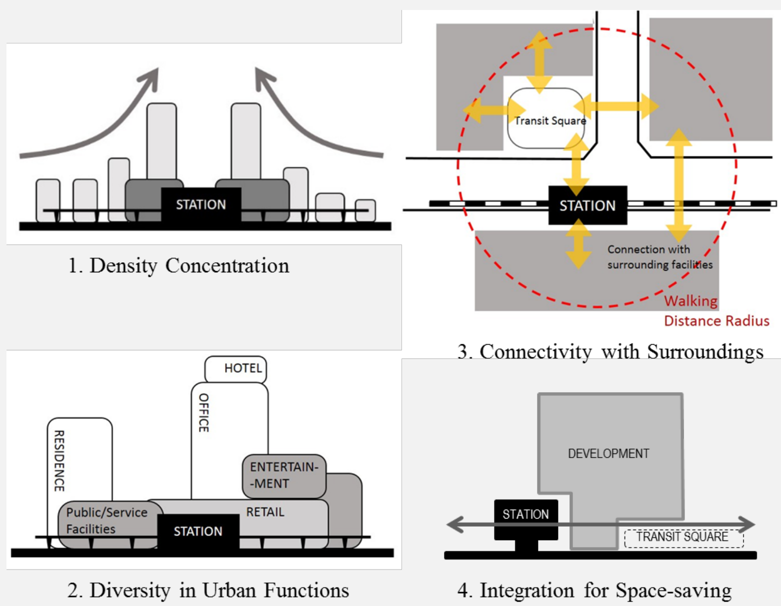
The City government has a plan for the development of LRT lines. A part of passengers in the city might shift to LRT users from car users due to the development of LRT.

Fig. 5.2.8. Plan of LRT Lines

(2) Developing a TOD(Transit Oriented Development) City along the LRT lines.

Urban development that integrally places mixed-use facilities and open spaces around public transport within an approximately 600-800 m radius (about a 10-minute walk).





Left
Fig. 5.2.9. TOD historical concept of city development
Source: Peter Calthorpe , "The Next American Metropolis: Ecology, Community, and the American Dream"

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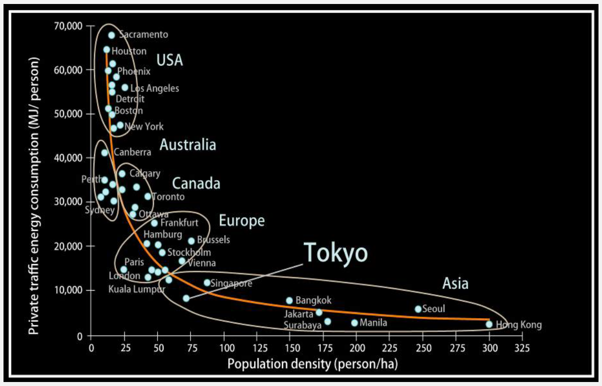
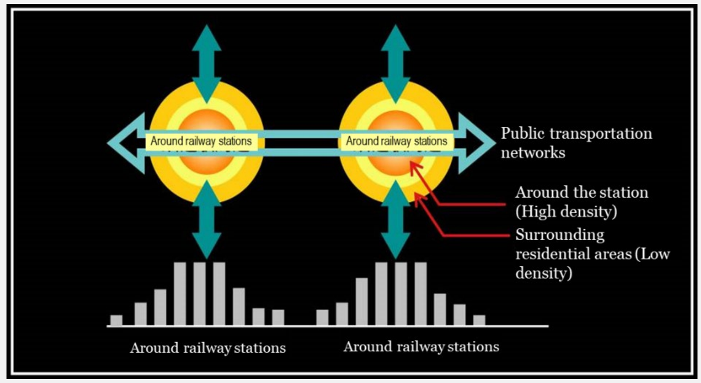
Fig. 5.2.10. Principles in designing Rail and Stations for TOD city
Source: Nikken Sekkei Ltd.

Develop multi-purpose urban areas around a station and realize living and working environments that require minimal trip-length, environment-friendly lifestyles with less dependence on automobiles. Therefore TOD city may lead low carbon city.



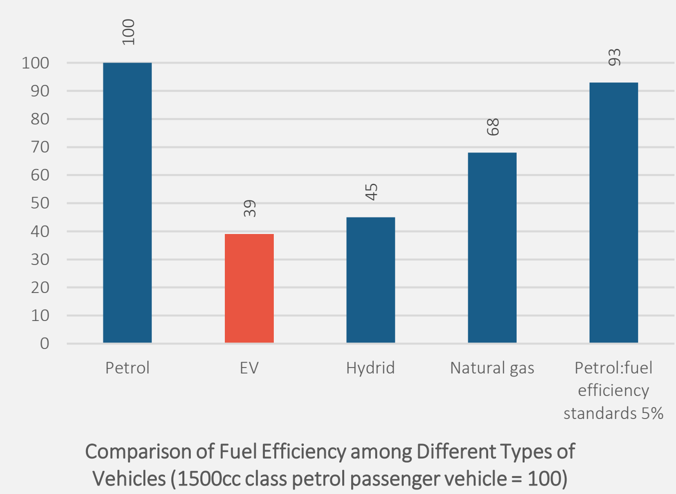


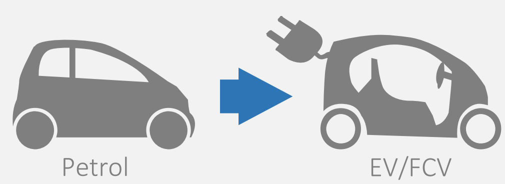
Left
Fig. 5.2.11. Relationship between population density and transportation energy consumption per person in cities
Source: P. Newman and J. Kenworthy, SUSTAINABILITY AND CITIES. Island Press, 1999

Right
Fig. 5.2.12. TOD Concept of city development with compact cities centered around a station
Source: Nikken Sekkei Ltd.

(3) Shifting petro vehicles towards EV

Carbon emission shall be reduced by replacing private cars, taxis, Bus cars currently in use with EVs and low-carbon vehicles.





Left
Fig. 5.2.13. Comparison of fuel efficiency by fuel type
Source: MLIT of Japan

Right
Fig. 5.2.14. Image of shift to EV from petrol car
Source: Project Teams (NSRI)

(4) Introducing electric private mobility (PM)

A use of small-size private motilities (PM) shall be introduced for short-distance movements such as from a station to own house, shop.

Table. 5.2.8. Specific measures for CO2 reduction in transport sector

Task	Direction of measures		Specific measures
Shifting to use of public transportation	Shifting public transportation with developing the LRT network and stations		Developing the new LRT lines
	Development and management user friendly LRT stations.		Developing the transit changing space and information system with ICT technology.
			Promotion for developing the TOD area.
Changing to low carbon city	Developing the low carbon city(TOD)		Promotion for defusing Evs, EV-bikes and development of charging points
Introducing low carbon vehicles	Shifting petro vehicles towards EV		Development of path for bicycle and PM
			Promotion of sharing (cars, bicycles, PM) system
	Introducing electric private mobility(PM)		Promotion and development of sharing port.

Source: Project Team (NSRI)

3) CO2 reduction effect from the CO2 reduction measures

(1) Shifting public transportation with developing the LRT network

With the LRT in the center of Khon Kaen City, it is expected that some passengers might use the LRT and public transport from cars. In this study, the service area of the LRT route has covered the whole of Khon Kaen City. The assumption of changing rate from automobiles and motorcycles to LRT is set as shown in the below table.

The changing rate is set based on the existing survey results * 1). (* 1: Designing Low Carbon Transport System for Khon Kaen)

Table. 5.2.9. Assumption of shifting rate to LRT

	Vehicle	Y2030	Y2050
Shift to LRT	Car	15%	30%
	Motor cycle	10%	20%

Source: Project Team (NSRI)

The result of the calculated CO2 emission is shown in the below table.

Table. 5.2.10. Result of CO2 emission due to shifting to LRT Unite: Unite:000tCO2/Year

	Current	2030	2050
BAU	109	111	119
M1-Shft to LRT	-	98	96

Source: Project Team (NSRI)

(2) Developing a TOD(Transit Oriented Development) City along the LRT lines.

It is expected that buildings will be concentrated around the LRT station due to TOD development. Generally, users of buildings near the station have a higher utilization rate of public transportation such as LRT or buses, so set the shift rate to public transportation as follows.

Table. 5.2.11. Assumption of shifting rate to LRT

	Vihcle	Y2030	Y2050
TOD	Car	5%	10%
	motorcycle	5%	10%

Source: Project Team (NSRI)

The result of the calculated CO2 emission is shown in the below table.

Table. 5.2.12. Result of CO2 emission due to shifting to LRT Unite: Unite:000tCO2/Year

	Current	2030	2050
BAU	109	111	119
M2-TOD	-	107	107

Source: Project Team (NSRI)

(3) Shifting petro vehicles towards EV

Set the EV penetration rate in Thailand in 2030 and 2050 as follows

Table. 5.2.13. Result of CO2 emission due to introducing EV

Vehicle	Y2030	Y2050
Car	10%	30%
motorcycle	20%	40%

Source: Project Team (NSRI)

The result of the calculated CO2 emission is shown in the below table.

Table. 5.2.14. Result of CO2 emission due to introducing PM Unite: Unite:000tCO2/Year

	Current	2030	2050
BAU	109	111	119
M3-EV	-	102	88

Source: Project Team (NSRI)

(4) CO2 reduction by measures

The amount of CO2 reduction by the above measures is shown in the table below.

The CO2 emission in 2030 is estimated to be 84,000tCO2 / year, and in 2050 it is estimated to be 45,000tCO2 / year. The one with the largest reduction rate for BAU is the development of LRT and the introduction of EV in 2030, and the introduction of EV in 2050.

Table. 5.2.15. Result of CO2 emission by measure

Unite: Unite:000tCO2/Year

		CO2 Emission		Reduction Rate	
Year	2020	2030	2050	2030	2050
BAU	109	111	119	100.0%	100.0%
LRT	-	13	23	11.7%	19.3%
TOD	-	4	12	3.6%	10.1%
EV	-	9	31	8.1%	26.1%
PM	-	1	8	0.9%	6.7%
Sub Total		27	74	24.4%	62.2%
Total		84	45	75.7%	37.8%

Source: Project Team (NSRI)

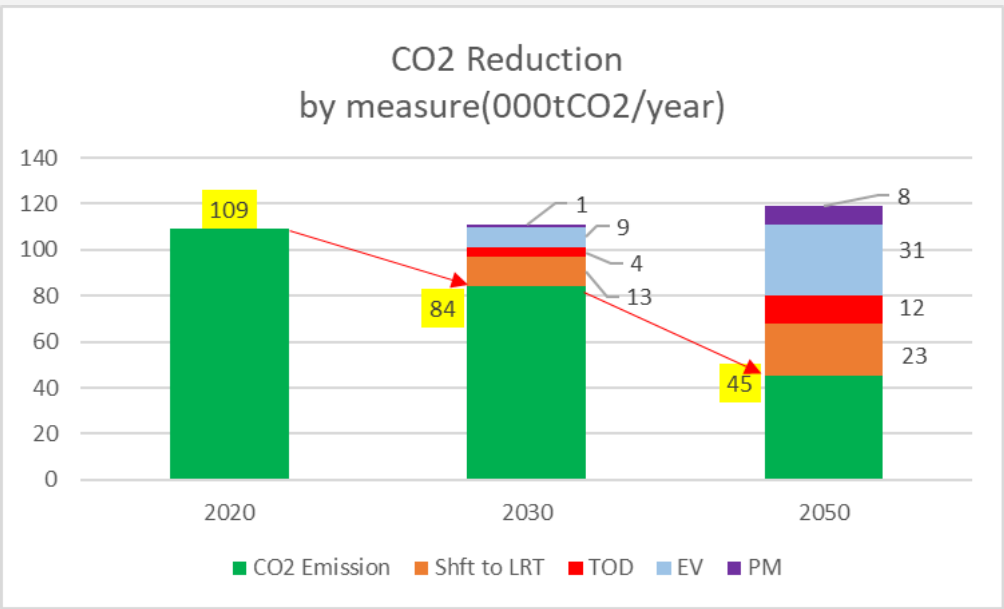


Fig. 5.2.16. CO2 Emission by measures

Source: Project Team (NSRI)

(5) Cost Estimation of transportation measures

The results of estimating costs by the measure are shown.

Table. 5.2.16. Result of cost estimation by measure

Measures	Cost estimation items	Assumption	Cost (mil. BTH)
Developing new LRT lines	Construction of LRT lines	Length of LRT Lines:123.6km Construction cost per km (*1):0.597billion/km *1:Phuket Island light rail transit (58.6km) The cost of the project is estimated at 35 billion baht(0.597billion/km) .	73.8billion BTH
Developing a TOD	In order to realize TOD, it is necessary to design urban planning systems and develop infrastructure to induce urban development along the LRT line, and it is difficult to calculate the costs of these.		
Diffusion of Low carbon vehicles	EV charging station	Number of new portss:30 stations *1) Station density:500/1000km2(cf. Japan experience) ×Khon Kaen City area:46km2 *2 EV charging station costs approximately 1.8million BTH(In case of fast charge)	54 million BTH
Introducing a new personal mobility	Electric private mobility port	Number of new stations:150 stations *1) Station density:3/km2 ×Khon Kaen City area:46km2 *2 Port development costs (15 m^2/5 units, o.3 million BTH/place)	45 million BTH

Source: Project Team (NSRI)

(6) Setting up priority measures among the proposed CO2 reduction measures

Based on the CO2 measures and cost estimation of each measure, the proposed road map of CO2 reduction is shown as a blow table.

	Short term(2025)	Middle term(2030)		Long term (2050)	
Developing new LRT lines			13		23
Developing a TOD			4		12
Diffusion of Low carbon vehicles			9		31
Introducing a new personal mobility			1		8
CO2 Reduction(000tCO2/year)			27		74

Fig. 5.2.16. CO2 Emission by measures

Source: Project Team (NSRI)

5.2.4 Low Carbon measures by Untapped Energy

Untapped energy is a general term for energy that has not been used to date despite its potential for effective utilization, such as waste heat from factories, waste heat from air conditioning and heating in subways and underground malls, and rivers and sewage that have a temperature difference from the outside temperature. Unused energy is distributed "widely and thinly", and in many cases, the source of supply is far from the place of demand, so there is a need for efficient utilization technology. Unused energy utilization technologies can be combined with a variety of other environmental and energy technologies to help create a low-carbon society.

1) Heat Exhaust (NOT included in the low carbon scenario calculation)

As a potential, the following uses of waste heat are generally considered.

- Waste heat from factories
- Waste heat from cleaning plants
- Waste heat from substations
- Waste heat from ultra-high voltage underground power lines
- Waste heat from heating and cooling of subways and underground malls

2) Temperature difference energy (NOT included in the low carbon scenario calculation)

As a potential, the following uses of waste heat are generally considered.

- The heat from domestic wastewater, sewage, and geothermal heat
- The heat from river water and seawater

For hot water demand, because factories and cleaning plants have a large volume of waste heat, it will have a significant low-carbon effect on large hot water and heating demands (pool heating, botanical garden greenhouses).

For cooling demand, geothermal heat pumps are an effective measure. Shimada et al.[2] investigated a geothermal heat pump (rated cooling capacity: 4 kW) in a small building in Bangkok, Thailand, and reported a 40% energy reduction compared to an air source heat pump (ASHP). That report (Shimada et al. 2020) found the following.

- Considering the high temperature during the daytime in Thailand, the obtained result clarifies the high potential of the GSHP to reduce the energy consumption of a building over the long term. Combining the above-obtained results, we propose operational conditions for utilizing GSHPs as follows.
- The 90th percentile value of the hourly HP inlet temperature shown should not exceed 5 °C above that of the hourly annual ambient temperature during the third year of operation.
- The required BHEs were not large for the building to achieve approximately 40% energy savings. This may be feasible because we can install them inside a site such as in a car park. Thus, a small-scale GSHP in Bangkok may result in high efficiency over the long term within space limitations.
- GSHPs cannot treat all cooling loads in large-scale buildings such as department stores and office buildings, because the required number of BHEs will be tremendous in a tropical climate. The cooperative operation of the ASHPs with a cooling tower may be a solution in the case of large-scale buildings.

[2] Shimada, Y.; Uchida, Y.; Takashima, I.; Chotpantarat, S.; Widiatmojo, A.; Chokchai, S.; Charusiri, P.; Kurishima, H.; Tokimatsu, K. A Study on the Operational Condition of a Ground Source Heat Pump in Bangkok Based on a Field Experiment and Simulation. *Energies* 2020, *13*, 274. https://doi.org/10.3390/en13010274

Since the low-carbon effects of Untapped Energy are highly uncertain to quantify, the low-carbon scenario is not shaped for calculation.

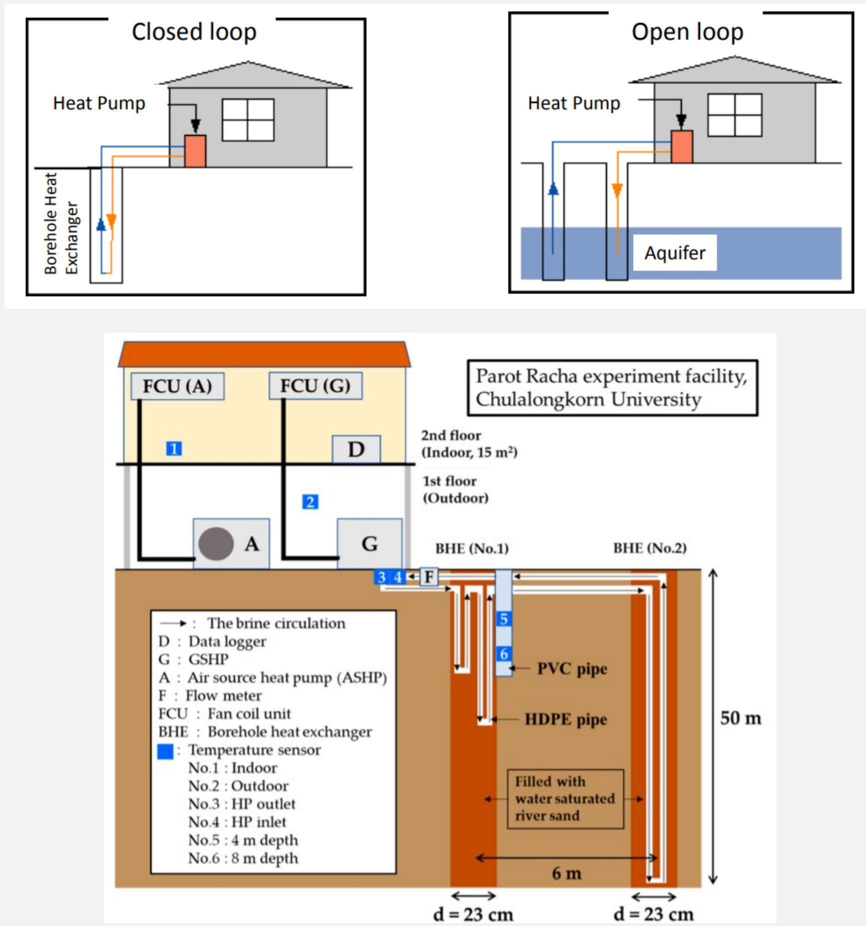


Fig. 5.2.17. Ground source heat pumps (abobe), Ground source heat pomp demonstration experiment in Thailand
Source: Geo-Heat Promotion Association of Japan, Shimada, Y.; Uchida, Y.; Takashima, I.; Chotpantarat, S.; Widiatmojo, A.; Chokchai, S.; Charusiri, P.; Kurishima, H.; Tokimatsu, K. A Study on the Operational Condition of a Ground Source Heat Pump in Bangkok Based on a Field Experiment and Simulation. Energies 2020, 13, 274.

5.2.5 Low Carbon measures by Renewable Energy

One of the most universally available forms of renewable energy is sunlight. An enormous amount of energy is pouring down from the sun onto the earth. The benefits of solar energy are available everywhere, making it the most versatile of renewable energies. To calculate the usable energy of solar energy by photovoltaic power generation facilities, various constraining factors must be considered. The main ones are the current technical constraints such as the efficiency of conversion to electricity, the constraints related to the installation location, and the constraints related to the price. In urban areas, it is necessary to take these factors into account when estimating the amount of solar energy used, since there are also shadows caused by surrounding buildings and restrictions specific to the region. The amount of electricity generated by solar power is proportional to the size and number of solar cells (modules). In other words, if there are not enough of them, the amount of electricity generated will be less, and if there is more, the amount of electricity generated will be more. The power generation efficiency itself does not change depending on the size and number of modules.

1) PV on buildings

The installation of PV on the roof of a building is a common method to realize ZEB. It was assumed that 30% (2030) and 50% (2050) of all non-residential buildings in the Khon Kaen would be PV capable buildings. It was assumed that PV would be installed on 40% of the rooftop area of these buildings. For residential buildings, we assumed that 30% (2030) and 85% (2050) of all residential buildings would be equipped with PV. It was assumed that PV would be installed on 15% of the roof area of the installed residential building.

2) PV on the pond

When installing a mega solar power plant, securing a suitable location is important. In addition to the land-based method, there is also the pond-based method, which has great merits. Unlike the land-based method, it does not take time to cut down trees and build up the land, and the construction period can be shortened. In addition, the surface of the water allows the surface temperature of the panels to be lowered by sprinkling water, thus improving the power generation efficiency. However, it is necessary to take adequate measures against strong winds. We assumed that PV will be installed in the following locations.

Fig. 5.2.18. PV on pond
Source: SOLAR Journal (https://solarjournal.jp/solarpower/28327/)

About 50,000m2
Nearby Bangkok Hospital Khon kaen By 2030

About 100,000 m2
Ban Ped Sub-district, Khon Kaen. 40000 by 2030

Fig. 5.2.19. Assumption of Mega Solar Installation in Khon Kaen
Source: Porject Team (NSRI)

3) Solar water heating system (NOT included in the low carbon scenario calculation)

In buildings with high demand for hot water supply, "Solar water heating system" can be useful in terms of CO2 reduction. The system is simple, and the initial cost is low enough.

In the planning process, it is important to investigate the hot water supply load and load pattern of the facility and design a solar heat utilization system according to the load. In particular, the following points should be noted

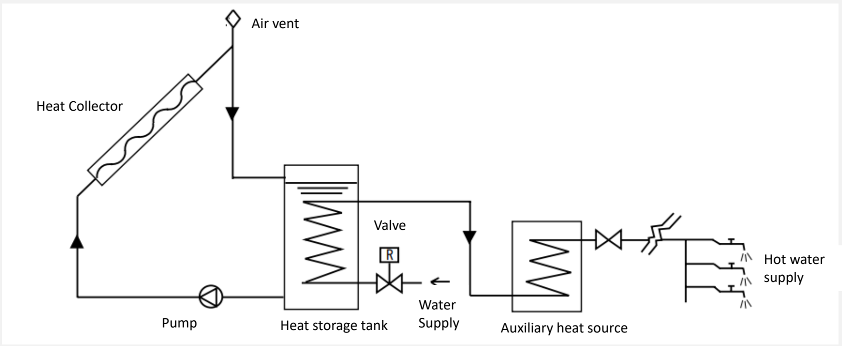


Fig. 5.2.20. Solar water heating system
Source: Design Guidelines for Commercial Solar Thermal Systems, https://www.enecho.meti.go.jp/category/saving_and_new/attaka_eco/reference/pdf/sekkei/sekkei.pdf)

- The hot water load for buildings varies greatly depending on the use, size, and capacity of the building. Public bathrooms, hotels, hospitals, welfare facilities, athletic facilities (heated swimming pools, gym showers, etc.), restaurants, etc. have large hot water loads, while office buildings have small loads.
- Consider reducing the load by reducing the amount of hot water used, reducing heat loss in hot water storage tanks and pipes, selecting high-efficiency water heaters, hot water supply systems, and control methods.
- Since hot water supply has a year-round load, it is more economical to use a tilt angle that provides the most solar energy throughout the year.
- The solar dependency ratio shouldn't exceed 100% on sunny days in the summer when the load on the hot water supply is small so that the collected heat is not wasted.
- Note that the water supply temperature differs depending on the installation area and water source, and the water heating load differs even if the required water heating volume is the same.

Since the solar water heating system is not expected to be installed on a large scale, the Therefore, it is not included in the low-carbon scenario.

4) CO2 reduction by Renewable Energy

PV will be an effective measure for renewable energy. The PV was assumed to be installed on residential and non-residential roofs and mega-solar systems (on the pond), and the CO2 reduction effect was calculated. Reduction scenarios were calculated by prioritizing the measures, including other measures. The priorities of the measures are described in Section 7.

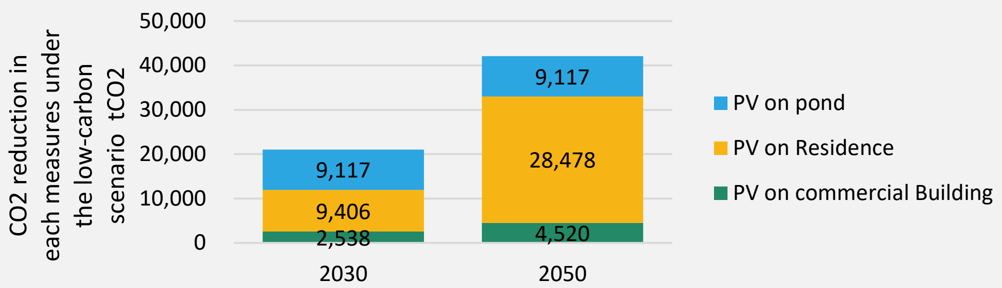


Fig. 5.2.21. CO2 reduction by Renewable Energy
Source: Porject Team (NSRI)

5.2.6 Low Carbon measures by Multi Energy System

1) Co-generation system

A typical example of a Multi Energy System is a cogeneration system. A cogeneration system is a system that uses gas or kerosene as fuel to generate electricity, and effectively uses the heat generated during power generation to improve overall efficiency and save energy. In recent years, fuel cells have been spreading widely, especially in the residential sector, and fuel cell cogeneration systems with excellent power generation efficiency have emerged. In the field of alternative energy use, gas engine cogeneration facilities with a larger power generation capacity are becoming popular. The key to adoption is whether the conditions for effective use of waste heat (sufficient demand for heat and water) are in place and whether the system can be operated for a long time in the output zone with high power generation efficiency. As shown below, economies have established promotion systems as follows.

Key point

- Buildings with high demand for hot water supply, such as hospitals and hotels, can be expected to be particularly effective.
- In buildings with a demand for cooling, the waste heat from CGS can be fed into absorption chillers to produce chilled water.
- The low-carbon effect is estimated to be a reduction of about 10% of the overall carbon dioxide emissions of the building. In the low-carbon roadmap, CGS is to introduce the system in "**hotels**" and "**hospitals**.

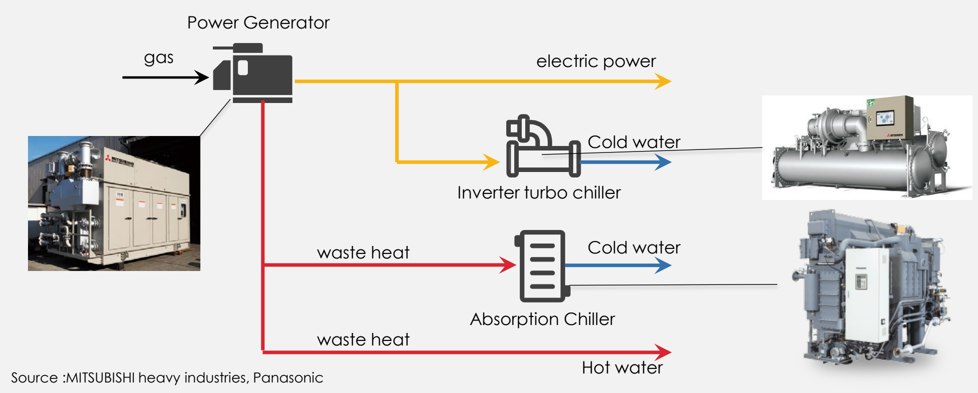


Fig. 5.2.22. Cogeneration system
Source: MITSUBISHI heavy industries, Panasonic, NSRI

Table. 5.2.17. Measures to promote CGS in Europe

	Feed-in Tariff	Feed-in Premium	Quota Obligation & Certificates	Capital Grant	Tender Scheme	Tax Incentives	Other Support	No support
Austria	✓			✓				
Belgium – Flanders			✓	✓		✓		
Bulgaria								✓
Czechia		✓		✓				
Germany	✓	✓		✓	✓	✓		
Finland		✓		✓	✓	✓		
France	✓	✓	✓				✓	
Greece		✓						
Hungary							✓	
Italy			✓					
Netherlands	✓					✓		
Poland			✓	✓				
Portugal	✓							
Romania		✓						
Slovenia	✓	✓			✓			
Spain	✓							
Sweden			✓			✓		
Turkey							✓	
United Kingdom	✓		✓	✓	✓	✓		

Source: COGEN Europe, Snapshot Survey 2018-2019

In calculating the low-carbon scenario, it was assumed that the system would be installed in hotels and hospitals where the hot water load is expected to be sufficient. Based on past results, we assumed that the CO_2 emissions of the entire building would be reduced by 10%.

2) CO2 reduction by Multi Energy System

The cogeneration system is effective in the Multi Energy System, and the amount of CO_2 reduction was calculated assuming that CGS is installed in hotels and hospitals. Reduction scenarios were calculated by prioritizing the measures, including other measures. The priorities of the measures are described in Section 7.

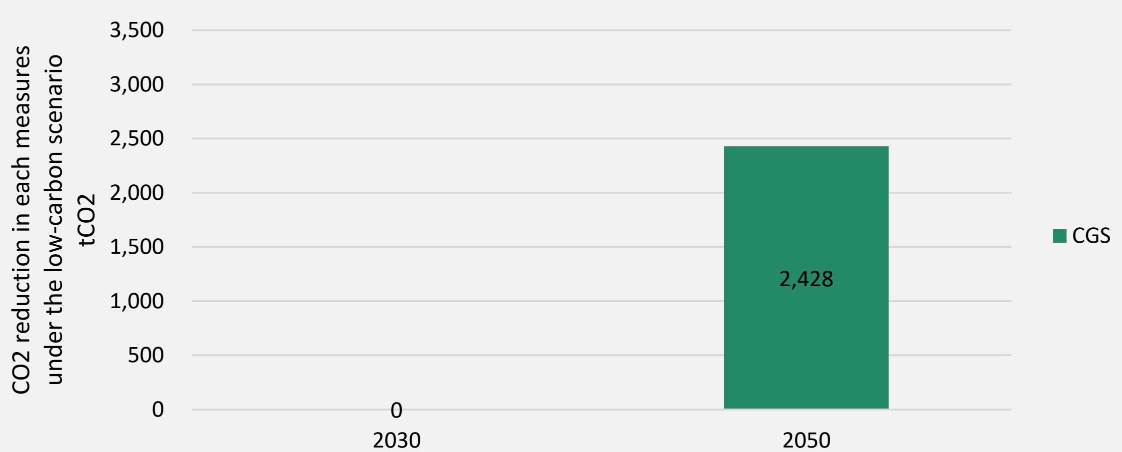


Fig. 5.2.23. CO2 reduction by Multi Energy System

Source: Porject Team (NSRI)

5.2.7 Low Carbon measures by Policy Framework

(NOT included in the low carbon scenario calculation)

Phase 1. This phase includes setting up the committee, goals, CO2 emission strategies and identifying the problems and current situation in Khon Kaen.

Phase 2. This phase includes the development and implementation of the policy. The implementation could include the following.

1. Price-based instruments
   - Taxes on CO2 directly
   - Taxes/charges on inputs or outputs of the process (e.g. fuel and vehicle taxes)
   - Subsidies for emissions-reducing activities
   - Emissions trading systems (cap and trade or baseline and credit)

2. Command and control regulations
   - Technology standards (e.g. biofuel blend mandate, minimum energy performance standards)
   - Performance standards (e.g. fleet average CO2 vehicle efficiency)
   - Prohibition or mandating of certain products or practices
   - Land-use planning, zoning

3. Technology support policies
   - Public and private research, development and demonstration (RD&D) funding
   - Green certificates (renewable portfolio standard or clean energy standard)
   - Feed-in tariffs
   - Public investment in underpinning infrastructure for new technologies
   - Policies to remove financial barriers to acquiring green technology (loans, revolving funds)

4. Information and voluntary approaches
   - Rating and labelling programs
   - Public information campaigns
   - Education and training
   - Product certification and labelling
   - Award schemes

Phase 3. Validation. Here are included monitor implementation and evaluation of effectiveness after proposed implementation of the project.

Phase 4. Improving and ensuring sustainability. After the validation process and setting the timeframe of the implementation of the measures it is needed to prepare a plan for improving for the sectors related to the C02 emissions reduction.

Fig.5.2.24. Plan to set the Policy Framework based on the level of implementation
Source: Project Team

5.2.8 Low Carbon measures by Greenery

(NOT included in the low carbon scenario calculation)

In this section, we will focus on greening in urban and architectural spaces. Greenery in cities is the only source of absorption in cities. Urban greening can also be a countermeasure for heat islands, improving the thermal environment and enhancing the landscape. The effects of greening in architecture are shown below. In addition to absorbing carbon dioxide, rooftop greening and wall greening have the effect of reducing the indoor heat load by improving thermal insulation and solar radiation shielding performance.

However, the low-carbon effects of greenery are not included in Khon Kaen's low-carbon scenario because of the small reduction effect in total emissions. The basic unit of absorption by greening is as follows: 9.78 t-CO2/(ha year) × greening area ha (in the case of greenery such as urban parks with 200 trees/ha or more, Source: Kyoto Protocol, Article 3).

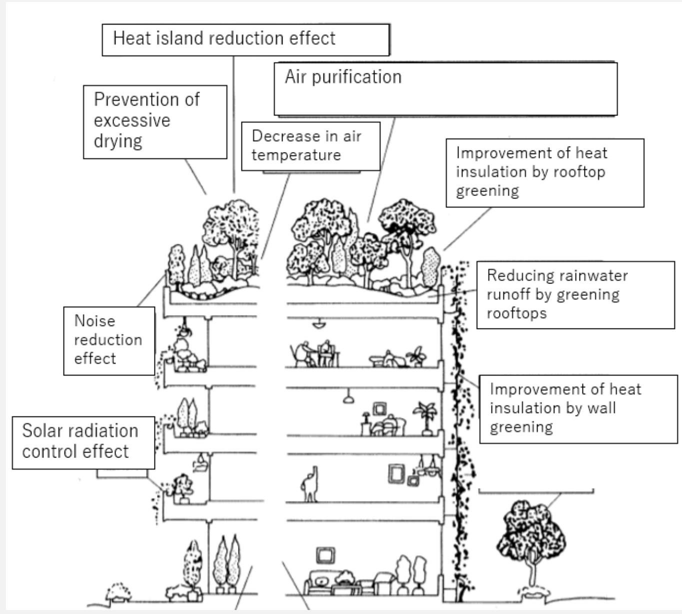


Fig. 5.2.25. Green environmental adjustment effect
Source: Akira Hoyano (Professor Emeritus, Tokyo Institute of Technology)

Fig. 5.2.26. Example of greened architecture (Shanghai Green Space Center)
Source: NIKKEN SEKKEI

5.2.9 Low Carbon measures by Waste Management

(NOT included in the low carbon scenario calculation)

To manage waste, it is important to integrate it with business models. To integrate business models with waste management, it is important to address the five business models of the circular economy. These are a) Circular Supply-Chain, b) Recovery & Recycling, c) Product Life Span Extension, d) Sharing Platform, and e) Product as a service. Each of them is explained below.

a) Circular Supply-Chain
This is a movement to replace raw materials for products with raw materials that have less impact on the environment. For example, Nike has been innovating its raw materials. Approximately 73% of Nike's sports shoes and sportswear contain recycled materials, and 99.9% of its manufacturing waste is recycled rather than disposed of. For example, Nike's Fly leather material is made from natural leather fibres, at least 50% of which are recycled from leather scraps.

b) Recovery & Recycling
Recovery and recycling are now being adopted by many companies. Ideally, the recovered resources should be used for as long as possible while maintaining the highest possible value. This includes, for example, using steel recovered from cars to make new cars or upcycling it into higher-value products, rather than downcycling it into lower value products.

c) Product Life Span Extension
For example, smartphones are being exhausted in a few years even though they still have a lot of product life left. Product life span extension" is the intentional extension of a product's useful life by making it repairable, replaceable, or resalable in a secondary market. Patagonia, the seller of outdoor and mountaineering equipment, has the largest repair facility in North America. This also increases brand loyalty and makes it easier to get product feedback from customers.

d) Sharing Platform
Shared ownership and use of products can also be effective. High-value products such as houses (see below Fig.), and cars can benefit from this. In the case of large companies, creating a sharing platform requires a major change in the existing business model or the launch of a new experimental venture. For example, Mercari and others have succeeded as a business model by providing a platform where individuals can freely buy and sell used goods.

e) Product as a service（PaaS）
A company retains ownership of a product and provides its value to customers on a "product as a service system". The PaaS model has based on the premise that a company builds a long-term relationship with its customers and sells them additional services, while the company uses the user information gained to develop new business.

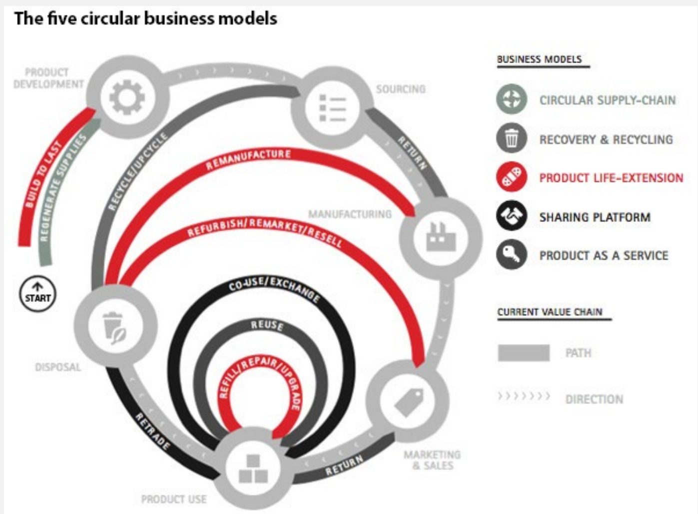


Fig.5.2.27. Five Business Models for a Circular Society
Source: Consultancy.ukc

Waste management is not included in the low-carbon scenario due to its large uncertainties.

- ✓ Houses generate a large amount of waste when they are disposed of.
- ✓ By sharing empty houses and rooms through sharing platforms (e.g., Airbnb), we can make effective use of idle assets and reduce waste.

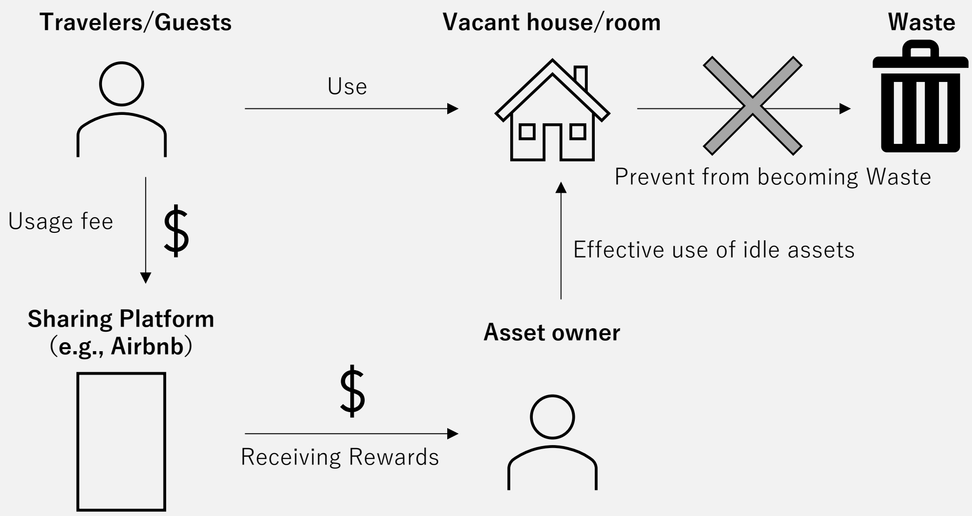


Fig.5.2.28. Example of a housing sharing platform
Source: Project Team

To increase the amount of recyclable waste collected and to reduce waste, many local governments have created incentive systems, including providing subsidies to local community organizations that practice group collection. In the group collection, the applicable target person from the activities is exempted from the fee and a volunteer seal is issued. The program supports a part of purchase costs such as household garbage processing machines to promote the reduction of garbage.

This FS recommended the implementation of the waste collection program in Khon Kaen which could be a great motivation to the local community and organisations in order to improve the eco-recycling. The group collection reduces waste collection costs not only for local governments but also for waste collectors by enabling them to efficiently collect specific amounts of waste. The program could be applicable for resident groups in local communities, including neighbourhood associations, district organizations, and volunteer groups, etc.

PROPOSALS FOR LOW CARBON SCENARIO

06

CHAPTER 6. Low carbon scenario for Phu Quoc District, Viet Nam

6.1. Background research and Define baseline in BAU scenario

6.1.1. Background research and Define baseline in BAU scenario

This section of the report discusses the Business as Usual (BAU) scenario of the following specific sectors for Phu Quoc.

In Phu Quoc, three scenarios of electricity demand have already been drawn up from 2010 to 2030. Each scenario, baseline, high and low are established based on the growth rate of each sector. In this report, the Business as Usual (BAU) scenario is established based on the baseline scenario.

Table. 6.1.1. Forecasting results of electricity demand on Phu Quoc in the period 2010-2030 – Baseline Scenario

No	Sector	Year 2010			Year 2015			Year 2020			Year 2030			Growth rate (%/year)		
		A (MWh)	%A	P (kW)	A (MWh)	%A	P (kW)	A (MWh)	%A	P (kW)	A (MWh)	%A	P (kW)	11-15	16-20	21-30
1	Industry–Construction	5.465,4	11,2%	1.758,8	14.215,3	8,1%	4.052,6	61.290,4	14,3%	14.644,5	120.183	10,3%	27.041,2	21,07	33,95	7,0
2	Agriculture–Forestry – Fishery	139,6	0,3%	132,6	387,9	0,2%	368,5	1.000,0	0,2%	950,0	3.106	0,3%	2.458,8	22,68	20,85	12,0
3	Commerce-Services	10.829,5	22,3%	2.747	76.989,5	43,8%	20.949,1	200.683,1	46,7%	51.690,2	612.714	52,7%	149.843,7	48,04	21,12	11,8
4	Offices-Residences	27.080,0	55,7%	9.446,9	66.749,5	38,0%	22.214,1	125.857,5	29,3%	37.607,4	298.426	25,7%	80.614,7	19,77	13,52	9,0
5	Other	5.095,5	10,5%	1.630,0	17.425,3	9,9%	4.713,1	41.138,5	9,6%	10.567,9	127.770	11,0%	31.942,5	27,88	18,74	12,0
6	Commercial volume	48.609,9	100,0%		175.767,6	100,0%		429.969,5	100,0%		1.162.198	100,0%		29,31	19,59	10,5
9	Loss	10,0%			9,0%			7,5%			6%					
10	Total power	54.011,0			193.151,2			464.831,9			1.236.381			29,03	19,20	10,3
11	Pmax all district (kW)			12.258			41.838			92.368			232.763,2	27,8	17,2	9,7
12	Tmax (hr/yr)			4.406			4.617			5.032			5.312			

Source: Phu Quoc Power Development Masterplan, 2011-2020

Table. 6.1.2. Forecasting results of electricity demand on Phu Quoc in the period 2010-2030 – High Scenario

No	Sector	Year 2010			Year 2015			Year 2020			Year 2030			Growth rate (%/year)		
		A (MWh)	%A	P (kW)	A (MWh)	%A	P (kW)	A (MWh)	%A	P (MW)	A (MWh)	%A	P (kW)	11-15	16-20	21-30
1	Industry–Construction	5.465,4	11,2%	1.758,8	14.215,3	7,2%	4.052,6	98.040,4	17,8%	23.832,0	217.937,9	14,6%	47.840,0	21,07	47,14	8,3
2	Agriculture–Forestry – Fishery	139,6	0,3%	132,6	387,9	0,2%	368,5	1.000,0	0,2%	950,0	3.105,8	0,2%	2.458,8	22,68	20,85	12,0
3	Commerce-Services	10.829,5	22,3%	2.747,1	92.032,7	46,4%	25.650,1	260.608,9	47,4%	68.954,7	791.813,6	53,2%	195.918,7	53,41	23,14	11,8
4	Offices-Residences	27.080,0	55,7%	9.446,9	74.358,5	37,5%	24.539,0	148.883,6	27,1%	43.962,4	347.289,2	23,3%	87.825,3	22,39	14,90	8,8
5	Other	5.095,5	10,5%	1.630,0	17.425,3	8,8%	4.713,1	41.138,5	7,5%	10.567,9	127.770,0	8,6%	31.942,5	27,88	18,74	12,0
6	Commercial volume	48.609,9	10,5%		198.419,8	100,0%		549.671,3	100,0%		1.487.916	100,0%		32,49	22,60	10,5
9	Loss	10,0%	100,0%		9,0%			7,5%			6%					
10	Total power	54.011,0			218.043,7			594.239,3			1.582.890			32,19	22,20	10,3
11	Pmax all district (kW)			12.258			47.459			117.131			292.788	31,1	19,8	9,6
12	Tmax (hr/yr)			4.406			4.594			5.073			5.406			

Source: Phu Quoc Power Development Masterplan, 2011-2020

Table. 6.1.3. Forecasting results of electricity demand on Phu Quoc in the period 2010-2030 – Low Scenario

No	Sector	Year 2010			Year 2015			Year 2020			Year 2030			Growth rate (%/year)		
		A (MWh)	%A	P (kW)	A (MWh)	%A	P (kW)	A (MWh)	%A	P (MW)	A (MWh)	%A	P (kW)	11-15	16-20	21-30
1	Industry–Construction	5.465,4	11,2%	1.758,8	14.215,3	10,1%	4.052,6	48.060,4	14,4%	11.337,0	66.160	8,0%	14.886,0	21,07	27,59	3,2
2	Agriculture–Forestry – Fishery	139,6	0,3%	132,6	387,9	0,3%	368,5	1.000,0	0,3%	950,0	3.105,8	0,4%	2.458,8	22,68	20,85	12,0
3	Commerce-Services	10.829,5	22,3%	2.747,1	42.823,1	30,6%	10.272,1	125.554,1	37,7%	30.171,2	378.794	45,5%	89.693,5	31,65	24,00	11,7
4	Offices-Residences	27.080,0	55,7%	9.446,9	65.261,7	46,6%	21.835,5	117.562,0	35,3%	34.747,5	256.309	30,8%	66.280,4	19,23	12,49	8,1
5	Other	5.095,5	10,5%	1.630,0	17.425,3	12,4%	4.713,1	41.138,5	12,3%	10.567,9	127.770,0	15,4%	31.942,5	27,88	18,74	12,0
6	Commercial volume	48.609,9	100,0%		140.113,4	100,0%		333.315,0	100,0%		832.139	100,0%		23,58	18,93	9,6
9	Loss	10,0%			9,0%			7,5%			6%					
10	Total power	54.011,0			153.970,8			360.340,5			885.254			23,31	18,54	9,4
11	Pmax all district (kW)			12.258			32.993			71.974			168.314	21,9	16,9	8,9
12	Tmax (hr/yr)			4.406			4.667			5.007			5.260			

Source: Phu Quoc Power Development Masterplan, 2011-2020

6.1.2. Data Collection and existing analysis for target areas

1) Building Sector

Phu Quoc is a city where tourism is very important. Therefore, it is a model that considers both local people and increasing tourists. It has plenty of lands that can be implemented with renewable energy. Therefore, both the demand and supply side low carbon measures should be considered in this city. It is a model with the stakeholders such as the town government, developers, as well as the energy company. The energy from this town can serve both in and outside the town. It can make use of future development and make a balance between demand and supply-side.

Land use data for 2021 and 2030 were obtained from the Vietnamese government. The area of each sector is shown in the table below.

Table. 6.1.4. ALLOCATION CRITERIA FOR LAND USE PLAN IN 2021 OF PHU QUOC CITY

No.	Land use parameter	Code	Total area	Area divided by administrative unit								
				Duong Dong ward	An Thoi ward	Cua Can commune	Ganh Dau commune	Cua Duong commune	Ham Ninh commune	Duong To commune	Bai Thom commune	Tho Chau commune
(1)	(2)	(3)	(4)= (5)+...+(13)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	TOTAL NATURAL AREA		**58,927.48**	**1,506.20**	**3.429.11**	**4.016.78**	**5,790.25**	**18,472.11**	**6.287.40**	**8.177.82**	**9,849.78**	**1.398.04**
1	**Agricultural land**	**NNP**	**44,734.87**	**526.03**	**1,455.04**	**2,904.79**	**4.694.17**	**16,808.95**	**4.151.25**	**4,385.42**	**8,620.52**	**1,188.69**
1.1	Paddy land	LUA										
1.2	Land for cultivation of other annual crops	HK										
1.3	Land for cultivation of perennial trees	CLN	7,692.08	313.34	327.01	989.68	61.90	3,307.02	905.94	1,319.08	467.64	0.46
1.4	Land for protection forests	RPH	7,612.77	212.69	1,128.02			1,152.35	1,087.09	2,844.39		1,188.23
1.5	Land for special-use forests	RDD	29,392.16			1,903.09	4.632.28	12,343.17	2,139.29	221.95	8,152.38	
1.6	Land for production forests	RSX										
1.7	Land for aquaculture	NTS	16.45			12.01			3.94		0.50	
1.8	Land for salt production	LMU										
1.9	Other agricultural land	NKH	21.41					6.42	14.99			
2	**Non-agricultural land**	**PNN**	**12,912.62**	**980.17**	**1,858.49**	**1,098.44**	**1,057.23**	**1,663.16**	**1,260.72**	**3,792.40**	**997.13**	**204.87**
2.1	Land for economy defense purposes	CQP	900.24	63.82	193.42	65.72	42.59	95.57	1.91	146.52	114.08	176.62
2.2	Land for security purposes	CAN	12.41	3.24		4.79				3.88	0.50	
2.3	Land for industrial parks	SKK										
2.4	Land for export processing zones	SKT										
2.5	Land for industrial clusters	SKN	59.16						59.16			
2.6	Land for trading and service	TMD	5,758.62	209.22	910.24	694.06	761.76	538.22	698.56	1.377.83	568.72	
2.7	Land of non-agricultural production units	SKC	99.82	2.34	5.08	0.03	78.67	11.65		1.68		0.36
2.8	Land used for mining activities	SKS										
2.9	Land for infrastructure development at economy, provincial, district and commune levels	DHT	2,667.50	175.38	110.12	75.37	53.84	405.22	226.78	1,507.09	93.70	20.00
2.10	Land with historical-cultural relics spots	DDT	8.99	0.02	8.02						0.96	
2.11	Land with scenic spots	DDL										
2.12	Land for waste dumping and treatment	DRA	19.40	0.01	0.58		5.16		11.66	2.00		
2.13	Rural residential land	ONT	1,473.07			167.54	99.17	262.34	214.88	583.89	139.75	5.50
2.14	Urban residential land	ODT	1,029.07	423.98	605.09							
2.15	Land for construction of offices	TSC	24.51	5.52	1.86	2.78	0.85	3.49	2.17	4.77	1.99	1.08
2.16	Land for construction of offices of non-business units	DTS										
2.17	Land for construction of diplomatic facilities	DNG										
2.18	Land used by religious institutions	TON	20.55	8.88	1.76			0.72		9.20		
2.19	Land used for cemeteries, graveyards, funeral service centers and cremation centers	NTD	27.75	5.73	3.11		0.37		UI	11.88	5.54	
2.20	Land for production of building materials, and pottery	SKX	14.94					9.43		5.51		
2.21	Land for community activities	DSH	2.73	0.12	0.10	0.40	0.31	0.63	0.09	0.65	0.42	0.01
2.22	Land for public entertainment and recreation	DKV	81.95	20.40	7.52	5.63		7.93		30.80	9.66	
2.23	Land used by belief institutions	TIN	12.23	1.57	1.15	1.54	0.72	1.24	0.23	5.70		0.09
2.24	Land with rivers, streams, canals, springs	SON	698.32	59.67	10.24	80.58	13.80	326.71	43.31	100.99	61.81	1.22
2.25	Land with special-use water surface	MNC										
2.26	Other non-agricultural land	PNK	1.34	0.26	0.21				0.88			
3	**Unused land**	**CSD**	**1,279.99**		**115.58**	**13.55**	**38.84**		**875.43**		**232.12**	**4.47**
4	**Land for hi-tech park***	**KCN**										
5	**Land for economic zone***	**DBT**	**58,923.00**	**1,506.32**	**3,428.23**	**4,016.72**	**5,789.98**	**18,472.10**	**6,287.40**	**8,177.86**	**9,846.46**	**1,397.93**
6	**Urban land***	**DDL**	**4,935.31**	**1,506.20**	**3,429.11**							

Source: Decision No. 776, People's Committee of Kien Giang, 2021

Table. 6.1.5. ALLOCATION CRITERIA FOR LAND USE PLAN IN 2030 OF PHU QUOC CITY

No	Land category	Planned to 2030		Ratio	Planned to 2030		Ratio
		Approved as per Decision 633			Approved as per Decision 868		
		Benchmark	Area		Benchmark	Area	
		(m2/person)	(ha)	(%)	(m2/person)	(ha)	(%)
	Total natural area		58.923	100		58.923	100
1	Urban construction	80-90	3.852	6,54	80-90	3.852	6,54
2	Tourism		3.861	6,55		4.003	6,79
2.1	- Ecotourism (of which golf field of 474ha)		3.051			3.051	
2.2	- Mixed use tourism (of which golf field of 244ha)		810			810	
	- Mixed use tourism					142	
3	Tourism, service and residence complex		1.235	2,1		3.325	5,64
3.1	- Mixed use tourism		667			667	
	- Mixed use tourism (complex and golf field) in Dong Cay Sao and North Cua Can Stream					2.090	
3.2	- Low density residence		235			235	
3.3	- Public works		181			181	
3.4	- Transportation		152			152	
4	Special use		1.489	2,53		1.489	2,53
4.1	- Craft industry		211			211	
4.2	- Non-tariff area		101			101	
4.3	- Racing and training courses		170			170	
4.4	- Main transportation		666			666	
4.5	- Cultural and historical land (of which protection forest is 140 ha)		342			342	
5	Greeneries, water surface and open spaces		3.399	5,77		3.399	5,77
6	Technical infrastructure headworks		1.135	1,93		1.135	1,93
6.1	- Airport, seaport		920			920	
6.2	- Waste and wastewater treatment		100			100	
6.3	- Power plant, water plant		65			65	
6.4	- Cemetery		50			50	
7	Forestry		37.802	64,16		37,430	63,52
7.1	- Special use forest		29.596			29.596	
7.2	- Phu Quoc Island protection forest		7.038			6.666	
7.3	- Tho Chu Isle protection forest		1.168			1.168	
8	Agricultural land		5.813	9,87		3.953	6,71
8.1	- Farming land		4.177			2.719	
8.2	- Rural residence, craft village		1.636			1.234	
9	Security and defense, reserve for development		337	0,57		337	0,57

Source: the proposal of Ministry of Construction in Appraisal Report No. 07, 2021

2) Transport Sector

Transportation for Phu Quoc traffic includes only road and airways – with roadways being the major means of transportation.

(1) Types of Transport

Transport services in the Phu Quoc city consist mainly of 2-wheelers and 4-wheeler passenger transport which includes cars, taxis which are privately owned and operated. The other significant category of vehicles is commercial vehicles present for freight transport.

Based upon the Viet Nam level data of vehicle registration number of vehicles present in the economy has been derived as given in Table below.

Table. 6.1.6. Number of vehicles in Viet Nam

	No. of vehicles (in thousand)							
Type of Vehicle	2010	2011	2012	2013	2014	2015	2016	2017
2W	31452	33167	38000	40072	42256	44560	45000	47453
4W Passenger vehicle	654	812	827	1027	1275	1583	1484	1842
Goods vehicles	552	614	652	725	806	897	1109	1233

Source: WHO, VNExpress, BHQ 2014

Table. 6.1.7. Share of fuels across 2W and goods vehicles segment in Viet Nam

No.	Type of Vehicle	Share of Diesel	Share of Petrol
1	2W	0%	100%
2	Goods vehicles	100%	0%
3	Taxis (4W passenger)	0%	100%
4	Personal vehicles (4W passenger)	100%	0%

Source: BAQ 2014 presentation

(2) Vehicle traffic

Vehicle traffic data for Viet Nam in terms of million passenger-km (in case of 2W and 4W passenger vehicles) and million tonne-km (in case of freight vehicles) have been derived from the data available in Viet Nam Statistical Handbook as given in Table below.

Table. 6.1.8. Vehicular traffic in Viet Nam

Viet Nam	Vehicle traffic (million passenger km/million tonne km)							
Vehicle Type	2010	2011	2012	2013	2014	2015	2016	2017
2W	67787	76148	83171	88063	94048	101767	110553	120704
4W Passenger vehicle	1410	1865	1811	2257	2838	3615	3646	4686
Goods vehicle	36179	40130	43469	45668	48190	51515	57377	63459

Source: Vietnam Statistical Handbook

(3) Energy Consumption by fuel types

At the Viet Nam level, the total energy consumption in the entire transport sector is available which is used along with the average utilization of each category of vehicles to calculate the energy consumed, given in Table below.

Table. 6.1.9. Energy consumption of vehicles in Viet Nam

Viet Nam	Vehicle category-wise energy consumption (KTOE)							
Vehicle Type	2010	2011	2012	2013	2014	2015	2016	2017
2W	6369	6323	6242	6074	6197	6739	7648	7820
4W Passenger vehicle	133	155	136	156	187	239	252	304
Goods vehicle	3399	3332	3262	3150	3176	3411	3969	4111
Total	**9900**	**9810**	**9640**	**9380**	**9560**	**10390**	**11870**	**12235**

Source: International Energy Agency (IEA)

As mentioned beforehand, based on fuel type for each category of the vehicle the total energy consumed in the sector is based on fuels. Results are provided in the teble below.

Table. 6.1.10. Fuel wise energy consumption in Viet Nam

Viet Nam	Fuel-wise energy consumption (KTOE)							
Fuel Type	2010	2011	2012	2013	2014	2015	2016	2017
Diesel	3425	3289	3181	3213	3459	4020	4172	4291
Gasoline	6447	6351	6199	6347	6931	7850	8063	8324
Total	**9872**	**9640**	**9380**	**9560**	**10390**	**11870**	**12234**	**12615**

Source: International Energy Agency (IEA)

6.2. Define CO2 emission baseline BAU scenario for target areas

6.2.1 Define BAU of CO2 emission baseline in energy sectors

The CO_2 emissions from building sectors are estimated by building floor area and energy consumption unit of different types of building.

> Building energy consumption＝ Σ ｛Building energy consumption unit according to building use(MJ/ m2) × Building floor area (m2)｝

The CO_2 emissions BAU was calculated from the electricity demand Scenario in the baseline case and the area for each sector. For emission factors, an IGES list of grid emission factors was used; combined Margin EF ： 0.599 ton CO2/MWh.

The calculation result of BAU is shown below. The annual CO2 emissions in the current situation of the building sector in the Phu Quoc is about 258,000 t-co2. It'll increase about 270 % by 2030. This is because areas are developed and improvement of energy standards.

In addition, CO2 emissions in 2050 were set according to the growth rate from 2021 to 30. It'll increase by about 330 % by

Table. 6.2.1. Energy consumption on Phu Quoc in the period 2020-2030 – Baseline Scenario

No	Sector	Land use area in 2021			Year 2020		energy consumption per sqm	Land use area in 2030			Year 2030		energy consumption per sqm	Growth rate (%/year)	Land use area in 2050	Year 2050
		ha	floor area ratio*1	thousand sqm	A (MWh)	%A	kWh/sqm	ha	floor area ratio*1	thousand sqm	A (MWh)	%A	kWh/sqm	21-30	ha	A (MWh)
1	Industry – Construction	193	10%	193	61,290	14%	317.0	215	10%	215	120,183	10%	559.0	7%	245	137,009
2	Agriculture – Forestry – Fishery	44,735	5%	22,367	1,000	0%	0.0	41,383	5%	20,692	3,106	0%	0.2	-	37,311	2,800
3	Commerce - Services	2,644	40%	10,576	326,541	47%	30.9	3,627	40%	14,508	911,140	53%	62.8	12%	4,381	1,109,443
4	Offices - Residences					29%						26%		9%		
5	Other	10,075	10%	10,075	41,139	10%	4.1	13,699	10%	13,699	127,770	11%	9.3	12%	16,987	158,435
6	Unused area	1,280						0								
	Commercial volume	**58,927**			**429,970**			**58,924**			**1,162,199**				**58,924**	**1,407,687**

*1 Assumed based on aerial photographs and sample area

Source: Calculated by NSRI based on electricity demand and land use plan

Table. 6.2.2. CO2 emission on Phu Quoc in the period 2020-2030 – Baseline Scenario

		Year 2020	Year 2030	Year 2050
Industry	t-CO2	36,713	71,990	82,068
Agriculture	t-CO2	599	1,860	1,677
Commerce, Office, Residence	t-CO2	195,598	545,773	664,556
Others	t-CO2	24,642	76,534	94,902
Total	t-CO2	257,552	696,157	843,204

* Combined Margin EF ： 0.599 ton CO2/MWh (IGES List of Grid Emission Factors)

Source: Calculated by NSRI based on electricity demand and land use plan

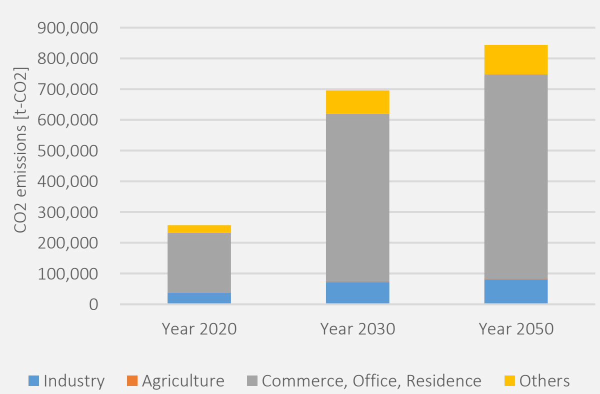


Figure 6.2.1. Estimation of BAU CO2 emission in Phu Quoc

Source: Calculated by NSRI based on electricity demand and land use plan

6.2.2 Define BAU of CO2 emission baseline in transport sectors

CO2 in the traffic field is mainly emitted by private automobiles. One reason for this is because, as compared with public transportation such as railways and buses, automobiles emit a large amount of CO2 per person. In order to reduce CO2, it is effective to control the traffic volume of automobiles, use forms of public transportation with less CO2 emissions, reduce travel distance and reduce the amount of CO2 emitted by each car. In addition, it is effective to change bus transportation, which is the main form of public transportation, to vehicles with low CO2 emissions, and to reduce the amount of CO2 emitted by each bus.

Due to a lack of data on the total number of vehicles running (on-road) in Phu Quoc Island, the Master Plan was referred. The Master Plan indicate a total number of yearly tourists with target years of 2020 and 2030. The same number has been considered for person trips in our study. In the long-term roadmap, BAU will be estimated with the target year of 2050 based on the capacity of Phu Quoc International Airport being upgraded to handle 7.0 million visitors per year.

In this study, the CO2 emissions expected from the future increase of tourists and defined as BAU in the transport sector. Most of the tourists are expected to travel by bus from the airport to the commercial facilities and hotels in the city center, this study assumes that 80% of the trip is by bus, and the other means are private cars (and hired cars).

To calculate the CO2 emissions for tourists, multiply the Traffic volume in each vehicle and Travel distance. To that value, the CO2 emission indicator is integrated to calculate the CO2 emissions of the car.

CO2 emission ＝ Traffic (Traffic volume) × Travel distance (Distance traveled)

× Emission factor (Emission intensity)

The number of person trip in Phu Quoc is estimated as shown below. The number is 232,000 annually (BAU).

Table. 6.2.3. The number of person trip (BAU)

Car type	Number of Trip	Trip distance (km/vehicle)	CO2 emission indicator (g-CO2/km)	CO2 emission (g-CO2)
Bus	200,000	10.0	140.7	281,400,000
Car	32,000	10.0	119.8	166,720,000
Total	**232,000**			**448,120,000**

Source: Project Team (NSRI)

The following are estimates of CO2 emissions by tourists in transport sectors.

Table. 6.2.4. CO2 emission in Transport sectors (BAU)

	Share ratio	2020	2030	2050
Bus	80%	166,720,00 g-CO2	416,800,000 g-CO2	583,520,000 g-CO2
Car	20%	281,400,00 g-CO2	703,500,000 g-CO2	1,969,800,000 g-CO2
Total	**100%**	**448,120,000 g-CO2**	**1,120,300,000 g-CO2**	**2,533,800,000 g-CO2**

Source: Project Team (NSRI)

As for CO2 reduction in 2030, we propose to switch to bus transportation and private automobiles to environmentally-friendly vehicles. For conversion of general vehicles to electric vehicles, we have assumed a level of 30% in 2030. In 2050, we further estimated the amount of CO2 reduction, assuming the dissemination of EV and the introduction of EV shuttle buses.

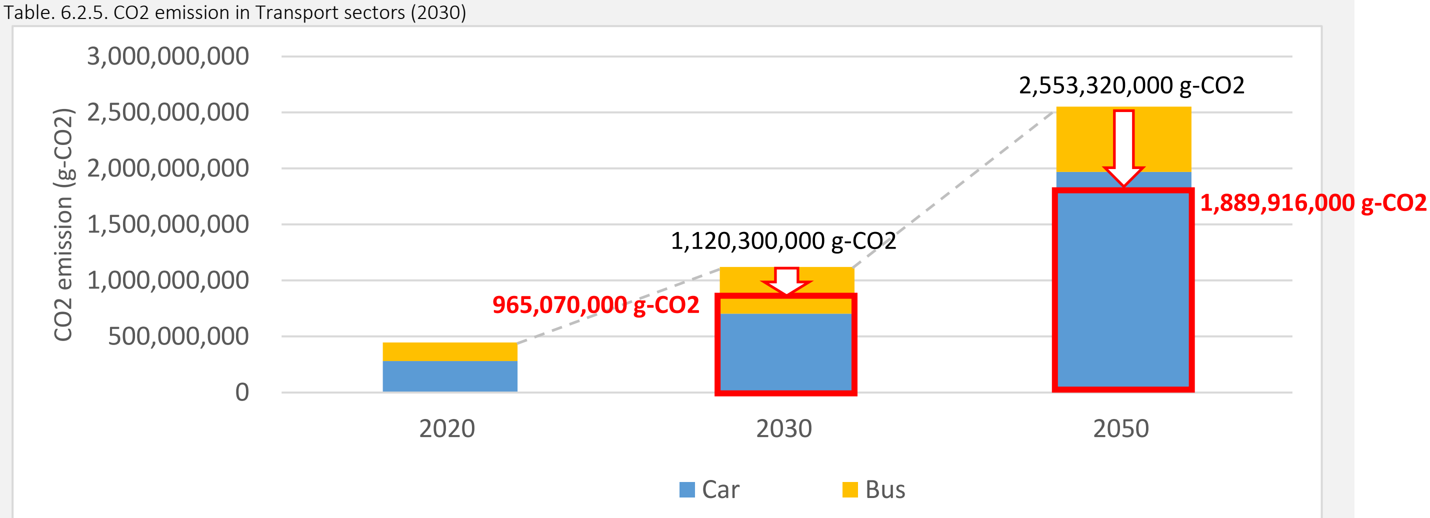
Table. 6.2.5. CO2 emission in Transport sectors (2030)

Car type	Number of Trip	Trip distance (km/vehicle)	CO2 emission indicator (g-CO2/km)	CO2 emission (g-CO2)
Bus	500,000	10.0	140.7	703,500,000
Car	80,000	10.0	119.8	416,800,000
Total	**580,000**			**1,120,300,000**

Source: Project Team (NSRI)

We estimated the CO2 emissions in 2020 (BAU) to be 448,120,000 g-CO2 per year as follows. Although it will be 2,553,320,000 g-CO 2 considering the increase of tourists by 2050, it can be expected to be reduced to 1,889,916,000 g-CO 2 (26% reduction) by promoting the intervention of electric tourist buses and electric vehicles.

Table. 6.2.5. CO2 emission in Transport sectors (2030)



Source: Project Team (NSRI)

6.3. Low Carbon measures for target areas

As is observed from the baseline scenario, the sector-wise emissions provide the areas where low carbon interventions should be focused on. Especially, given the importance for the city, the incorporation of sustainable tourism will have a positive impact on the living conditions of the city as well as contribute to the abatement of emissions. Based on this premise, the following interventions have been considered as constituting the low carbon development strategy for Phu Quoc.

6.3.1 Concept and basic approach

1) Building Sector

To reduce CO2 emissions in the building sector, the most important things to do are (1) to save energy thoroughly, and (2) to use renewable energy sources such as PV.

Concerning energy efficiency and conservation methods, for residential buildings, (a) use of heat pumps for hot water supply or Solar water heating system, (b) improvement of heat insulation performance, (c) LED lighting is particularly important as energy efficiency and conservation measures. In particular, heat insulation and a high-efficiency hot water supply system can greatly improve not only CO2 emissions but also occupant performance.

For commercial buildings, it is important to (a) high-efficiency heat source such as district cooling, Multi-energy system, etc., (b) use of Untapped Energy (c) control the heat load through insulation and actively use natural ventilation and lighting, (d) improve the efficiency of equipment systems.

With regard to the use of renewable energy, the most common method is the installation of PV on roofs and rooftops. PV is particularly effective because the demand curve for cooling and the power generation curve for PV often show a similar trend.

A low-carbon scenario for 2030 and 2050 was developed, in which the most effective measures described in Section 6.3.2 and later are implemented systematically, resulting in a reduction of 25% in 2030 compared to BAU, and 54% in 2050 compared to BAU.

Table.6.3.1. Reduction of CO2 emissions in each method in Low carbon scenario for the building sector

	Year 2030			Year 2050		
	Energy saving rate	Install rate	Amount of energy saving (t-CO2)	Energy saving rate	Install rate	Amount of energy saving (t-CO2)
Energy saving in buildings	35%	50%	95,510	60%	70%	279,114
District cooling	6%	30%	9,824	9%	30%	17,943
Incineration plant	6%	5%	1,853	9%	5%	3,360
Seawater Heat source	6%	5%	1,637	9%	5%	2,991
Solar heat	2%	5%	546	2%	5%	665
PV (lake, MEGA)	-	0.5%	43,971	-	1%	126,861
CGS	11%	30%	18,011	13%	30%	25,918
CO2 emissions	-	-	524,805	-	-	386,355
rate	-	-	75%	-	-	46%

Source: Project Team (NSRI)

Table.6.3.2. Install capacity of PV and reduction of CO2 emissions

	Year 2030				Year 2050			
	Install area	Install capacity	Amount of CO2 reduction		Install area	Install capacity	Amount of CO2 reduction	
	ha	MW	t-CO2/MW	t-CO2	ha	MW	t-CO2/MW	t-CO2
PV (lake, MEGA)	207	14	3,188	43,971	373	40	3,188	126,861

Source: Project team (NSRI)

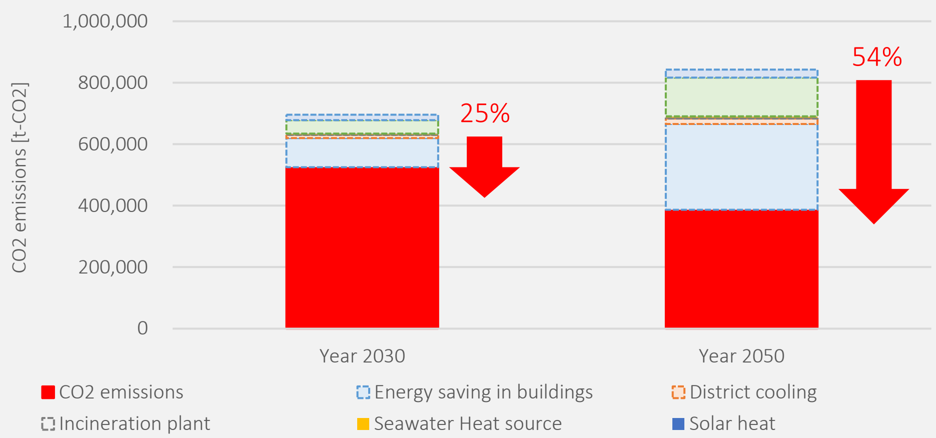


Fig.6.3.1. Reduction of CO2 emissions in each method in Low carbon scenario for the building sector
Source: Project team (NSRI), https://www.triplepundit.com/story/2012/combined-heat-and-power-pros-and-cons/81856

6.3.2 Buildings

Phu Quoc has a warm climate throughout the year. There is a cooling demand throughout the year; thus, air conditioning accounts for a large portion of the energy consumption. Approximately 60% of the power consumption of commercial buildings stems from air conditioning.

1) ZEB (Zero Energy Building)

ZEB approach is important to reduce the CO2 emissions of buildings. ZEB is a low-carbon approach to buildings that achieves significant energy savings without degrading indoor or outdoor environmental quality. The basic concept of net-zero energy is that the amount of energy consumed within a building or site, such as air conditioning, lighting, ventilation, and hot water supply, is roughly equal to the amount of energy generated within the site by photovoltaic power generation.

Definition of ZEB

A net-zero energy building is defined as a building that has high energy saving through load reduction, natural energy use and highly efficient systems and appliances without decreasing the environmental quality both indoors and outdoors. With the introduction of on-site renewable energies, the on-site energy supply will be equal to or greater than the energy demand within the building in a year. The amount of energy supply and demand could be replaced by relevant indicators multiplied.

Evaluation of ZEB

Using an energy balance of normalized energy supply (G*) and normalized energy demand (C*) which is converted into a non-dimensional numeric as annual primary energy consumption of a reference building. The energy performance evaluation and labeling are as follows;

G* : Normalized Energy Generation = (Energy generation of target building) / (Energy consumption of reference building)

C* : Normalized Energy Consumption = (Energy consumption of target building) / (Energy consumption of reference building)

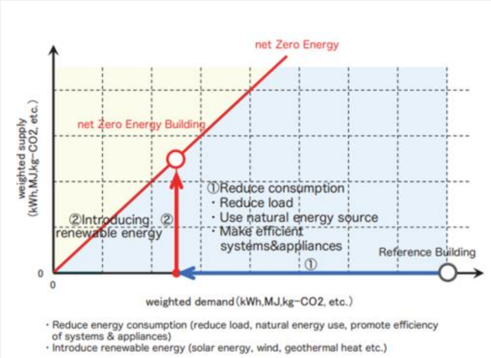


Fig. 6.3.2. Evaluation of ZEH for improvement of low-carbon development in La Molina
Source: The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan. Net Zero Energy Building Advanced Case

In the design phase of ZEB, it is important to maximize the use of building planning methods (passive methods) such as thermal insulation, solar radiation shielding, use of natural ventilation, and use of daylight, while also upgrading the energy-saving performance of the building envelope, which has a long life and is difficult to retrofit, and then superimposing the upgrading of building facilities. In order to achieve this, first, the load on the building should be controlled through high insulation of the building frame and the use of natural energy. On top of that, energy-saving technologies will be introduced to achieve thorough energy conservation. Finally, it is important to introduce renewable energy sources such as solar energy to get as close to net-zero as possible.

2) Passive Design

The load of the building is controlled by keeping the surrounding environment and indoor environment appropriate. On top of that, a design method is required to actively utilize natural energy such as light and wind, or to control it well.

1. **Appropriate surrounding environment**: Appropriate building layout and construction planning, and appropriate exterior planning
2. **Load control**: Strengthening insulation of the building envelope and reducing internal heat generation
3. **Use of natural energy**: Use of natural lighting and ventilation
4. **Optimization of indoor environment**: Optimization of thermal environment, air quality environment, and light environment

3) Active design

In addition to introducing high-efficiency equipment systems, consider using untapped energy (e.g., temperature difference energy from groundwater and river water), minimize energy consumption, and introduce renewable energy.

1. **Higher efficiency of facilities and systems**: Higher efficiency of air conditioning and ventilation equipment, heat source equipment, lighting equipment, hot water supply equipment, etc.
2. **Introduction of renewable energy**: Photovoltaic power generation, wind power generation, etc.

4) Energy management

In addition, lifecycle energy management throughout the life of the building is necessary to ensure that a net-zero energy building can be operated properly for many years.

1. **Energy management**: Use of BEMS (Building Energy Management System), implementation of lifecycle energy management, visualization, etc.

6.3.3 Transportation

Phu Quoc has been rapidly urbanizing and the increase in population for the city has correspondingly resulted in the increase in vehicles. Transport services in Phu Quoc consist mainly of 2-wheelers and 4-wheeler passenger transport which includes cars, taxis (privately owned and operated) and buses (tourist buses). As is observed from the baseline scenario, the sector-wise emissions provide the areas where low carbon interventions should be focused on. Based on this premise, the following interventions have been considered as constituting the low carbon development strategy for Phu Quoc.

1) Use of electric tourist buses in specified routes (inter-city and airport shuttle buses)

City Green Growth Plan provides focus on alternate fuels for vehicles. In order to reduce the environmental impact while promoting tourism, low-carbon urban transportation between airports and urban areas can be an important measure.

Picture. 6.3.3. EV shuttle bus (LEFT) and Marunouchi Shutle (RIGHT)
Source: Soft bank and HInomaru limousine

In the intervention, EV buses could be introduced to promote low-carbon transportation for buses connecting the airport with commercial facilities and hotels in urban areas. It is also possible to improve the convenience of bus connections at bus terminals and other transportation nodes, improve the driving environment by improving bus lanes, and introduce bus location systems.

Also, these EV buses have advanced technology functions such as AI transportation management systems, linking with public transportation will lead to mitigating traffic congestion and enable low-carbon transportation in the region.

2) Replacement of existing gasoline-based 2W with electric 2W

Introduction of floating EV as a means of transportation for local people and hotels in the area, responding to low carbon emissions in the normal situation and disasters preventions

Picture. 6.3.4. FOMM EV (LEFT) and Floating in water at the time of flood damage (RIGHT)
Source: FOMM

3) Introduction to LRT linked to a walkable network in the city area

An introduction of LRT linked to the walkable network would be effective in reducing CO2 emissions. It will contribute to the Low carbon model town in accordance with the promotion of utilization for public transportation.

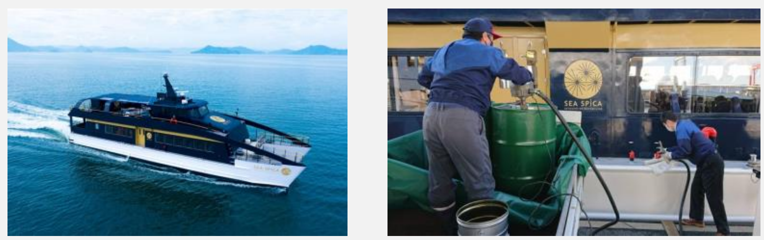
The introduction of orbital transportation such as LRT is considered here to promote the use of public transportation when moving within the region. In addition, a soft approach to encourage people to switch from private cars to orbital transportation may be considered, as well as the installation of renewable energy power generation facilities at bus stops and the introduction of vehicles that use storage batteries.

Picture. 6.3.5. Image of LRT

Source: Nikken Sekkei Construction Management

4) Low Carbon Waterway traffic (passenger ships, cruise ships, fishing boats)

For shipping, we aim to switch to progressively cleaner, greener ships. We expect the industry to drive and adopt technological improvements that will increase efficiency and reduce the environmental impact of these sectors. At the same time, we recognise that, even in the longer term, the decarbonisation of shipping and the switch to alternative fuel sources will be more challenging than for road and rail modes.



Picture. 6.3.6. SEA SPICA

Source: euglena

The introduction of alternative fuels and other technological solutions would be the main options to reduce GHG emissions from shipping. Alternative fuels that could be used to achieve the 2050 target include hydrogen, ammonia, LNG, synthetic carbon-recycled fuels and biofuels. Other GHG emissions reduction technologies than the use of alternative fuels include wind propulsion, battery propulsion and onboard CO2 capturing.

6.3.4 Area energy system

District Cooling (DC) system for areas with high heat demand, such as hotels and offices can make a high-efficiency system. District cooling system efficiently produces cooling water and saves machine space. And also can install large scale machines such as the use of seawater systems or Combined Heat and Power Plant (CHP).

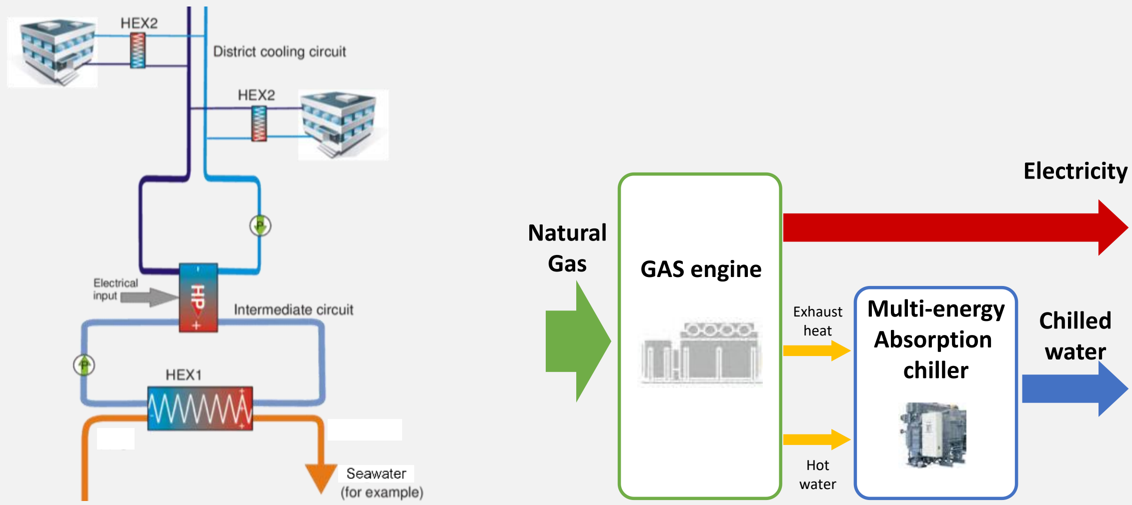
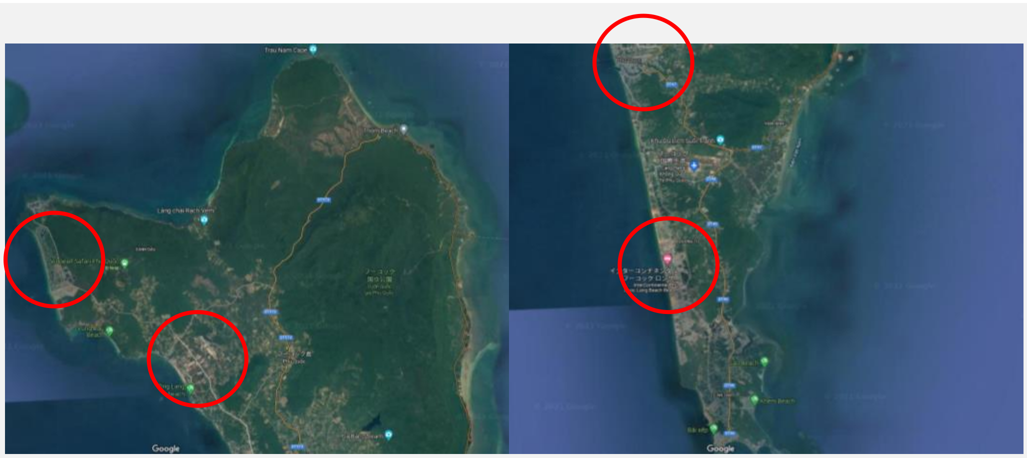


Fig. 6.3.7. left : District cooling system (ex. with the use of seawater heat), right : Combined Heat and Power Plant (CHP)
Source: Project Team (NSRI)

District Cooling (DC) system is expected to be installed in areas where buildings for high heat demand are densely populated. However, since the entire building data in Phu Quoc island could not be obtained, the setting was made based on the ratio of the area. Specifically, it is set the installation of DC system in 30% of commercial facilities, offices, and hotels. Since DC system can be equipped with large-capacity equipment and high-efficiency equipment, it can be expected to save 20% of energy in the heat source part compared to existing systems.

In this study, it is estimated that DC will be introduced in 30% of all commercial, office, and residential areas by 2030.



District cooling system installs in 30% area of commercial facilities, offices and hotels by 2030
Fig. 6.3.8. Assumption of District cooling system in Phu Quoc
Source: Project Team (NSRI), Google map

6.3.5 Untapped Energy

Untapped energy is a general term for energy that has not been used to date despite its potential for effective utilization, such as waste heat from factories, waste heat from air conditioning and heating in subways and underground malls, and rivers and sewage that have a temperature difference from the outside temperature. Unused energy is distributed "widely and thinly", and in many cases, the source of supply is far from the place of demand, so there is a need for efficient utilization technology. Unused energy utilization technologies can be combined with a variety of other environmental and energy technologies to help create a low-carbon society.

1) Heat Exhaust

- Waste heat from factories
- Waste heat from incineration plants
- Waste heat from substations
- Waste heat from ultra-high voltage underground power lines
- Waste heat from heating and cooling of subways and underground malls

In particular, waste heat from incineration plants is an item that can simultaneously manage wastes that are expected to increase in the future and energy saving.

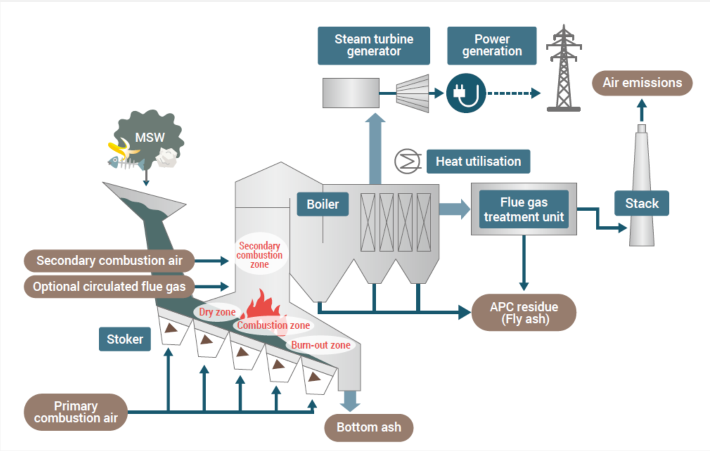


Fig. 6.3.9. Typical flow chart of WtE incineration plan
Source: Waste-to-Energy Incineration, Institute for Global Environmental Strategies.

2) Temperature difference energy

- The heat from domestic wastewater, sewage, and geothermal heat
- The heat from river water and seawater

We propose two measures that can be applied to the Phu Quoc area. The first one is the use of seawater heat, and the other is the use of heat from incineration plants.

The use of seawater heat is an effective measure. For cooling demand, seawater heat pumps can improve the efficiency of the cooling system.

The use of heat from incineration plants is useful for hot water demand. It will have a significant low-carbon effect on large hot water and heating demands (pool heating, botanical garden greenhouses).

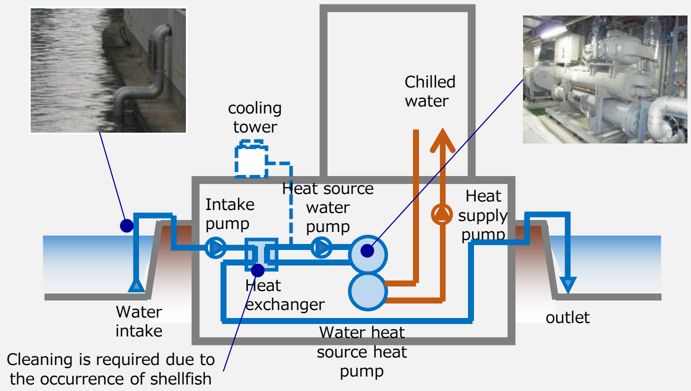


Fig. 6.3.10. The use of seawater heat in District cooling system
Source: Project Team (NSRI)

Since the Waste heat recovery from incineration plants and seawater heat utilization system can be easily applied to large-capacity equipment, it is assumed to be installed in District Cooling (DC) system where large equipment is installed. DC system uses an absorption chiller to convert waste heat from the incineration plant into chilled water. Since the incineration plant uses both electricity and waste heat, it enables highly efficient operation compared to existing systems. In addition, since the generated electricity is used in the nearby area, transmission loss is reduced. Since the temperature condition of the heat source water is advantageous in the seawater utilization system, the energy-saving operation becomes possible. The energy-saving effect of the incineration plant can be expected to be 6%, and the energy-saving effect of the seawater utilization system can be expected to be 20% at the heat source part.

In this study, a trial calculation is made assuming the use of waste heat and seawater from the incineration plant and DC. Specifically, the following conditions are premised.

- Assuming that the amount of electricity generated by the incineration plant will be approximately 51,600 MWh / year by 2030, electricity and heat will be used.
- Introduce seawater utilization equipment to 5% of all commercial, office and residential areas by 2030

6.3.6 Renewable Energy

One of the most universally available forms of renewable energy is sunlight. An enormous amount of energy is pouring down from the sun onto the earth. The benefits of solar energy are available everywhere, making it the most versatile of renewable energies. In order to calculate the usable energy of solar energy by photovoltaic power generation facilities, various constraining factors must be taken into account. The main ones are the current technical constraints such as the efficiency of conversion to electricity, the constraints related to the installation location, and the constraints related to the price. In urban areas, it is necessary to take these factors into account when estimating the amount of solar energy used, since there are also shadows caused by surrounding buildings and restrictions specific to the region. The amount of electricity generated by solar power is proportional to the size and number of solar cells (modules). In other words, if there are not enough of them, the amount of electricity generated will be less, and if there is more, the amount of electricity generated will be more. The power generation efficiency itself does not change depending on the size and number of modules.

1) PV on buildings

The installation of PV on the roof of a building is a common method to realize ZEB.

2) PV on the pond and MEGA PV system

When installing a mega solar power plant, securing a suitable location is important. In addition to the land-based method, there is also the pond-based method, which has great merits. Unlike the land-based method, it does not take time to cut down trees and build up the land, and the construction period can be shortened. In addition, the surface of the water allows the surface temperature of the panels to be lowered by sprinkling water, thus improving the power generation efficiency. However, it is necessary to take adequate measures against strong winds.

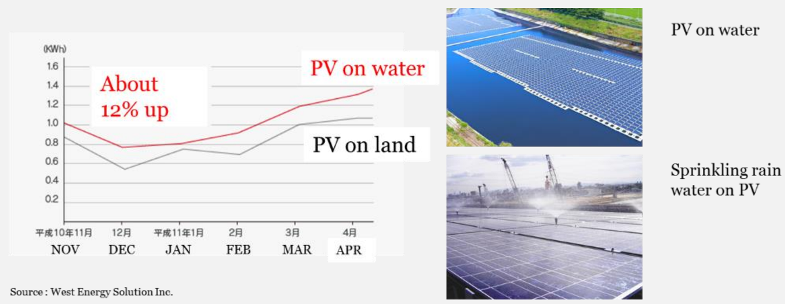


Fig. 6.3.11. Improvement of PV on pond
Source: West Energy Solution Inc.

About 200,000m2
Duong Dong Lake

About 2,000,000 m2
0.5% of Agriculture – Forestry – Fishery area By 2030

Fig. 6.3.12. Assumption of Mega Solar Installation in Phu Quoc
Source: Project Team (NSRI), Google map

There is a big pond in the Duong Dong area. By floating PV on the pond, PV efficiency improves. If the surface temperature of a PV exceeds 25 ℃, the efficiency will be reduced. The PV on water reduces the surface temperature due to the cooling effect of water.

Mega Solar power is assumed to be installed in Duong Dong Lake and forest areas. However, since there is a park, it is assumed that it will be installed in a forest area close to the place of residence within the range of protecting nature. And the setting was made based on the ratio of the entire island area. Specifically, it is set to install solar panels in 0.5% of the Agriculture, Forestry, and Fishery areas. It is necessary to discuss with the local government the location of the solar panel in the future.

The advantages of floating PV is high power generation efficiency, no shadow of obstacles, no land preparation required. And the disadvantage is to be required water installation experience, to take measures based on the water level changes and typhoons, and also wiring needs to be waterproof. The impact on ecosystems; increase in birds, increase in fish under floats, control of water plant growth, etc.

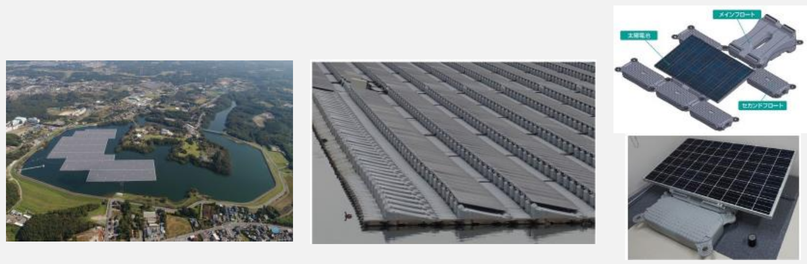


Fig 6.3.13. Floating PV in Chiba prefecture, Japan and Details of floating equipment
Source: KYOCERA, https://www.kyocera.co.jp/newsroom/news/2021/001683.html

3) Solar water heating system

Solar thermal utilization is to collect solar thermal energy by a solar energy absorber installed on the rooftop to warm water or air for hot-water supply or air conditioning. Hot water generated can be used for bath, heated pool, air conditioner, etc.

The Solar water heating system is assumed to be installed in hotels and residences where hot water supply-demand is high. However, since the entire building data in Phu Quoc island could not be obtained, the setting was made based on the ratio of the area.

Specifically, the installation of the Solar water heating system is set in 5% of the areas such as residences, commercial facilities, offices, and hotels. Compared to the existing system, the solar water heating system can be expected to save 20% of energy in the hot water supply part.

In this study, it is assumed that solar heat utilization equipment will be installed in 5% of the heat sources in all areas of commerce, offices, and housing by 2030.

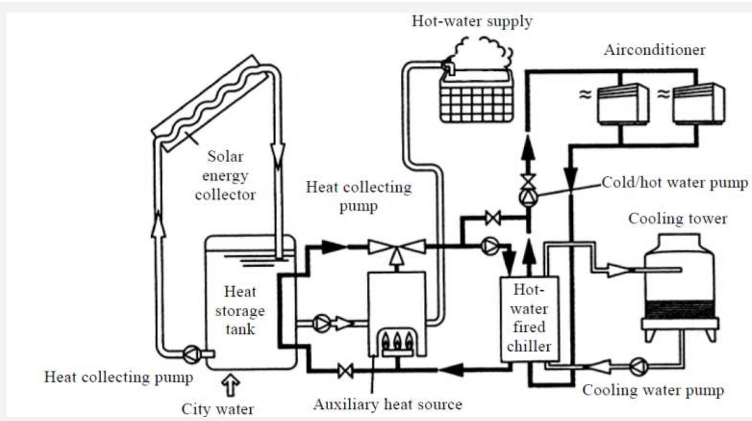


Fig. 6.3.14. Solar water heating system
Source: Solar Thermal Utilization, Resource and Energy Agency

6.3.7 Multi Energy System

1) Co-Generation System

The use of a cogeneration system can reduce energy. Additionally, electricity can be supplied even at the time of power outage. The below image shows a simple diagram of the cogeneration system, power generator. A power generator uses gas to make electricity and exhaust heat. To use exhaust heat for absorption chiller, we can make cold water for air conditioning. In the building where demand for hot water is high such as hotels and hospitals, exhaust heat can be used as hot water through a heat exchanger.

It is important to introduce CGS with priorities in the hotel area. In the short term, CGS should be installed in a government building, and a hotel or a hospital where heat and electricity consumption are large. In Long term, we plan to be installed in large scale buildings.

- Buildings with high demand for hot water supply, such as hospitals and hotels, can be expected to be particularly effective.
- In buildings with a demand for cooling, the waste heat from CGS can be fed into absorption chillers to produce chilled water.

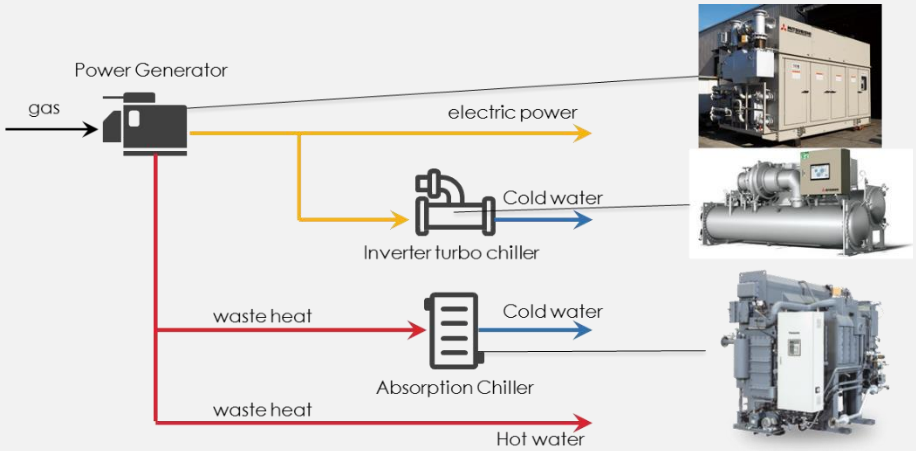


Fig. 6.3.15. Co-generation system
Source: MITSUBISHI heavy industries, Panasonic

Since CGS can be easily applied to facilities with large heat demand, it is assumed to be installed in District Cooling (DC) system where large equipment is installed. In the DC system, the generated electricity is used in the building. In addition, CGS exhaust heat is converted to chilled water using an absorption chiller. Since CGS uses both electricity and exhaust heat, it enables highly efficient operation compared to existing systems. In addition, since the generated power is consumed by itself, there is no transmission loss. The energy-saving effect of CGS 11% energy saving effect including power and waste heat utilization can be expected.

In this study, it is assumed that CGS will be introduced to 30% of the heat sources in all areas of commerce, offices, and residences by 2030.

6.3.8 Water Management

This section will introduce the implementation strategies for sustainable water management in order to improve Phu Quoc Island's water security, reduce water pollution, and expand the coverage of water supply and sewerage services. The section will focus on:

1) Rainwater harvesting

Water supply service on Phu Quoc Island was begun by KIWACO (Kien Giang Water Supply and Drainage One Member Limited Company) in 2006 targeting only Duong Dong district for water supply and by the World Bank-financed project, which not only supplied to Duong Dong and Duong but also the new international airport. However, projections on water demand are insufficient by a water supply amount of about 5,000 m3/d.

This study discusses and proposes the rainwater harvesting system. Rainwater harvesting is the collection and storage of rain, rather than allowing it to run off. Rainwater is collected from a roof-like surface and redirected to a tank, cistern, deep pit (well, shaft, or borehole), aquifer, or a reservoir with percolation. Its uses include watering gardens, livestock, irrigation, domestic use with proper treatment, and domestic heating. The harvested water can also be committed to longer-term storage or groundwater recharge.

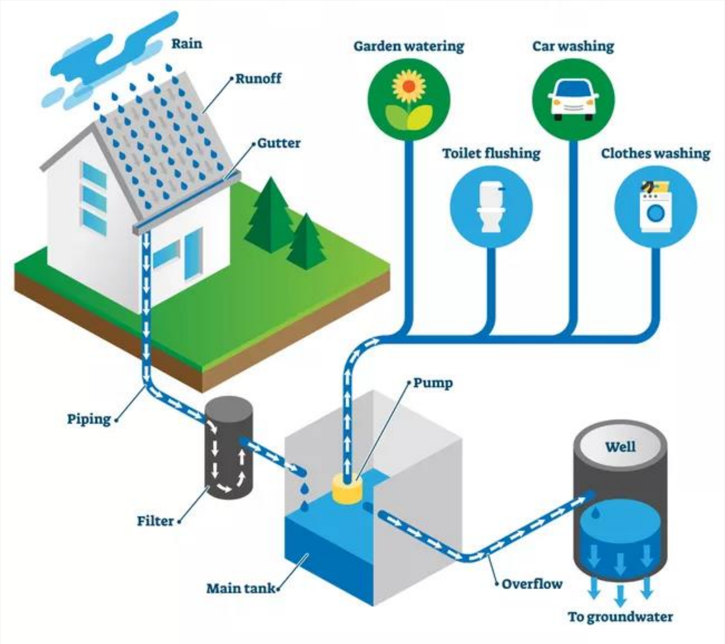


Fig. 6.3.16. Rainwater harvesting system diagram with hose roof water runoff, underground piping, filtering, collecting in tank for domestic use
Source: VectorMine / Getty Images

According to Treehugger, the benefits of the implementation of this system has been recognized in many cities around the world that now require or encourage rainwater harvesting systems. For example, Bermuda, the U.S. Virgin Islands, and Santa Fe, New Mexico, now mandate a rain catchment system on all new homes, and Texas offers a tax exemption for the purchase of harvesting systems to encourage the practice. Cities in Australia, Kenya, China, Brazil, and Thailand all utilize large-scale rainwater harvesting, and the airport in Frankfurt, Germany, collects rainwater for use in its terminal's toilets and landscaping.

2) Sewage facilities

Unfortunately, no sewage treatment plants are covering the general households of all Phu Quoc Island. The raw sewage of general households is treated by septic tanks set up at each household then discharged outdoors. Further, the wastewater of each household excepting raw sewage (e.g. kitchen drainage, shower drainage) is discharged outdoors untreated. Lodging facilities such as hotels are required to install treatment facilities and must satisfy permissible discharge water quality. However, water quality monitoring of water discharged from lodging facilities is not carried out by Kien Giang Province.

To efficiently promote countermeasures for domestic wastewater, several kinds of domestic wastewater treatment facilities have been constructed following regional characteristics in Japan (See table below).

Table. 6.3.3. Tape of sewerage facilities used in japan

Type of system or facility	Sewerage system	Rural sewerage system	Johkasou system	Night soil treatment facility
Purpose	Maintain the water quality of natural water resources and improve the living environment by collectively treating night soil, miscellaneous domestic wastewater, industrial wastewater and rainwater	Maintain agricultural water/wastewater clean/safe and improve the living environment by collectively treating night soil, miscellaneous domestic wastewater and rainwater	Maintain good water quality of public water bodies and a healthy living environment and promote public health by treating night soil miscellaneous domestic wastewater onsite.	Maintain healthy living environment and promote public health by treating collected night soil and Johkasou sludge.
Responsible agency	Municipalities	Municipalities	Individuals, communities and Municipalities	Municipalities
Applicable district	Mainly urban areas	Agricultural villages within specified districts where agriculture is being promoted	Districts where Johkasou installations are promoted	-
Applicable population	Approx. 10,000 or more	Up to about 1,000	-	-
Applicable wastewater	Night soil (flush toilet wastewater) miscellaneous domestic wastewater, industrial wastewater and rainwater	Night soil (flush toilet wastewater) miscellaneous domestic wastewater and rainwater	Night soil (flush toilet wastewater) miscellaneous domestic wastewater	Collected night soil and Johkasou sludge
Construction period	Approx. 5 years	3~5 years	Approx. 1 week up to 1 year	2~3 years
Competent authority	Ministry of Land, Infrastructure, Transport and Tourism	Ministry of Agriculture, Forestry and Fisheries	Ministry of the Environment	Ministry of the Environment

Source: Ministry of the Environment, Japan

(1) Johkasou system (wastewater treatment plant)

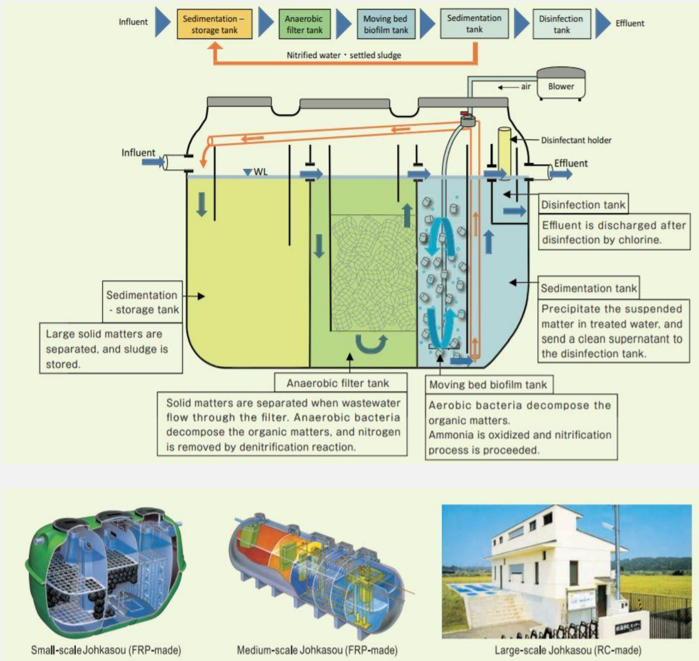
According to the Ministry of Environment of Japan, the capacity, the treatment process and materials of the Johkasou system (wastewater treatment plant) are depending on the usage of the building, quantity and quality of the wastewater and regulation issues of the discharge areas. In other words, the Johkasou is classified by the capacity of a number of users.

Johkasou systems are generally divided into ‘small-scale Johkasou,’ which are designed for the treatment of the domestic wastewater of individual houses, and ‘medium to large scale Johkasou’, which are designed for the treatment of the domestic wastewater of housing complexes, hospitals and other commercial facilities. The detailed information for the capacity of the system is shown below.

- Small-scale is used for the individual and small-scale wastewater with a capacity of 5 people equivalent (PE) and amount of wastewater less than 10m3/day.
- Medium-scale one is with capacity 51-500 PE, and the average amount of wastewater less than 100m3/day.
- And the large scale one is with a capacity of 501PE or more and with an average amount of wastewater of more than 100m3/day.

Regarding the regulations, it is essential to strengthening regulations at manufacturing, installations, operation and maintenance of the Johkasou among the administrative authorities, users and vendors. In the report, it will be provided with the Framework of the Johkasou Act and the relation with the Building Standards, wastewaters, etc.

In recent years, the number of Johkasous exported from Japan to overseas including Asia has been rapidly increasing. The installation of Johkasou is shown below.



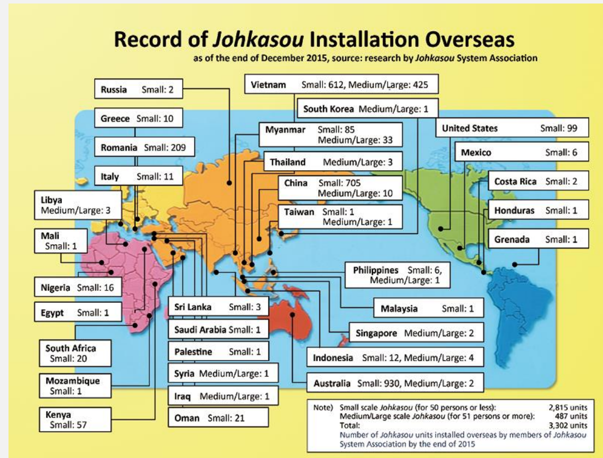


Fig. 6.3.17. Treatment principal and scale of Johkasou
Source: Ministry of the Environment, Japan

Fig. 6.3.18. Records of Johkasou installation oversea

(2) Sewerage system

In urban areas and villages with high population density, centralized systems such as sewerage systems and rural sewerage systems are planned and constructed. Sewerage systems are usually constructed in urban areas, where houses, factories and office buildings are concentrated, collecting wastewater through a piping network system and treating the wastewater in a centralized manner at wastewater treatment plants that are usually located in downstream areas of rivers or near the seacoast.

Wastewater from households, etc. is cleaned at sewage treatment plants before being released into the rivers and the sea. Thus sewerage is designed to safeguard the quality of natural waters as well as the environment.

Osaka City, Japan, has performed complete treatment including all the sewage treatment plants. To meet environmental standards on water pollution and create a cleaner water environment, Osaka City is working on the construction of remedial facilities for combined sewerage and advanced treatment facilities as well. In addition, all the sewage treatment plants are connected by piping to transport and treat sludge efficiently.

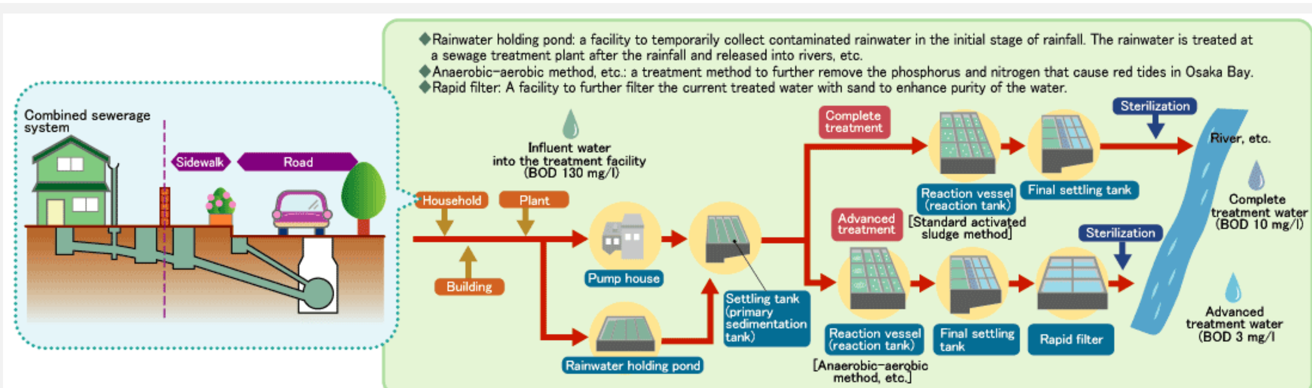


Fig. 6.3.19. Sewage treatment plants in Osaka City, Japan
Source: Osaka City, Japan

6.3.8 Waste management

According to the People's Committee of Phu Quoc district, on average, Phu Quoc island district (Kien Giang) generates about 150 tons of garbage every day. This amount of waste causes great pressure on the environment of the whole island district, in the context that the district does not have an operating waste treatment plant and temporary landfills are constantly overloaded.

Phu Quoc island district has had 3 temporary landfills. Phu Quoc has a waste power plant in Bai Bon hamlet, Ham Ninh commune invested by Global Renewable Energy Joint Stock Company. According to the local citizens, the factory only operated with a total capacity of 40 tons/day, affecting people's lives and the urban landscape of Phu Quoc.

The point of view of the province is that it is not possible to just put garbage in the temporary dump forever, but there must be a factory to treat garbage and operate effectively. One of the solutions is to be Integrated Waste Management. Efforts should be concentrated on waste recycling which should also involve source separation of waste to improve the quality of recycled products and reduce efforts in the processing of the solid waste for recycling activities.

Effective management of solid waste depends majorly on the types of waste, whether it is biodegradable, non-degradable, infectious, non-infectious, hazardous and non-hazardous solid waste. This makes sorting of the waste of great importance.

For biodegradable, non-infectious, non-hazardous waste, recycling will be the best option while landfilling is the most qualified method for biodegradable, infectious, non-hazardous waste, since the wastes will decompose and add to soil nutrients. For nondegradable, infectious and hazardous waste, incineration might be adopted and afterwards the ash could be reused in landfilling acidic soil or in the stabilization of unstable lateritic soil.

According to the mention above, this section proposes an implementation of Integrated Waste Management based on the Solid Waste Management and Recycling Technology implementation systems in Japan.

1) Waste recycling system and Implementation of an advanced waste incineration facility

From about 1960, Japan began disposing of urban garbage by incineration, and today, Japan possesses the world's leading garbage incineration facilities. Today, while high-level environmental conservation technologies are being introduced, technologies related to high-efficiency power generation and technologies related to safe operation, such as automatic incineration devices and automatic cranes, are also being developed.

The facility is able to handle diverse types of garbage, ranging from the low-calorie garbage, which was generated when incineration facilities were first being built, to the high-calorie garbage. Such technology can be utilized for the type of garbage generated in Phu Quoc District. The figure below shows one example of the latest technology: a facility exhibiting high pollution prevention and high-efficiency power generation capacity

In Asia, where urbanization is progressing at a rapid speed, the volume of waste is quickly increasing along with population increase. In many Asian cities, collected garbage is transported directly to repository sites. Due to the lack of land available for repository sites and concern for environmental pollution in areas near repositories, incineration plants are highly recommended for the Phu Quoc district.

Japan is a leader in the construction and management of incinerators, realizing incineration treatment of waste with its world-class standard of technology to dispose of from low-calorie to high-calorie garbage.

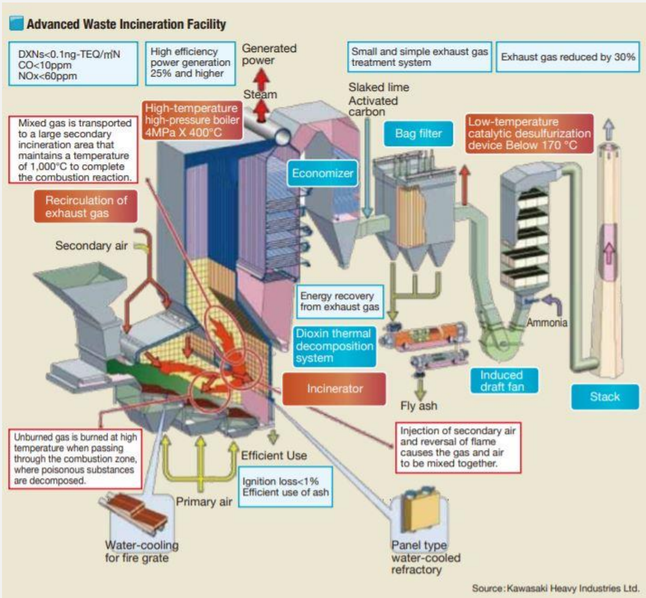


Fig. 6.3.20. Advanced Waste Incineration Facility
Source: Kawasaki Heavy Industries Ltd & Solid Waste Management and Recycling Technology of Japan

Fig. 6.3.21. Examples of some incineration plants delivered by Japanese enterprises in Asia
Source: Solid Waste Management and Recycling Technology of Japan

2) A solution to poisonous gas and dioxin emissions

According to the Ministry of the Environment for the Solid Waste Management and Recycling Technology of Japan, it is mentioned that incineration plants for municipal waste generate SOx, HC1, NOx, smoke and dioxin. From the perspective of environmental preservation and to obtain approval from people residing near the plant, harmful substances in the exhaust gas must be sufficiently reduced. In response to this need, many studies have been conducted by public and private institutes, where many countermeasure technologies were developed and improvements have been made on operation technology. Studies have shown that dioxin is produced by incomplete combustion of waste, and measures have been taken to prevent and reduce dioxin generation with complete combustion in the furnace. Other countermeasures taken include exhaust cooling to prevent the resynthesis of dioxin, application of bag filters to thoroughly eliminate dioxin contained in smoke, and the development of activated coal, which adsorbs and eliminates dioxin in exhaust fumes and a catalyst that decomposes dioxin.

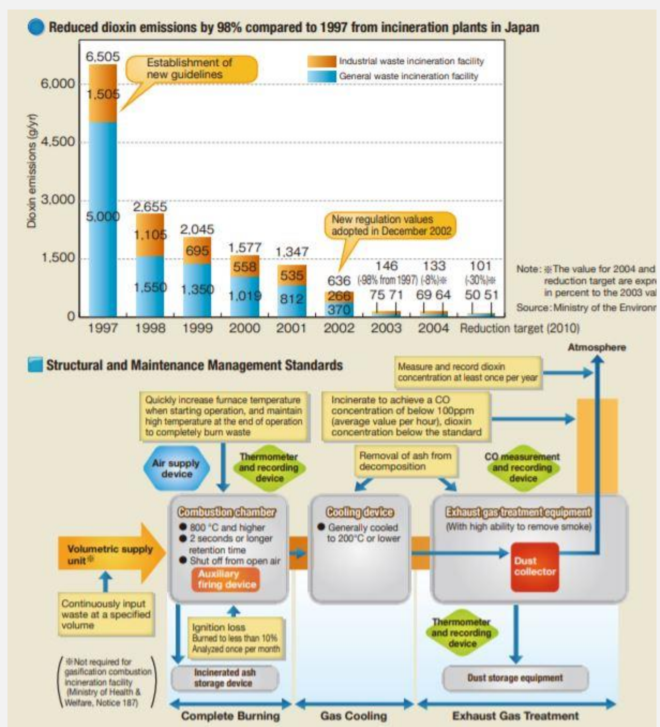


Fig. 6.3.22. Reducing the dioxin emissions
Source: Solid Waste Management and Recycling Technology of Japan

Based on the above-mentioned studies, structural and maintenance management standards for the incineration plants were established, as illustrated below.

The standards apply not only to new facilities but also to existing facilities, where improvements have been achieved.

3) Technology to efficiently recover electricity and fuel biomass waste

According to the Ministry of the Environment for the Solid Waste Management and Recycling Technology of Japan, the waste generated in cities and villages includes combustible waste with low moisture content, such as paper, plastic, and wood debris; and waste with high moisture content, such as food production waste, kitchen waste, manure, sewage sludge, biomass and other organic sludge. Waste with high moisture content will generate methane gas and hydrogen sulfide when buried without treatment, causing environmental pollution. Waste treatment, such as composting, methane fermentation, and use as animal feed, that best suits the features of the locale is selected. Below are examples of leading biomass technology in Hita City and Kyoto City, Japan.

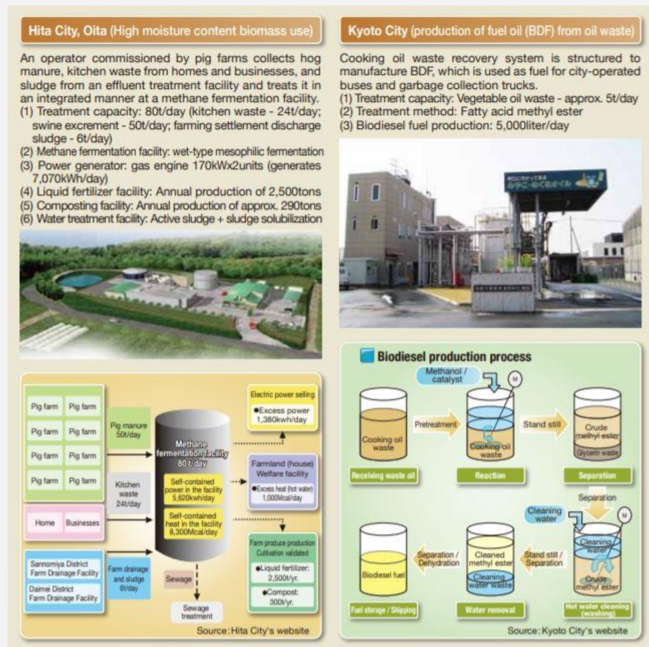


Fig. 6.3.23. Technology to efficiently recover electricity and fuel from biomass waste
Source: Solid Waste Management and Recycling Technology of Japan

BUSINESS SCHEME

07

CHAPTER 7. Business Scheme for Three Volunteer Town

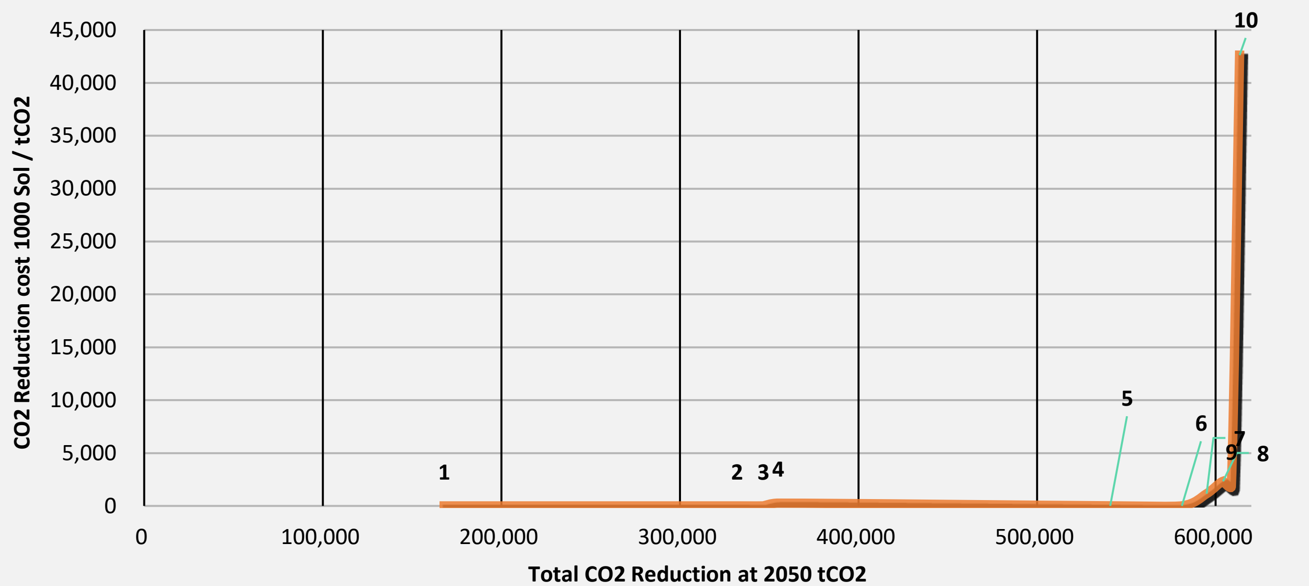
7.1. La Molina District, Lima, Peru

7.1.1. Prioritization of low carbon scenarios

1) Buildings

The CO2 emissions in 2030 and 2050 through the introduction of low-carbon methods in buildings are estimated to be reduced by 32% (up to 239 ktCO2eq/year) and 52% (up to 613 ktCO2eq/year) respectively compared to BAU in 2030 and 2050. The CO2 emission reduction is contributed by energy conservation, PV power generation, etc.

The below Figure shows the CO2 reduction in 2050 [tCO2] and the CO2 reduction cost [1000 sol / tCO2] in La Molina District. The CO2 emission reduction is contributed by energy conservation, PV power generation, etc. For more information, refer to Table 7.1.1.



※Cost prices were adjusted based on the International Construction Costs 2020

Fig. 7.1.1. Cost estimation in La Molina District Low carbon scenario

Source: Project Team (NSRI)

The measures, especially those for buildings, that has a cost of zero, means that they can be implemented without additional cost (Table 7.1.1). In La Molina District, such a measure are high efficiency of appliances and cooking equipment. The recommended level of achievement is within Y2025 which means that such an intervention has a short span for implementation.

It is important to be implemented measures that combine high-efficiency equipment and solar power generation in the existing and future buildings. In the La Molina district, because of the typical architecture and shape of the buildings (mostly the buildings have a flat roof), and because of the warm and sunny climate, the PV system is highly recommended. Our estimations show that at both residential and commercial areas in La Molina District, the installation of PV is possible on approximately 50% of the roof area of the total number of the buildings.

Table 7.1.1. Low carbon method and level of achievement

Item	Low carbon methods	CO2 reduction volume in 2050 [tCO2]	CO2 Reduction cost [1000 sol/t-CO2]	Level of achievement
1	Others	168,000	※	Mid-Long
2	High efficiency of appliances (residential and commercial)	163,925	0※※	Short
3	High efficiency of cooking equipment (residential and commercial)	14,768	0※※	Short
4	Lighting equipment (residential and commercial)	8,307	259	Short
5	PV on residential buildings (50% coverage)	185,990	6	Mid-Long
6	PV on commercial building (50% coverage)	40,133	6	Mid-Long
7	Hot water supply (residential and commercial)	13,845	1,154	Long
8	High efficiency of cooling equipment (residential and commercial)	9,230	2,331	Long
9	Building insulation: Roof thermal barrier coating (residential and commercial)	4,615	1,865	Long
10	Thermal insulation and solar radiation shielding (residential and commercial)	4,615	42,618	Long

※For reference, in the calculation of the reduction volume are added "others low carbon methods". The others include greenery and waste management. The cost estimation of greenery and waste management methods depend on the future master plan and waste management policies in 2050 in La Molina District.
※※Project Team (NSRI) Cost prices were adjusted based on the international construction costs 2020. Cost indicates the additional cost compaered to BAU. A cost of zero means that there is little or no increase in cost comapared to BAU (e.g. normal product) or that the initial cost investment can be recovered in a relatively short period of time through reduced utility costs.

For reference, in Table 7.1.1 in the calculation of the reduction volume are added “others low carbon methods”. The others include greenery and waste management. The cost estimation of greenery and waste management methods depends on the future master plan and waste management policies in 2050 in La Molina District.

In order to be implemented efficiently the green corridors and green interventions in La Molina, it is important the creation of the future green master plan for 2050 that include potential new green areas and corridors.

Because in La Molina Districts there are already started several events related to planting trees, eco-recycling, etc., we recommend implementation of the capacity and awareness-building activities at both the institutional level and at individual citizen level.

2） Transportation

In the La Molina district, the number of cars is expected to increase as the population grows, and the low population density may increase the dependence on cars. In order to reduce Co2 emissions in the area, it is essential to reduce the dependence on cars and shift to walking, bicycling, and public transportation.

In order to achieve this, it is necessary to reduce the environmental impact by promoting the creation of a system to shift from "ownership" of transportation to "use and sharing", improving the convenience and comfort of transportation for residents and others, and developing and enhancing the public transportation network.

Based on the above, we will propose a model for “improvement of the bus business” and “Promotion of bicycle-sharing” as a business scheme.

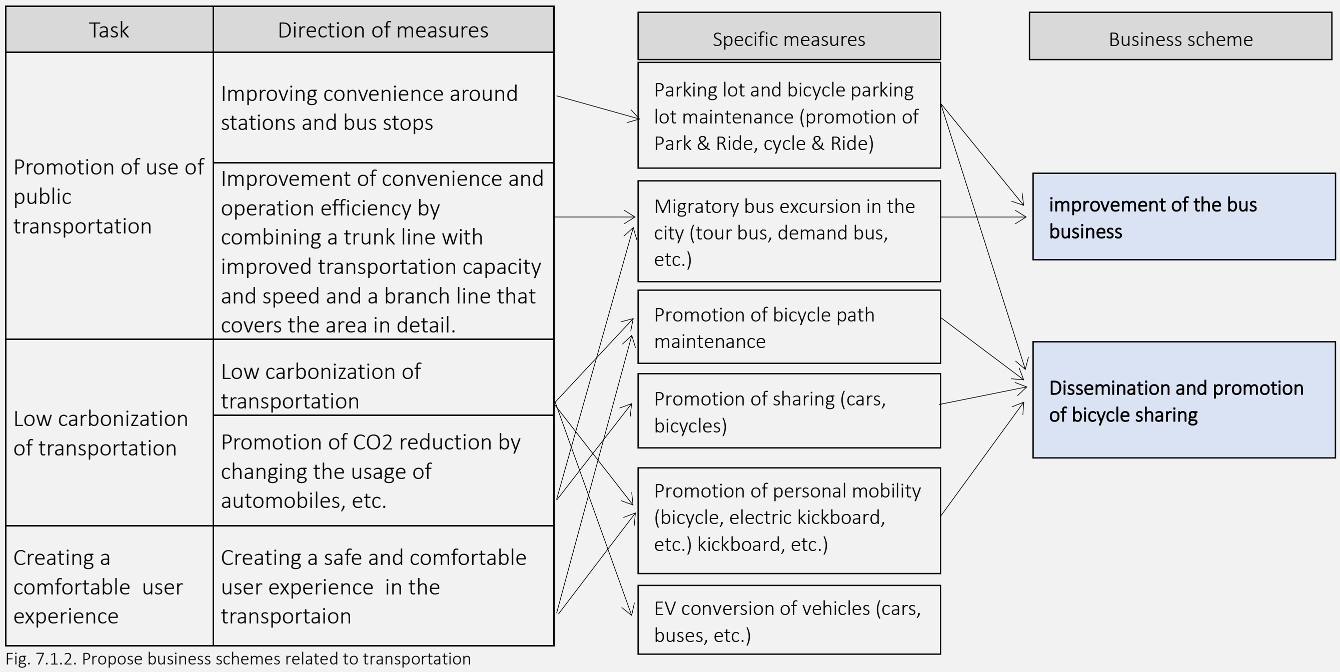


Fig. 7.1.2. Propose business schemes related to transportation
Source: Project Team (NSRI)

7.1.2. Buildings

According to the Climate Innovation Finance Strategy 2020, the Japanese government will take measures to attract private investment into green, transition and innovation initiatives toward steady low carbonization.

Moreover, several business model programs try to encourage the private and business sector providing the subsidy, give promotion points and certificates, reduction of utility costs, etc.

Such models could be very beneficial for la Molina District in order to reduce CO2 emission and their implementations are recommendable.

A similar type of program could be proposed in La Molina District where, instead of the conventional regulatory method, the building owner evaluates the environmentally-friendly efforts based on the guidelines, which encourages building owners to take voluntary initiatives using inductive methods. Such programs will surely benefit in reducing the energy consumption of the building sector.

Table 7.1.2. Rating items under Building Environment Plan System

Fields	Items
Efficient energy use	Reducing building thermal load (insulation), use of natural energy, energy-conservation systems, efficient management systems
Appropriate use of resources	Usage of eco–friendly materials, protection of ozone layer, measures for longer building life.
Preservation of the natural environment	Hydrological recycling, greening
Mitigation of the heat-island effect	Measures to reduce effects of artificial heat emissions, measures to reduce heat accumulation in sites and buildings, consideration for the wind environment

Source: Tokyo Metropolitan Government website. C40 cities website

1) Green and Cool Roof subsidy

Tables, 7.2.1 and 7.2.2 are shown the green roof and cool roof subsidies in different economies. Grants are available to support the installation of green roofs and cool roofs on homes and buildings in different economies and cities. Applications are accepted and reviewed on an ongoing basis and the application should be done before the beginning of work on the roof. Moreover, additional funding is available to help offset the cost of a structural assessment to determine if an existing building can carry the additional weight of a green roof.

Benefits of eco-roofs:

- ✓ Save energy
- ✓ Reduce greenhouse gas emissions
- ✓ Reduce urban heat
- ✓ Improve air quality
- ✓ Make city more environmentally friendly

The subsidiary aid including the credit limit is shown for each city in the tables as below.

Table 7.1.3. Green Roof subsidy

City	Condition	Subsidiary aid	Credit limit
Chicago	Maintain for 5 years	-	$5,000
Toronto	More than 50% of the roof area	$10 / m2	$20,000
Berlin		50% of the Cost	-
Basel	-	SFr.20 / m2	-
Stuttgart	-	50% of the Cost	-
Montreal	-	$54 / m2	-

Source: Ministry of the Environment, Japan

Table 7.1.4. Cool Roof subsidy

City	Condition	Subsidiary aid
California	Reflectance・emissivity 0.75~	$0.20 / square feet
Chicago	Reflectance 0.65~	$0.50 / Square feet
Georgia	Reflectance・emissivity 0.75~	Obligation
New York	Reflectance 0.65~	Obligation

Source: Ministry of the Environment, Japan

For example, in Toronto, Canada, the following grants applied for Grants for Green Roofs and Cool Roofs:

- ✓ Green Roof Incentives: $100 / m2 installed; up to $1,000.00 for a structural assessment
- ✓ Cool Roof Incentives: $5 / m2 for a cool roof with a new membrane; $2 / m2 for a cool roof coating over an existing roof

According to the Smart City Berlin, Germany, the department allocated € 2.7 million in funding to encourage property owners, initiative and interest groups, associations, meeting venues, retirement homes and other institutions to cultivate green roofs. The program is managed by IBB Business Team GmbH, a wholly-owned subsidiary of Investment Bank Berlin (IBB). The Berlin Rainwater Agency informs within a free consulting about the chances and advantages of green roofs as well as further activities on properties of rainwater management.

Another example of a grant related to the rood and building dwelling is the program “RénoPlex” in Montreal, Canada. For the project to be eligible for a grant, it is needed to meet the technical requirements described in the Program Guide. For example, a flat roof must be covered with a white membrane. Once the application is approved, the grant could cover the following:

- ✓ $1,200 to replace a lead water service line
- ✓ $320 to repair a crack in a foundation wall
- ✓ $970 to increase the capacity of an electric service entrance to 200 amperes.

2) Zero Emission point

"Home Zero Emission Action Promotion Project (Tokyo Zero Emi Point)" is a gift certificate and LED for Tokyo residents who have replaced the installed air conditioner/refrigerator/water heater with an air conditioner/refrigerator/water heater with high energy-saving performance. This is a business that grants "Tokyo Zero Emi Points" that can be exchanged for discount coupons.

In this program, points will be given to residents of Tokyo, Japan who have replaced their products with air conditioners, refrigerators, and water heaters that have high energy-saving performance. Approximately 80% of the applicants chose home appliances with high energy-saving performance as a result of this project.

Such a program could be very beneficial for La Molina District in order to reduce CO2 emissions using replacing the installed air conditioner/refrigerator/water heater with an air conditioner/refrigerator/water heater with high energy-saving performance.

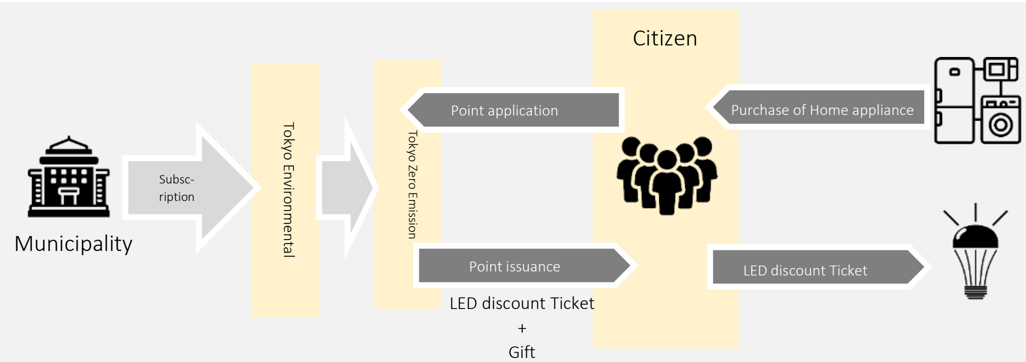


Fig. 7.1.2. Zero Emission point system
Source: Tokyo Metropolitan

4) Green Deal Program

The Green Deal is a UK government policy initiative that allows homeowners, landlords and tenants to pay for energy-efficient home improvements through the savings on their energy bills. The characteristics of this program are as below:

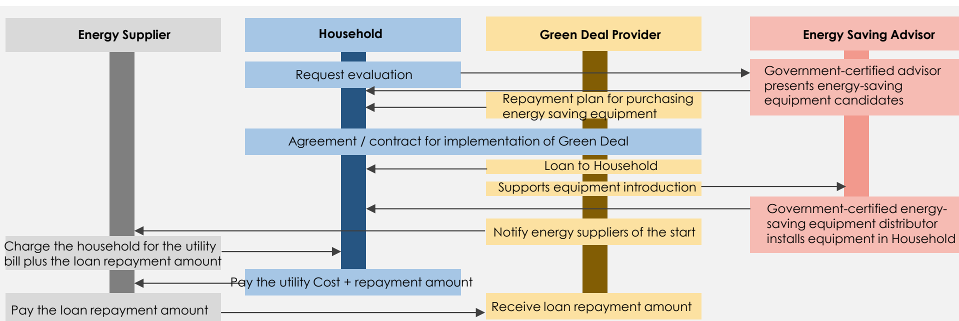


Fig. 7.1.3. Green Deal Program
Source: Ministry of the Environment, Japan

- By covering the cost of introducing energy-saving equipment at home with the reduction of utility costs due to the introduction of equipment, the investment burden is greatly reduced.
- Strengths are that energy saving of houses and offices can be evaluated as an overall package and that private funds and wisdom can be utilized.

The Green Deal helps to make energy-saving improvements to the home and to find the best way to pay for them. The improvements that could save the most energy depend on home, but typical examples include:

- insulation, such as a solid wall, cavity wall, or loft insulation
- heating
- draught-proofing
- double glazing
- renewable energy generation, such as solar panels or heat pumps

5) Power Purchase Agreements (PPA)

A Power Purchase Agreement (PPA) is an electricity supply agreement between two parties, usually between a power producer and a customer (an electricity consumer or trader).

The PPA defines the conditions of the agreement, such as the amount of electricity to be supplied, negotiated prices, accounting, and penalties for non-compliance. PPAs can be used to reduce market price risks, which is why they are frequently implemented by large electricity consumers to help reduce investment costs associated with planning or operating renewable energy plants.

Local municipality or area management body installs PV panels by utilization of rooftop of the building and unused land / open space within the designated area, and gain an income by selling electricity through the FIT system. In case the FIT system is terminated, Virtual PPA should be considered as an alternative scheme.

Table 7.1.5. Power Purchase Agreements (PPA) plan

	Self-owned	PPA
Owner of the PV	self-owned	PPA providers
initial investment	Necessary	Unnecessary
maintenance	Necessary	Unnecessary
electric utility charge	Free for self-consumption	Self-consumption also charged
capitalization	on-balance sheet	off-balance sheet
Project period	Return on investment in about 10 years	Contracts of 10 years or more

Source: Project team (NSRI)

6) Building Energy Management System (BEMS)

BEMS system as and when installed helps in energy reduction by up to 20% (Saving Energy using BEMS). The design of EMS varies based on its usage. Therefore, estimation of financial requirements will vary from project to project and policy in La Molina District.

As the energy consumption in the building sector is very high, the Government or Public sector bodies should aim to accelerate their investment in energy efficiency technologies through investment to save schemes. The government should provide funds for proven technologies that are cost-effective in saving CO2 and that can maximize the potential of any further energy-saving technologies.

Also, the energy efficiency service providers can come forward and invest in BEMS on ESCO (Energy Service Company) mode and can get returns on their investments when the building owner gets savings on their electricity bills.

Public sector

- Should accelerate their investment in energy efficiency
- Provide funds for proven technologies for GHG reducution

Private sector

- Boost ESCO market for EE Financing
- Good public policies can complement and drive private investment in EE

Fig. 7.1.4. Source of funding for BEMS
Source: Tokyo Metropolitan Government, 2005

7) Energy Service Company (ESCO)

ESCO is a business that contributes to the interests of the customers and the conservation of the global environment by comprehensively providing energy-saving services. ESCO business costs (construction costs, interest rates, ESCO service charges) are covered by the reduction in utility costs realized by energy-saving repair work. The provided energy services maximize the effects (energy-saving and cost-saving) for the customers.

According to Nihon Dengi, in general, in energy-saving repair work, the customer contracts with multiple companies in each process, but in the ESCO business, all of the energy-saving repair work could be contracted with one company in charge. The energy-saving effect (customer's profit) of introducing the ESCO business is guaranteed by the company in charge, which is an ESCO business. Since the customer bears the cost of energy-saving repair, there is no need to pay the cost of repair to the ESCO operator from the next fiscal year onward. During the contract period, the customer pays the service charge to the ESCO operator, the ESCO operator guarantees the energy-saving effect to the customer, and if the energy-saving effect is not achieved, the customer will be compensated for the unachieved amount.

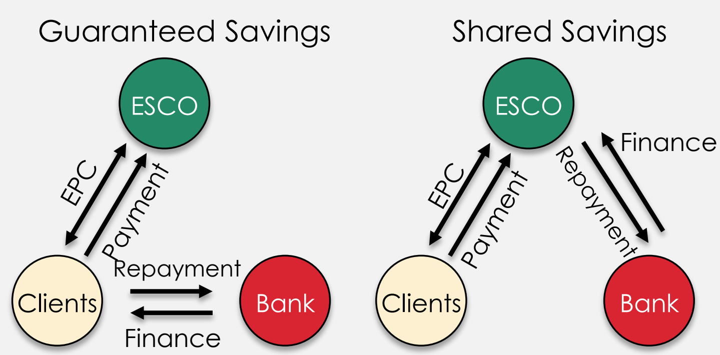


Fig. 7.1.5. Major contract methods
Source: Project team (NSRI)

8) ECO Tuning

CO2 emissions in the business sector have increased significantly since 1990. Since Japan has set a goal of reducing total emissions by 26% in FY2030 compared to FY2013, it is an urgent issue to implement effective reduction measures.

Since the Great East Japan Earthquake, many of the power-saving measures that have been taken economy-wide have been to promote energy-saving while ensuring comfort and productivity. Especially for commercial buildings, there were many cases where energy saving and CO2 reduction were achieved by "eco-tuning" such as appropriate operational improvement of existing equipment without introducing large-scale latest equipment that requires an initial investment. It is necessary to create an environment where such efforts can be carried out independently and continuously.

Therefore, the Ministry of the Environment in Japan aims to establish a business model that raises profits from utility costs reduced by "eco-tuning" of commercial buildings, etc. toward the realization of a carbon-free society, and from 2014, "eco-tuning businesses" are implementing a "model establishment project", training engineers, verifying the practice and effects of businesses in buildings economy-wide, and examining the establishment of a qualification certification system for engineers and a certification system for businesses.

In this business model, it is assumed that the utility costs reduced due to operational improvement through eco-tuning will be shared as profits between the building owner and the business operator who practices eco-tuning.

As the remuneration to the eco-tuning company is mainly paid by a certain percentage from the reduction amount of utility costs, if the reduction cannot be made, no payment will be made, which is a business model with less burden and risk for the building owner.

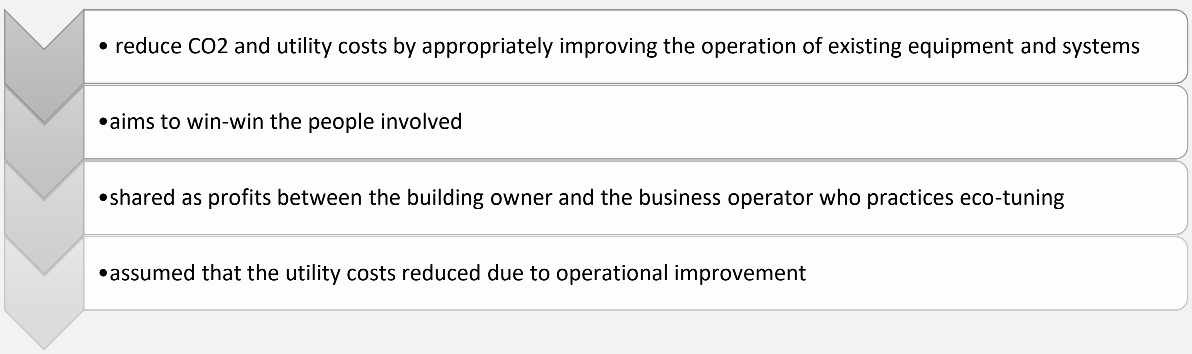


Fig. 7.1.6. Eco-tuning shame
Source: Eco-tuning

9) Introduction of low-carbon methods in rental buildings

The main points of this program are as follows:

- If the building owner and tenants sign a contract of "Green Lease", the public sector provide subsidy to the building owner as a part of the additional cost for low carbonization.
- After the building owner improves building equipment, reduction of utility costs caused by the above improvement, is divided by tenants and owner as an incentive of low carbonization for both sides.

MLIT has started this low-carbon action plan and Tokyo Municipality has found this mechanism as by law.

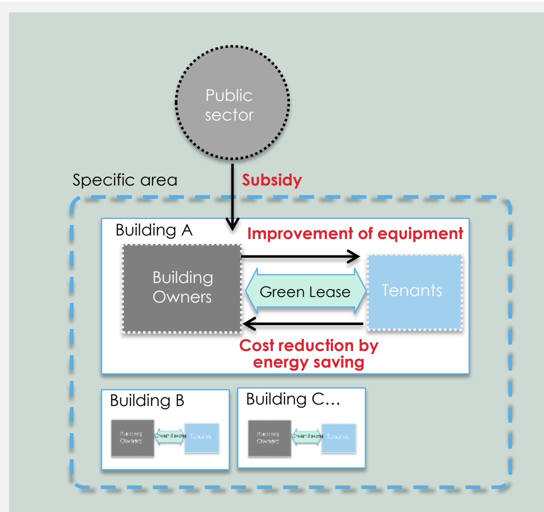


Fig. 7.1.7. Green Lease program
Source: Project Team (NSRI)

7.1.3. Untapped Energy

1) ESCO Geothermal District heating/cooling Business Model

The ESCO business model presented in the following is based on an energy-saving principle where a part of the payment consists of the savings and relative value. The value generated can have many different names, terms and forms.

Other contracting forms can also be relevant and are similar to ESCO, like Energy supply contracting (ESC); energy performance contracting (EPC) and the combination of those could be used. The ESC set-up is where the contractor implement measures that insures the heat supply (build and operate the whole system or a part of it) and also finance them.

It is repaid from the payments for heat. In the EPC model, the contractor implements measures that reduce energy use and also finance them. It is repaid from the savings. Very similar to ESCO, the EPC and ESC offers an added value to the business model and thereby increase profitability.

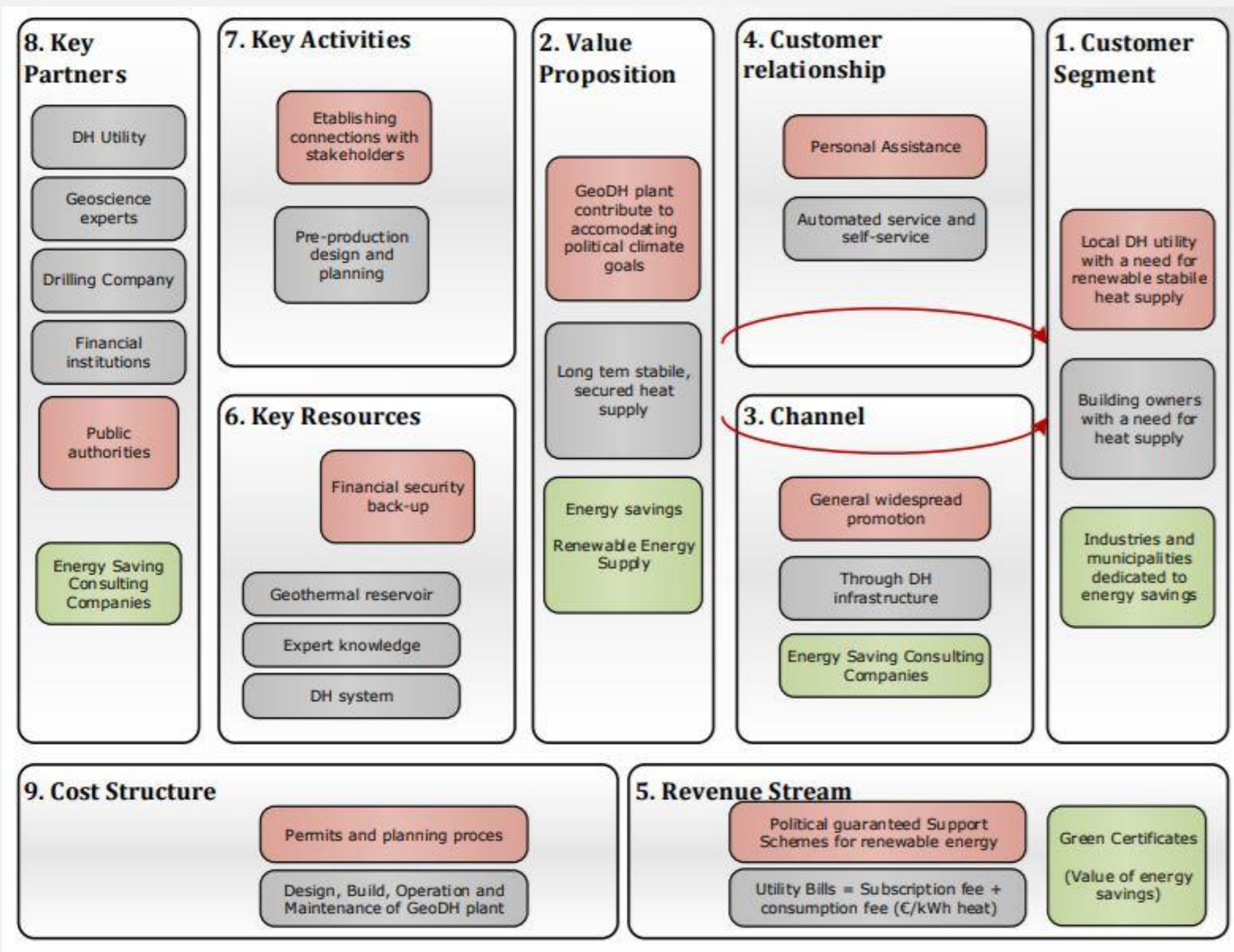


Fig. 7.1.8. ESCO Geothermal District Heating /Cooling Business Model
Source: BUSINESS MODELS ON GEOTHERMAL DH SYSTEMS

7.1.4. Renewable Energy

1) Community Solar Farm

Local municipality or area management body installs PV panels by utilization of rooftop of the building and unused land / open space within the designated area, and gain an income by selling electricity through the FIT system.In case the FIT system is terminated, Virtual PPA should be considered as an alternative scheme.

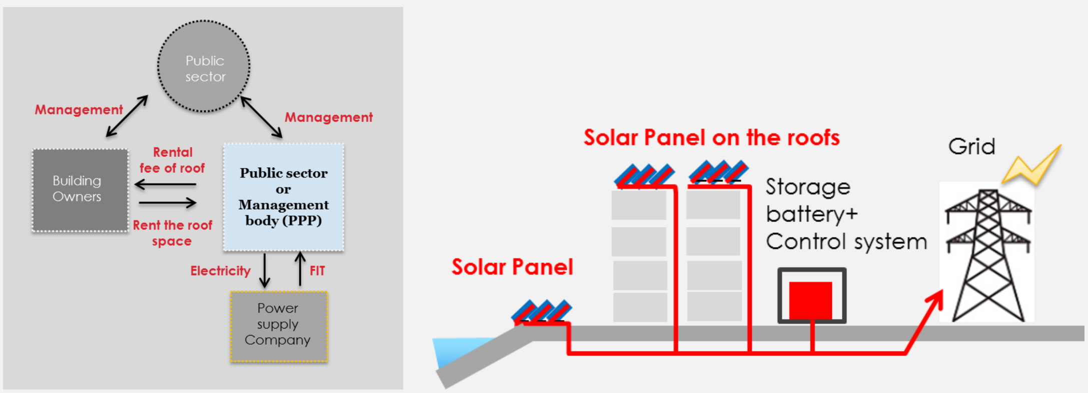


Fig. 7.1.9. Business scheme of Community Solar Farm
Source: Project Team (NSRI)

7.1.5. Greenery

Community Green Lease

There are many office buildings in the districts, and if building owners try to carry out low carbonization, they individually introduce energy-saving measures by themselves and at their own risk. In this scheme, the building owner who has a strong intention of low carbonization contracts a “Green Lease” with the public sector. The public sector (local municipality, etc.) provide subsidy to the building owner as a part of additional cost for low carbonization.

After the building owner improves building equipment, reduction of utility costs caused by the above improvement, is divided by tenants and owner as an incentive of low carbonization for both sides.It has already been introduced in Tokyo Metropolitan Government to promote low carbonization of private buildings.

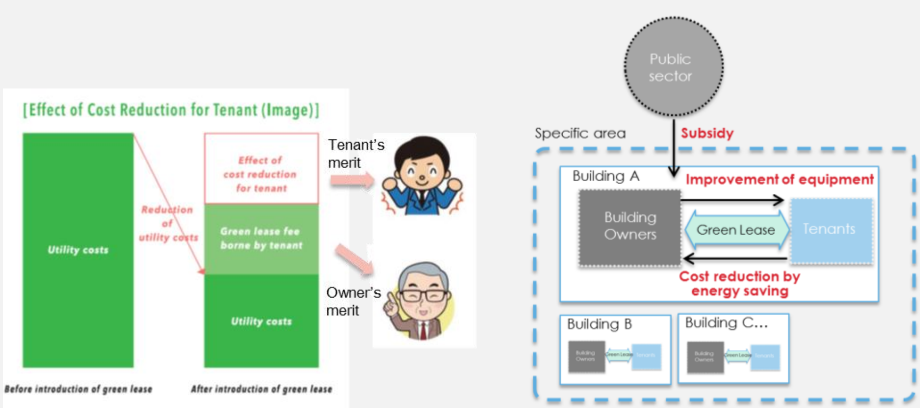


Fig. 7.1.10. Business scheme of Community Green Lease
Source: Project Team (NSRI), Tokyo Metropolitan Government

7.1.6. Waste Management

Group collection of waste is a system in which independent resident groups in local communities, including neighborhood associations, district organizations, and volunteer groups, collect recyclable waste discharged from homes, such as empty bottles, empty cans, used paper, and cardboard, in a specific place at a specific time, and deliver the collected waste to resource recycling operators in order to recycle waste as resources.

Group collection reduces waste collection costs not only for local governments but also for waste collectors by enabling them to efficiently collect specific amounts of waste. Group collection provides advantages to residents as well, such as enabling them to sort recyclable waste at home on specific days and creating new opportunities for communication with other residents. To increase the amount of recyclable waste collected and to reduce waste, many local governments have created incentive systems, including providing subsidies to local community organizations that practice group collection.

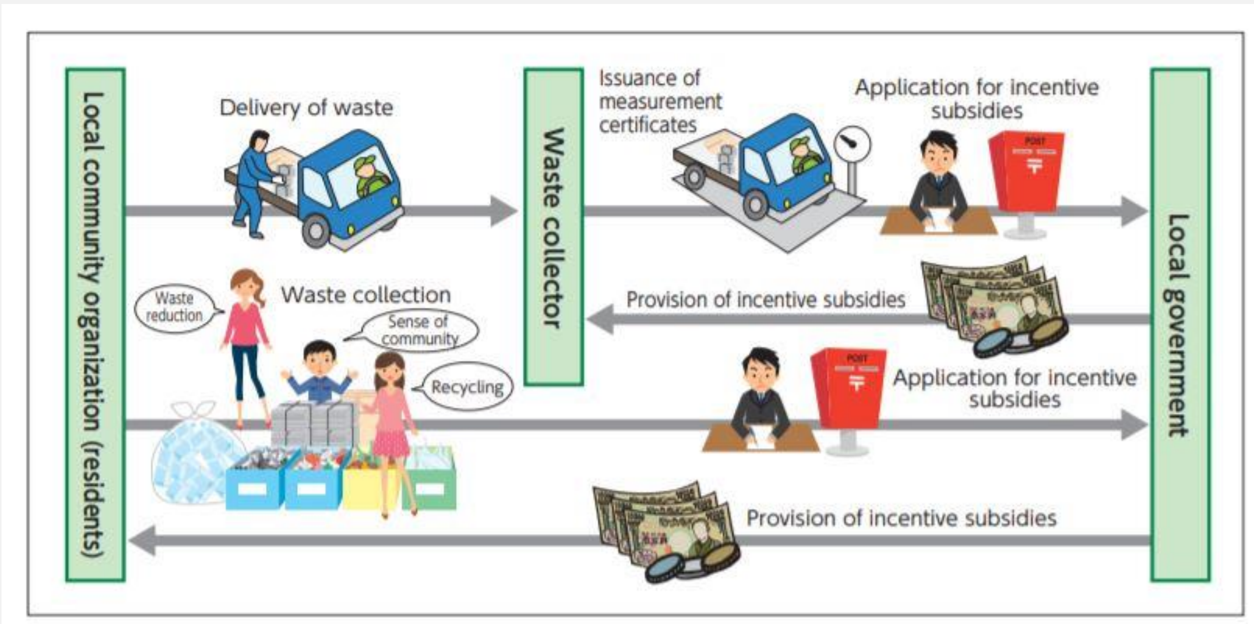


Fig. 7.1.11. Group collection
Source: Compiled from a figure on the website of Yokohama City

7.1.7. Transportation

1) Business scheme

(1) Business scheme for the improvement of the bus business

Improving the convenience of buses, which are an important means of transportation in the daily lives of residents, will lead to further reduction of CO2 emissions.

It is important to optimize the operation of bus routes by continuously reviewing and improving the routes and schedules. As a means to achieve this, efforts to visualize the operation status should be promoted.

While local governments are responsible for the development of bus infrastructure, bus operators will be obliged to provide data on their operations. This will make it possible to build a sustainable transportation system.

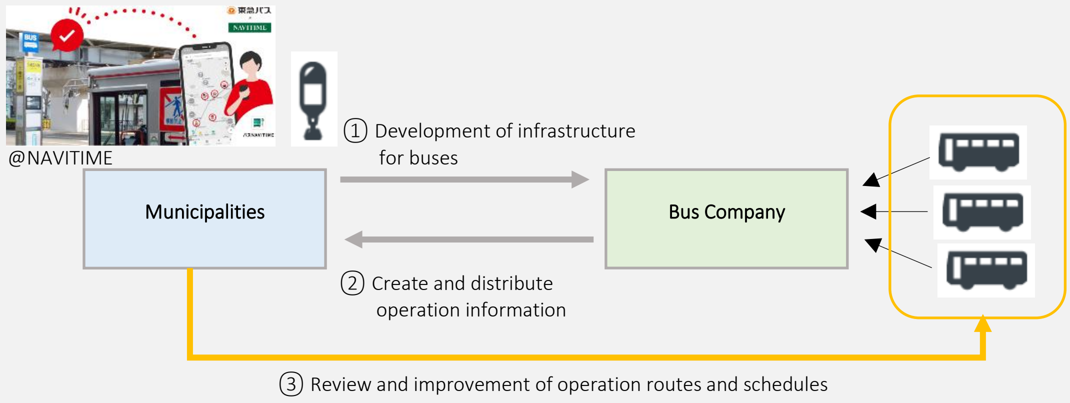


Fig.7.1.12. Image of area management contribution system
Source: Project teams (NSRI)

(2) Business scheme for promoting bicycle sharing

Unlike privately owned bicycles, shared bicycles are characterized as a means of transportation used by an unspecified number of people. They can be used by residents and tourists for a wide range of purposes, and are a means of public transportation that can address a variety of local issues, such as supplementing the functions of public transportation, revitalizing local communities, and reducing administrative costs by reducing the number of abandoned bicycles.

In order to promote the use of shared bicycles as a means of public transportation, it is necessary to strengthen the role of shared bicycles in the public transportation network by strengthening connections between shared bicycles and public transportation such as railroads and buses, promoting the installation of cycle ports, and promoting the development of transportation spaces. One of the major issues with shared bicycles is their low profitability. While the government bears the costs, it is desirable to consider measures to cover the costs, such as giving naming rights and exclusive rights for street advertising and utilizing the income from these rights.

In order for shared bicycles to succeed as a business, it is necessary to have a high density of ports. There is a correlation between the number of times shared bicycles are used and the density of ports, so increasing the density of ports will increase market penetration and create opportunities for shared bicycle use. This leads to an increase in fee revenue, which is very important from the perspective of ensuring profitability.

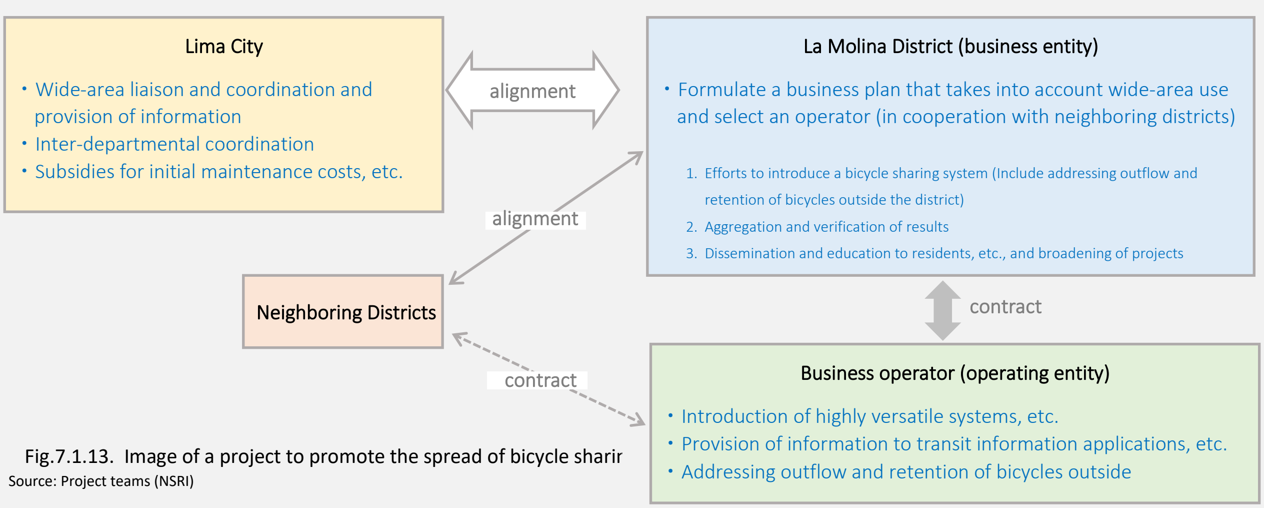


Fig.7.1.13. Image of a project to promote the spread of bicycle sharir
Source: Project teams (NSRI)

CitiBike (New York)
naming right

Vélib' Métropole (Paris)
Granting exclusive rights to street advertising and appropriating the proceeds

Fig.7.1.14. Port density and average frequency of use
Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan （English translation by NSRI）

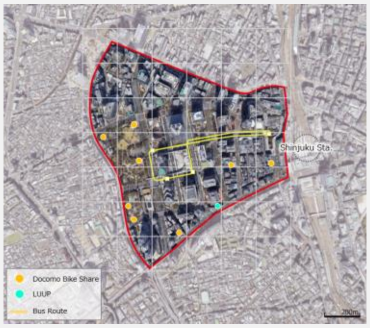
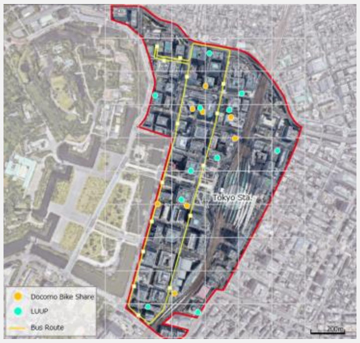
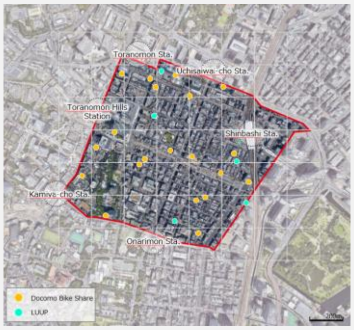
Item	Shinjuku	Otemachi, Marunouchi, Yurakucho	Toranomon
Target Area			
Area (ha)	96 ha	120 ha	108 ha
Block size ※	180×100 m	100×100 m	40×50 m
Number of ports	11	19	25
Port density (sites/㎢)	11.5	15.8	23.1
Port spacing	200 m	50-200 m	50-200 m
Daytime population in the area (2015)	173,466	209,774	103,258

Fig.7.1.15. Port Density / Same Scale Comparison in Tokyo, Japan
Source: Project team (NSRI)

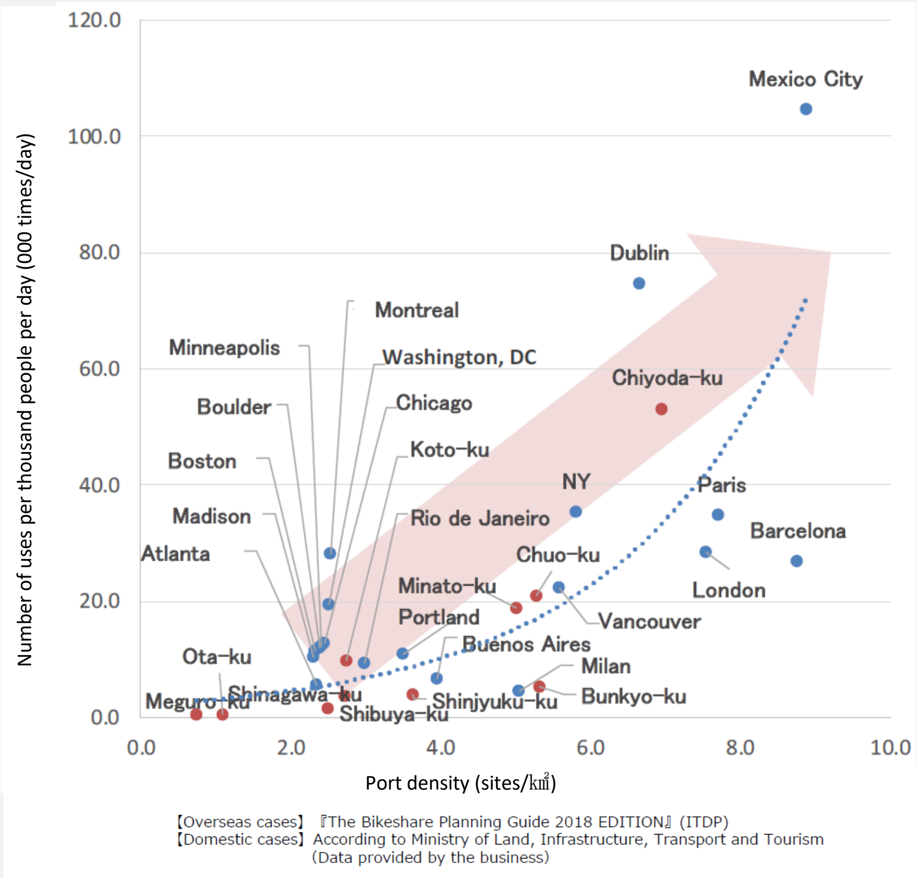


Fig.7.1.16. Port Density / Same Scale Comparison in Tokyo, Japan
Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan

2) Feasibility study of business scheme

Among the business schemes proposed in 1), we will study the estimated project cost and profitability of the shared bicycle system, which will be more effective for the community and residents in terms of reducing environmental impact, improving health, increasing convenience of living, and revitalizing the community.

The area to be studied will be the northeastern part of the La Molina district, where commercial, business and educational facilities are concentrated and a bicycle network is being formed.

- **Prerequisite**
  - The target number of ports is 5 per 1 ㎢, and 5 bicycles are to be deployed at each port. (Since the target area is about 10 ㎢, the number of ports is assumed to be 50 and the total number of bicycles is assumed to be 250.)
  - The bicycles shall be electrically power-assisted. The bicycles will be equipped with four mechanisms: cell phone signals, GPS devices, electronic locks, and remote control functions (e.g., control of borrowing and returning bicycles and monitoring the remaining battery life of the electric power-assist function). By making the functions available on the bicycle side, the system will save time and money on the bicycle parking side.
  - The ports will be installed on public land (roads, parks, educational facilities, etc.) as much as possible. In this way, there will be no expenditure for acquiring land for the ports.

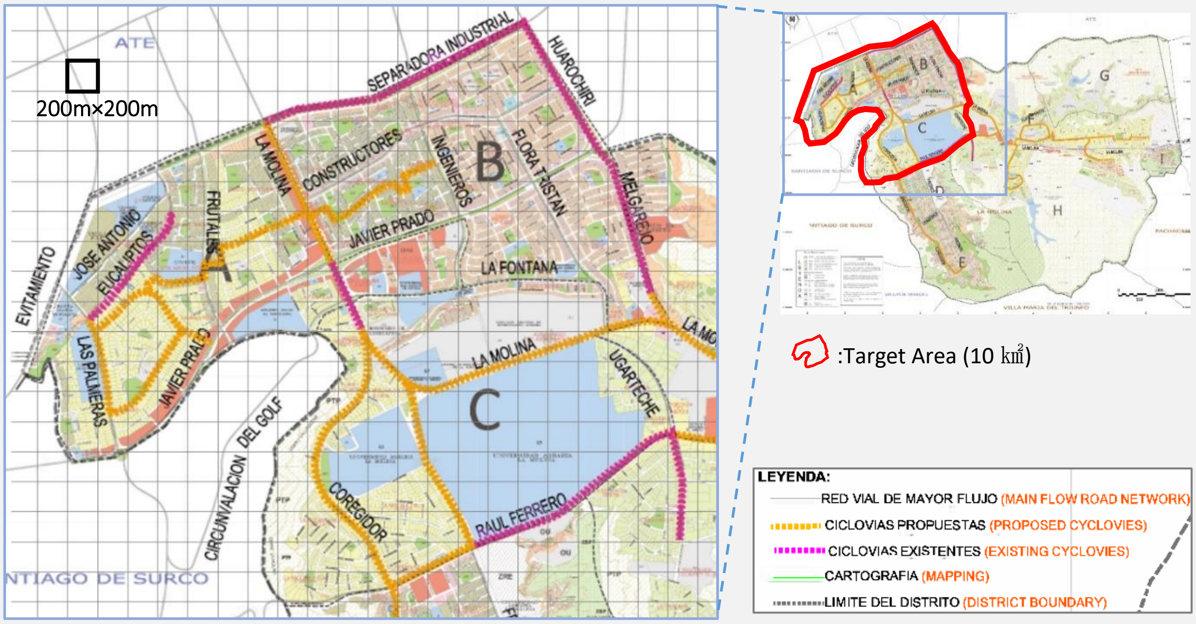


Fig.7.1.17. Target Area
Source: Project team (NSRI)

If the number of planned ports is 50, the estimated initial cost and running cost are as follows.

Table 7.1.6. Initial cost and running cost

	Initial cost	Running cost (annual)
Total	$ 478,261	$347,826
breakdown	Bicycle purchase cost: $1,739/unit x 250 units = $434,783 Chargers (installed at each port): $870 per location x 50 locations = $43,478	System service usage fee: $87/bike/year x 250 bikes = $21,739 Bicycle relocation cost: Assumed to be 30% of the total cost ($104,348) from the case study*. Other expenses (labor, communication line usage fees, general expenses, etc.) are assumed to be $221,739 based on the case study*. Land rent for port location: not included *Results of Japan Bicycle Promotion Association survey

Source: Project team (NSRI)

The annual fee revenue and advertising revenue are as follows

Table 7.1.7. The annual fee revenue and advertising revenue

	Fee revenue (annual)		Advertising revenue (annual)
	Usage fee （1time）		
Total	$0.88	$ 2.63	$52,174
	$238,043	**$714,130**	
Remarks	Turnover rate (times/unit/day) is assumed to be a maximum of 3 Maximum number of units set for operation = 250 units/day x 3 = 750 units		Naming rights, assuming advertising in port $4378.78 (per month) x 12 months=$52,174

Source: Project team (NSRI)

7.2. Khon Kaen Municipality, Thailand

7.2.1 Prioritization of low carbon scenarios

To achieve a low carbon, it is important to develop priorities for low carbon scenarios. The Marginal Abatement Cost Curves can be used as a reference for prioritization. The vertical axis shows the CO2 Reduction cost per CO2 reduction, and the horizontal axis shows the total CO2 reduction of Khon Kaen in 2050. The horizontal axis shows Khon Kaen's total carbon dioxide reduction in 2050. The CO2 reduction costs per unit of carbon dioxide reduction are numbered in order of decreasing cost.

The costs are estimated by NSRI in local currency, considering local construction prices. Many of the measures, especially those for buildings, have a cost of zero, which means that they can be implemented without additional cost at the time of the next equipment renewal for existing buildings, or the design stage for new buildings.

The recommended time spans were divided into short, middle, and long spans so that the total carbon dioxide reduction for each would be roughly equal. The recommendations for the short span are No.1 to No.14, which are mainly measures related to building equipment. In particular, the replacement of high-efficiency home appliances in No. 9 and diffusion of Low carbon vehicles (EV) in No. 11 has a particularly large impact.

As for the middle term recommendations, the promotion of solar panels (No.21 and 22) will have a great impact, as the mega-solar power plant (No.21) is located on the water and can be expected to improve power generation efficiency. As a recommendation for the long term, No. 25, the use of heat pumps for hot water supply in houses, will have a significant impact. In recent years, the price of heat pumps for hot water supply has gradually become cheaper. In addition, although the cost of heat insulation and solar radiation shielding in house No. 32 is rather high, it also has the effect of improving the comfort of the indoor environment through improved heat insulation performance.

Thus, it will be important to combine measures such as solar power generation and the use of heat pumps for hot water supply with measures for building facilities.

The following section is a list of methods that may be effective in implementing each measure.

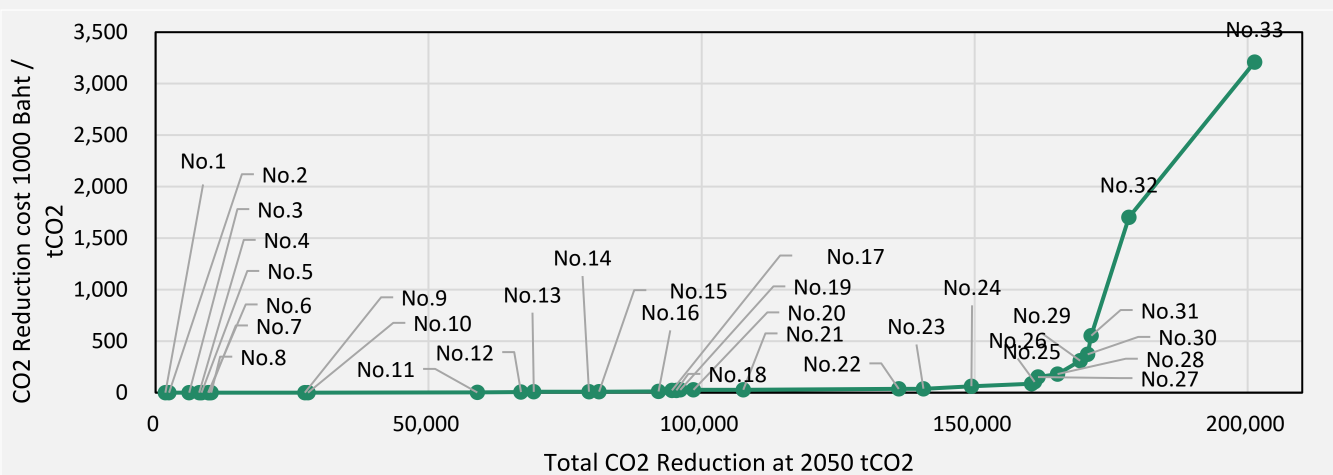


Fig. 7.2.1. Marginal Abatement Cost Curves at Khon Kaen Low carbon scenario

Source: Project Team (NSRI) Cost prices were adjusted based on the International Construction Costs 2020.

Table. 7.2.1. Low carbon method and recommended time span

No	Low carbon methods	Category	CO2 reduction volume (at 2050)	CO2 Reduction Additional costs	Recommended time span
			t-CO2	1000 Baht/t-CO2	
No.1	Reduction of internal heat generation(Non-residential building)	Building	1,791	0*	Short
No.2	Inverter(Water conveyance)(Non-residential building)	Building	674	0*	Short
No.3	Inverter(Air conveyance)(Non-residential building)	Building	3,697	0*	Short
No.4	Conversion to heat pumps(Non-residential building)	Building	1,820	0*	Short
No.5	Reduced power(Outlet)(Non-residential building)	Building	427	0*	Short
No.6	High efficiency fan (air conveyance)(Non-residential building)	Building	1,214	0*	Short
No.7	Improve pump performance(Non-residential building)	Building	181	0*	Short
No.8	Smart operation elevator(Non-residential building)	Building	382	0*	Short
No.9	High efficiency of home appliances(residential)	Building	17,143	0*	Short
No.10	High efficiency of cooking equipment(residential)	Building	587	0*	Short
No.11	Diffusion of Low carbon vehcles (EV)	Transportation	31,000	2	Short
No.12	Introduction new personal mobility	Transportation	8,000	6	Short
No.13	High efficiency ventilation fan(Non-residential building)	Building	2,346	8	Short
No.14	High-efficiency equipment(Non-residential building)	Building	10,104	9	Short
No.15	Introduction of CO concentration control of parking fans(Non-residential)	Building	1,854	10	Middle
No.16	Lighting equipment (LED)(residential)	Building	10,895	12	Middle
No.17	Illuminance correction(Non-residential building)	Building	2,453	23	Middle
No.18	Inverter(Heat source auxiliary)(Non-residential building)	Building	816	23	Middle
No.19	Human Sensor(Lighting)(Non-residential building)	Building	701	26	Middle
No.20	CGS (in hotel, hospital)	Multi Energy System	2,428	27	Middle
No.21	PV on pond	Renewable Energy	9,117	28	Middle
No.22	PV on residence	Renewable Energy	28,478	36	Middle
No.23	PV on commercial building	Renewable Energy	4,520	39	Middle
No.24	High efficiency of lighting equipment(Non-residential building)	Building	8,783	63	Middle
No.25	Hot water supply equipment(residential)	Building	11,055	86	Long
No.26	CO2 ventilation control(Non-residential building)	Building	528	105	Long
No.27	Introduction of high efficiency transformers(Non-residential building)	Building	610	151	Long
No.28	Glass performance improvement(Non-residential building)	Building	3,583	180	Long
No.29	High efficiency of cooling equipment(residential)	Building	4,139	310	Long
No.30	Roof thermal barrier coating(residential)	Building	1,380	372	Long
No.32	Thermal insulation + solar radiation shielding(residential)	Building	6,898	1,702	Long
No.33	Developing new LRT lines	Transportation	23,000	3,209	Long

Source: Project Team (NSRI) Cost prices were adjusted based on the International Construction Costs 2020. * Cost indicates the additional cost compared to BAU. A cost of zero means that there is little or no increase in cost compared to BAU (e.g. normal product) or that the initial cost investment can be recovered in a relatively short period of time through reduced utility costs.

7.2.2. Buildings

1) Energy Service Company (ESCO)

Energy Performance Contracting (EPC) is a contract scheme for clients to introduce low-carbon methods without incurring initial costs. In Japan and the United States, the private sector has also made great results through EPC. Major low-carbon methods through EPC are inverter of pumps and fans, renewal of refrigerator, LED lighting. By using the EPC scheme, LEDs and inverters in our proposal are more quickly installed.

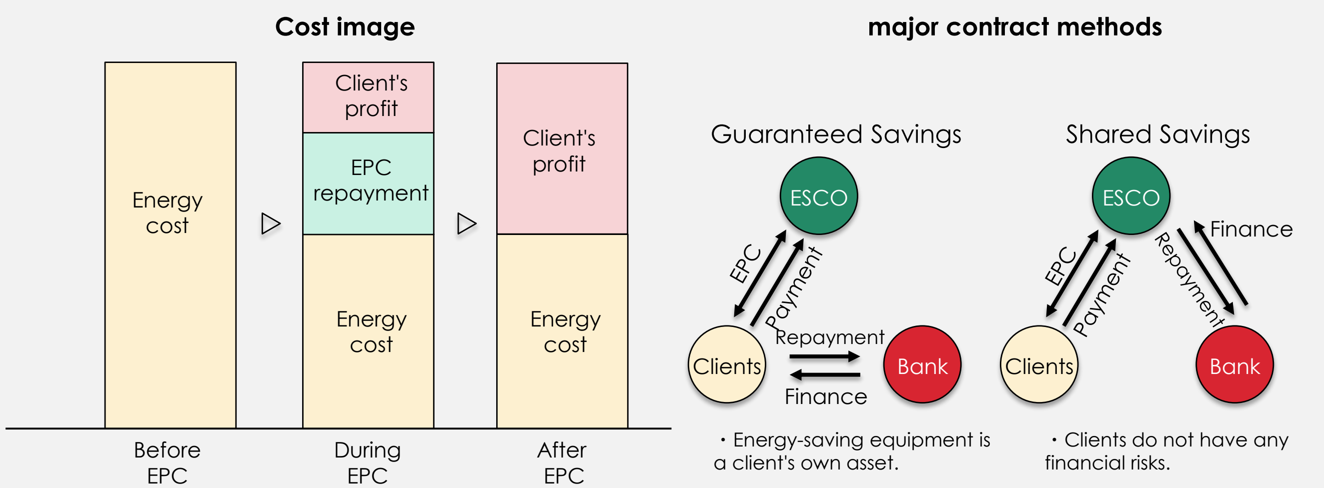


Fig. 7.2.2. Concept of ESCO
Source: Project Team (NSRI)

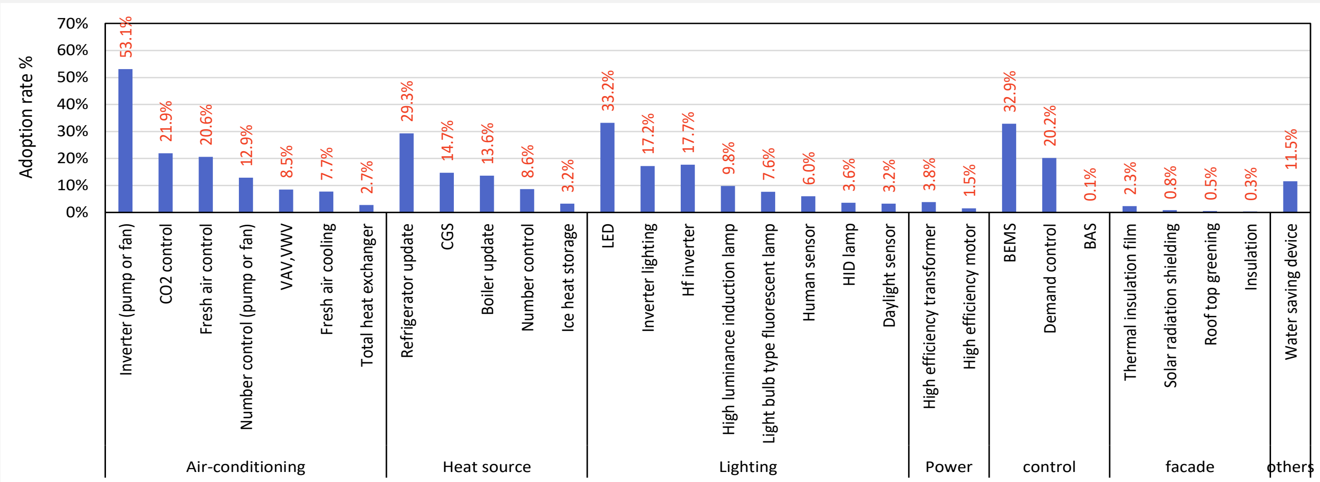


Fig. 7.2.3. low-carbon methods adopted by EPC (2001~2015, office & commercial building in Japan)
Source: Japan Association of Energy Service Companies

7.2.3. Transportation

1) Community-based MaaS (Mobility as a Service)

Currently, in Thailand, sharing mobility services such as Grab are popular, and it is no exception at the site.

The public sector or management body runs a traffic information platform in the designated area. Management body effectively collaborates the existing business such as Grab, etc. It is forecasted that more incubator business happens by utilizing the platform.

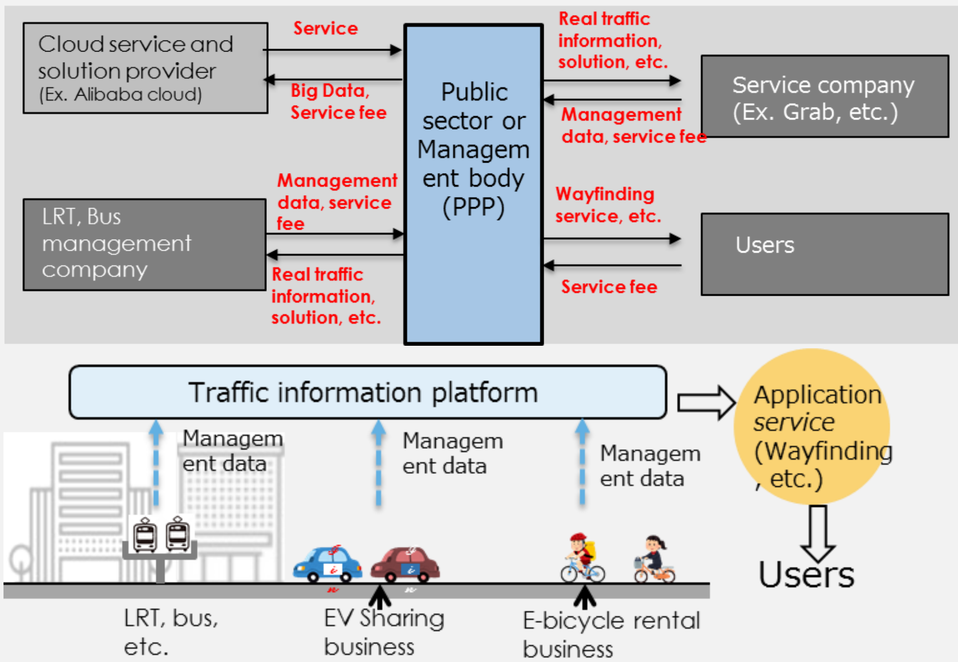


Fig. 7.2.4. Business scheme of Community based MaaS
Source: Project Team (NSRI)

2) Promotion of TOD (urban development in which the station and town are integrated)

By promoting urban development based on the use of public transportation, such as the development of plaza space around LRT stations, the creation of liveliness through the concentration of functions, the development of a pedestrian network, and the improvement of regional mobility through the strengthening of ties between transportation methods such as bus and bicycle sharing and the railroad network, we will By promoting urban development that is based on the use of public transportation, such as improving regional circulation by strengthening the linkage between the railroad network and other means of transportation such as stations, we will improve the convenience of public transportation and implement low-carbon urban development.

The following business scheme is proposed to induce urban development in which the station and the city are integrated.

1. Promotion of the establishment of traffic storage facilities
2. Promotion of area management
3. Improve the bus business

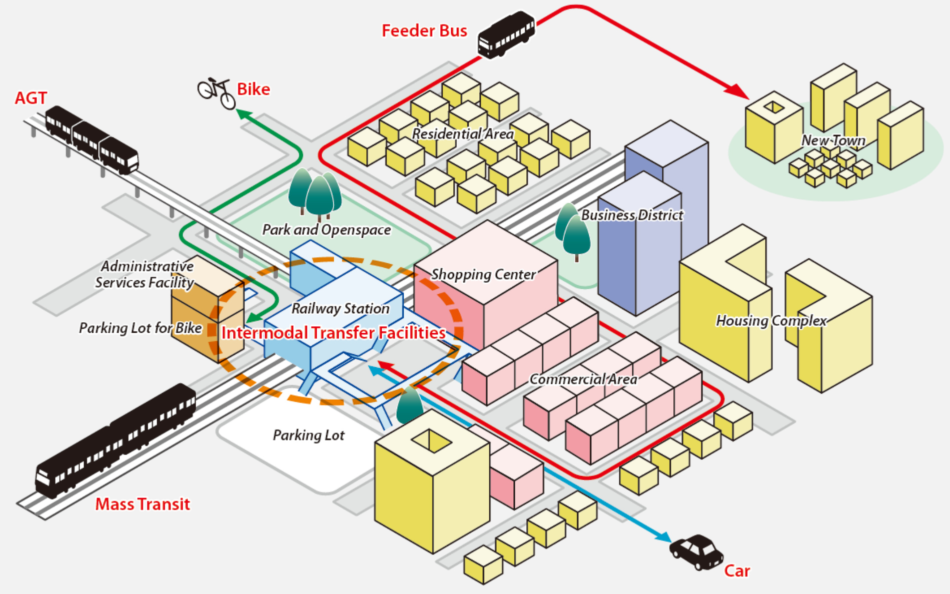


Fig.7.2.5. Maintenance image that integrates the station and the town
Source : ALMEC CORPORATION

3) Business scheme for the establishment of traffic storage facilities

In urban development, the contribution to the development and improvement of the traffic environment in the area and surrounding urban areas will be evaluated, and the standard floor-area-ratio limits will be relaxed, and specific rules for the contribution and relaxation of the floor-area-ratio will be set according to the actual conditions of the district. In this way, the project will promote the development of projects by landowners and private businesses, and the formation of a traffic environment.

※Transportation complementary facilities to be evaluated: public parking lots, public bicycle parking lots, transportation plazas, bus terminals, cab bays, etc.

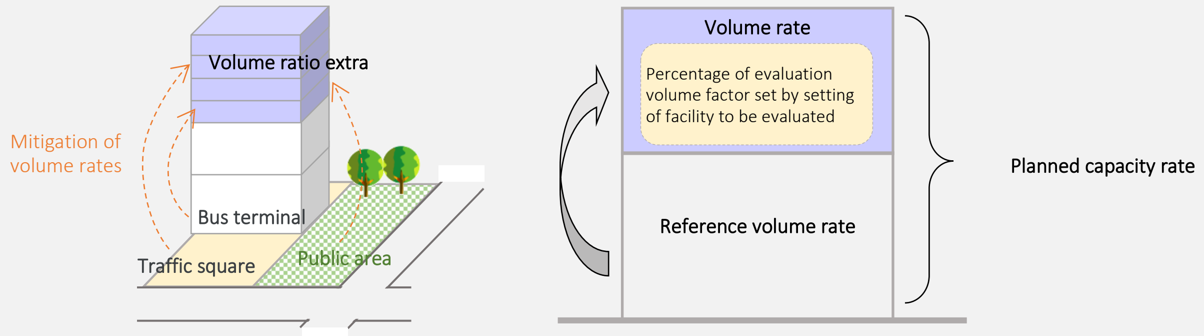


Fig.7.2.6. Image that mitigates the volume
Source : Project team (NSRI)

4) Business scheme for an area management promotion

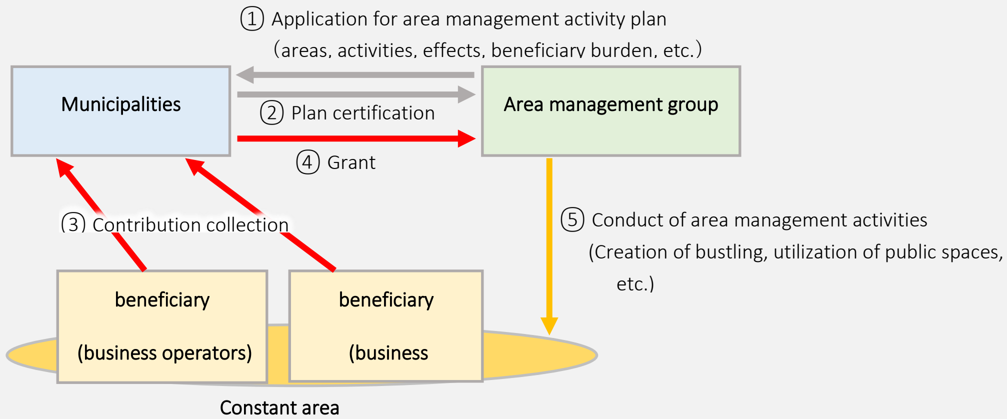


Fig.7.2.7. Image of area management contribution system
Source : Cabinet Office (Japan (English translation in NSRI)

5) Business scheme for the improvement of the bus business

Improving the convenience of buses, which are an important means of transportation in the daily lives of local residents, will lead to further reduction of CO2 emissions.

It is important to optimize the operation of bus routes by continuously reviewing and improving the routes and schedules. As a means to achieve this, efforts to visualize the operation status should be promoted.

While local governments are responsible for the development of bus infrastructure, bus operators will be obliged to provide data on their operations. This will make it possible to build a sustainable transportation system.

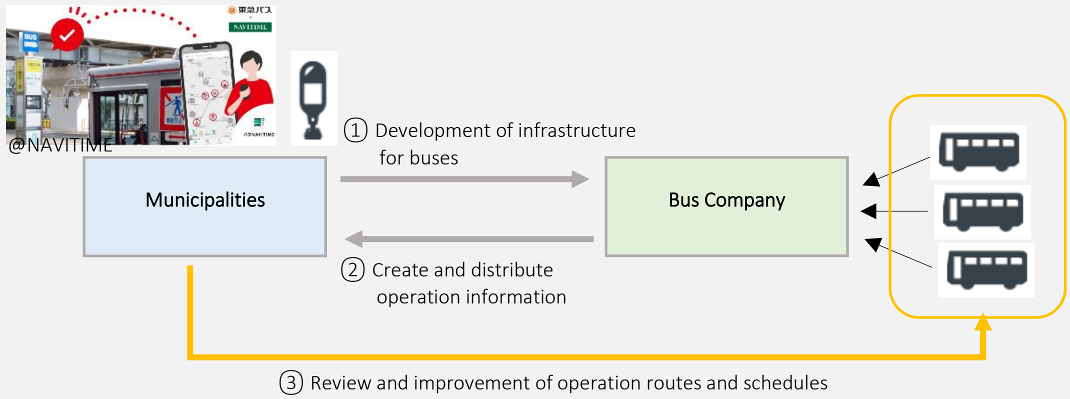


Fig.7.2.8. Image of area management contribution system
Source: Project teams (NSRI)

7.2.4. Renewable Energy

1) PPA

"Power Purchase Agreement (PPA) model is a contractual model between a power producer (PPA providers) and a consumer (user of electricity). There is no need for initial investment or maintenance when consumers install solar power. The initial cost is often a hurdle in the introduction of solar power, and the PPA model can solve this problem.

Solar power systems installed under the PPA model have two unique features compared to general solar power system installations.

The first is that the PPA provider will incorporate a system for remote monitoring and management of power generation. The loss of power generation opportunities due to equipment failure, etc., is a major blow to PPA providers who earn revenue from the power they generate, so it is necessary to have a system in place to prevent this from happening and to respond immediately.

Secondly, electricity meters (measuring instruments) will be installed to measure the amount of electricity generated. In a system where the amount of power generated is controlled without reverse powering excess power to the power grid, which is called "full in-house consumption," the power measured by the meter is billed to the power user as the amount of power used. In addition, in systems that reverse flow surplus power to the power system, the amount of power used is billed to the power user as the amount of power used after subtracting the power measured by the existing watt-hour meter from the power generated by this watt-hour meter.

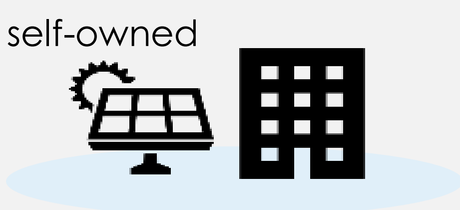
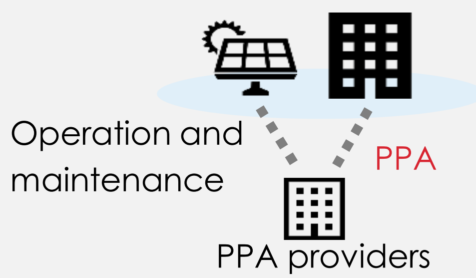
	self-owned	PPA
		
Owner of the PV	self-owned	PPA providers
initial investment	Necessary	Unnecessary
maintenance	Necessary	Unnecessary
electric utility charge	Free for self-consumption	Self-consumption also charged
capitalization	on-balance sheet	off-balance sheet
Project period	Return on investment in about 10 years	Contracts of 10 years or more

Fig. 7.2.9. Business scheme of PPA

Source: Project Team (NSRI)

7.2.5. Waste management

To increase the amount of recyclable waste collected and to reduce waste, many local governments have created incentive systems, including providing subsidies to local community organizations that practice group collection.

In the Arakawa ward in Tokyo, Japan, based on the Arakawa Ward Volunteer Seal Grant Guidelines, there are volunteer activities that temporarily discharge garbage. The applicable target person from the activities is exempted from the fee and a volunteer seal is issued. The program supports a part of purchase costs such as household garbage processing machines to promote the reduction of garbage. The subsidy limit is 20,000 yen.

This FS recommended the implementation of the waste collection program in Khon Kaen which could be a great motivation to the local community and organisations in order to improve the eco-recycling. The group collection reduces waste collection costs not only for local governments but also for waste collectors by enabling them to efficiently collect specific amounts of waste.

The program could be applicable for resident groups in local communities, including neighbourhood associations, district organizations, and volunteer groups, etc.

The type of collected waste discharged from homes could be empty bottles, empty cans, used paper, cardboard, etc. After collection of the garbage, they are delivered to resource recycling operators. The Figure below shows the group collection mechanism.

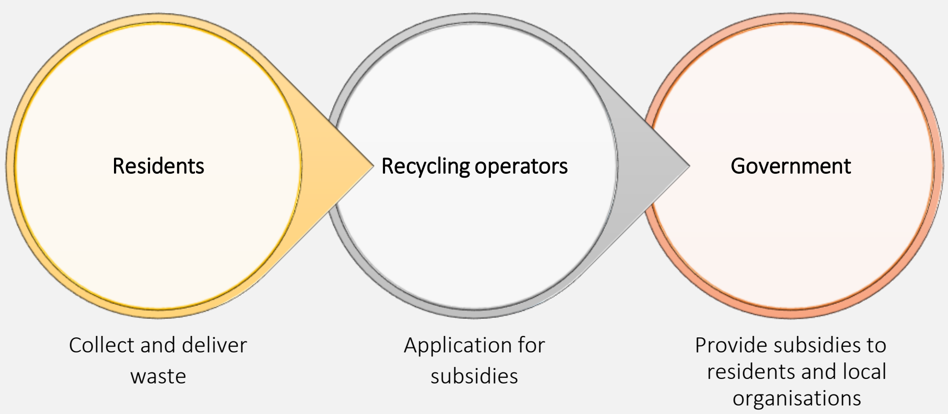


Fig. 7.2.10 Collection of waste
Source: Project Team (NSRI)

Another good example is the waste collection in Furthermore, Kitakyushu City in Japan. The Kitakyushu City provides training, education and subsidies to residents for purchasing composting equipment. The city provides incentive payments to the children's associations to collect newspapers and magazines based on the amount of collection. The city also set up collection points at supermarkets to collect cartons and trays, electric appliances, fluorescent lights, used cooking oils, and small metal items.

7.3. Phu Quoc District, Kien Giang Province, Viet Nam

7.3.1 Prioritization of low carbon scenarios

To achieve a low carbon, it is important to develop priorities for low carbon scenarios. The Marginal Abatement Cost Curves can be used as a reference for prioritization. The vertical axis shows the amount of CO2 reduction, and the horizontal axis shows the investment cost of Phu Quoc in 2030. The horizontal axis shows Phu Quoc's total investment cost in 2030, about 600 million USD.

NSRI calculated the amount of CO2 reduction and investment amount up to 2030. The costs are estimated by NSRI in local currency, considering local construction prices. The cost of each item is calculated at the ratio of the construction cost in consideration of Viet Nam's condition. However, CGS and Seawater Heat source systems are calculated based on Japan's cost, because they are supplied by the machinery equipment manufacturer.

Regarding the amount of CO2 reduction compared to the investment amount, PV was the highest, followed by energy-saving investment on the building side and machinery equipment such as CGS was low.

In the future, it will be possible to make more accurate calculations using total floor area data by each use.

Table.7.3.1. Reduction of CO2 emissions and investment cost

	Year 2030		
	Investment cost	Amount of CO2 reduction	USD/t-CO2
	Million USD	t-CO2	USD/t-CO2
PV (lake, MEGA)	12	43,971	282
Energy saving in buildings	413	95,510	4,329
Solar heat	2	546	4,546
Incineration plant	9	1,853	4,963
District cooling	52	9,824	5,303
CGS	109	18,011	6,038
Seawater Heat source	12	1,637	7,576

Source: Project team (NSRI)

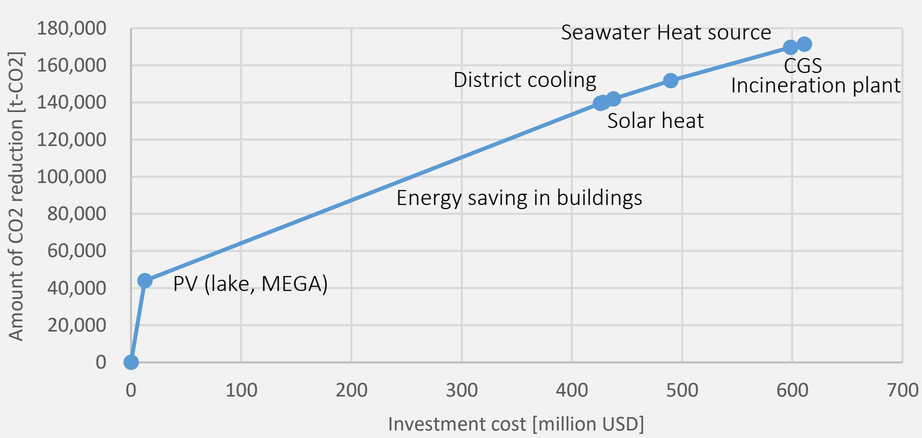


Fig.7.3.1. Reduction of CO2 emissions and investment cost

Source: Project team (NSRI),

7.3.2. Area Energy System

District cooling (DC) company

In many cases, developers or building owners establish SPC and SPC establish DC company. Priority is given to areas with high heat demand as heat supply areas, and make a heat supply contract with the building owners. If DC company own renewable energy (such as solar power) at a heat supply facility, DC company can sell the generated electricity to an electric power company.

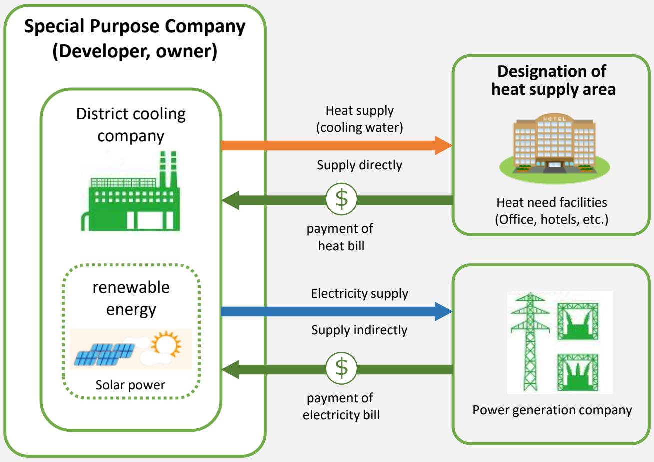


Fig. 7.3.2. Business scheme of District cooling system
Source: Project Team (NSRI)

7.3.3. Untapped Energy

Waste heat use from incineration plants

Conclude a heat supply contract to supply the waste heat of the incineration plant to heat consumers. It is conceivable to directly supply heat to a building with a large heat demand or to supply heat to a district heating facility with large heat demand. When the demand for hot water is low, it is conceivable to use the exhaust heat of the incineration plant to produce chilled water. However, in the case of an absorption chiller, equipment with a large capacity is required, so chilled water is produced from a district cooling company. In many cases, the electricity generated from the incineration plant is sold to the electric power company and indirectly supplied to the development area.

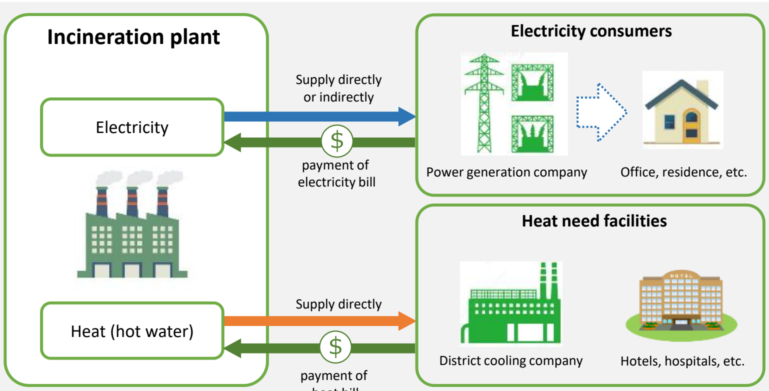


Fig. 7.3.3. Business scheme of Waste heat use from incineration plants
Source: Project Team (NSRI)

7.3.4. Renewable Energy

1) Community Solar Farm

Local municipality or area management body installs PV panels by utilization of rooftop of the building and unused land / open space within the designated area, and gain an income by selling electricity through the FIT system.

In case the FIT system is terminated, Virtual PPA should be considered as an alternative scheme.

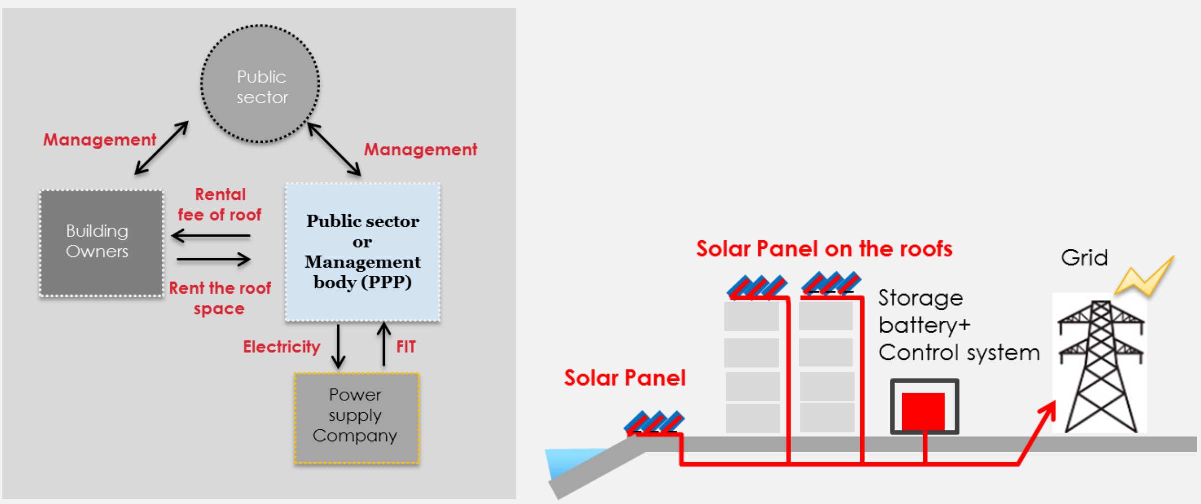


Fig. 7.3.4. Business scheme of Community Solar Farm

Source: Project Team (NSRI)

2) Urban photovoltaics

Electricity generated from renewable energy is characterized by instability. Therefore, it is desirable that the electric power company purchases the electricity generated from the renewable energy company and supplies the stabilized electric power from the electric power company to a wide area. Electric power companies can also sell the purchased electricity derived from renewable energy to consumers as green electricity.

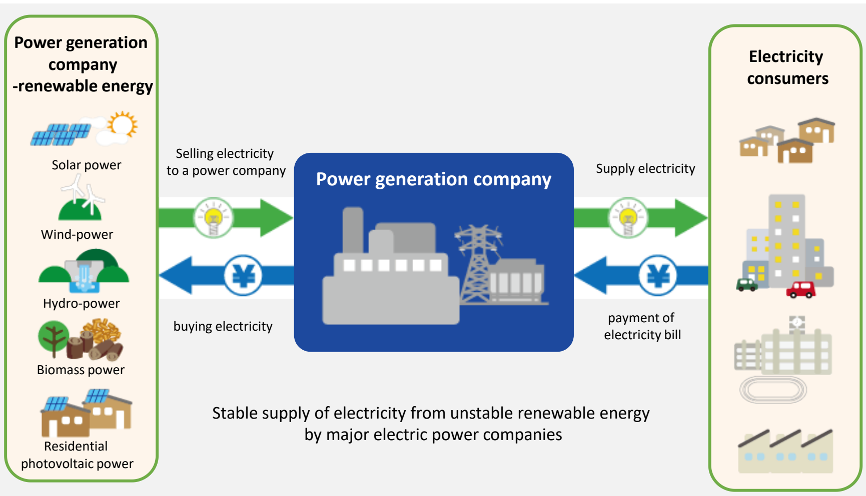


Fig. 7.3.5. Business scheme of Urban photovoltaics

Source: Project Team (NSRI)

7.3.5. Multi-Energy System

Co-Generation System

Facilities or buildings with high heat demand will install Co-Generation System (CGS) and use produced electricity and heat. The electricity and heat produced will be preferentially supplied to the area supplied by the District Cooling area (or building) for self-consumption. It is conceivable that the surplus electricity will be sold to the electric power company in reverse. The efficiency of exhaust heat from CGS is high when the exhaust heat is supplied as hot water, but when the demand for hot water is small, the high temperature exhaust heat is converted into chilled water and supplied by using an absorption-type facility.

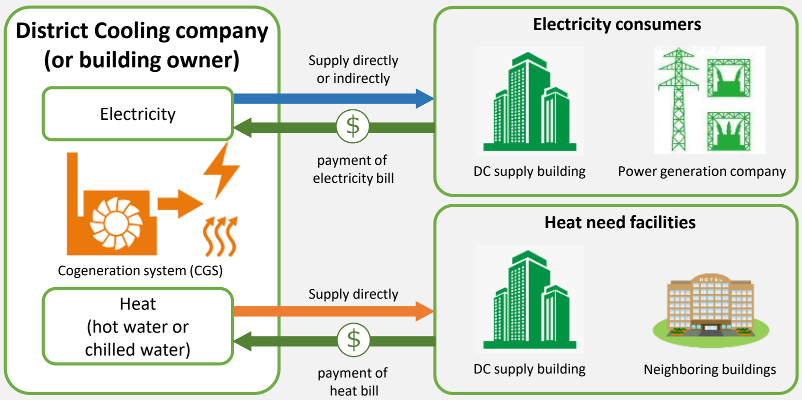


Fig. 7.3.6. Business scheme of Waste heat use from incineration plants

Source: Project Team (NSRI)

7.3.6. Water management

1) Subsidy Programs for Johkasou (wastewater treatment plant) installation

There are two municipal water treatment system installation programs (the treatment of the domestic wastewater) promoted by the Ministry of the Environment in Japan:

- Small-scale Johkasou Installation Program for Local Government and
- Medium-scale Johkasou Installation Program for Local Government

Both of the above programs are promoted individually by municipalities as a public enterprise to install small-scale or medium-scale for decentralized or centralized treatment. The important point is that the municipalities can issue bonds and receive local allocation tax money as part of the installation cost from the Government.

Such an implementation of the program will have great application in the Phu Quoc District as well as could promote the installation of the wastewater plants in order to improve the Wasta management.

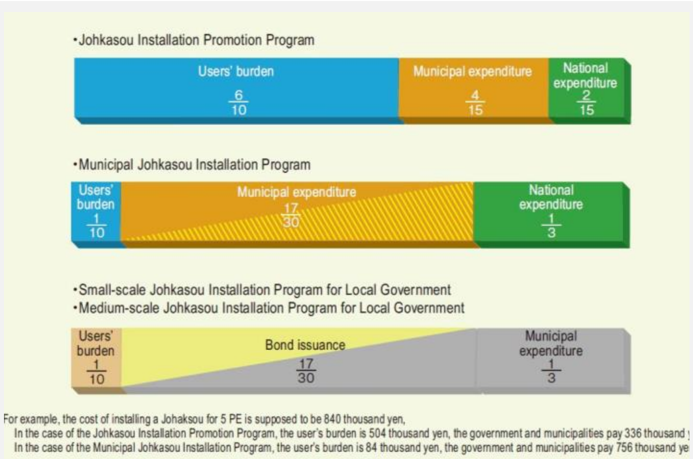
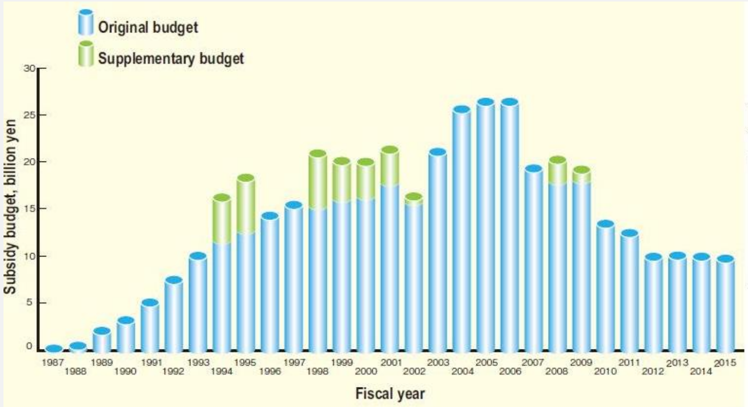


Fig. 7.3.7. Subsidy Programs for Johkasou

Source: Ministry of the Environment, Japan



An example of maintenance cost of BOD removal type Johkasou

	A Johkasou for 5 PE	A Johkasou for 7 PE
Annual cost	65,000 yen	81,000 yen
Items		
maintenance fee	21,000 yen	22,000 yen
desludging fee	26,000 yen	35,000 yen
electricity fee	13,000 yen	19,000 yen
inspection fee	5,000 yen	5,000 yen

Fig. 7.3.8. Subsidy Programs for Johkasou and example of the maintenance cost (yen)
Source: Ministry of the Environment, Japan

2) Fund Wastewater and Drinking Water Loans

- The State Revolving Fund (SRF) Loan Programs, Indiana, USA, provide low-interest loans to eligible entities for the planning, design, construction, renovation, improvement or expansion of wastewater and drinking water systems. SRF Program Loans or other financial assistance is available for improvements to wastewater and drinking water plants, sewer line and water line extensions projects.

- Funds are also available for the costs associated with non-point source water pollution abatement projects, such as wetland restoration/protection, erosion control measures, stormwater projects that improve water quality practices, and wellhead and source protection measures

The State Revolving Fund (SRF) Loan Program

Provide low interest loans to eligible entities

Eligible Entities

Incorporated cities, towns, regional sewer/water districts, conservancy districts and water authorities

Amount Available

Loans are fixed rate 20-year loans. Rare is set below 90% of the average 20 year.

Fig. 7.3.9. Fund Wastewater and Drinking Water Loans
Source: Project team based on Indiana Department of Environment Management

7.3.7. Waste management

Group collection of waste is a system in which independent resident groups in local communities, including neighbourhood associations, district organizations, and volunteer groups, collect recyclable waste discharged from homes, such as empty bottles, empty cans, used paper, and cardboard, in a specific place at a specific time, and deliver the collected waste to resource recycling operators in order to recycle waste as resources.

Group collection reduces waste collection costs not only for local governments but also for waste collectors by enabling them to efficiently collect specific amounts of waste. To increase the amount of recyclable waste collected and to reduce waste, many local governments have created incentive systems, including providing subsidies to local community organizations that practice group collection.

The group collection of waste could be an essential business model in order to motivate the local community and organisations and improve the eco-recycling.

Local community (residents)	•Collect and deliver waste to the waste collector
Waste collector	•Application for subsidies to the Local Government
Local Government	•Provide subsidies to the local communities and waste collector

Fig. 7.3.10. Group collection
Source: Project Team (NSRI)

7.3.8. Transportation

Cost estimation

Restricting buses operating on diesel from entering city limits and replacing such buses with electrically operated buses can help reduce emissions and traffic congestion. Restricting entry of private vehicles within city limits and introducing electric public transportation to passengers from drop off point to city center.

When selecting routes for introduction, it is necessary to secure places for recharging and refueling near the route area, based on the cruising range of the vehicles to be introduced.

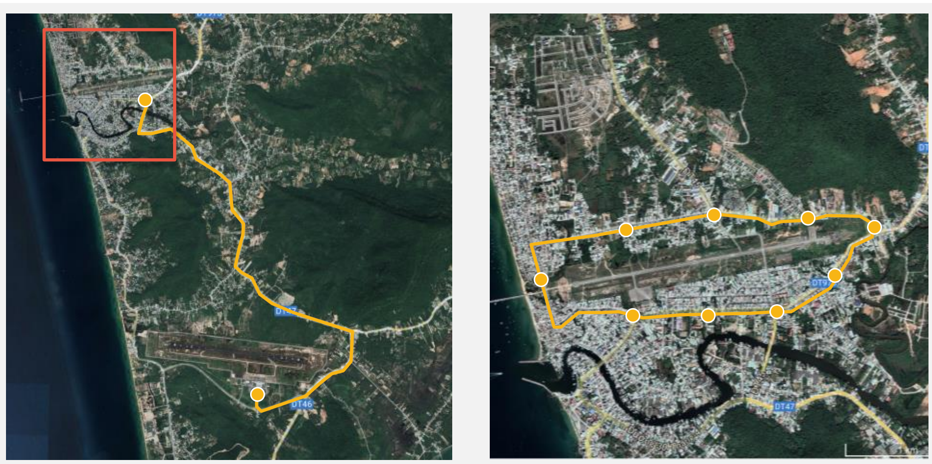


Fig. 7.3.11. Airport Shuttle Bus Route (LEFT) and Proposed Circulation Bus Route (RIGHT)
Source: Project Team (NSRI)

The following assumptions are taken to calculate the financial feasibility of Intervention:

The electric bus considered is BYD J16 with a seating capacity of 31 people. The variant is under operation in China and Japan. The cost of an electric bus is USD 200,000 and the cost of setting up a fast-charging station is USD 30,000. The charging station can be used for simultaneously charging 2 e-buses. As for facilities such as bus stops and information boards, it will be possible to ensure the profitability of the project by supporting their operation with subsidies from the government. Also, a pilot implementation will help understand on-ground technical issues that are present in implementing intervention as well as assess the effect of the Circulation EV Bus system. Accordingly, the development of appropriate infrastructure/facilities/policies to support the initiative can be assessed and implemented before scaling up activities.

2) Shifting petro vehicles towards EV

EV charging station costs approximately USD 2,000 or USD 50,000 (in the case of fast chargers) to set up. The introduction of the EV service would require a separate study to determine the number of Charging points required, corresponding infrastructure requirements. Based on these parameters, the financial requirement would be determined, which in turn would affect the tariff.

3) Electric private mobility (PM)

For the introduction of electric private mobility, port development costs (15 m^2/5 units, 1 million yen/place) will be required. The pilot phase would involve the introduction of one port every 300 meters and on-ground technical issues will be assessed. Based on the route chosen for the introduction of private mobility and existing market prices of alternate modes of transport, an appropriate fare can be determined.

ANNEX

Capacity Building

1. La Molina District, Lima, Peru

Capacity building for La Molina-1

1. Introduction

This report is intended to be in brief form only (not as a formal or external report). We have included a few sections to assist NSRI on this project and other relevant organisations given Carbon Trust experience. We present the sectoral examples to illustrate, but certain elements would be relevant to the sub-project in Peru.

The conclusions for each sector and their respective good practices (see Table 1) are preliminary and should not be understood as the result of an exhaustive analysis, since they are limited by the scope of the present study, i.e., the opportunities for capacity building at the general level of the municipalities, which has the primary aim of providing a first idea of where further studies should be directed with a deeper level of analysis.

2. Analytical framework[1]

The Carbon Trust has developed a matrix to score the capacity[2] of a given organisation, it uses seven general categories that are widely applicable across organisation types and sectors: policy, internal responsibility, data management, communication & training, finance & investment, procurement, and monitoring & evaluation. These categories are briefly summarized in the following sections[3].

Table 1. Carbon Trust's best practice matrix for the seven areas of organisational capacity building.

	Policy	Responsibility	Data Management	Communication & Training	Finance & Investment	Procurement	Monitoring & Evaluation
5 BEST	Specific, Measurable, Achievable, Relevant and Time-bound targets with senior buy-in. Clear delivery plan with aims and progress reviews. Associated strategy document.	Clearly defined roles and communication channels. Dedicated management, with senior stakeholder commitment and engagement.	Defined and reliable data collection, collation, storage and availability. Complete coverage of required estates and data areas.	Topic-specific induction and training. Dedicated team commitment and monthly engagement, and reporting. Holistic stakeholder engagement strategy.	Project appraisal with defined investment criteria. Finance engagement across teams, including financial reporting. Ring-fenced project fund and active assessment of funding.	Competitive tendering for high-quality and reliable equipment, with well-defined works contracts supported with legal review. Understanding of legislation. Use of frameworks, or registers for large-scale works.	Ongoing monitoring and evaluation of project performance, and topic-specific strategy at senior level. Project performance assessed with measurement & verification (IPMVP)
4	Targeted policy, with clear delivery plan and progress reviews, developed. Further refinement and importance required to leverage impact.	Specific management identified, but limited support. Some stakeholder engagement and senior support, but limited due to being under-resourced.	Data management covering most aspects of topic/estate - but not all encompassing, up to date, or digitalised for storage.	Regular communication internally with stakeholders, including circulation of reporting. Engagement and training intermittent.	Some opportunity appraisal, quarterly financial reporting, and cross-team engagement. No dedicated pot available for topic-specific projects. Some understanding of other funding options.	Competitive tendering for project works, but of limited scale (not large scale multi-site projects). Understanding of legislation, but limited capability and legal input to work contracts.	Regular project review and management performance review with some senior engagement. Limited strategy performance review.
3	Policy in place but out of date / not relevant / not topic specific. Shows senior commitment but no direction for ongoing engagement.	Topic area is part-time responsibility of a few staff. Some stakeholder engagement, but no senior input.	Some data management of topic/estate data, but not all encompassing, and significant gaps in data. Collection of data is unreliable.	Regular dedicated team communication and reporting, but no circulation or engagement to wider stakeholders. No specific training to staff.	Ad hoc financing for topic-specific projects. Limited opportunity appraisal and annual financial reporting.	Competitive tendering but no formal procurement process followed. No formal works contracts used or legal input.	Regular team evaluation of performance and projects, but no senior input. No review of management approach.
2	No specific policy, and no topic coverage or direction in other policies or strategies. Mission aspiration at senior level, but not defined or communicated.	Topic is part-time responsibility of an individual, but no resource or importance given to. Not a role of responsibility that can make an impact. No stakeholder support.	Minimal collection of topic/estate data, but not consolidated or stored in an efficient manner. Minimal granular data available.	No regular dedicated team meeting - only ad hoc team engagements. Reporting is not regular.	Ad hoc financing for topic-related projects. No opportunity appraisal or reporting.	Limited projects delivered, and those that are use informal direct procurement. No understanding of procurement legislation.	Ad hoc reviews of performance, but no project reviews. No regular meetings.
1 Worst	No specific policy. No senior engagement or aspiration to formalise topic areas with policy.	No topic specific responsibility designation.	Specific or relevant data not compiled.	Poor communication within team, no dedicated reports, and no stakeholder engagement or training.	No internal financing or funding for topic specific projects.	No topic-specific projects procured.	No specific monitoring or evaluation.

Source: "Capacity building in Shah Alam City, Malaysia. APEC LCMT Phase 1 Support"

[1] This section is largely based upon the document "Capacity building in Shah Alam City, Malaysia. APEC LCMT Phase 1 Support", which was prepared by Carbon Trust as part of the deliverables in Phase 1 of the APEC LCMT project.
[2] The conceptual framework developed by the Carbon Trust includes three aspects for defining capacity: human resources development, organizational development, and institutional and legal framework development. This report focuses on the capacities in the last aspect, i.e., institutional and legal framework, so the report can provide the general status for each sector.
[3] For more information, refer to the full document "Capacity building in Shah Alam City, Malaysia. APEC LCMT Phase 1 Support".

2.1. Policy

A ‘policy’ is a course of action, adopted or proposed by an organisation or individual, and is an essential tool for organisations to drive forward low carbon development, as it demonstrates senior level commitment that can be passed down through an organisation. It needs to include a clear goal that defines the overall direction and intent, as well as conditions for progress reviews to occur (quarterly), bringing together senior-level management and stakeholders. Policy needs to be set at the senior-level, as this helps communicate both its importance, as well as the existence of multi-level buy-in across the organisation, ensuring thorough implementation. Policies should be launched both internally and externally, developing maximum buy-in as well as greater traction.

2.2. Responsibility

‘Internal responsibility’ is the process within which decisions, actions, and accountability move through the organisational hierarchy. It is where an employee can easily raise a query with the right person, and quickly get a response, decision or action. A clear ‘internal responsibility’ structure within an organisation is crucial. This helps define the overall senior sponsor for a low carbon project or group of projects, the dedicated manager of this work area, any supplementary support roles, and beyond that, the wider group of key stakeholders with influence across the organisation or city.

2.3. Data Management

Data Management is the activity of development, collection, storage, retrieval and dissemination, archiving, and disposal of data. For the effective delivery of low carbon projects, the collection, storage and reporting of energy and transport data (amongst others) is a key activity. Ensuring that energy data is accurate, available, and shared in a timely manner makes sure that activities are based on real data, they are relevant at time of use, and comparable for performance monitoring purposes. Data could include metrics such as energy consumption (kWh), floor space, no. of occupants, and other fuel consumption. This is then used and presented in energy reports, project registers / forecasts, policy/strategy documentation, energy team minutes/actions, project monitoring and evaluation reports.

2.4. Communication & training

Communication and training are essential tools for leveraging organisational buy-in and they should come together at regular updates. Communication is vital to ensure that efficient processes and awareness are driven across organisations. This helps to ensure that all key stakeholders are fully engaged and that a project has ongoing and lasting engagement. Training introduces staff to why the different capacity areas are important, and how each individual can make their own contribution to the wider mission of the organisation/ team.

2.5. Finance & Investment

Finance expertise and organisational finance policies provide staff with the knowledge and resources to make financial decisions that are financially robust, in line with financing / borrowing constraints, and such that the procured outcome benefits are fully understood. Finance impacts directly on establishing the financial business case for low carbon projects and proving capital or other funding for investment. Reporting of energy/carbon data and project performance in financial terms, supports the understanding of value of projects across the organisation, and can help to raise the importance of undertaking mitigation projects.

2.6. Procurement

Procurement is the process of finding, negotiating terms and acquiring goods, services or works from an external source, via a tendering (competitive bidding) process. Effective procurement ensures maximum value for money and quality of goods is obtained through an open, transparent and standardised process. Regardless of their value or complexity, all procurement flows should follow a standard sequence of actions: requirement to purchase, plan the process, prepare the documentation, identify possible suppliers, issue/receive back the tender/quotation documentation, evaluate the submissions, negotiate, award and place the contract, delivery, pay the supplier, manage and monitor the contract, and review the process.

2.7. Monitoring and Evaluation

Monitoring and Evaluation (M&E) must be understood in its wider context and should be implemented using the accepted steps. M&E sits between the levels of measuring, reviewing and reporting, that are mainly distinguished by scale. It is important to identify the differences between them:

- Measurement, Reporting & Verification (MRV) focuses on reviewing the landscape of various programs across a economy in terms of UN COP21's Nationally Determined Contributions. Thus, it includes more varied factors, such as land use.
- Monitoring and Evaluation (M&E) is the tracking of a landscape of different programs across an economy to inform the policy, effectively grouping together all the individual Measurement and Verification (M&V) programs.
- Measurement and Verification (M&V) refers to verifying a specific project, for example, the energy savings made by an ESCO installing energy efficiency measures for an EnPC, which then justifies the contractual payments. Fundamentally, M&V provides the crucial trust needed for organisations to engage with EnPCs and install energy saving measures.

The following sections will describe the current situation in Peru according to the categories shown in Table 1. The intention is to describe in general terms the status of each sector analysed in this project. Most of them refer to instruments and regulations, which are in scope of the economies. As far as possible, an attempt will be made to relate the situation of the economy with relevant opportunities at the municipal level.

A common aspect in all sectors are the opportunities for the generation and collection of information on a regular basis, using standard procedures that allow for analysis and comparison in a coherent and consistent manner across time and sectors. It is not a one-off, systematic analysis, but rather an attempt to describe the current situation in a general way that serves as a starting point for further, more in-depth analysis.

3. Buildings

3.1. Background

In the last years, Peru has improved in energy efficiency and sustainable buildings. The Peruvian government has established legislation, incentives, certifications, goals, and mitigation actions to reduce its carbon emissions in this sector and others.

At the level of the economies, nine laws regarding energy efficiency and sustainable buildings are found, being the most important the Sustainable Construction Code. Besides the legislation, it also exists municipal incentives and a green loan from the Ministry of Construction and Housing, beyond the certifications LEED (Energy and Environmental Design Leadership), EDGE (Design for Higher Efficiency), and BREEAM (Building Research Establishment Environmental Assessment Methodology).

3.2. Policy

Throughout the years, Peru has had ups and downs towards energy efficiency implementation. In 1973, Peru's government released legislation on energy efficiency and renewable energies, specifically electricity efficiency. However, until 1990, higher levels of subsidies in energy hindered the development of energy efficiency programs. Later, between 2002 and 2006, the government did not consider energy efficiency as a priority (WRI Mexico, 2021).

It was in 2006 when the Law No. 28832 on Electricity Generation Efficiency was published that energy efficiency, renewable energies, and the environmental challenges took off (WRI Mexico, 2021). In 2015, the Sustainable Construction Code was launched, which is obligatory for the houses on the "Mi Vivienda" program, but no for other buildings around the economy, as it is considered a voluntary standard (WRI Mexico, 2021). From the policy analysis, it was identified that the economy does not have regulatory instruments to incentivise the energy efficiency labelling (WRI Mexico, 2021). The most relevant legislation found regarding sustainable buildings is presented below:

Legislation	2000 – Law No. 27345 Efficient Use of Energy 2006 – Law No. 28832 Efficiency Electricity Generation 2006 – Technical standard EM 010 Interior Electric Installations 2006 – Decree No. 011-2006-VIVIENDA National Regulation for Buildings 2007 – Promotion regulation of the Efficient Use of Energy Law 2008 – Decree No. 034-2008-EM, Energy saving in the public sector 2010 – Decree No. 064-2010 National Energy Policy 2010-2040 2011 – PLANAA National Action Plan, ecoefficiency in the public sector 2009 – Plan of Efficient Use of Energy 2009-2018 2014 – Technical Standard EM 110 Energy efficiency thermic and lighting comfort 2014 – National regulation for Buildings, Decree No. 006-2014-VIVIENDA 2015 – Sustainable Construction Code 2016 – Regulation of the Urban Development Planning 2017 – Decree No. 009-2017-EM, Energy efficiency labelling 2019 – Technical standard for heating energy efficiency calculations 2020 – Technical Standard for energy efficiency on electric water heaters 2021 – Law project on Sustainable Urban Development

In this context, according to the conceptual framework in section 2, it was identified that the overall policy needs to include a clear goal that defines the overall direction and intent, as well as conditions for progress reviews to occur, bringing together senior-level management and stakeholders. That is, using Table 1 as reference, policy score could be between 3 and 4. Suggested strategies are delivering workshops together with the local authority, bringing together a diversity of opinion and experience, and opening communication regarding buildings regulation. This diversity of discussion creates a more robust policy. It is also valuable to train individuals/ teams on how to track their progress against policy targets effectively, e.g., how to run efficient and regular progress reviews, particularly with building's energy efficiency targets.

3.3. Responsibility

The decision making differs among entities from the economy and municipal levels. The Ministries are the main responsible entities of the federal policies development and coordination with the local governments. Nonetheless, the lack of financial resources and different administration priorities has caused much of government-level work to be ineffective. On the other hand, the municipality focuses on local needs and prioritizes local actions. Some local governments are currently developing their voluntary regulation and control measures on sustainable buildings infrastructure. (WRI Mexico, 2021)

The next list shows the relevant stakeholders around the topic buildings and energy efficiency:

Stakeholders	• Ministry of Energy and Mines • Ministry of Environment • Ministry of Construction and Housing • "Mi Vivienda" Fund • National Institute of Competency Defense and Intellectual Property Protection, INDECOPI • Peruvian Architects Association • National Council of Science, Technology and Technological Innovation, CONCYTEC • National Society of Industries • Peruvian Engineers Association • National Meteorological e Hydrology Service. SENAMHI • National University of Engineering • Real Estates Association, ASEI • Peruvian Construction Association, CAPECO • Peruvian Energy and Infrastructure Association, EPEI • National Service for Training the Construction Industry, SENSICO • Green Building Council, GBC

In terms of responsibility, at municipal level, it was identified that management in energy efficiency issues are responsibility of few staff with limited support, i.e., it is limited due to being under-resourced. Hence the responsibility score could be between 3 and 4. In this sense, it would be important to clearly define roles and communication channel within the municipality and higher levels.

3.4. Data Management

The certifications implemented in Peru (LEED, EDGE, BREEAM, SITES, WELL, and FITWEL) do not share the information collected, so there is no knowledge of the advancement of energy efficiency measures in buildings. Additionally, there is no other data collection system in place. (WRI Mexico, 2021).

In this sense, it is necessary to generate a better articulation between the different sectors and to establish links with local and international organisations, through greater communication and participation, for the definition of incentives to promote sustainable construction.

At economical and local level, the public sector has limited technical capacities, which results in a lack of enforcement and enforcement. On the private sector side, the implementation of international sustainable building certifications, such as LEED or EDGE, is preferred, as the added value of regulations of the economy is not perceived.

The work undertaken by municipalities through ordinances to promote sustainable construction in the economy is relevant; however, it is recommended that they coordinate with the Ministries involved, so they provide technical support and contribute with experiences to promote the implementation of these regulatory instruments at the level of the economy. In addition, it is essential to develop information systems on energy efficiency in buildings to establish benchmarks, targets and monitoring of energy efficiency. These systems should be constantly updated, based on consistent methodologies that allow for solid databases.

At the municipal level, energy information systems would also be a key part of measuring progress on a decarbonisation pathway. However, this proves to be a challenge due to limited financial and human resources. For municipalities, schemes that allow the generation of information should be sought, and this requires coordination at different levels of government.

In this context, regarding the data management capabilities of the municipality, municipal collection of data is not consolidated in an efficient matter. Hence, the data management score would be two (see Table 1). For the effective delivery of low carbon projects, the collection, storage and reporting of energy is a key activity. Ensuring that energy data is accurate, available, and shared in a timely manner makes sure that activities are based on real data, they are relevant at time of use, and comparable for performance monitoring purposes. Therefore, two core areas of capacity building regarding data management are (i) collection and storage, and (ii) quality and use. Collecting granular data, and ensuring it is readily available, provides the evidence base to propose measures and enact change.

Integrated policies for data management

The design and implementation of information systems for the collection, storage and management of information requires a set of actions and public policies involving different levels of government, as well as the consideration of different regulations that include aspects such as privacy and security in the information handling.

The design of the information systems and data management requires the establishment of regulations and mechanisms for monitoring the buildings' market to ensure the implementation of local and federal regulations that include sustainability criteria through information systems and indicators. This system will allow monitoring through indicators related to certified buildings and endorsed by existing regulations.

The development of such systems requires also training of human resources in order to strengthen capacities for the administration, storage and processing of statistical information, both in the technical fields as well as in other aspects that influence the energy sector, automating systems with modern tools and enhancing the economy's information management and energy planning models.

On the other hand, through implementation of information systems, municipalities and states will harmonise the methodology for preparing energy balances, in accordance with, for instance, the United Nations' International Recommendations on Energy Statistics (IRES), so that the economy's energy information will use standardised concepts, promoting comparability at regional and global level.

Finally, the formulation of indicators and their automatic calculation through the combination of economic, social, energy and environmental information will enhance the analysis of the sector and provide better elements for planning. In this way, sub-economy governments will be able to use the tools to support decision-making and the development of energy planning in their economy. That is, the development of information systems requires specific policies, regulations (addressing security and privacy issues), financing and technical training.

3.5. Communication & Training

Regarding training, SENCICO (National Service for Construction Industry Training) is responsible for also research, innovative systems evaluation, and construction regulation development sharing responsibilities with the Architect and Engineers Associations. However, it was found that there are not activities for the Sustainable Construction Code committee, which in the past it gave promotion to sustainable edification. Moreover, there is no campaigns of energy efficiency and thermal comfort sustainable actions.

Overall, it is advised the strengthening of the communication among different government levels, sectors, and institutions. This is important at municipal level. It is suggested to strengthen strategies for the dissemination and promotion of existing regulations and incentives, as well as to strengthen local capacities in sustainable construction and in the development and implementation of regulations.

It would be of great benefit the articulation between Ministries and Municipalities, to achieve progress at the local level, in that sense, greater scope in promotion and dissemination of the ordinances that are in force and technical support to these entities, which are currently being supported by the IFC and GBC Peru. Likewise, the great relevance of the work of organisations, NGOs, and international cooperation for the development of Sustainable Construction in the economy has been demonstrated.

Regarding the identification of a regular dedicated team in communication and reporting issues, there was not much information, so score could be between 2 to 4. In any case, it is important to create and to follow a holistic stakeholder engagement strategy, which will be crucial and will ensure staff is properly engaged across central/ municipal government, other public bodies, private businesses, and community groups.

3.6. Finance & Investment

In 2015, the Fund “Mi Vivienda” was released as a financial tool for incentivising the acquisition of a certified sustainable house. The Fund has received financial resources from the French Development Agency (AFD) and the KfW Development Bank. This program is currently in phase II for the 2019-2021 period and has warrantied the Sustainable Construction Code. Besides this Fund, other international organisations such as IFC, USAID, World Bank, and AECID have funded other sustainable actions in Peru.

Furthermore, Peru has other public financing programs like FIDECOM for financing research on technological innovation; the COFIDE, a bank that finances infrastructure; and the FONDCODES, that supports the creation of sustainable activities in rural households with extreme poverty. The private financial credits for buildings discovered are nine which work with the Fund “Mi Vivienda”. Nonetheless, it was identified that these private credits are not popular among house buyers as they are not used at full capacity (WRI Mexico, 2021).

It is suggested to implement an access to finance platform for each economy, identifying and linking existing sources of finance and international funds, to encourage and facilitate access to resources for sustainable construction projects and to publicise existing incentives.

Currently, it is difficult to identify sources of funding or incentives, especially at the international level for Sustainable Construction, and this could be included in the monitoring platform proposed in previous points. It is suggested that a fund for the promotion and dissemination of energy efficiency, thermal comfort and sustainable construction be created, which could be led by the competent secretariats or ministries, with the participation of international cooperation agencies and NGOs.

The creation of an Energy Efficiency Financing Fund has been evaluated during the last years in the Peruvian state, however it would be of great importance to include Sustainable Construction, which would boost its promotion and implementation.

In this context, some ad-hoc financing for energy efficiency was identified but limited, i.e., we would score it with three. The proposal to fill these gaps is to implement a mechanism to identify granular and effective financing devices and funding sources. One method of achieving this is to undertake an options appraisal of financing pathways, for example, private capital finance, state-sponsored finance schemes, grant funding and internal capital. In the following table, some financial sources for projects related to sustainable buildings and energy efficiency are described.

Table 2. Multilateral development institutions

Financial source	Description	Projects	Investment type	Available resources (USD)	Energy efficiency projects	Sustainable buildings projects	Financed projects
IADB	IADB is an institution providing financial and technical support to the economies of Latin America and the Caribbean, with the aim of reducing the poverty and inequality, while, promoting sustainable and environmentally friendly development.	Support for the design and implementation of urban development policy	Technical cooperation	200,000	Yes	Yes	https://www.iadb.org/es/project/PE-T1346 https://www.iadb.org/es/projects-search?country=PE&sector=DU&status=&query=&page=0
		Support for the revitalization and reopening of urban centres in Metropolitan Lima	Technical cooperation	295,000		Yes	https://www.iadb.org/es/project/PE-T1457
		Investment program and improvement of the downtowns of Lima, Arequipa, Trujillo and Ayacucho	Loan Operation/ Counterparty Financing	30,000,000		Yes	https://www.iadb.org/es/project/PE-L1246
		Support for the National Platform for Sustainable Cities and Climate Change in Lima	Technical Cooperation / Counterpart Financing	6,422,019		Yes	https://www.iadb.org/es/project/PE-T1355
		Implementation of the Emerging and Sustainable Cities Initiative (ICES) - Cuzco	Technical cooperation	600,000		Yes	https://www.iadb.org/es/project/PE-T1346
		Knowledge exchange in sustainable housing between Peru and Mexico	Technical cooperation	18,000		Yes	https://www.iadb.org/es/project/PE-T1319
		Strengthening the progressive construction system	Technical cooperation	150,000		Yes	https://www.iadb.org/es/project/PE-T1313
		CMAC Maynas: Strengthening patrimonial and mortgage credit for social interest housing	Technical cooperation	2,000,000		Yes	https://www.iadb.org/es/project/PE-L1095
		CONFIANZA: Financing for progressive construction	Technical cooperation	10,000,000		Yes	https://www.iadb.org/es/project/PE-L1170
		Access to construction financing and advisory.	Loan Operation/ Counterparty Financing	20,000,000		Yes	https://www.iadb.org/es/project/PE-L1142
COSUDE	Swiss Cooperation in Peru and the Andes promotes development that preserves natural resources. It contributes to finding a solution to environmental problems and offers new perspectives to young people and women through vocational training and income growth.	CEELA Project "Strengthening capacities for Energy Efficiency in buildings in Latin America					

Table 3. Institutions of the economy

Financial source	Description	Projects	Investment type	Available resources (USD)	Energy efficiency projects	Sustainable buildings projects	Financed projects
Fund "Mi vivienda"	It is a benefit to acquire a home that incorporates sustainability criteria in its design and construction, thus reducing the impact on the environment.	Bond "Mi vivienda verde"	Non-refundable subsidy	S/ 8 millions in 2021			
FIDECOM	"Research and Development Fund for Competitiveness". It is a competitive fund that aims to co-finance projects aimed at promoting research and development of technical and productive innovation projects.	Design and build prototype of Housing with Thermal Comfort and Solar Luminosity for Andean areas.	70% Non-Refundable Financing	N.D.			
		"Improvement in the efficiency of the manufacture of the artisanal clay brick type King Kong through the efficient use of the combustion process with the innovation of the burner and furnace for multipurpose solid fuel.	70% Non-Refundable Financing	N.D.			
COFIDE	It is a development bank and is mainly dedicated to attracting financial resources from multilateral organizations, in order to promote and finance productive investments and public and private infrastructure at the level of the economy.	SUSTAINABLE BOND Micro-Enterprise Financing Category	Financing for MSMEs / Intermediary Credits	$30,000,000			
FONCODES	It is a program of the economy that works on generating greater sustainable economic opportunities for extreme poor rural households.	Project "Mi Abrigo"	Donations	S/101,100,000			https://andina.pe/agencia/noticia-estado-invierte-s-1011-millones-casitas-calientes-para-familias-de-andes-801893.aspx

3.7. Monitoring & Evaluation

Usually, each governmental entity implementing a certification, incentive or financing, carries out the corresponding monitoring. However, there is no monitoring of overall sustainable construction achievements by the State.

Therefore, it is proposed to create a monitoring or tracking scheme for the sustainable construction sector or to develop an online tool or platform that allows access to updated sector data. The data update could be provided by the coordinating institution and the tool could be developed by public research institutes and universities in collaboration with public and private organisations.

In Peru, there is no platform to monitor or follow up on all the actions that have been implemented related to Sustainable Construction; an example of this is the MRV platform developed by the United Nations Development Programme (UNDP) and the Ministry of Energy and Mines (MINEM).

In addition, it is suggested to have an entity in charge of aligning initiatives and avoiding duplication of efforts, as well as articulating policy of the economy at the local level. The Technical Committee on Sustainable Construction (formed by the Ministry of Housing, Construction and Sanitation (Presidency), the Ministry of Environment (Technical Secretariat) and twelve (12) entities specialised in design and construction issues, as well as the construction sector) worked until a few years ago as a committee, in that sense it would be necessary to activate it again to be in charge of aligning the initiatives referred to sustainable construction.

Regarding the monitoring and evaluation at municipal level, not much information was identified, so score could be between 2 and 4. However, it is important to establish different level of monitoring:

- **Measurement, Reporting & Verification (MRV)** focuses on reviewing the landscape of various programs across an economy in terms of UN COP21's Nationally Determined Contributions.
- **Monitoring and Evaluation (M&E)** is the tracking of a landscape of different programs across an economy to inform the policy, effectively grouping together all the individual Measurement and Verification (M&V) programs.
- **Measurement and Verification (M&V)** refers to verifying a specific project, for example, the energy savings made by an ESCO installing energy efficiency measures for an energy performance contract (EnPC), which then justifies the contractual payments. Fundamentally, M&V provides the crucial trust needed for organisations to engage with EnPCs and install energy saving measures.

In this sense, it is particularly relevant the implementation of monitoring and evaluation systems.

3.8. Examples

Some experiences have been identified at the municipal level where they have direct provisions related to sustainable building.

The Municipality of Miraflores has Ordinance N°539/MM, which establishes, regulates, and promotes conditions for sustainable buildings in the District of Miraflores. This Ordinance is applicable to construction projects at building level, which meet the conditions of sustainability required in this ordinance and that are developed on land located in the district of Miraflores and primarily in the roads and urban sectors of the district of Miraflores, provided that they have freely and voluntarily accepted the scope of the same.

Regarding the incentives, in all sustainable buildings, the benefit of increasing the roofed area for public use will be compulsorily applied, and the other benefits may be applied optionally and at the request of the owner. Any lot located in the district of Miraflores will be able to generate the established building rights, which will be applied according to the provisions of this ordinance.

On the other hand, the Municipality of Bellavista, Callao, the ordinance No. 015-2020-MDB is intended to promote the construction of sustainable buildings in residential and commercial areas in the District of Bellavista, and establish the technical criteria for its design and construction, promoting proper management of natural resources by promoting energy and water efficiency, creating healthy and comfortable spaces that contribute to the development of a sustainable city, balancing urban development and environmental care, and improving the quality of life of the population. The programme is applicable throughout the district to new building projects for multi-family and commercial use, which are located in residential and commercial use.

Finally, in the Municipality of Lima work has already been done on the construction of the urban development vision, through a participatory process with local officials and leaders in the 43 districts. This reflects the citizens' interest in orienting their progress towards a city that prioritises the quality of life of its inhabitants, establishes a sustainable relationship with the environment and capitalises on its development opportunities to provide higher levels of well-being and prosperity.

This instrument of planning and public management for the progress of Lima will also have a portfolio of projects that will establish models of intervention that generate urban improvements in strategic areas of the metropolis, articulating and integrating all municipal initiatives and those of various state entities that participate within its jurisdiction.

Opportunities for further analysis

In this context, some relevant opportunities on building’s energy efficiency in close cooperation with international and local development agencies and banks are:

- Technical support on adoption of high efficiency cooling technologies
- Support on building code enforcement and implementation
- Develop an energy efficiency standard of the economy for commercial buildings based on the standardized methodologies.
- Support the deployment of certification programs for energy efficient residences that offers financial benefits to real estate developers.
- Support on capacity building for municipalities to develop technical capacities at local level to support the adoption of the energy conservation codes for buildings.

4. Waste sector

4.1. Background

In 2002, it was calculated that the waste generation at level of the economy was around 12.9 kt/day, approx. 4.8 million tonnes per year. The study showed that from the 73.7% of population with waste collection service, only 19.7% of the collected waste ended up on landfills, while the rest was disposed inappropriately in dumps. Such conditions generate severe health and environmental issues, reason why the National Environmental Council decided to elaborate and implemented the first National Solid Waste Plan (NSWP).

As part of the Environment Ministry's (MINAM) commitment to improve environmental conditions, the National Action Agenda and the National Plan for Environmental Action 2011-2021 have incorporated waste management as priority. Additionally, the Ministry has enhanced the local and regional waste service including building infrastructure, education and training, and responsible consumption.

In 2014, a new study showed that the conditions slightly improved with a slightly less than 50% waste collected going to landfills[4], which is not only related to lack of infrastructure but to financial resources available for the operation costs. Another analysis revealed that in 2012 the environmental costs were around 3.5 to 5% of the GDP in Peru the same year (MINAM, 2016). Therefore, the Ministry had the initiative to renew the Waste Plan for 2016-2024 including a systematic work approach with a share responsibility among governmental institutions.

4.2. Policy

Peru's government has stated that its environmental regulation and activities are aligned to the following list:

International agreements	1989 - Basel Convention of hazardous waste 1992 - Earth Summit UNCED 1992 - UNFCCC 1995 - The United Nations Fourth World conference on Women 1997 - The Commission on the Status of Women 1998 - The Rotterdam Convention 2000 - Millennium Summit in New York 2001 - Stockholm Summit 2002 - World Summit on Sustainable Development 2012 - United Nations Conference on Sustainable Development Río +20 2013 - Minamata Convention 2015 - The Beijing Platform for Action + 20 2015 - Sustainable Development Goals 2016 - Environmental Impact Assessment analysis done by OCDE and ECLAC

[4] For instance, in 2002 just 19.7% of waste collection was disposed in controlled landfills.

Legislation	1990 – Environmental and Natural Resources Code No. 613 1994 – National Environmental Council Law No. 26410 2000 – General Solid Waste Law No. 27314 2004 – Solid Waste regulation No. 057-2004-PCM 2005 – National Solid Waste Plan (PLANRES) No. 004-2005-CONAM/CD 2008 – Creation, Organization, and Functions of the Environmental Ministry law No. 1013 2008 – Public financing with Private sector assists law No. 29230 2008 – Creation of the Fiscal and Evaluation Agency 2009 – National Environmental Policy 2009 – Recycling organisms regulation No. 29419 2010 – National Solid Waste Plan for Health services 2010-2012 2011 – National Plant for Environmental Action No. 014-2011-MINAM 2011 – Bicentenary Plan: Peru 2021 No. 054-2011-PCM 2012 – Incentives Plan for Enhancement of Municipal Organization 2012 – Nation Environmental Education Policy No. 017-2012-ED 2012 – Strategic Sectorial Plan for the Environmental Sector 2012 – Solid Waste regulation for Agriculture 2012 – National Regulation for Electronic appliances Waste Management 2013 – Management Regulation for Waste from construction activities 2014 – National Agenda for Environmental Action 2015 – Action Plan formulation for Climate Change 2015 – National Determine Contributions 2015 – NAMA Solid Waste 2016 – Environmental Performance Analysis 2003-2013

The table above shows multiple policy instruments that the government has developed. These include economic and regulatory instruments, as well as plans and strategies. A relevant aspect to analyse in the context would be to analyse their impact at sub-economy levels, *i.e.,* whether municipalities have the capacity and resources for the implementation of these regulations to ensure their correct application and thus achieve the objectives described in the policy instruments.

In this context, MINAM, through the Poverty and Environment Initiative (PEI) Project, saw the need to update the National Solid Waste Plan (PLANRES) with the aim of establishing a framework for the period 2016-2024 towards meeting the goals of the National Environmental Action Plan (PLANAA) by 2021 and to incorporate new priorities and interventions to be addressed at the level of the economy. It also recognises the importance of working in coordination, since environmental management is cross-sectoral and decentralised, and the achievement of the objectives and goals of the PLANAA is the shared responsibility of all State entities, as well as the private sector and society as a whole.

It is in that context that a targeted policy is present, with clear delivery plan. However, it is not clear how progress reviews have been developed since the release of the PLANRES, hence policy score could be in fourth place according to Table 1. The ideal policy should establish specific, measurable, achievable, and relevant time-bond targets with progress reviews. In this sense, delivering workshops with across different levels of government could bring together a diversity of opinion and experience, and opens communication in the waste sector, particularly in reference to progress on objectives, consistent with the plans of the economy.

4.3. Responsibility

MINAM has set multiple commitments on the waste sector, with the aim of improving the current situation. The ministry recognized that its problem goes beyond waste, but it also relates to the poverty levels and gender equality[5].

For protecting people and environment from hazardous components, MINAM has set campaigns for electronic waste collection with the help of international organisations, and it is expanding the capacity for hazardous waste handling in the economy. Moreover, it is enhancing the traceability and availability of the information about waste generation which helps with the economy's waste estimations and decision-making.

It is established on the National Solid Waste Plan (NSWP), that exists a share responsibility for the waste management. Although, the waste handling is considered as "common responsibility", the MINAM transfers responsibility to generators at the same level of their waste characteristics and volume. The government also gives a "extended responsibility for the manufacturer" to those materials generated that for their nature or generation levels requires external intervention for their correct disposition.

According to the legislation in force, provincial municipalities must regulate and control the process of final disposal of solid and liquid waste and industrial discharges at the provincial level; and industrial discharges at the provincial level; as well as the district municipalities must provide public cleaning service by determining areas of waste accumulation, sanitary landfills and industrial waste sanitary landfills and the industrial use of waste.

In this sense, responsibilities for different government levels are identified, but with limited support. Likewise, some stakeholder engagement in waste disposal is observed, but limited due to being under-resourced regarding human and financial resources. Hence responsibility score could be in fourth place.

According to the analytical framework (see Table 1), some solutions could be to have clear responsibilities of 'who is doing what' i.e., both in households, as waste generators, waste collectors, waste separators and disposal sites operators, so the waste disposal could be more efficient. Through developing the network of responsibility collaboratively, it has much greater clarity in the minds of those involved and it will be more efficient in social and economic terms.

4.4. Data Management

The government has an information platform, called SIGERSOL[6] where information regarding solid waste is collected from generators, i.e., public, and private sectors. It is expected that by 2024, this platform would include high-quality technical, economic, and social (if possible) information about waste management. Additionally, SIGERSOL would be linked to the National Environmental Information System.

MINAN acknowledges that the platform is lacking sectorial classification but continues updating and incentivizing its used. The last Action Plan report mentions that more non-municipal organizations are joining and that at the end of 2020 the platform will contain waste manifestos and operators reports (stated on the last Action Plan report mid-2020 published in July 2021).

By the year 2024, the objective is to have a platform for local governments, public institutions, and private organisations where waste technologies management are share for research purposes.

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[5] For instance, in Arequipa municipality in Peru, 85.8% of people in the formal recycling sector are women, while in the informal sector is 50% (UNDP, 2018). The UNDP report highlight the main social dimensions that must be improved to strengthen women empowerment, which includes normative, market, participation and organization dimensions.

[6] Sistema de Información para la Gestión de Residuos Sólidos

This aspect is of crucial importance given that in the estimation of the baseline it was identified that the main limitation is the lack of periodical information that would allow the analysis of the behaviour of key variables in previous years to be able to evaluate their historical trajectory and future projections.

Since its creation SIGERSOL has been able to access information and the number of users continues to increase. Through this system it is possible to obtain data and information on solid waste management at provincial and district level.

In regard to data management, SIGERSOL system covers many aspects of waste related issues, but is seems to have some limitations such as up to date data or completely digitalised. Hence, data management score could be in fourth place, with opportunities in having defined and reliable data, collation, storage and availability.

Therefore, the creation of standardised processes and capture documents for data collection and storage could be advantageous to ensure high standards in collecting and providing information. Likewise, assessing the level of success of current policies and procedures and looking at where the gaps could be translated into actions to be taken to drive improvements.

4.5. Communication & Training

The NSWP mentions that it is acknowledged how important the international, technical and financial cooperation is to strengthen capacities and assist technology transfer. Therefore, its decree No. 719 – International Technical Cooperation, states the utilization of international aid for the matter.

Among the international organisations that Peru has worked with for developing technical capacities on the economy, are: IDB, JICA, SDC, UNEP, UNDP, AECID, USAID, NEFCO, GCF, GEF, CAF, GIZ. And at the local level, Peru has FONAM (National Environmental Fund), and the FINCYT (National Fund for Science and Technology) as experts.

The population also is being directly educated through making students more competent on the topic and doing massive sensibilization programs where 4 million citizens have participated. It is calculated that on 80% of households, at least there is one person who knows how to manage solid waste properly. Additionally, some local governments (25%) have trained their collaborators on solid waste management.

Likewise, through capacity building, the aim of the PLANRES was to generate substantial changes in the knowledge and behaviour of people directly or indirectly linked to solid waste management, through the development of knowledge and capacities oriented towards technological innovation and academic excellence in relation to solid waste management. Some examples at municipal level were:

- Four courses on Solid Waste Management and Public Investment Projects were given to 250 municipal officials.
- A PAT-SNIP Technical Assistance Programme was disseminated in 22 departments economy-wide.
- 17 training workshops were held for municipal officials and waste pickers for their formalisation.
- Provincial and district municipalities were trained in the updating of the Integrated Solid Waste Environmental Management Plan (PIGARS) guide and its application, Characterisation Studies and Management Plans, Source Segregation Programme and Selective Collection.

In this context, regular communication with municipalities was identified, as well as engagement and training. Hence, communications and training score could be in fourth place, and opportunities could be found in the development of a holistic stakeholder engagement strategy.

It is important to emphasize that creating and following a holistic stakeholder engagement strategy is crucial and ensures persons of influence are properly engaged across central/ municipal government, other public bodies, private businesses and community groups, which involves a five-step iterative process: identification, mapping, prioritisation, planning and engagement.

4.6. Finance & Investment

Although the cost and income gap are closing, the government has identified that the revenue from recovered materials is much lower than the operational expenses which represents a challenge for improving the services.

From the extended responsibility for the manufacturer principal, the government is promoting private investment on the waste management for those companies that produce, import, and commercialize products that once disposed are considered important due to their volume and harmful components.

Moreover, exist the FONIPREL (Public Regional and Local Investing Fund) which is an institution that promote public investment funding related to basic infrastructure, giving preference to those that assist poverty alleviation.

In the PLANRES some finance mechanisms are described. The funding required for the implementation of PLANRES can come from various sources depending on the activities to be implemented as well as the actors involved in its execution. In this regard, a cost estimate for the implementation of PLANRES 2016-2024 was prepared for its fulfilment and the goals of PLANAA 2011-2021.

There is also the Regional and Local Public Investment Promotion Fund (FONIPREL), which is a competitive fund, whose main objective is to co-finance public investment projects and pre-investment studies aimed at reducing the gaps in the provision of basic services and infrastructure, which have the greatest possible impact on the reduction of poverty and extreme poverty in the economy.

In this sense, some ad-hoc mechanism for specific projects were identified, but no project appraisal with defined investment criteria was identified. Under best practice, a mechanism should be put in place to identify granular and effective financing devices and funding sources. One method of achieving this is to undertake an options appraisal of financing pathways, for example: private capital finance, state-sponsored finance schemes, grant funding and internal capital. Hence finance score could be between 3 and 4.

Table 4. Multilateral development institutions

Financial source	Description	Projects	Investment type	Available resources (USD)	Financed projects
BID & JICA	Inter-American development Bank and the Japanese International Cooperation Agency.	The Government has implemented a solid waste management budget programme to improve the management and infrastructure of urban solid waste in 16 of the economy's main cities.	Loan		This involves the construction of 31 sanitary landfills for the final disposal of urban solid waste and the institutional strengthening of municipalities in this area (DAR, 2015).
KOIKA	Korean International Cooperation Agency	Waste Management & Waste-to-Energy (Ecuador, Colombia, Guatemala, Bolivia, Perú)	Donation	26,915	https://euaidexplorer.jrc.ec.eu-ropa.eu/SearchPageAction.do
Finish Government	Finland	Recycling Center of Cuna Nazareth	Donation	155,024	http://formin.finland.fi / public/default.aspx?contentid=285934&nodeid=48020&- contentlan=2&culture=en-US

4.7. Procurement[7]

Through the years, the government has improved the number of solid waste disposal infrastructure, from 11 to 21 proper final disposition sites in one year (2014-2015). The last published list of waste infrastructure (September 2021) registers 64 Landfills and 6 hazardous disposal sites. In 2015, information gathered from local governments showed that despite that the 93.8% of population had waste collection services, only 50% of collected trash ended in landfills while the rest is presumed to be improperly disposed. However, in the same year, 1,477 tons of waste were sent to recycling sites. On the last report of the Action Plan (Sep 2021), it is mentioned that there was a 20% increment on the collection of non-municipal waste. Similarly, 58 kt of municipal waste were recovered, this is, it was recycled or sent to recycling plants (MINAM, 2021). From those 58 kt, 34.5% were inorganic materials and the rest organic matter.

There is a relevant initiative regarding procurement. The Co-financed Private Initiative (IPC) is the mechanism through which the private sector submits Public Private Partnership (PPP) projects to State entities and is classified according to Article 4 of Legislative Decree No. 1012. These may be submitted by local or foreign legal entities, by consortiums of these, or by consortiums of natural persons with local or foreign legal entities. No more institution and provisions were identified regarding this subject, so the procurement score could be set between 2 and 4 place. This issue es very relevant since competitive tendering for high-quality and reliable equipment or services is a basis for an efficient service in waste disposal. Well-defined work contracts are also a relevant issue for transparency and accountability.

4.8. Monitoring & Evaluation

Regarding monitoring and evaluation of the waste sector, Peru has developed some characterization studies of waste management in the economy and communicated the results publicly. Hazardous waste was highlighted as a problem due to the lack of enough specialized handling organizations.

In 2013, the generation reached 100 kt, data that came from voluntary reporting from some generators which does not include all the economic sectors. On the last list of waste facilities registered, there are 6 sites that are competent to receive hazardous materials. From the studies of waste characterization, it was detected that the sectors with significant hazardous waste generation were manufacturing, textiles, fishing, agriculture, health sectors. Nonetheless, the MINAM, has released regulation and some campaigns for collecting and disposing electronic waste.

They also developed evaluation instruments for monitoring the Environmental Action Plan's activities. Since 2012, it has released annually an Evaluation and Monitoring report from the Action Plan. This Action Plan contains very comprehensive waste actions, and the last report (September 2021) shows a positive implementation and advancement on the Plan goals. Among the most relevant actions are:

1	Increase the solid waste management capacity with 25 more infrastructure
2	Strengthen the waste management
3	Plastic usage reduction
4	2% recovery of solid waste degraded ecosystems
5	16% of municipalities implementing the Environmental education Plan

[7] The National Plan (MINAM, Plan Nacional de gestión integral de residuos sólidos 2016-2024, 2016) recognises the importance of the private sector in waste management and emphasizes that this is a joint responsibility of the public sector, society, and the private sector. In this sense, the Plan considers the private sector as a key stakeholder in integrated waste management, in particular in relation to the generation and exchange of knowledge on waste management technologies, making it a key player in terms of procurement.

It is very important to carry out regular project review and performance assessment, which was not completely identified in this sector. So, monitoring and evaluation score could be between 3 and 4. Some opportunities could be in establishing regular reporting periods, such as quarterly, or designed to track a specific program as it is rolled out. As part of this, it is important that M&V be built into every stage of a project; it should be discussed from the earliest planning stages, not as afterthought.

4.9. Opportunities for further analysis

In this context, some relevant opportunities on the waste in close cooperation with international and local development agencies and banks are:

- Technical support about the opportunities to capture and use of methane from landfills and to use urban solid waste to generate energy. Likewise, technical support in waste-to-energy opportunities to use the remaining energy of solid waste and use of the organic fraction for composting. Finally, an analysis to identify barriers for development within the existing regulatory and institutional framework, including relevant actors, stakeholders, institutions, formal and informal standards, and incentives that shape the energy sector in Peru.

5. Transport

5.1. Background

In the last 10 years, the vehicles sales in Peru have grown, as the GDP[8] does, especially for new brand cars purchases, something that was different before 2008 (MINAM, 2014a) It is estimated that the economy growth rate of the transport fleet is around 6%, whereas in Lima and Callao is around 5.8%. This last area is the one with the highest vehicles fleet percentage (Agenda Urbana, 2021).

Through the years, the urban mobility has become more complex, and so, difficult to implement efficient actions. A report from the Lima's life quality study[9] done in 2019 says that 46.2% of citizens considered public transport as a problem in the city. Nonetheless, data from CAF (Latin American Development Bank), shows that more than half of the trips made are done by public transport. Just in Lima, 10 million of trips are done using motorized transport and 85% are done by collective transportation (ATU, 2020).

The National Urban Transport Policy mentions that in Lima, the transport time distribution is 19.3% less than 30 minutes, 25.8% between 30 and 60 minutes, and 50.3% more than an hour (ATU, 2020). In 2019, the initiative *"Lima cómo vamos"* released a yearly report where it was estimated that in the Metropolitan area of Lima and Callao, the percentage of households with bicycles decreased significantly since 2012, except in 2020 where it sightly grew, possibly due to the pandemic (Agenda Urbana, 2021). In the 2018, the most popular transport service was bus and panel van. However, the people reported some portions of walking or the whole trip (Lima como vamos, 2019b)

5.2. Policy

Peru has some transport regulation, the most important being the National Urban Transport Policy and the Regulation from the law No. 30900, that organized the formation of the Urban Transport Agency. From this last one, it was conceived the Urban Mobility Plan as a technical instrument for sustainable transportation planification.

Another important strategy at level of the economy is the National Peruvian Strategy for Cleaner and Efficient Fuels and Vehicles launched in 2015. The last strategic instrument that Peru has launched is the Metropolitan Urban Development Plan 2021-2040, PLANMET[10], where mobility is taken into consideration. The PLANMET is on the fourth phase doing public consultation (fifth phases in total).

Legislation	• National Urban Transport Policy • Directive from the law No. 30900, Creation of the Urban Transport Agency • National Peruvian Strategy for Cleaner and Efficient Fuels and Vehicles • Urban Mobility Plan • Initiative Sustainable Individual Transport System, SITIS • Sustainable Mobility Institutional Plan Guide, PIMIS • Metropolitan Urban Development Plan 2021-2040, PLANMET • Law No. 30936 that promotes bicycle. • Various guides for no motorized transport, standards creation, cycling recommendations.

[8] Between 2005 and 2014 the PIB grew 250% Source: MINAM, 2014
[9] Décimo informe de percepción sobre calidad de vida en la ciudad del Observatorio Lima Como Vamos (Lima como vamos, 2019a)
[10] More information, please click: https://imp.gob.pe/plan-met-2040-2/

Likewise, MINAM approved a new emission standards and permissible emission limits, as of 1st April 2018, vehicle emission standards are Euro 4 / IV, Tier 2 and EPA 2007. This measure has the objective of the reduction of pollutants from motor vehicles, which can help to improve air quality, with health and environmental benefits. It is estimated that emissions of nitrogen oxides could drop by up to 35 per cent and particulate matter (PM 2.5) by up to 70 per cent. The maximum permissible pollutant emission limits are applicable to new and used vehicles that will be incorporated into the vehicle fleet, as well as to vehicles already in circulation within the National Land Transport System, considering the environmental impact of the new vehicles. The regulation complements with the Supreme Decree No. 025-2017-EM of the MINEM, which regulates the reduction of sulphur content below 50 ppm in gasoline.

In this context, it is noted that there are multiple policy and regulatory instruments addressing different aspects of the transport sector in Peru. In this context, it is noted that there are multiple policy and regulatory instruments addressing different aspects of the transport sector in Peru. It could therefore be placed in the fourth place in the transport score. In other words, there is a targeted policy, with clear delivery plan and progress reviews. It was not identified whether there are measurements in place to measure the progress and effectiveness of this policy, which would be necessary to have an effective policy.

Likewise, promote articulation in the different branches of government in favour of local, regional planning. From the Legislative Branch, promote coordinated work to identify urban priorities through Regional Groups (Lima como vamos, 2019a).

5.3. Responsibility

The Urban Transport Agency of Lima and Callao[11] (ATU) is the authority that manage and promote the sustainable mobility in the municipality. Due to the COVID-19 pandemic, it implemented measures to prevent and control the infection spread. Therefore, ATU, reduced the public services capacity and promoted active mobility, beside other integrated public transport activities (Agenda Urbana, 2021). From that situation, it emerged in June 2021, the Sustainable Mobility Institutional Plan Guide (PIMIS) which objective is to help public and private organizations managing their collaborators commuting. More specifically, PIMIS aims to stimulate cycling and other non-motorize vehicles for short trips (ATU, 2020).

The PIMIS considers five steps:

1	Conceptualization phase where the implementation team is formed
2	Data collection to know the mobility patterns
3	Categorization and analysis of the information gathered
4	Strategic planning
5	Implementation and monitoring

Additionally, it is planned a Sustainable Urban Mobility Plan for Lima metropolitan area by the ATU, that would consist of a share responsibility between the three government levels and the participation of public and private institutions, aiming to establish short to long term policies. And it is also intended to start the 2040 Transport Plan for Lima and Callao.

The ATU is being active in the implementation of two new lines for the metro transportation, finding resources and having conversations with other government economies to achieve a better implementation. Nonetheless, the current pandemic has hindered the works on the topic (Agenda Urbana, 2021).

[11] Created in 2019

Stakeholders	• Transport and Communications Ministry, MTC • Urban Transport Agency, ATU • National Engineering University • National Institute of Statistics, INEI • Electric Train Authority, AATE • Metropolitan Planification Institute, IMP

In terms of responsibility, at municipal level, it was identified that management in mobility issues are responsibility of few staff with limited support, i.e., it is limited due to being under-resourced, both in terms of human and financial resources. Hence the responsibility score could be between three and four. Therefore, it would be important to clearly define roles and communication channel within the municipality and higher government levels to identify opportunities that generate benefits in various aspects, such as health, road safety and mobility, which are closely related to different levels of government.

5.4. Data Management

In the PIMIS is stated that the studies perform to develop all the Plans and Policies should be aligned and have sustainable transportation support as core and considered Transit-Oriented Development (TOD) concepts. It also mentions that some of the data used for the analysis and planning of the strategies came from the *"Décimo informe de percepción sobre calidad de vida en la ciudad del Observatorio Lima Como Vamos"* (Lima como vamos, 2019a). For the PIMIS was considered the mobility pyramid where the pedestrian has the priority. However, it is mentioned that this focus is limited as does not reflect land planning and dimensioning. Therefore, the pyramid was modified to the Lima metropolitan area needs, i.e., on top massive transportation for long trips, follow by cycling, pedestrians, heavy vehicles, and at the bottom private cars (ATU, 2020). The World Bank has worked with the Peru government for the development of cycling infrastructure and strategic plans (World Bank Group, 2020a) and (World Bank Group, 2020b).

There is little public information at the municipal level, particularly on the level of activity in the transport sector. Likewise, outdated, and disaggregated information was identified for some years. For 2013 and 2015, sources from regional bodies and relevant information cooperation agencies were identified in which disaggregated information is reported (JICA, 2013) and (CAF, 2015). Therefore, data management score could be between two and three. Improving the current status in the sector, it is necessary to strengthen institutions responsible for mobility by improving data collection, implementation and permanent updating of systems that make information transparent in order to promote more effective interventions by authorities and civil society; and collect data on flows in a systematic way, through big data registration, censuses and/or other methods deemed appropriate, as well (Lima como vamos, 2019a).

5.5. Communication & Training

The Report of Lima's life quality study was made by the Observatory *"Lima como vamos"* which works since 2010 and collects, monitor, and share information about the life quality in Lima and Callao. One of the recommendations in that report is providing information on eco-efficient driving practices to reduce fuel consumption through workshops and campaigns aimed at drivers and the general public.

No programme of courses or workshops for awareness-raising and systematic communication among stakeholders in the transport sector was identified, so the communication & training score could be between two and three. While there are efforts, to socialise mobility programmes, no entity with relevant leadership was identified, so there are opportunities to increase the reach of these information campaigns, both to the population and to all stakeholders in all sectors and levels of government.

5.6. Finance & Investment

The GFEI[12] (Global Fuel Economy Initiative, backed by the UNEP) has supported the delivery of technical advice for strategic development on introducing international low-carbon vehicles, clean fuels, and fuel and vehicles performance standards. Moreover, it assisted on the promotion of sustainable activities and on stakeholders' discussions and capacity building (MINAM, 2014b).

On the other hand, it is important to provide resources and strengthen the work of the Urban Transport Authority (ATU) to guarantee its role in planning, regulation, management, supervision, oversight and supervision and to promote the operation of the Integrated Transport System in Lima and Callao (Agenda Urbana, 2021).

In this sense, no consistent effort was observed among all levels of government to allocate the flow of resources for an effective urban mobility strategy, so finance score could be in third place. As with other sectors, financial policies need to be integrated into a broader strategy. To this end, policies from the municipal to the city level should be considered, monitored and their effectiveness evaluated to design increasingly integrated and financially sustainable measures.

[12] For more information about the GFEI in Peru visit this link https://www.minam.gob.pe/calidadambiental/iniciativa-mundial-de-ahorro-de-combustible-y-asociacion-para-combustibles-limpios/

Table 5. Multilateral development institutions

Financial source	Description	Projects	Investment type	Available resources (USD)	Sustainable Transport projects	Financed projects
GEF	The Global Environment Facility is a partnership created in 1991 for international cooperation in which 183 economies work together with international institutions, civil society organizations and the private sector to address environmental problems.	"Improving the sustainability of electric mobility for low-carbon urban transport and focusing on REP in batteries and vehicle components"	Non-reimbursable subsidy / Technical Cooperation			
JICA	Japan International Cooperation Agency supports a sustainable economy in topics such as - Agricultural and Rural Development - Private Sector Development - Urban and Regional Development - Ensure Access to Affordable and Clean Energy - Development of Transport Infrastructure	Master Plan for Urban Transport in the Metropolitan Area of Lima and Callao	Loans and technical cooperation		Yes	https://openjicareport.jica.go.jp/pdf/11798261_01.pdf
		Information-gathering survey for urban transport in Lima and Callao			Yes	https://openjicareport.jica.go.jp/pdf/12087532_01.pdf
Other energy-related projects						
UNDP	It is the United Nations Development Programme, they have a global network that promotes the Sustainable Development Goals (SDGs), human rights and gender equity, and we provide technical assistance in order to achieve sustainable human development taking into account the priorities of each economy.	"System for the accreditation of mitigation actions with potential in the carbon market. (PMR)"	Non-reimbursable subsidy / Technical Cooperation			-
		Strengthen the Capacity of the Peruvian Government to Identify and Structure Appropriate National Mitigation Actions (NAMAs) in the Energy Sector	Non-reimbursable subsidy / Technical Cooperation			-
World Bank	It is an international organization in finance whose main activity is to help developing economies that need economic support through loans or credits and that are in a situation of poverty.	Rural Electrification 1 and 2	Freely available loan	50,000,000		
		Programmatic Financing for Development Policies (Development Policy Financing) focused on supporting (i) the response of the Peruvian State to the pandemic and (ii) the necessary reforms to enable a recovery that is more inclusive, environmentally sustainable and resilient.	Freely available loan	750,000,000		
		Human Capital Development Program	Freely available loan	50,000,000		https://www.bancomundial.org/es/news/press-release/2020/03/24/peru-recibira-us-50-millones-del-banco-mundial-para-fortalecer-estrategias-clave-de-proteccion-social-y-educacion
AECID	The Spanish Agency for International Development Cooperation (AECID) has an approach based on human rights and fundamental freedoms, the gender perspective, environmental quality, and respect for cultural diversity, in line with the new 2030 Agenda for Sustainable Development, adopted in 2015 and which will govern global development plans for the next 15 years. 17 Sustainable Development Goals (SDGs) are proposed	FONPRODE "Fund for the Promotion of Development"	Reimbursable cooperation			http://www.aecid.pe/como-trabajamos/modalidades-e-instrumentos-de-cooperacion/cooperacion-reembolsable
USAID	United States Agency for International Development (USAID)	Natural Infrastructure Project for Water Safety	Cross-sectoral collaborative work / Donations			https://forest-trends.org/infraestructura-natural-en-peru/#elproyecto

5.7. Procurement

To meet the National Urban Transport Policy, the ATU is looking for doing analysis and evaluation to develop a Sustainable Urban Mobility Plan for the Lima metropolitan area. One of the Policy's objectives is to increase infrastructure in function of the transport system requirements and other policies.

The SITIS, managed by ATU and implemented by the municipalities, comprises cycling lanes system design, planning, development, and monitoring. For this initiative, ATU is coordinating with the National Engineering University the development of the minimum safety and quality standards for a Peruvian bicycle prototype (ATU, 2020).

Despite the reduction on the percentage of households with bicycles, in 2020 and the first quarter of 2021, the importations of bicycles increase considerably. Just in August, it was reported a 184% increment compared to 2019 imports (Agenda Urbana, 2021). At the end of 2020, the Ministry of Transport announced the facilitation of technical support to 25 municipalities for the implementation of 430 km of bicycle lanes (Agenda Urbana, 2021).

In this context, no clear provisions on public procurement in this sector were identified, so that, in general terms, its position could be between places 2 and 4 in the procurement score. One recommendation is to give preference in contracts and tenders to those companies that provide transport services based on renewable energies or electromobility, incorporating clauses that incorporate clean energies in tenders (Lima como vamos, 2019a). The above would support a competitive and sustainable tendering

5.8. Monitoring & Evaluation

An ad-hoc system of monitoring and evaluation for the transport sector was not identified, only some initiatives were present. As part of the PIMIS development, it was evaluated the potential of short trips with the help of *"Lima como vamos"* platform. From this platform report it was found that 42% of all trips in Lima and Callao last 30 minutes or less (ATU, 2020). The same percentage was confirmed from the World Bank study (World Bank Group, 2020b).

On the other hand, as the GFEI is implemented, its focus on bringing awareness of the number of vehicles and fuels that are sold and produced. One of the activities involved are data collection and analysis, standards development and implementation, capacity building, stakeholders' engagement, and control and monitoring (MINAM, 2014b).

Likewise, there was not a consistent effort at a monitoring system observed. Some efforts to generate information for the generation of diagnostics were identified, but it was not possible to verify whether these efforts were aimed at evaluating and measuring the progress of the policies implemented, hence the score is between 2 and 4. Systems that facilitate the tracking of the measures implemented will help in the evaluation of the effectiveness of the measures, so that increasingly more sophisticated and useful systems are available for the evaluation of transport-oriented policies and Programmes.

5.9. Opportunities for further analysis

In this context, some relevant opportunities on transport sector in close cooperation with international and local development agencies and banks are:

- Update of origin-destination studies with the aim of determining travel patterns of traffic; and assisting long-range traffic planning.
- Technical support to municipalities in the design of public policies, such as congestion charges, low emission zones or other public transport measures, to induce the shift from high emitting private transport modes to low carbon transport modes and to public transportation.

- Technical support in the development of economic instruments such as feebates, scrappage programs, and mandatory labelling to incentivize more energy efficient vehicles technologies.
- Technical support in the update energy efficiency standards for passenger cars.
- Technical support in the adoption of electric buses on the main public transport routes in municipalities and larger metropolitan areas.

6. Overall conclusions

This document attempted to describe in general terms the most relevant aspects of the status and opportunities for increasing the capacity of municipalities and different levels of government in the transport, building and waste sectors.

Based on the conceptual framework of capacity building, some areas of opportunity for future projects in the economy or, in general, for the region were identified. In addition to the specific needs of each sector, the opportunities identified could be broadly classified as in the following three main categories:

a. Information systems.

- Through information systems, municipalities and states can harmonise the methodology for preparing technical information, so that the government's energy information will use standardised concepts, promoting comparability at regional and global level.
- The formulation of indicators and their automatic calculation through the combination of economic, social, energy and environmental information will enhance the analysis of the sector and provide better elements for planning.
- Sub-economy governments, such as municipalities, could use the tools to support decision-making and the development of energy planning in their economy. For instance, in the transport sector, origin-destination surveys have the potential of providing relevant information for the planning process. It could help in the transport planning process: information is used to relate demographic characteristics to travel patterns. This serves to understand existing travel patterns and how the population uses existing transport infrastructure and services. But in addition to this, this type of information serves as an input to develop transport models capable of generating forecasts.
- In the building sector, information systems on energy efficiency in buildings could help to establish energy efficiency benchmarks. Such systems help in assessing the energy performance of existing and new buildings, which could provide base information to identify opportunities to increase efficiency, that is, information on the opportunities in increasing energy efficiency. Likewise, this information could support for future buildings labelling, based upon energy performance.
- Finally, information systems are crucial for monitoring and verification. In this sense, the generation of consistent information could help in assessing the overall performance across all sectors.

b. Technical training

- One of the main issues in the region is the need for training of municipal employees on technical knowledge and skills for the elaboration, execution, evaluation and implementation of urban planning and mitigation instruments.
- Given the constrained capabilities in the municipalities in both technical and human resources, it is important to provide technical support to officials of the municipalities to develop capacities aimed at identifying climate change mitigation actions, so that they are measurable, reportable and verifiable.

c. Finance & investment

As final remarks, the municipalities commonly face financial constraints to carry out mitigation actions, hence the identification of alternative financial sources is important. Some international and economy financial sources in Peru are described since financing is one of the most important components to attain the emissions reduction objectives. Regarding the agencies, there are at least 22 financial sources. In the following Figure are described according to the financial resources amount.

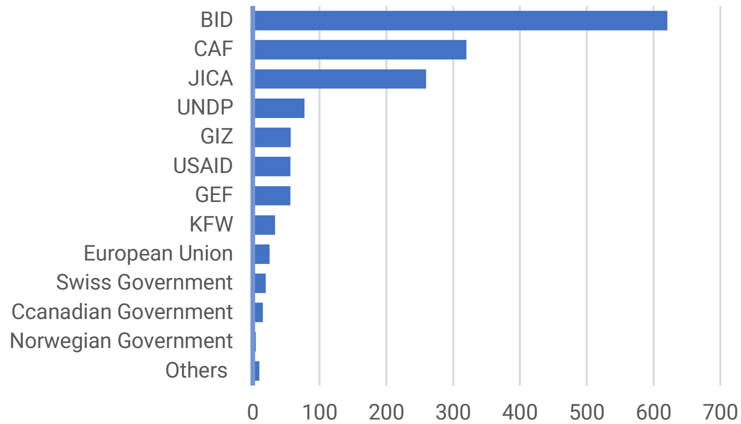


Figure 1. Financial climate sources in Peru, 2010-2014 (million USD)

Source: DAR (2015)

On the other hand, the financial support among the climate-related sector varies across all activities. In the case of energy, funding is allocated to the infrastructure necessary for electricity generation from low-carbon sources. In transport, resources have been allocated to the development of more efficient urban transport (DAR, 2015).

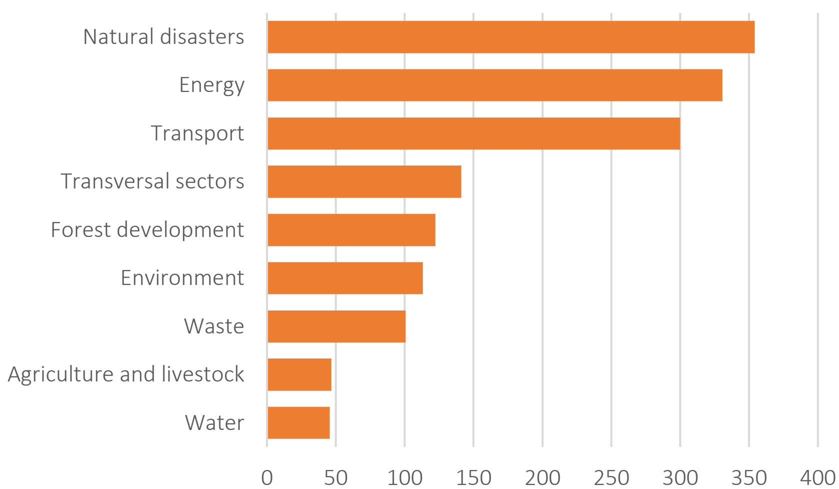


Figure 2. Source of financial climate by sector in Peru, 2010-2014 (million USD)

Source: DAR (2015)

The information presented is intended to give an overview of the sources of funding as well as the sectors to which these resources are allocated. For more detailed information on projects and funding sources for Peru from 2014 to 2018, (DAR, 2015) provides a broader perspective on these aspects.

References

Agenda Urbana. (2021). *Politica de transporte sostenible en Peru.* Obtenido de http://www.limacomovamos.org/wp-content/uploads/2021/09/Documento-de-politica-Movilidad.pdf

ATU. (2020). *Guia para la Formulación de un Plan Institucional de Movilidad Individual Sostenible.* LIma: NAMA Faciity. Obtenido de https://cdn.www.gob.pe/uploads/document/file/1942449/Gu%C3%ADa%20PIMIS.pdf.pdf

DAR. (2015). *Financiamiento Internacional para el Cambio Climático en Perú.* Lima: Derecho, Ambiente y Recursos Naturales y Grupo de Financiamiento Climático LAC.

Lima como vamos. (2019a). *Décimo Informe Urbano de Percepción sobre calidad de vida en la Ciudad.* Obtenido de http://www.limacomovamos.org/wp-content/uploads/2019/11/Encuesta-2019_web.pdf

Lima como vamos. (2019b). *Noveno Informe de Indicadores sobre calidad de vida.* Obtenido de http://www.limacomovamos.org/wp-content/uploads/2019/11/Informe-2018_web.pdf

MINAM. (2014a). *REPORTE Seguimiento Ambiental del Mercado Automotriz Peruano: 2006-2014.* Obtenido de https://www.minam.gob.pe/calidadambiental/wp-content/uploads/sites/22/2016/02/seguimiento-ambiental-del-mercado-automotriz-peruano-corregido.pdf

MINAM. (2014b). *Seguimiento Ambiental del Mercado Automotriz Peruano.* Obtenido de https://www.minam.gob.pe/calidadambiental/wp-content/uploads/sites/22/2014/07/SEGUIMIENTO-AMBIENTAL-DEL-MERCADO-AUTOMOTRIZ-PERUANO-final.pdf

MINAM. (2016). *Plan Nacional de gestión integral de residuos sólidos 2016-2024.* Peru: Ministerio del Ambiente. Obtenido de https://www.minam.gob.pe/calidadambiental/wp-content/uploads/sites/22/2013/10/IMPRIMIR-PLANRES-2016-2024-25-07-16.pdf

MINAM. (2018). *Informe Final del Grupo Multisectorial para Implementación de las NDC.* Obtenido de https://www.minam.gob.pe/cambioclimatico/wp-content/uploads/sites/127/2018/12/Informe-final-GTM-NDC_v17dic18.pdf

MINAM. (2021). *Reporte de avance de la Agenda ambiental al bicentenario al primer semestre de 2020.* Peru: Ministerio del Ambiente. Obtenido de https://www.gob.pe/institucion/minam/informes-publicaciones/2175127-reporte-de-seguimiento-de-la-agenda-nacional-de-accion-ambiental-al-primer-semestre-2020

UNDP. (2018). *El enfoque de género aplicado a la gestión integral de residuos en Perú.* Peru: United Nations Development Programme.

World Bank Group. (2020a). *Propuesta de actualizacion del Plan de Infraestructura Cicloviaria para Lima y Callao.* Obtenido de https://documents.worldbank.org/en/publication/documents-reports/documentdetail/294041589874919754/propuesta-de-actualizacion-del-plan-de-infraestructura-cicloviaria-para-lima-y-callao

World Bank Group. (2020b). *Propuesta y recomendaciones para la formulacion de una estrategia para la Bicicleta en Lima Metropolitana.* Obtenido de https://documents.worldbank.org/en/publication/documents-reports/documentdetail/804721589870386400/propuesta-y%02recomendaciones-para-la-formulacion-de-una%02estrategia-para-la-bicicleta-en-lima-metropolitana

WRI Mexico. (2021). *Fortaleciendo capacidades para la eficiencia energética en edificios en América Latina (CEELA) – Fase 1.* (Internal Report).

Capacity building for La Molina 2

1. Introduction

While the previous sections provide insights of the magnitude of the emissions issue in La Molina and the potential interventions for emission reduction, institutional capacity to support implementation also needs to be developed simultaneously. Along with institutional capacity, awareness building among citizens will also help stimulate participation from citizens to accelerate the movement towards a Low-Carbon Model Town concept. With increased activity in low-carbon transformation of La Molina, institutional strengthening by capacity addition both in terms of human resource and infrastructure to support both implementation as well as effective monitoring and evaluation of low-carbon interventions can also be undertaken in future.

In order to formulate a project-specific framework for capacity building activities on low-carbon transformation of La Molina, United Nations Development Assistance Framework (UNDAF)'s guidance on Capacity Building was reviewed[13].

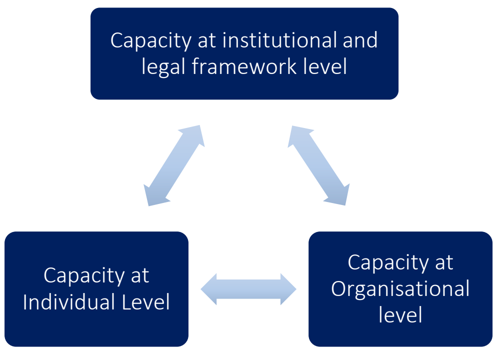


Figure 3: Interconnected levels of capacity building as per UNFPA

The guidance shows three interconnected levels that need to be targeted for effective capacity building at on organization level. In case of La Molina municipality, this would imply develop institutional capacity by having requisite tools to support low-carbon urban transformation, appropriate organization structure to for allocation of responsibilities to support transformation process and capacity of individual human resources present in the organization to undertake relevant tasks.

While tasks related to organization structure are beyond the scope of the project, capacity building of human resources will be addressed in this document.

An additional layer to this organizational capacity is community engagement to ensure citizen participation in the low carbon transformation program.

Based on this understanding, this document aims to achieve the following objectives:

1. Activities to be undertaken by La Molina municipality to increase capacity of relevant staff members in assessing city-level GHG scenario; identification, assessment and implementation of low-carbon interventions
2. Propose interventions to help improve awareness of citizens on the need and benefits of low-carbon growth path for the city as well as need for their active participation to facilitate implementation
3. Propose interventions to engage non-governmental agencies to support capacity and awareness building activities

In order to achieve the stated objective, the following information areas have been elaborated:

1. List of interventions to support institutional and community level capacity building
2. Global case studies providing examples of successful implementation of identified interventions
3. Implementation plan to assist La Molina officials in implementing identified interventions

The following sections elaborate the areas listed above.

[13] Source: Capacity Development UNDAF Companion Guidance (UNDAF, 2017)

2. Capacity Building interventions

Summary of intervention

As mentioned in the previous section, this document aims to enhance awareness of relevant stakeholders on low-carbon transformation as well as improve capacity for assessment and implementation of low-carbon interventions. Based on this understanding, the following interventions have been proposed:

Type of activity	Brief description	Intended audience
Training/ Workshop	• Dissemination of benefit and implementation guidelines for recommended interventions across each Government department. • Guidelines on efficient energy use to be communicated to citizens	Government departments
	• Training on proposed interventions to support in community outreach initiatives for awareness building or supporting implementation activities	NGOs operating in sustainability space (E.g.: Ecoswell)
Media communications	• Design Behaviour change campaigns focused on specific user-groups and functional areas. • The campaigns will help identify areas where emission reduction can be achieved by changing patterns of energy usage and waste management behaviour in residential, commercial buildings. • Communication of benefits of efficient energy use & practices, waste segregation/recycling to achieve it through multiple media like: o Ads in newspapers, billboards etc. o Flyers with gas and electricity bills	Citizens
Events	• Organize cultural events “Eco-Festivals” to spread awareness of low-carbon initiatives through innovative means – music, posters, banners, competitions etc. • E.g.: Americas Latino Eco Festival (USA), Eco-Festival Colchester (UK)	
Peer-to-peer twinning	• This approach consists in pairing an expert in a subject/field to an individual, who needs to improve his/her skills in that particular field, to achieve a —learning by supervised doing|| effect. • Twinning not only cover the dimension of knowledge transfer, but also provides the opportunity to put the newly acquired knowledge and skills into practice with the guidance of a mentor, who can provide feedback and support throughout the learning process	Government Department
ICT based platform	• The use of ICT provides great opportunities for disseminating information, proving platforms for auto-learning and/or interactive learning (e.g. eLearning), and they serve as instruments for networking and establishing strategic relationships.	Citizens & Government Department

Further elaboration of each set of intervention is given below, which provides detailed description of intervention, an implementation plan and accompanying case study exemplifying implementation concept.

3. Training and Workshop

3.1. Description of concept

The objective of this intervention is to develop institutional capacity as well as capacity of non-government agencies to support assessment and implementation of low-carbon interventions.

A) *For Government bodies*

Government bodies in this respect entails specific departments within municipality organization like Town planning, Waste management etc. which be required to implement the interventions provided as part of project output. Accordingly, the indicative areas where trainings need to be imparted are given below:

a. Developing Zero-Energy Guidelines and integration with municipal bye-laws
b. Developing Demand Traffic System and urban traffic planning
c. Developing Zero Waste concept for La Molina
d. Financing options for low-carbon interventions

The trainings can be in the form of offline classroom program, ranging into multiple days, supplemented with a workshop before commencement and post closure of the program. The trainings will aim to impress on framework for planning implementation activities, additional considerations for implementation of low-carbon solutions. The program can also include trainings on specific models/software packages that are required for designing the interventions.

B) *For non-government organizations*

La Molina Municipality can collaborate with non-governmental organizations to extend citizen outreach possibilities as well as support responsible Government agencies in implementation. The Municipality can connect with NGOs operating in Peru focusing on sustainable development and can contribute to the identified interventions for low-carbon model town for La Molina

An example of sustainable development-oriented NGO is EcoSwell[14], which operates in Peru and undertakes implementation of sustainable development initiatives in renewable energy and waste management, apart from other areas.

The Municipality can engage with similar NGOs and undertake workshops to apprise representatives from such

Figure 4: Examples of projects undertaken by EcoSwell NGO

organizations on the initiatives planned for Low-Carbon development in La Molina and probable methods to deliberate on how the organizations can assist in implementation.

[14] Source: EcoSwell

3.2. Implementation Plan

A step-by-step approach for implementation of Training/workshops aimed at enhancing capacity is given below:

1. Conduct a rapid assessment of the areas where internal departments and other Government institutions require assistance in developing capacity for planning, implementing and subsequent operations of the identified Low-Carbon interventions. Typical areas that can be focused on are as follows:
    a. Explanation of low-carbon interventions and key actions required for implementation of intervention
    b. Compilation of processes and approvals along with most probable turnaround time, to support planning of infrastructure interventions
    c. Financing low-carbon infrastructure projects – process for exploring multi-lateral funding, Government funding and compilation of market-based financing options like public-private partnership
2. Identify external agencies (i.e. beyond La Molina Municipality) that are required to be involved in the project lifecycle like power distribution company (for EV related initiatives), local transport department (for Demand Traffic system), public works department (for bicycle lane upgradation) etc.
3. Undertake rapid assessment of knowledge requirements of identified agencies for conveying importance of low-carbon interventions for La Molina, key requirements for successful operation of the interventions and expected role of the agencies
4. Development of annual Training Plan that provides details on the areas where training will be provided, brief of training contents, target audience, sequencing of training events and tentative schedule
5. Additionally, identify non-government organizations (like Swell) or private organizations operating in target areas of the LCMT concept (i.e. Buildings, Untapped energy, Renewable energy, Greenery and Waste Management). Identify and develop workshop materials to convey proposed role of these agencies in the interventions and seek input on support that can be provided by the agencies.
6. Integrate workshop for external agencies and develop a combined Training and Workshop Plan, which will be utilized for budget and human resource allocation.
7. The municipality can choose to engage a specialized agency for delivery of the Training and Workshop plan including development of requisite materials and delivery according to the schedule. Alternately, Municipality can nominate internal resources for delivery of the Training and Workshop Plan.

3.3. Case study 1: Capacity Building Workshop and Science-Policy Dialogue on Climate Change: Low Carbon and Adaptation Initiatives in Asia[15,16]

Objective	Aim to strengthen the global response to climate change set forth in Article 2 of the Paris Agreement and in line with celebrating four years of support for low-carbon development by both APN and LoCARNet.
Target	Government Officials

[15] Source: Mission Report (lcs-rnet.org)
[16] Source: Capacity Building Workshop and Science-Policy Dialogue (apn-gcr.org)

Method/ Approaches	• The Low Carbon Asia Research Network (LoCARNet), together with the Asia-Pacific Network for Global Change Research and the Regional Resource Centre for Asia and the Pacific (RRC.AP) of the Asian Institute of Technology (AIT), organised a three-day capacity building workshop and policy dialogue on climate change, low carbon and adaptation initiatives in Asia. • The three-day activities look at results from APN's funded projects under its Low Carbon Initiatives (LCI) framework and Climate Adaptation framework, as well as the latest outcomes from partner organisations that support implementation of the Paris Agreement with the aim of sustaining a planet under the 2^{0}C scenario. • The activities include a capacity building workshop (one day), and a science-policy dialogue for knowledge exchange (management, communication, etc., two days) that engages economies in Asia. • The Science-Policy Dialogue includes talks on the role of green investment in cities, low carbon and energy-efficient technology, a better water-energy-carbon nexus, among others. In addition, participants join "café kiosks" and discuss issues of effective "science and policy interactions", "knowledge management" and "networking and capacity building" to realise a low-carbon and resilient Asia. • Decision-making games also form part of the activities engaging participants in making decisions that are or may be, high-risk decisions
Tools/ Instruments	• Multi-stakeholder workshop, which brings together academia, policy makers and Government officials on same platform for dialogue exchange
Implementation	• Workshop contained day-specific agenda, with topics discussed as given below: o Science-based Research and Integrated Climate Policy o Role of research community in supporting capacity building o Case Studies from APN Low Carbon Initiatives Framework and other global case studies related to climate change adaptation and mitigation

4. Behavior change campaign

4.1. Description of concept

A comprehensive program that assesses and identifies opportunities for emissions savings that can be achieved through behavioural change in consumers and utilize suitable public outreach platforms to affect the change. The campaign aims to gradually change in energy consumption, waste disposal habits by sustained communication of benefits of behavioural change, along with requisite knowledge tools and psychological reinforcement through public outreach. This outreach can be achieved through print media and community outreach programs communicating key financial benefits and responsibilities of citizens.

4.2. Implementation Plan

Implementation of such a behavioural change program will involve the following activities:

1. Study energy use in residential, commercial and public buildings, waste management practices in households, commercial establishments
2. Identify areas where changes in pattern of energy usage can lead to lower consumption of energy. Similarly, identify changes in waste management pattern that will lead to higher proportion of waste recycled, reused or can reduce amount of waste reaching the landfill
3. Identify touchpoints of target consumers through which material designed for behavioural change can be communicated.

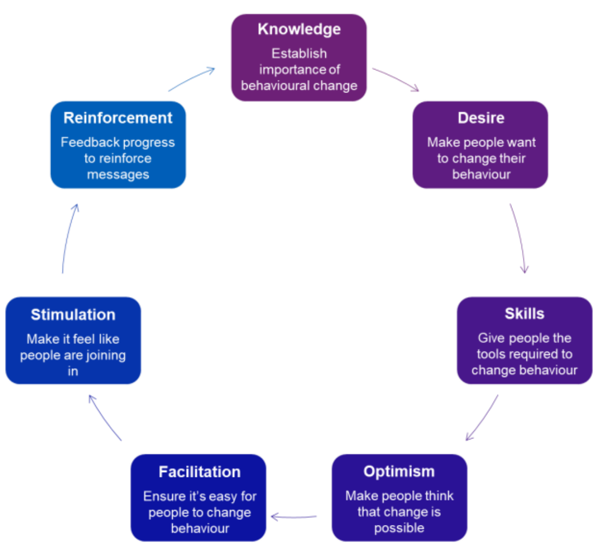


Figure 5: Framework for designing behavioural change strategy

4. Develop media communication strategy focussed on behavioural change based on the following framework[17]:
5. Design targeted community outreach program to address each area of the framework.

Given the specialist expertise required for behavioural analysis and subsequent design of behaviour change program, it would be helpful if La Molina municipality engages specialist agency specifically for this program. Delivery can be undertaken by the Municipality staff independently or by taking assistance of a firm having experience in delivering public outreach programs

4.3. Case study 2: Behavioural change campaign by The Carbon Trust, UK[18]

Objective	Helping businesses and residents adopt greener habits
Target	Citizens and Organisations
Method/ Approaches	• Carbon Trust has run a number of innovative projects in cities across the UK to change behaviours within both households and organisations. • Independent studies to understand and target the underlying motivations that inform the decisions and behaviours that emit CO_2. Accordingly, financial/non-financial incentives and psychological reinforcement strategies were designed • A strategy used to nudge individuals and businesses to make green decisions is the *desirability of greener lifestyles and products.* E.g.: Introducing planning criteria that supports cycle infrastructure or car clubs over private car parking
Tools/ Instruments	• Trust developed online tools which help business leaders to estimate how much money and carbon they can save within their organization.
Implementation	• Tools, alongside information and advice, changes the emphasis towards the benefits – of a change in behaviour – to the business, and away from the more intangible arguments of environmental responsibility and "Thinking Global". • The most successful programmes use the nudge principle to help individuals "make better choices (as judged by themselves) without forcing certain outcomes upon anyone." For example, a London police authority reduced energy costs by shutting down their computers each night because they were concerned for information security rather than energy savings. And working from home initiatives have been more successful when promoted as saving workers' time rather than saving on transport related emissions. • In California, recycling became socially desirable and even competitive between residents when the waste pick up was moved from the back yard to the more visible front lawn. This change resulted in a significant rise in recycling and a reduction in waste.

5. Eco-Festival

5.1. Description of concept

Eco-festival is designed as a cultural event with a centralized theme of environmental sustainability. Globally, 25+ such cultural festivals are organized annually or have been organized at least once[19]. The idea is to bring together advocates of environmental sustainability and spread the message through various cultural events. Normally, such eco-festivals are multi-day events in a specific location wherein sustainable event practices are implemented and various cultural activities like music, dance, plays are organized.

Many festivals like the Americas Latino Eco Festival (as given in Case study 3) have follow-up events that are focused on the same theme, which are organized in smaller scale in multiple locations in order to promote the event. These follow-up events can also help in spreading awareness of sustainable environment. Additionally, such events help bring together environment enthusiasts and sustainability professionals in academia, industry, non-profits as well as Government administration, which can help build momentum in sustainability action.

[17] Source: Low Carbon Behaviour Change (Carbon Trust)
[18] Source: Incentives | Centre for Cities
[19] Source: Eco-festivals - Appropedia: The sustainability wiki

5.2. Implementation Plan

1. Study international cases of Eco-Festivals to identify main event activities like music concert, target artists and side-event activities like skits/street play competitions, group discussion events and accordingly, draft an event schedule.
2. Identify festival location and eco-friendly facilities related to sanitation, waste management, energy supply, transportation etc. which complement the central theme of environmental sustainability
3. Utilize international case studies to identify satellite events that can be organized to promote the event
4. Develop media communication strategy both during festival period as well as during satellite events to spread awareness on low-carbon interventions undertaken by La Molina Municipality as well as communications on behavioural change.
5. Engage specialist agencies with experience in organizing Eco-Festivals to refine festival events, on-ground facilities as well as media communications to ensure alignment with the central theme of environmental sustainability. Organizations like "A Greener Festival" that specialize in organizing Eco-Festivals or have previous experience in the field can be engaged in this case after preliminary study of requirements has been conducted independently by the Municipality[20].

5.3. Case study 3: Americas Latino Eco Festival by Americas for Conservation + the Arts (AFC+A), USA [21]

Objective	Promote environmental sustainability through cultural program
Target	Citizens
Method / Approaches	• Americas Latino Eco Festival (ALEF)- a nonprofit event free and open to all- is a Latino hosted multicultural event aimed at fostering collaboration to better tackle environmental problems from many angles and using "arte y cultura" (Art and Culture) approach to message environmental awareness and shared values. • It is organized by Colorado (USA)-based non-profit Americas for Conservation + the Arts (AFC+A) and the festival is organized mainly in Denver, USA and with satellite events taking place in Latin communities • Additional events, which have been implemented in conjunction with ALEF which aim at environmental and multicultural education and an integrated, diverse, and inclusive conservation agenda include: o Descubre El Bosque (inspiring tweens and their parents to reconnect with nature) o Journey for Climate Justice JCJ (advancing justice through adventure) o Latina Environmental Giving Circle (empowering the next generation of Latina green leadership). • The festival acts as a meetup of Latino American environmental minds, and a home for artists, scientists, advocates, public policy leaders, and communities from across the Americas, committed to advancing a healthy environment, both locally and globally, through arts, education, and engagement of culturally diverse populations.
Tools / Instruments	• Cultural events to bring together key stakeholders in environmental sustainability and ordinary citizens.
Implementation	• Develop festival schedule and satellite event schedule comprising wide variety of cultural events like music performance by renowned artists, art exhibition and workshop, book fairs, film and documentary presentation, Plenaries on environment sustainability topics • Identify list of participants and performers for the identified events • Undertake promotion activities to target audience group for the events • Conduct events and undertake feedback through online and/or physical surveys

[20] Note: Official website of A Greener Festival - Home - A Greener Festival
[21] Source: ABOUT | ALEF/FELA (americaslatinoecofestival.org)

6. Peer-to-peer twinning

6.1. Description of concept

Peer to peer learning partnerships in the form of 'twinning' projects foster cooperation between institutions in order to 'promote institutional capacity building' across the public sector. Under the twinning concept for institutional capacity building, an institution, interested in strengthening in capacity is paired with another institution which have displayed abilities of institutional capacity. In case of La Molina in context of LCMT concept, the municipality can choose to 'twin' with another municipal authority which has experience in implementing low-carbon initiatives, especially those that have been presented under this project.

Engaging in twinning arrangement will not only help La Molina gain technical and commercial knowledge of the on-ground requirements of implementing low-carbon solutions but will also provide market knowledge of vendors that can supply requisite technologies.

6.2. Implementation Plan

1. Conduct research of target cities and geographies with whom La Molina municipality can engage for the twinning arrangement[22] – it will involve cities or regional bodies in relatively advanced economies which have previous experience of implementing target low-carbon interventions
2. Global best practices provided as part of the intervention case examples (given in the report) or regional groups of municipalities and local bodies having such facilities can also be targeted. An example of regional group is given in the case study.
3. Additionally, La Molina can communicate with cities in Latin America region interested in sustainable development and create a regional forum which can collaborate on knowledge exchange in the region. One such forum of Latin American cities specifically for sustainable mobility is already operational (*MobiliseYourCity Latin America*[23]) and La Molina municipality can opt for participation in such fora.

6.3. Case study 4: Twinning program – Covenant of Mayors for Climate and Energy, EU[24]

Objective	Increase capacities of local authorities and learn from cities where climate change mitigation activities have been undertaken
Target	Government organizations
Method / Approaches	• Undertaken by Covenant of Mayors for Climate and Energy (an organization for sustainable urban development) • It offers municipalities across Europe the opportunity to take part in twinning exchanges that aim to increase local authorities' capacity and knowledge to mitigate and adapt to climate change.
Tools / Instruments	• Physical visits to cities which have already implemented climate change adaptation and mitigation measures as well as to cities which are interested
Implementation	• Two different types of exchanges are possible: o *Peer-to-peer exchanges:* In this type of exchange, selected applicants are at a similar phase/level of development of their strategies and plans. They are matched one-to-one, based on common needs and effective solutions. The aim is to create exchanges that work both ways so that each municipality gets new insights and inspiration for their climate and energy actions. o *Mentoring exchanges:* These twinning exchanges connect one local authority that is rather at the beginning of its mitigation and adaptation work (learner) to another one that has already successfully designed or implemented strategies to substantially decarbonise its territory and/or make it more resilient

[22] Note: As reference the list of EU based groups of municipalities and urban local bodies which can be referred for twinning is given in the following link: European Sustainable Cities Platform | Local sustainability frameworks
[23] Note: A group of Latin American cities for sustainable mobility: MobiliseYourCity Latin America | MobiliseYourCity
[24] Source: Twinning program (covenantofmayors.eu)

	(mentor). Although differentiation is made between learners and mentors, aim is to create exchanges that work both ways. Past twinnings underlined that the mentors also get new insights and inspiration for their climate and energy work. • To foster the creation of long-term partnerships between European local authorities, each exchange will include two twinning visits. Each selected authority will host one of the two visits and will travel to its partner for the other: o In the case of mentoring exchange, the first visit will take place at the mentor's while the return will be held by the learner o For peer-to-peer exchange, participants will be asked to specify if they are willing to host the first or the second visit. • Local authorities will be paired according to their climatic and geographical features, socio-economic and institutional context, level of implementation/design of adaptation and mitigation measures • Interested municipalities have provide an application to Covenant of Mayors for Climate and Energy to be considered in the program

7. ICT platform

7.1. Description of concept

ICT media provide a unique set of platforms for enhancing public outreach as well as capacity building of target audience. The nature of the ICT solutions ensures a personalized output can reach individual members of target audience through a single platform. In the context of capacity building for low-carbon urban development, the following applications of ICT can be envisaged:

1. Training of municipality officials: Municipal officers can be provided courses already available in multiple platforms operated by multi-lateral funding organizations and non-profit organizations to develop internal capacity of municipality for planning and implementing low-carbon development strategy. These further elaborated in the Implementation Plan section.
2. Tool to support behaviour change program: Can benefit from findings of behaviour change program to understand key areas where energy consumption pattern can be changed. Multiple methods of supporting behaviour change program through ICT solutions – these are discussed in detail under Implementation Plan section

7.2. Implementation Plan

1. For training of municipality officials:
   a. Identify online courses which can be attended by staff to enhance knowledge on sustainable development and be exposed to low-carbon interventions case studies globally. Two globally recognized platforms for learning on sustainable urban development have been identified
      i. *Learning resources under Urban Agenda Platform*[25]*:* A global platform for sharing progress on, action and knowledge for sustainable urban development, maintained by The United Nations Human Settlements Programme (UN-Habitat). UN-Habitat is the United Nations programme for human settlements and sustainable urban development.
      ii. *Knowledge resources under Global Platform for Sustainable Cities*[26]*:* Funded by the Global Environment Facility (GEF), the platform comprises approximately 30 cities and a range of knowledge partners which aims to assist partner cities advance toward their visions and goals of being cities that are competitive, inclusive, and resilient.

   Further research regarding similar platforms can be undertaken by the municipality independently. It should be noted that these platforms also provide access to international fora and groups, that can open up prospects of Peer-to-peer twining as given in Section 6

[25] Source: Learning | Urban Agenda Platform
[26] Source: Knowledge Resources | GPSC (thegpsc.org)

b. Nominate officials from relevant departments to attend identified trainings – this will act as training-of-trainer activity. The nominated officials will utilize knowledge gained from the trainings to undertake training sessions within individual departments of the municipality.
c. Develop annual training plan for training-of-trainer and subsequent department-wide staff training exercise. Utilize training plan to secure budgetary allocation and subsequently implement training plan.

2. Tool to support behaviour change program:
   a. Identify elements where integration with behavioral change program can be established – ICT platforms can be used for spreading awareness on identified low-carbon interventions as well as overall citizen awareness building and participation
   b. Develop digital communication/outreach strategy to achieve behavioural change. It is recommended to include other stakeholders in the process to target focused consumer groups. E.g.: Power distribution company to increase awareness on reducing power bills for commercial and residential consumers
   c. Develop online tools as part of digital communication/outreach strategy (like the power consumption tools given in Case study 5 or organization specific carbon reduction tools as give in Case study 2). The tools can be supplemented with additional data analytics to facilitate behaviour change. For example, the tool for calculating power consumption as given in Case study 5, can be, can be supplemented with a knowledge base for recommending consumers with an energy efficient scenario for their consumption pattern. The energy efficient scenario will recommend the energy efficient variant of appliances currently used by the consumer, which will help reduce power bills and help gain cost savings post payback period. Accordingly, further analytic outputs can be provided to help consumers take informed decision. Examples of analytic outputs are given below:

IMPLICATION Of USER SELECTED REPLACEMENT

Annual energy savings	3010.46
Quarterly energy savings (in kWh)	752.62
Annual energy cost savings	27064.04
Quarterly energy cost savings	6766.01
Net capital investment	182000.00
Net discounted payback period (in yrs)	7.80

IMPLICATION OF RECOMMENDED REPLACEMENT

Annual energy savings (in kWh)	655.96
Quarterly energy savings (in kWh)	163.99
Annual energy cost savings	5431.02
Quarterly energy cost savings	1357.76
Net capital investment	18330.00
Net discounted payback period (in yrs)	3.38

Figure 4: Example of analytics for power consumption assessment tool to recommend energy efficient use to consumers

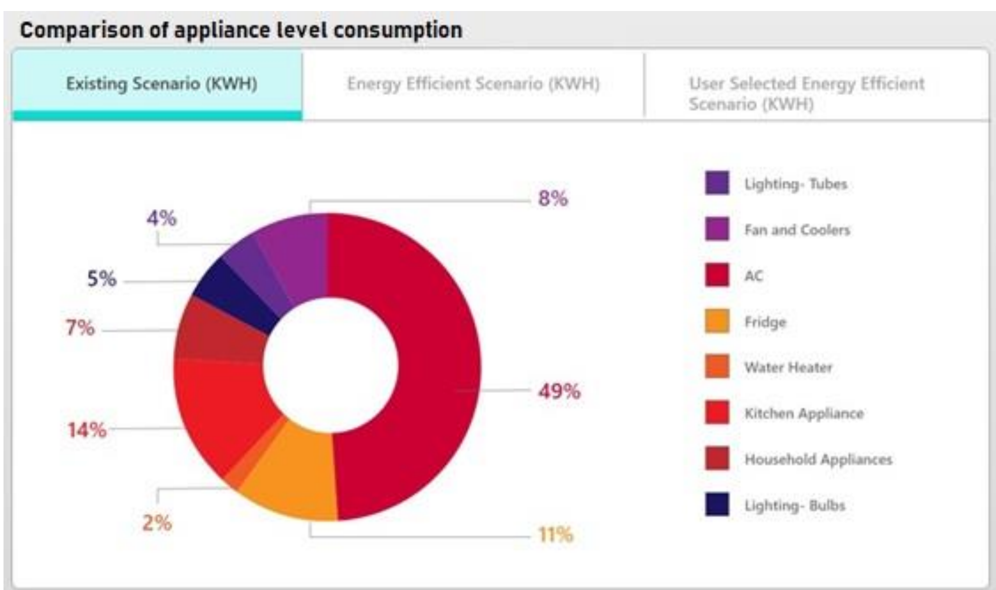


Figure 5: Data visualization example to exhibit power consumed by each appliance under existing scenario and proposed energy efficient scenario

d. Development of online tools would require engagement specialist agencies who would undertake requirements gathering based on the brief provided by the municipality, design the user interface, develop back-end data management system and data analytics, launch and provide maintenance support for the tool for a brief period (usually 2-3 years) and subsequently, conduct knowledge transfer on operating, maintaining and updating the tool while handing over ownership to municipality.

e. As part of the behavioural change program, utilize online social media platform and develop communications conveying benefit of low-carbon urban development, citizen guidelines to reduce emissions, knowledge on practices and interventions undertaken by municipality to reduce carbon footprint of city.

f. Social media platform can be used to organize online competitions to solicit low-carbon/sustainable solutions from citizens – such solutions can be low impact interventions but can help in increasing public engagement in low-carbon development of city.

7.3. Case study 5: Power consumption calculator – Maharashtra State Electricity Distribution Company Limited, India[27,28]

Objective	Improve awareness of consumers on charges for power consumption
Target	Citizens and other commercial power consumers
Method/ Approaches	• Maharashtra State Electricity Distribution Company Limited (MSEDCL) is the power distribution company catering to Maharashtra, one of the largest states in India • MSEDCL developed two online tools for calculating power consumption based on user inputs: o *Energy Bill Calculator:* Provides details of power tariff based on user inputs on connection details (type of consumer – residential, commercial; type of connection – low-tension/LT, high-tension/HT; sanctioned load etc.) and consumption levels. Screenshot of the system is given below:

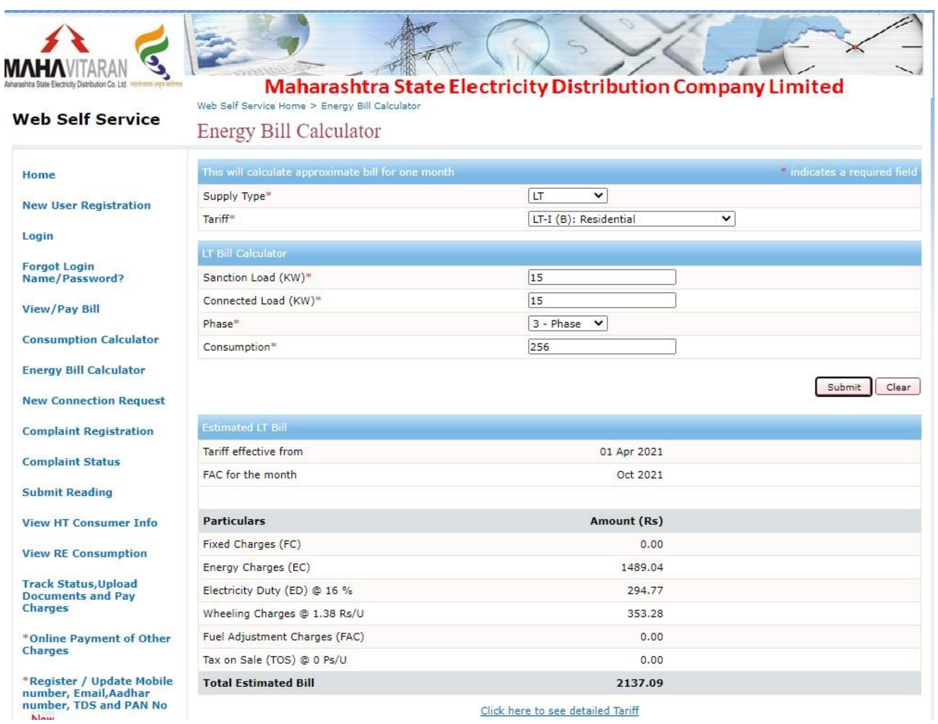


Figure 6: Screenshot of Energy Bill Calculator

[27] Source: Monthly consumption Calculator (Mahavitran website)
[28] Source: Energy Bill Calculator (Mahvitran website)

- ○ *Monthly consumption calculator:* Users can provide input on type of appliance and hours of usage per day in a month, which will provide the estimated consumption bill for the user. Multiple variants of the appliance normally used in the region were provided as options. The calculator comprises individual pages to input details of multiple categories of appliance, as given below:

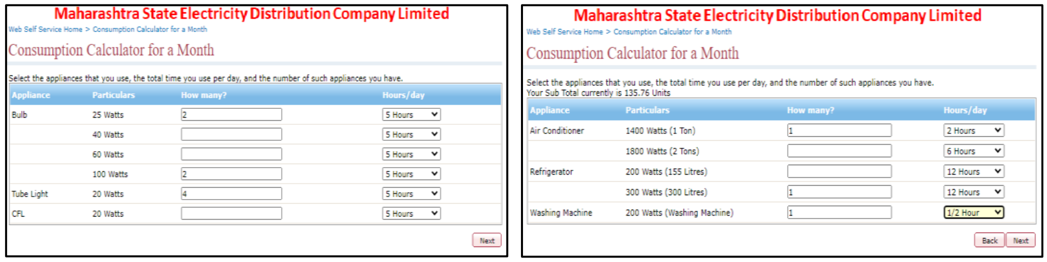


Figure 7: Screenshot of input pages of Monthly Consumption Calculator

As a final output, the estimated monthly power bill based on the appliance usage input will be displayed, along with a disclaimer that faulty appliances can lead to higher power consumption and difference in power rating of appliances

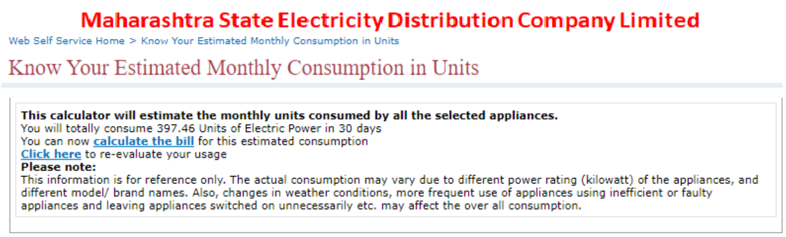


Figure 8: Screenshot of output page for Monthly Consumption Calculator

- While Energy Bill Calculator tool can be used by both commercial and residential users, Monthly Consumption Calculator can only be used by residential consumers. The tools can assist consumers in calculating estimated power consumption and power bills, which can be used to plan their usage and save power bills

Tools/ Instruments	• Online tool hosted on the website of power distribution company that can be accessed by general public for information purposes
Implementation	• For Energy Bill Calculator: ○ Compilation of consumer variants, connection variants and tariff structure and identify additional user input parameters required to generate power consumption bill ○ Develop logic model for data analysis to generate output and design portal modules for integration with existing website • For Monthly Consumption Calculator: ○ Compilation of appliance types and their variant commonly used in the region under the jurisdiction of MSEDCL ○ Listing of power ratings of individual appliance variant and common daily usage duration for each type of appliance ○ Develop back-end logic model for data analysis and design portal modules that can be integrated with existing website

2. Khon Kaen Municipality, Thailand

Capacity building for Khon Kaen

1. Trainning session 1

Definition of Low Carbon Model Town

First, this session provides overview of Global Warming and Climate Change which includes root-causes, and concrete implementation framework to tackle with those issues at international and local level. As well as the conceptual of APEC low-carbon model town and general development procedures are described to create an understanding about the Project; and variety cases study (best practice) on low-carbon city can provide clearly picture to the trainee.

1.1. Definition of Global Warming

This section provides the briefly definition of Global Warming and Climate Change situation; therefore, the trainee should understand the current global environmental concerns under this session. The definition is "Global Warming is caused by an increase in the global average temperature, whether surface or ocean temperature and leads to the Climate Change situation. Human activities are a major contributor to the increase in greenhouse gas concentrations and caused Greenhouse Effect which is the currently root-cause of global warming"

1.2. International Agreement to Respond the Climate Change

Since trainee understood the global environmental concerns from previous session, this session illustrates the concrete collaboration framework among economies member and timeline to respond the Global Warming and Climate Change issue. Firstly, the initiation of framework through the first Conference of Parties (or COP1) in Y1979 is described and then the importance of establishment for United Nations Framework Convention on Climate Change (UNFCCC); also presents the definition of Annex I and Non-Annex I economy. The previous GHG emission reduction targets under KYOTO Protocol in Y2005 are explained.

For Thailand, the briefly of Thailand's Nationally Determined Contribution (or NDC) is described to trainee which is a commitment to reduce GHG emissions by 20-25% from projected BAU levels by 2030. Then, the Thailand Climate Change Master Plan B.E.2558-2593 is explained as the economy development pillar on Climate Change which bring to the latest economy target on the intention to achieve "Carbon Neutrality" within Y2050 and "Net Zero Carbon" within Y2065, respectively.

1.3. Conceptual of APEC Low-Carbon Model Town

In this regard, the key objective of this Project is described as "Promoting the development of Low-Carbon Model Town in the APEC region is to provide a fundamental concept for the central government and local governments of Member States in planning effective low-carbon policies and implementing appropriate measures which takes into account the economic situation, society and characteristics of the city". The conceptual of APEC Low-Carbon model town as shown in Figure 1-1 below.

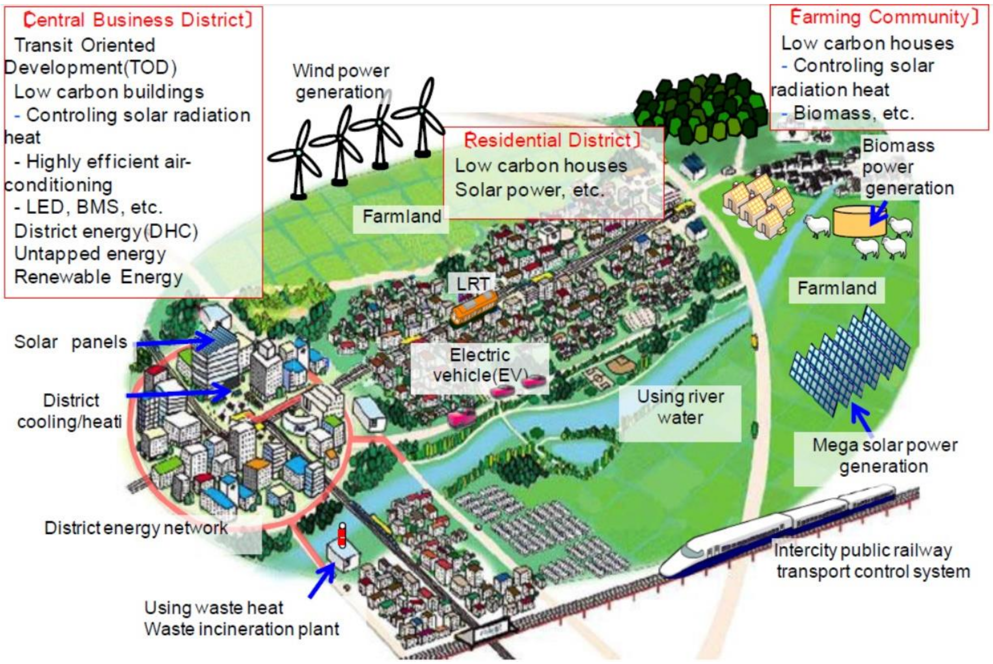


Figure 1-1 The concept of Low-Carbon Town in The APEC Region

1.4. Implementation Guidance to Develop APEC Low-Carbon Model Town

This session explains the research framework to achieve low-carbon model town under this Project which includes 8 main steps as shown in Table 1-1 and overalls methodology on the Project development as shown in Figure 1-2, respectively:

Table 1-1 Research Framework to Achieve Low-Carbon Model Town

Step	Detail
1	Background research and data collection
2	Develop a high-level Low-Carbon vision
3	Define the CO_2 emission baseline as BAU (Business as Usual) scenario
4	Define comprehensive, specific, and feasible Low-Carbon measures • Define CO_2 emission reduction and environment target of the town • Prepare a low carbon guideline for categories of low carbon town design challenges • Select CO_2 emissions reduction measures in design
Analyze CO_2 emissions reduction and costs for selected design measures	
5	Perform scenario analysis of implementation alternatives and analyze CO_2 reduction efficiency
Study the implementation methodology and action plans of proposed CO_2 reduction measures	
6	Identify regulatory agencies and approval process and develop the business model required for Low-Carbon Methodologies in three volunteer towns
7	Governance development • Governance vision • Training / Education
8	Analysis financial efficiency of Low-Carbon business model in three volunteer towns

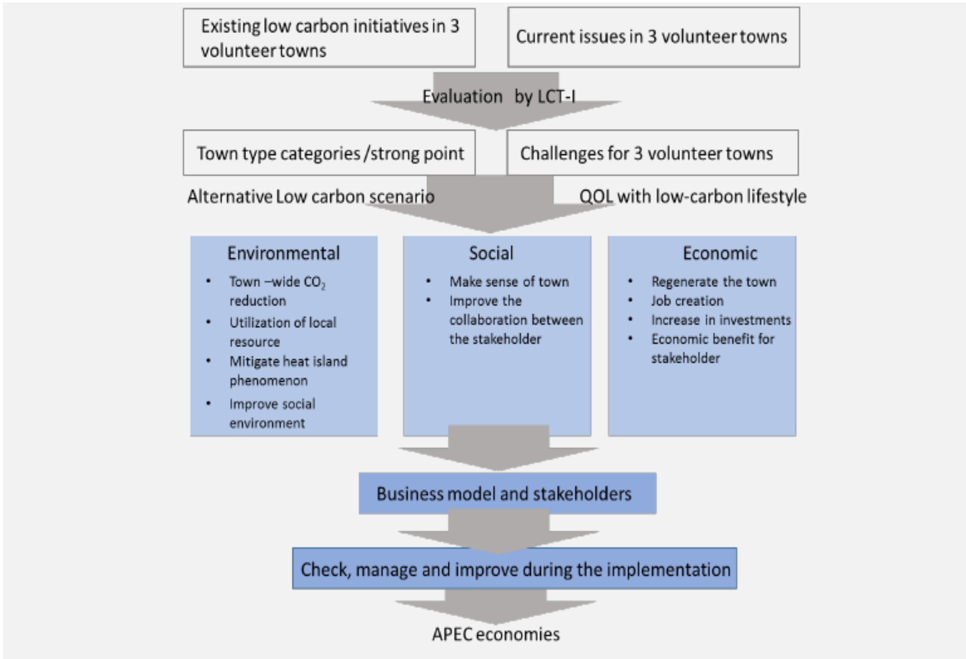


Figure 1-2 Overalls of the Project Development

Assessment targets of Low-Carbon measures comprised 5 major items (Tier 1), 14 mid-level items (Tier 2) and 36 lower-level items (Tier 3), as shown in Table 1-2. As well as this session aims to emphasize on the level which applied to identify measures for Khon Kaen, Tier 2 indicators.

Table 1-1 Assessment Targets of Low-Carbon Measures

Tier 1	Tier 2	Tier 3
Demand Side	1. Town Structure	1. Adjacent workplace and residence 2. Land use 3. TOD
	2. Building	1. Energy saving construction 2. Green Building or Low Carbon Building
	3. Transportation	1. Promotion of public transportation 2. Improvement in traffic flow 3. Introduction of low carbon vehicles 4. Promotion of effective use
Supply Side	4. Area Energy System	Area Energy
	5. Untapped Energy	Untapped Energy
	6. Renewable Energy	Renewable Energy
	7. Multi Energy System	Multi Energy
Demand & Supply Side	8. Energy management system	Energy management of building / area
Environment & Resources	9. Greenery	Securing green space
	10. Water management	Water resources
	11. Waste management	Waste products
	12. Pollution	1. Air 2. Water quality 3. Soil
Governance	13. Policy framework	1. Efforts toward a low carbon town 2. Efforts toward sustainability
	14. Education and management	A life cycle management

1.5. Current Conceptual of Khon Kaen SMART CITY and Cases Study

Due to Khon Kaen had developed their SMART CITY development pathways, this session aims to provide the linkage idea between current conceptual of Khon Kaen SMART City (Table 1-3) and APEC Low-carbon Model Town. This able to create a clearer picture in terms of the impacts of Smart City on Low-Carbon Model Town.

Table 1-2 Current Conceptual of Khon Kaen SMART City

	Detail
Smart Mobility	Smart Traffic Light / LRT / Shuttle buses / Smart bus shelter / Effective TOD / Drone and RTK for transportation / Smart Loop / Public EV
Smart Living	Medical and Healthcare Application Services / City management by apply IoT / CCTV and Drone / Smart and Emergency single App / Smart Home
Smart Economy	Development in TOD in urban design context / Smart Farming / E-San (Northeast region) Trading Center
Smart Citizen	Capacity building and create community participation by IoT / Smart Education / Creative space in city / Smart volunteer
Smart Environment	Create green spaces along the public roads / waste management at source / Promote Green Building / Promote RE
Smart Governance	Apply IoT to communicate government information to people / E-Government / Apply Drone to explore and gather data to improve town plan / Innovation and Digital Park / Limited company of local administration

The case study on low-carbon city applied from three effective cities (London, New York City, and Singapore) which have solid GHG mitigation measures for each sector, clear timeline, and target. This might provide the general ideas of GHG mitigation measures which corresponds with city current characteristic, priority, and environmental concerns; as shown in Table 1-4 to Table 1-6, respectively.

Table 1-3 Case Study on London, United Kingdom

Timeline	Detail
Y2041	80 percent of transportation will rely on walking cycling and public transportation (increase from 68 percent)
Y2033	All Taxi and car rental in London will EV
Y2037	All bus in London will EV
Y2050	All type of vehicle in London will EV
Implementation Guidance	
• Develop a resilient, low or zero-carbon energy infrastructure that allows London to generate more of its own energy and that is secure and scalable long-term. • Implement a “Healthy Streets” approach, cutting down on car traffic to make local streets more pleasant for pedestrians. • Build the biodiesel industry to fuel government-owned vehicles, which is also good for green jobs. • Improve energy efficiency in buildings. RE:NEW is helping many organizations carry out renovation projects to make buildings more energy efficient. By January 2017, RE:NEW had helped improve 127,500 London homes with energy savings of 46,000 tons of CO2 per year. • Replace and repair Londoners’ inefficient and broken boilers with the £1m Better Boilers fund, saving 310 tons of carbon emissions a year.	
Target	
“Zero-carbon city by 2050”	

Table 1-4 New York, United States of America

City GHG Mitigation Measures
• Reducing Demand Through Energy Efficiency and Demand Response • Decarbonizing the Gas Network with Renewable Natural Gas and Hydrogen • Reducing Methane Emissions at upstream level by transition to RNG and hydrogen • Integrate innovative technologies to decarbonize heat under any heating sector • Utilizing Large Scale Renewables with a 21st Century Grid e.g. solar, wind • Utilizing Energy Storage from RE • Eliminating Sulfur hexafluoride (SF6) which is used in electric networks for its insulating properties • Advancing Clean Transportation which will convert to a 100% electric fleet by 2030
Target
“Zero-carbon city by 2050”

Table 1-5 Singapore

City GHG Mitigation Measures

Target
"33 $MtCO_2e$ by 2050 and Net Zero"

2. Trainning session 2 and 3

Data Collection Procedures and Calculation Methodology for GHG Emission

Second, this session provides the example of data collection procedures within the city boundary, criteria to identify source of data, and methodology to calculate baseline emission in BAU scenario. As the results from CO2 calculation, the training contents should pay attention on building and transportation sector due to both are the significant city emission hotspot; as well as these sectors align with current city's priority and their Khon Kaen SMART CITY development pathways. The overview of this session on data collection and calculation on GHG emission as shown in Figure 2-1 below

Methodologies to Identify and Collect Data	Define CO_2 emission baseline in BAU scenario
<u>Data in demand-side</u> 1. Local economy 2. Lifestyle 3. Physical characteristics of the residential, buildings and transportation sector 4. Energy consumption in residential, commercial and transportation sector <u>Data in supply-side</u> 1. The current situation of energy supply 2. The energy resource structure 3. Infrastructure information of the city <u>Activity data survey</u> • Estimate energy consumption <u>based on current data</u>. • Estimate the data obtained <u>from the area (Secondary data)</u> • Estimate the data obtained from <u>online data</u> of the relevant authority	Data collection and define the baseline in BAU Scenario The methodology to identify BAU scenario in <u>residential, building, and transportation sector</u> • Evaluate from energy consumption in building • Evaluate for BAU in short-term and long-term 1. Evaluate from the GDP growth rate and energy consumption 2. The relationship with urban development <u>The principles to identify low carbon targets</u> • Low carbon targets must be realistic • Low carbon indicators • Targets and indexes will be composed of quantifiable • Targets and indexes will require ongoing efforts throughout the life cycle of the project

Figure 2-1 Overview of Data Collection and Calculation on GHG Emission

2.1. The Creation of Data Collection Methodology to Calculate City's GHG Emission

The effective data is very essential foundation to identify city GHG emission; therefore, this section provides basic principle to identify types of data, and its potential sources which corresponds with the specific city characteristic and activity. This section allows the city to apply as a guidance to optimize their further data collection procedures as the contents below.

1) Identify Type of Data

There are 2 main types of data includes:

- Primary Data is the first set of information to be used on the process. Such information can be obtained from the survey site by using the data collection template survey for interviews and record data. This type of information must not be selected or picked up from information previously collected by other parties or authorities.
- Secondary Data is the second set of information to be used. Such information can be obtained from authorities' summary report and are publicly available such as statistical reports, academic research, journal, or academic textbooks, etc.

2) Data Collection Procedures

There are 4 main data collection procedures which able to perform at the city. This allows the city to adopt the appropriate procedures according to their aptitude and prioritize.

- Directly Data Collection from Main Source – the data is directly obtained through on-site data collection activity and/or directly interview from the specified data source e.g. data on electricity consumption, waste management, etc.

- Data obtained from the Survey – Survey is a method for collecting data by using a questionnaire from sampling group, e.g. households, commercial, and government institution, state enterprise, etc. The survey process can be divided into 3 steps include 1) preliminary design, 2) perform data collection, and 3) final analysis of results, respectively.
- Data Evaluation from Supporting Sources – the data is collected from available sources e.g. authorities' annual report, website, etc. The example of data collected include amount of sewage, amount of waste, rate of energy consumption for buildings and transportation, greenery area.
- Data from Measurements – This data type is the most accuracy data and lower error; however, the significant challenge is higher implementation cost, appropriate with sampling size level (or small-scale) and time-consuming.

3) Potential Data Sources

This session provides the example of potential sources of data which used to calculate city GHG emission. The data source concentrates on both local and central government agency which the data quality is more reliable, transparency, continually collected as a general responsibility. Therefore, the example below shown the specific source of data which categorized by type of data.

- Electricity Consumption e.g., rate of electricity usage by public road, public park, which able to collect from PEA, or MEA.
- Electricity Consumption by Residential e.g., rate of electricity and LPG usage, which able to collect from the PEA, Department of Energy Business, or Nation Statistical Office.
- Electricity Consumption by Commercial Buildings e.g., rate of electricity usage by commercial business, rate of fuels consumption by department store, hotel, or hospital, which able to collect from PEA, DEDE (database on designated buildings), Department of Energy Business, or Nation Statistical Office.
- Community Wastewater e.g., rate of annual sewage, existing treatment system, number of plant and its capacity, which able to collect from the Municipality Development Plan, or Provincial Waterworks Authority.
- Municipal Waste e.g., rate of annual/dairy waste generated in the municipality, and its components, treatment methods (generally channeled to landfill) and its capacity, which able to collect from the Municipality Development Plan.
- Energy Consumption by Transportation Sector e.g., travelling distance, rate of fuels usage by vehicles, which able to collect from the Department of Land Transport, Provincial Transport Office, National Statistical Office, etc.
- Forest Area and Green Area e.g., total forest area and available in the city boundary, utilized space, which able to collect from Provincial Agricultural Extension Office, land develop department.

2.2. Calculation for CO2 emission baseline in BAU scenario

This session provides simple methodology to calculate city GHG emission in BAU scenario which concentrates on buildings and transportation sector. The selection criteria on methodology consists of widely used in economy, convenience to perform calculation, and able to apply emission factor at local and international level. Therefore, the methodology is categorized into 2 approaches

Approach 1 : Bottom-Up Approach – In case the data can be directly applied for calculation:

- In case of GHG emissions generated by energy consumption: CO2 Emission = Energy consumption x Emission Factor
- In case of GHG emissions generated by fuel consumption: CO2 Emission = Fuel consumption x Emission Factor

Approach 2 : Top-Down Approach – In case the data cannot by directly applied for calculation:

- In case of GHG emissions generated by energy consumption:

  CO2 Emission = Energy consumption indicators (kWh/m2) x Total floor area of each building x Emission Factor

- In case of GHG emissions generated by fuel consumption:

  CO_2 Emission = Energy consumption indicators (MJ/m2) x Total floor area of each building x Emission Factor

- In case the GHG emissions generated by transportation sector which the data on fuel consumption are not available:

  CO_2 Emission = Number of trips x travelling distance x Heating value

2.3. Calculation of Emission reduction

The calculation on amount of GHG emission reduction is crucial to identify the Project outcomes; this can be done by the comparison on amount of GHG emission between baseline emissions (BE) and total GHG emissions reduction from the project emissions/measures (PE) which the equation below shall be applied:

Total GHG Emission Reduction = Baseline Emission (BE) – Project Emission (PE)

3. Trainning session 4

Procedures to Identify GHG Mitigation Recommendation and Measures

This session allows trainee to realize the Project outcomes and understand the simple principles to identify potential GHG mitigation options. As stated in previous session, both building and transportation sector are the significant city emission hotspot and align with their priority under Khon Kaen SMART CITY development pathways. Therefore, this session does not only provide the comprehensive information on Project outcomes (GHG mitigation measures and its potential in terms of amount of CO2 reduction) but also examine on sample procedures to identify GHG mitigation recommendation and measures which concentrate on 1) Buildings and 2) Transportation sector, respectively

3.1. GHG Mitigation Recommendation and Measures for Building Sector

Under the Project, the buildings sector is categorized into 2 types include 1) residential (household), and 2) commercial building. The key results of GHG mitigation measures (as shown in Table 3-1) are introduced as an overview of this session and prepare the trainee for deeply explanation in each recommendation and measures.

Table 3-1 Overview of GHG Mitigation Measures for Building Sector

Residential	Commercial Building
• Solar hot water installation • Utilization of natural light • Improvement of heat Insulation • Apply LED for lighting system • Enhanced protection system against heat and UV ray • Solar PV rooftop installation • Energy efficiency of appliance	• Promote energy efficiency on appliance • Improvement of heat insulation • Improve cooling system and utilization of natural light • Improve the efficiency of equipment • Energy management system

The Project outcomes focus on the conceptual of “Zero Energy Buildings” which shall be able to minimize the amount of energy consumption at least 50 percent compared with reference building; and focus on the installation of renewable energy systems. Also, this type of buildings should be designed under the conceptual of less-energy consumption and self-produced energy through various technologies applied. Therefore, this content intended to provide the design conceptual for “Zero Energy Buildings” which corresponds with the geography of economy, and city characteristic. This allows the city to understand the sample principle to develop energy efficiency in buildings as shown in Figure 3-1 below.

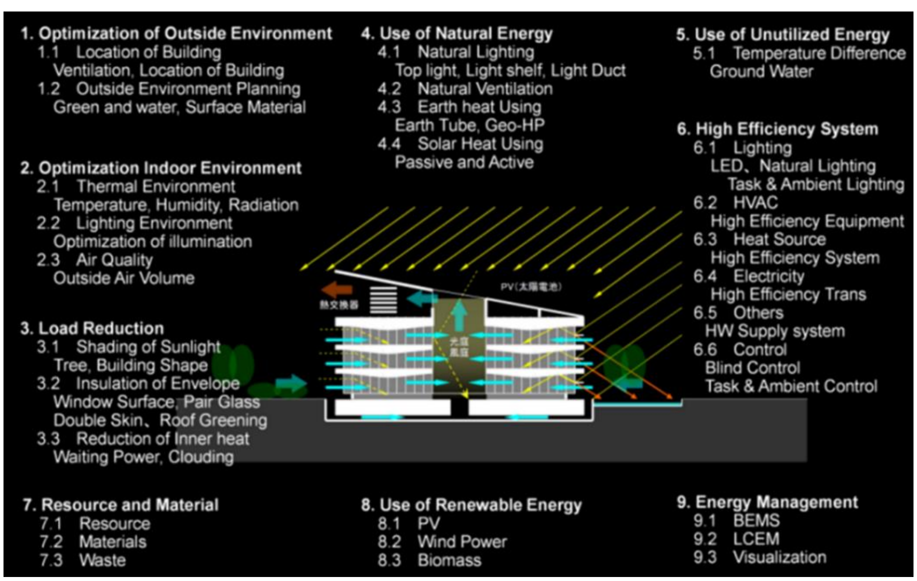
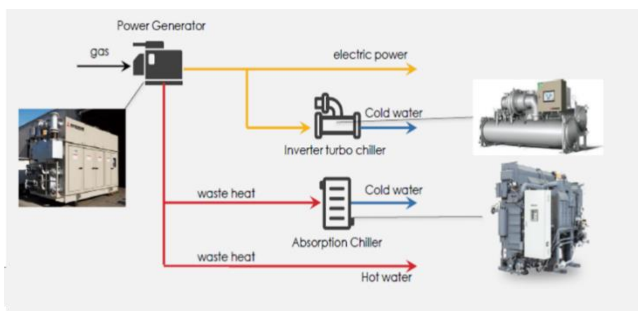


Figure 3-1 Conceptual of Zero Energy Buildings

Additionally, this section also provides other Project outcomes on energy management recommendation in building sector as shown in Table 3-2 and illustrates the results of GHG emissions reduction against the mitigation measures as shown in Figure 3-2.

Table 3-2 Project Outcomes on Energy Management Recommendation

<table>
<tr><th>Area of Energy Management</th><th>Recommendation</th></tr>
<tr><td>Untapped Energy</td><td>Focus on 2 aspects include:
<table>
<tr><th>Heat Exhaust</th><th>Temperature difference energy</th></tr>
<tr><td>Utilization of waste heat from:
• Factories
• Cleaning plants
• Substations
• Ultra-high voltage underground power lines
• Heating and cooling of subways and underground malls</td><td>Utilization of heat from:
• Domestic wastewater, sewage, and geothermal heat
• River water and seawater</td></tr>
</table></td></tr>
<tr><td>Renewable Energy</td><td>Concentrate on solar energy which is potential renewable energy in Thailand includes:
• Solar PV rooftop installation in PPA scheme
• Solar hot water installation
• Solar floating at the available reservoirs e.g.
- About 50,000 m^2- Bangkok Hospital Khon Kaen by 2030
- About 100,000 m^2- Ban Ped Sub-district by 2050</td></tr>
<tr><td>Multi Energy System</td><td>

Focus on Cogeneration or Trigeneration
The system performance is over 80% and able of apply with large group of buildings (Mixed Use)</td></tr>
</table>

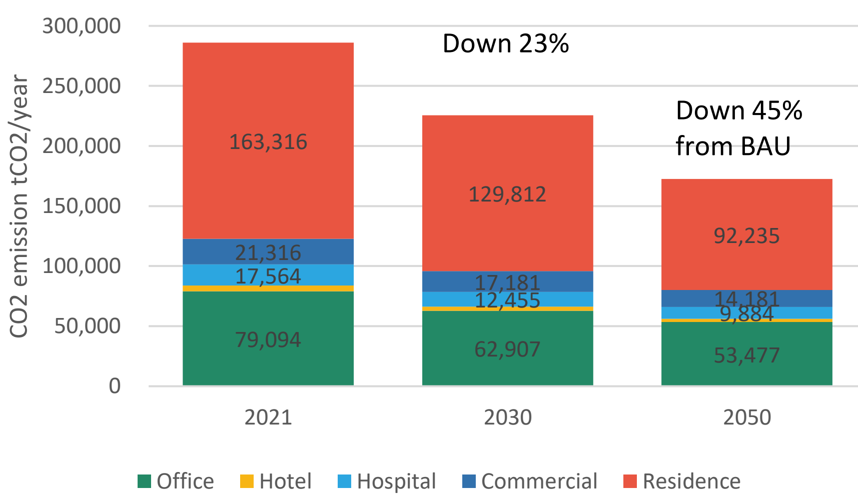


Figure 3-2 Results of GHG Emissions Reduction in Building Sector

3.2. GHG Mitigation Recommendation and Measures for Transportation Sector

Development in transportation sector is one of the top priorities under current Khon Kaen SMART CITY plan. Under this circumstance, the Project outcomes and this section focus on the improving of public transportation, TOD, LRT establishment, and shifting to EV, respectively (the details as shown in Table 3-3) which these are key concept to enhance the achievement of Khon Kaen SMART CITY and minimize the GHG concentration as shown in Figure 3-3.

Table 3-3 Project Outcomes on Transportation Recommendation

<table>
<tr><th>Recommendation</th><th>Detail</th></tr>
<tr><td>Developing new LRT lines</td><td>This recommendation aligns with the current city development pathways – the significant purpose is to minimize the numbers of personal car usage through the establishment of LRT.
The rate of GHG emission reduction as shown below:
<table>
<tr><th></th><th>Vehicle</th><th>Y2030</th><th>Y2050</th></tr>
<tr><td rowspan="2">Shift to LRT</td><td>Car</td><td>15%</td><td>30%</td></tr>
<tr><td>Motorcycle</td><td>10%</td><td>20%</td></tr>
</table></td></tr>
<tr><td>Developing a TOD City along the LRT lines</td><td>Integrate TOD with the city development pathway and the design concept of LRT rail and station should comply with TOD.
The rate of GHG emission reduction as shown below:
<table>
<tr><th></th><th>Vehicle</th><th>Y2030</th><th>Y2050</th></tr>
<tr><td rowspan="2">TOD</td><td>Car</td><td>5%</td><td>10%</td></tr>
<tr><td>Motorcycle</td><td>5%</td><td>10%</td></tr>
</table></td></tr>
<tr><td>Shifting Petrol Vehicles towards EV</td><td>Promote private EV vehicle in the city to minimize petrol vehicle.
The rate of GHG emission reduction as shown below:
<table>
<tr><th></th><th>Vehicle</th><th>Y2030</th><th>Y2050</th></tr>
<tr><td rowspan="2">EV</td><td>Car</td><td>10%</td><td>30%</td></tr>
<tr><td>Motorcycle</td><td>20%</td><td>40%</td></tr>
</table></td></tr>
<tr><td>Introducing a New Personal Mobility</td><td>Such as electric kickboard, sharing bicycle, etc.</td></tr>
</table>

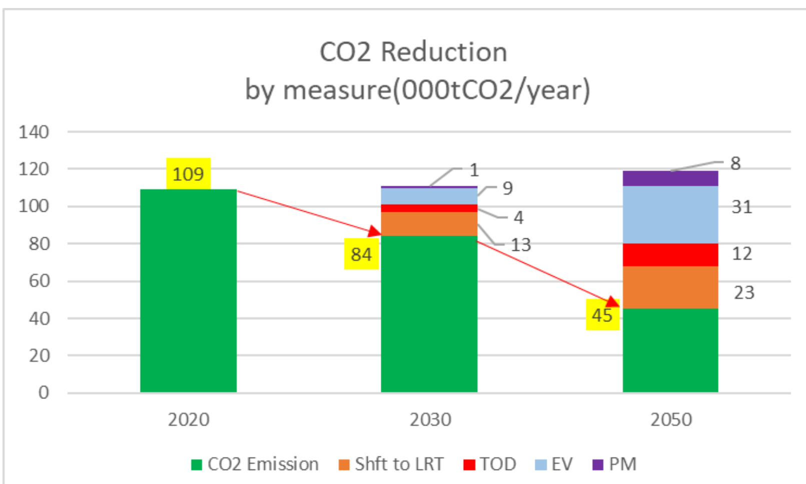


Figure 3-3 Results of GHG Emissions Reduction in Transportation Sector

4. Trainning session 5

Expected Outcomes from the integration of GHG Mitigation Recommendation and Measures

This session provides the explanation of expected outcomes from the integration of GHG mitigation recommendation and measures under this Project. The content includes sample methodology to identify effective low-carbon measures, variety criteria (or matrix) to evaluate the achievement of Low-Carbon Model Town development and responsibility of local administrations and people sector to create sustainable low-carbon town, respectively.

4.1. Methodology to Identify Low-Carbon Measures

This section illustrates the sample methodology to identify effective low-carbon measures and/or policy which should correspond with city characteristic and priority; also, the low-carbon measures is essential to integrate with the future City Development Plan. The sample methodology includes 4 key steps as the detail shown in Table 4-1 below.

Table 4-1 Methodology to Identify Low Carbon Measures

Step	Detail of Methodology under this Step
1. Data on City GHG Emission	This step should include the completely information about • City GHG emission results under BAU scenario • Effective GHG mitigation options which should comply with the city characteristic and priority
2. Create City Development Plan	To define the effective GHG mitigation measures, the city shall perform 1) Public hearing from stakeholders related and 2) Consultation among the Municipality to identify the potential of measures. The significant criteria to consider should include but not limited to: • Authority and responsibility of each institution to implement the GHG mitigation measures • Source of financial support on each GHG mitigation measures • Finalize City Development Plan which includes GHG mitigation measures (with suitable business model) • Identify city's working group * These actions might be integrated with the Municipality Development Plan as one of the city's KPIs and usual activity.
3. Action Plan on City Development	After the variety of GHG mitigation options are effectively identified, the city should integrate with the City Development Plan and create further action plan to accelerate the implementation; e.g. Municipal GHG Reduction Roadmap 2020 – 2030. The action plan should identify the timeframe of every measure in terms of short-terms, medium-terms, and long-terms measures; this allows the city to prioritize their tasks along the action plan. Then, the city can perform the GHG mitigation measures.
4. Review the current GHG situation	Once the GHG mitigation measures are all implemented, it is essential to identify the MRV framework (Monitoring, Reporting and Verification) to tracking the progress of GHG emission reduction. The MRV report should include but not limited to amount of GHG emissions and removals by sinks, mitigation actions and their effects, and support needed and received, respectively. *The evaluation against KPIs should perform under this session to identify the potential and achievement of GHG mitigation measures.

4.2. Matrix to Evaluate the Achievement of Low-Carbon Model Town

Once the GHG mitigation measures are identified and already integrated with the City Development Plan, it is very essential to determine the matrix to evaluate the potential and achievement of GHG mitigation measures against several performance indicator. The matrix is a significant tool to scoring on the level of achievement for each indicator includes policy, responsibility, data management, communication and training, finance and investment, procurement, monitoring and evaluation as shown in Figure 4-1 below.

	Policy	Responsibility	Data Management	Communication & Training	Finance & Investment	Procurement	Monitoring & Evaluation
5 Best	Specific, Measurable, Achievable, Relevant and Time-bound targets with senior buy-in. Clear delivery plan with aims and progress reviews. Associated strategy document.	Clearly defined roles and communication channels. Dedicated management, with senior stakeholder commitment and engagement	Defined and reliable data collection, collation, storage and availability. Complete coverage of required estates and data areas.	Topic-specific induction and training. Dedicated team commitment and monthly engagement and reporting Holistic stakeholder engagement strategy.	Project appraisal with defined investment criteria. Finance engagement across teams, including financial reporting. Ring-fenced project fund and active assessment of funding.	Competitive tending for high-quality and reliable equipment, with well- defined works contracts supported with legal review. Understanding of legislation. Use of frameworks, or registers for large-scale works.	Ongoing monitoring and evaluation of project performance, and topic-specific strategy at senior level. Project performance assessed with measurement & verification (IPMVP)
4	Targeted policy, with clear delivery plan and progress reviews, developed. Further refinement and importance required to leverage impact.	Specific management identified, but limited support. Some stakeholder engagement and senior support but limited due to being under-resourced.	Data management covering most aspects of topic/estate-but not all encompassing, up to date, or digitalized for storage.	Regular communication internally with stakeholders, including circulation of reporting. Engagement and training intermittent.	Some opportunity appraisals, quarterly financial reporting, and cross-team engagement. No dedicated pot available for topic-specific projects. Some understanding of other funding options.	Competitive tendering for project works, but of limited scale (not large-scale multi-site projects). Understanding of legislation, but limited capability and legal input to work contracts.	Regular project review and management performance review with some senior engagement. Limited strategy performance review.
3	Policy in place but out of date/not relevant/not topic specific. Shows senior commitment but no direction for ongoing engagement.	Topic area is part-time responsibility of a few staff, some stakeholder engagement, but no senior input.	Some data management of topic/estate data, but not all encompassing, and significant gaps in data. Collection of data is unreliable.	Regular dedicated team communication and reporting. But no circulation or engagement to wider stakeholders. No specific training to staff.	Ad hoc financing for topic-specific projects. Limited opportunity appraisal and annual financial reporting.	Competitive tendering but no formal procurement process followed. No formal works contracts used or legal input.	Regular team evaluation of performance and projects, but no senior input. No review of management approach.
2	No specific policy, and no topic coverage or direction in other policies or strategies. Mission aspiration at senior level, but not defined or communicated.	Topic is part-time responsibility of an individual, but no resource or importance given to. Not a role of responsibility that can make an impact. No stakeholder support.	Minimal collection of topic/estate data, but not consolidated or stored in an efficient manner. Minimal granular data available.	No regular dedicated team meeting-only ad hoc team engagement. Reporting is not regular.	Ad hoc financing for topic-related projects. No opportunity appraisal or reporting.	Limited projects delivered, and those that are use informal direct procurement. No understanding of procurement legislation.	Ad hoc reviews of performance, but no project reviews. No regular meeting.
1 Worst	No specific policy. No senior engagement or aspiration to formalize topic areas with policy.	No topic specific responsibility designation.	Specific or relevant data not complied.	Poor communication within team, no dedicated reports, and no stakeholder engagement or training.	No internal financing or funding for topic specific projects.	No topic-specific projects procured.	No specific monitoring or evaluation.

Figure 4-1 Matrix to Evaluate the Achievement of Low-Carbon Model Town

4.3. Role of People Sector and Local Government to Achieve Low-Carbon Model Town

It is the fact that both local people and local government are the significant sector to enhance the achievement of Low-Carbon Model Town. Therefore, Figure 4-2 and Figure 4-3 illustrates the example roles of people sector and local government (Municipality) to promote Low-Carbon Model Town.

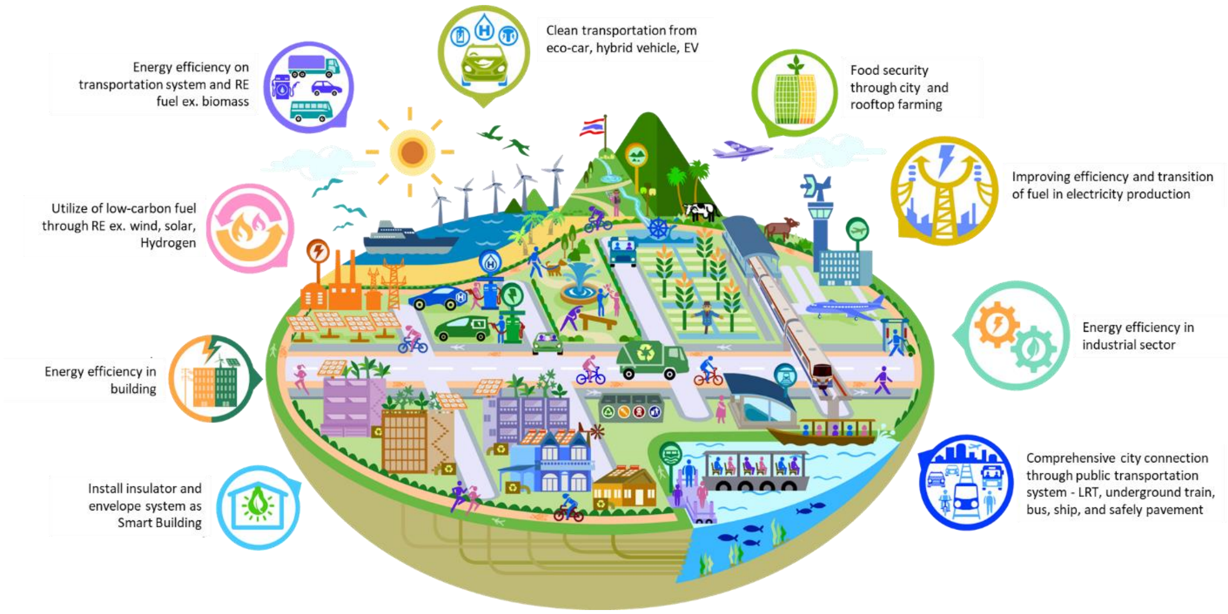


Figure 4-2 Role of People Sector to Achieve Low-Carbon Model Town

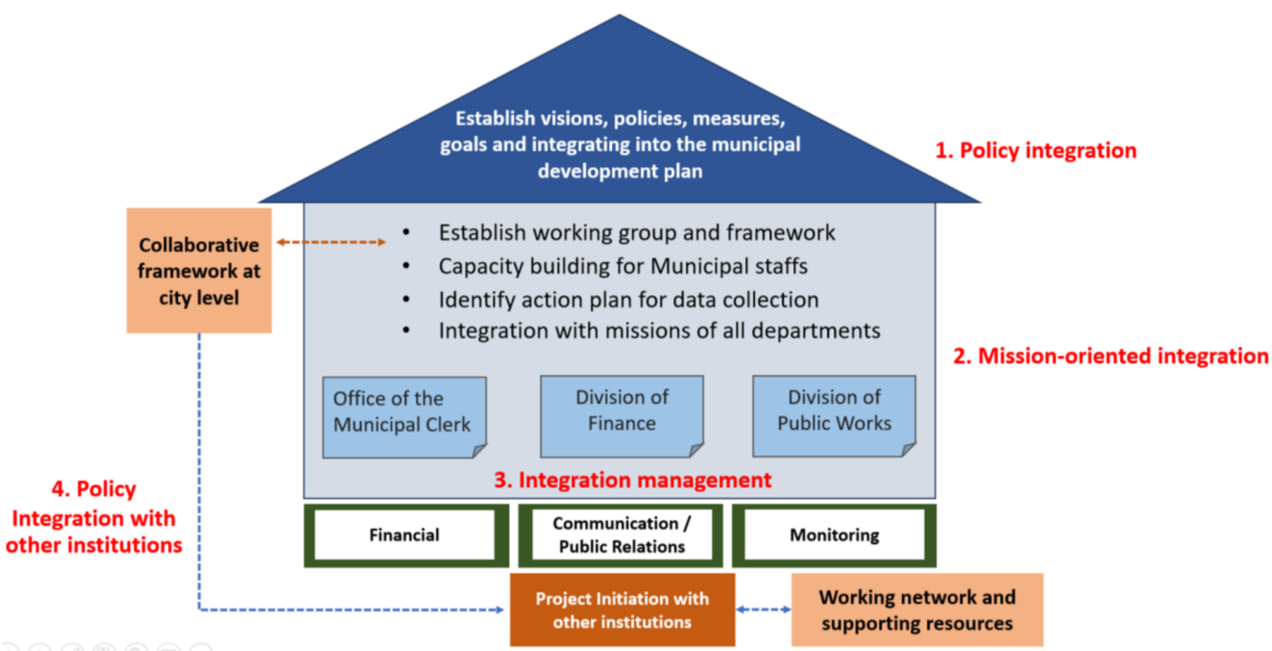


Figure 4-3 Role of Local Government to Achieve Low-Carbon Model Town

5. Trainning session 6

Business Model Development

This final session provides the explanation of different business models to enhance the achievement of Low-Carbon Model Town. The example types of low-carbon business model emphasize on building and transportation sector which is key energy consumption sector and align with the current city development pathways.

5.1. Low-Carbon Business Model

"Low-Carbon Economic" at organization level can be defined as the business operation with usual organization's activity that promotes electricity consumption reduction or energy efficiency and GHG emission reduction. The example of 7 key steps to develop a low-carbon business model as shown in Figure 5-1 and detail of each step shown in Table 5-1 below.

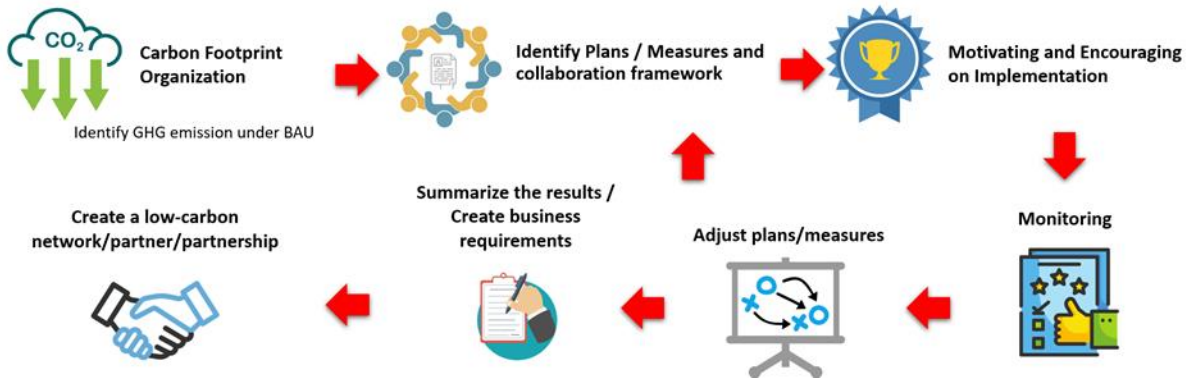


Figure 5-1 Example of Low-Carbon Economic Pathways

Table 5-1 Example of Low-Carbon Economic Pathways

Step	Detail
1. Carbon Footprint Organization	The first step is to quantify the Carbon Footprint Organization (CFO) under the BAU scenario. This allows the organization to identify the hotspot activity and being as an essential data for next step.
2. Identify plans/measures and collaboration framework	The organization should identify GHG mitigation measures and plan which apply CFO as a key information. Also, the plans/measures should align with the organization situation and priority. Then, the strong collaboration framework among internal and external organization should be well-identified to determine role and responsibility of each institution.
3. Motivating and encouraging on implementation	To accelerate the implementation, it should identify motivating and encouraging strategy among institutions to ensure continued implementation of GHG mitigation measures.
4. Monitoring	The monitoring procedures should be identified to tracking the progress of GHG emission reduction and their effects. This step is to ensure that the mitigation measures are effectively implemented and avoid any risks.
5. Adjust plans/measures	Once the monitoring results show lower than expected, it is essential to reprocess and reconsideration on Step 2 (Identify plans/measures) – the plans/measures adjustment process should apply the information from previous steps as significant guidance to identify new plans/measures.
6. Summarize the results and create business requirements	This step is to summarize the results of potential GHG mitigation plans/measures which will apply as one of the important criteria to create business requirements.
7. Create a low-carbon network/partner/partnership	This step is to prepare stakeholders to ready for implementation through the creation of strong low-carbon network/partner/partnership.

At city level, Figure 5-2 shown the example conceptual of low-carbon business model which the city requires to perform 5 key dimensions and synchronize with SMART TECHNOLOGY development.

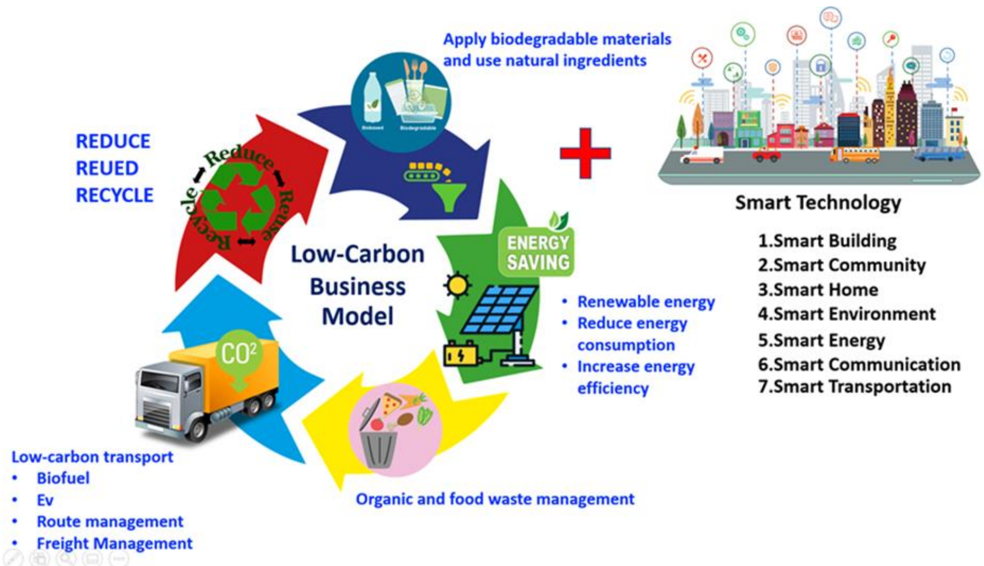


Figure 5-2 Example Conceptual of Low-Carbon Business Model

5.2. Types of Business Model to Enhance Low-Carbon Model Town

The example types of low-carbon business model emphasize on building and transportation sector which is key energy consumption sector and align with the current city development pathways. This aims to provide the idea for the city to understand the key conceptual of possible business model and align with city characteristics which details as shown in session below.

1) Business Model for Building Sector

The building sector should apply the services from ESCO (Energy Service Company) to drive the energy efficiency program which is key dimension for this sector to reduce energy consumption and able to convert to GHG emission reduction. The conceptual of ESCO and possible business scheme which focuses on Power Purchase Agreement (PPA) for RE as shown in Figure 5-3 and Table 5-2 below.

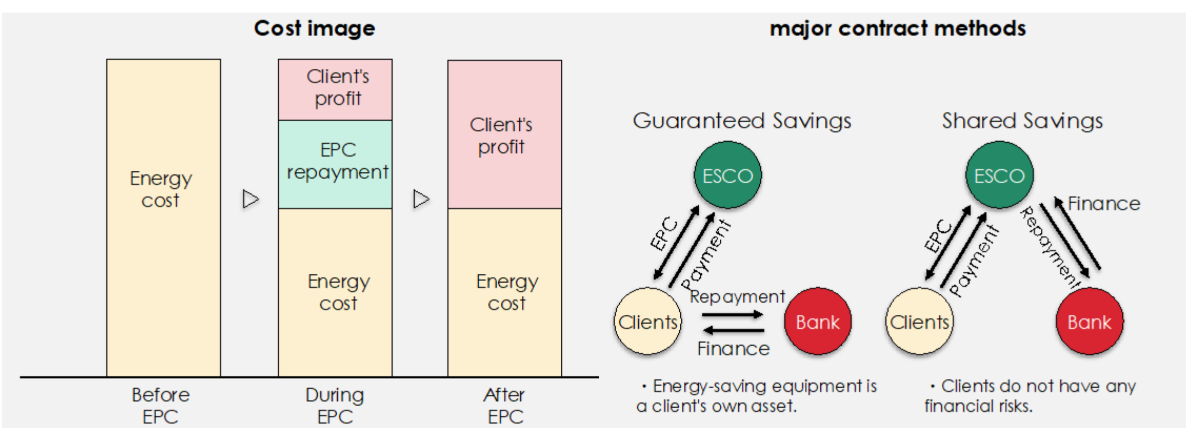
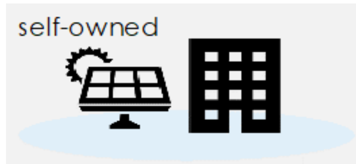
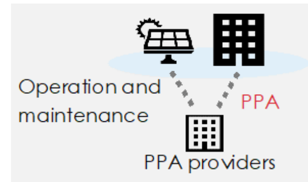


Figure 5-3 The Conceptual of ESCO

Table 5-2 Power Purchase Agreement (PPA) for RE

	Self-owned	PPA
		
Owner of the PV	Self-owned	PPA providers
Initial investment	Necessary	Unnecessary
Maintenance	Necessary	Unnecessary
Electric utility charge	Free for self-consumption	Self-consumption also charged
Capitalization	On-balance sheet	Off-balance sheet
Project period	Return on investment in 10 years	Contracts on 10 years or more

2) Business Model for Transportation Sector

The transportation sector is essential sector for the city to enhance Low-Carbon Model Town due to this sector is already integrated with the SMART CITY development plans and City Development Pathways. This session provides the additional information on possible business model which the potential scheme and stakeholders are identified as guidance for the city. There are totally 5 possible business models which are developed, and the details as shown below:

- Mass Transit and Transportation Services : This scheme aims to enhance the potential of city public transportation services by create new framework between local government and private business. The local Government agencies or other relevant agencies who owned the traffic information platform in the specific area will develop the application service on city traffic information; then, general users and existing private businesses such as Grab, taxi, etc. can access to the application and obtain the real-time data on traffic information, EV charging station, car rental location, etc. as shown in Figure 5- 4.

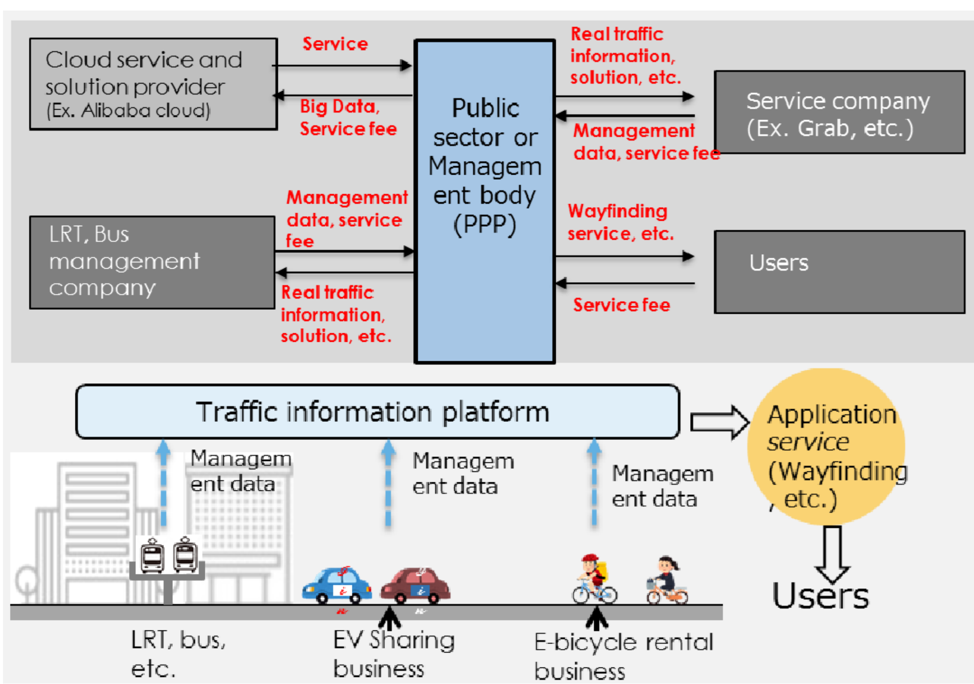


Figure 5-4 Mass Transit and Transportation Services

- Transit-Oriented Development or TOD : This scheme is one of the current city transportation projects which aims to integrate urban places designed to bring people, activities, buildings, and public space together, with convenience and safe for walking and cycling; also, the public vehicle should be available to connect people to the rest of the city. Therefore, the session provides additional ideas about TOD through the establishment of public vehicle storage facilities, enhance areas management, and improve the public bus business, as shown in Figure 5-5.

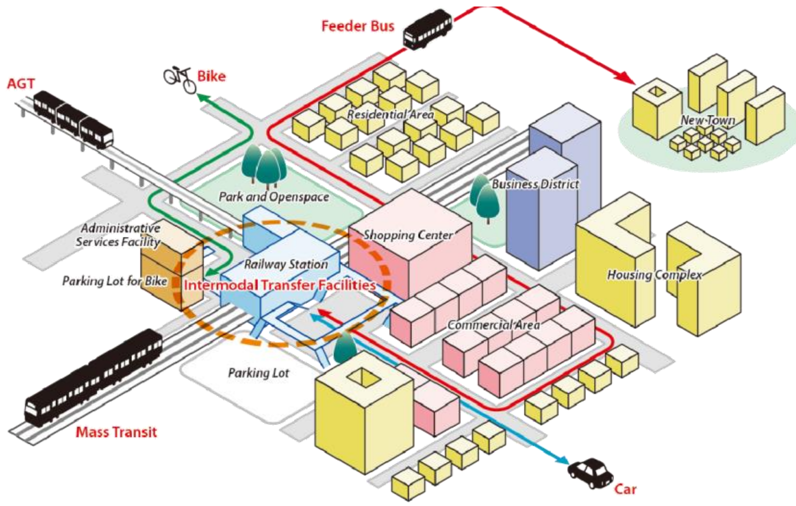


Figure 5-5 Transit-Oriented Development or TOD

- Establishment of vehicle storage business : This scheme is to create additional storage facility which able to improve the limitation of parking-space in urban area and allows people to connect with other modes of public transportation as shown in Figure 5-6.

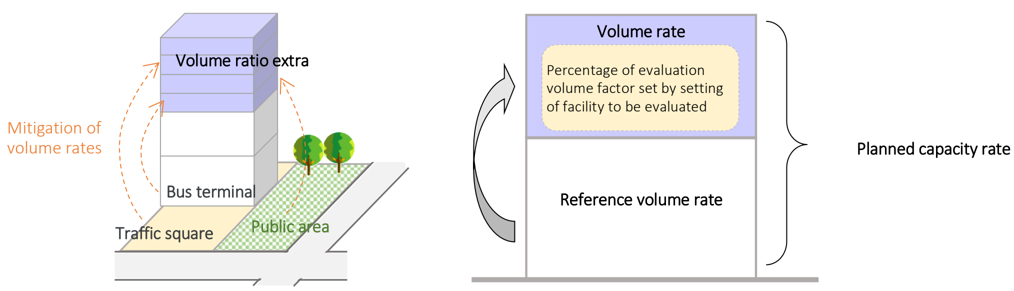


Figure 5-6 Establishment of Vehicle Storage Business

- Area management business : This scheme is to emphasis on the establishment of "Area management group" which the purpose is to provide the services on creating new utilization spaces, planning, maintenance, and others management within the area of TOD. Additionally, the plan certification, final decision, and financial support are granted by the Municipality and creates the collaboration framework with local stakeholders, business operator, to reflect the local requirement and contribution collection as shown in Figure 5-7.

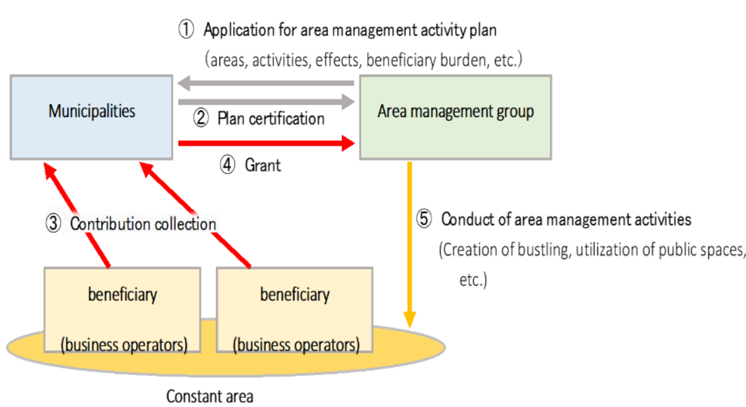


Figure 5-7 Development of Public Bus Busines

5.3. Sustainable of Low-Carbon Business Development

The most significant target of low-carbon business development is to implementing with sustainable practice. Therefore, this section provides list of indicators in 3 key aspects (includes environmental, economy, and social) as shown in Table 5-3 which the city shall be well-performed and thoughtful systematic review to ensure the sustainability low-carbon business development.

Table 5-3 Indicator to ensures the Sustainable of Low-Carbon Business Development

Aspect	Indicator
Development in Low-Carbon and Sustainable in Environmental Aspect	1. The use of natural resources that can be restored to its original and reduce emissions. 2. Effective management to mitigate global warming and climate change 3. GHG emission reduction in the organization 4. GHG emission reduction in the products 5. Promotion of rewards related to change climate
Development in Low-Carbon and Sustainable in Economy Aspect	1. Implementation under the Sustainable Development Goals 2. Risks and opportunities of businesses associated with climate change 3. Targets and indicators for GHG emission reduction that related to business operations 4. Carbon-trading mechanism
Development in Low-Carbon and Sustainable in Social Aspect	Stakeholder engagement to reduce GHG emission 1. Employee 2. Suppliers 3. Customer 4. Social 5. Partnership

Reference

1. UN Environment Programme. (2017, November 16). Retrieved from UN Environment Programme: https://www.unep.org/news-and-stories/story/london-aims-be-zero-carbon-city-2050

2. NYC Mayor's Ofiice of Climate and Sustainability. (2021, April 15). Retrieved from NYC Mayor's Ofiice of Climate and Sustainability: https://www1.nyc.gov/site/sustainability/our-programs/carbon-neutral-nyc-pr-04-15-2021.page

3. Charting Singapore's Low-Carbonand Climate Resilient Future. (2020). National Climate Change Secretariat.https://unfccc.int/sites/default/files/resource/SingaporeLongtermlowemissionsdevelopmentstrategy.pdf

3.Phu Quoc District, Kien Giang Province, Veit Nam

Capacity building for Phu Quoc

1. Introduction

While the previous sections provide insights of the magnitude of the waste management, emissions from transport vehicles and climate change adaptation in Phu Quoc and the potential interventions for emission reduction, institutional capacity to support implementation also needs to be developed simultaneously. Along with institutional capacity, awareness building among citizens will also help stimulate participation from citizens to accelerate the movement towards a Low-Carbon Model Town concept. With increased activity in low-carbon transformation of Phu Quoc, institutional strengthening by capacity addition both in terms of human resource and infrastructure to support both implementation as well as effective monitoring and evaluation of low-carbon interventions can also be undertaken in future.

In order to formulate a project-specific framework for capacity building activities on low-carbon transformation of Phu Quoc, United Nations Development Assistance Framework (UNDAF)'s guidance on Capacity Building was reviewed[29].

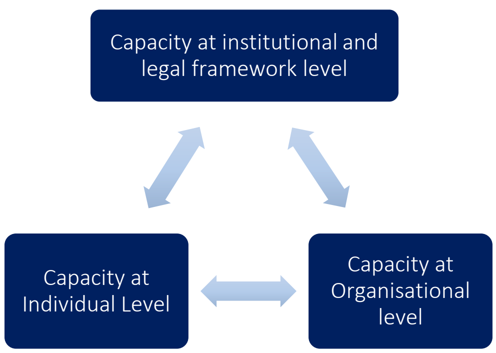


Figure 1: Interconnected levels of capacity building as per UNFPA

The guidance shows three interconnected levels that need to be targeted for effective capacity building at on organization level. In case of Phu Quoc municipality, this would imply develop institutional capacity by having requisite tools to support low-carbon urban transformation, appropriate organization structure to for allocation of responsibilities to support transformation process and capacity of individual human resources present in the organization to undertake relevant tasks. While tasks related to organization structure are beyond the scope of the project, capacity building of human resources will be addressed in this document.

An additional layer to this organizational capacity is community engagement to ensure citizen participation in the low carbon transformation program.

Based on this understanding, this document aims to achieve the following objectives:

1. Activities to be undertaken by Phu Quoc municipality to increase capacity of relevant staff members in assessing city-level GHG scenario; identification, assessment and implementation of low-carbon interventions
2. Propose interventions to help improve awareness of citizens on the need and benefits of low- carbon growth path for the city as well as need for their active participation to facilitate implementation
3. Propose interventions to engage non-governmental agencies to support capacity and awareness building activities

In order to achieve the stated objective, the following information areas have been elaborated:

1. List of interventions to support institutional and community level capacity building
2. Global case studies providing examples of successful implementation of identified interventions
3. Implementation plan to assist Phu Quoc officials in implementing identified interventions

The following sections elaborate the areas listed above.

[29] Source: Capacity Development UNDAF Companion Guidance (UNDAF, 2017)

2. Capacity Building interventions

Summary of interventions

As mentioned in the previous section, this document aims to enhance awareness of relevant stakeholders on low-carbon transformation as well as improve capacity for assessment and implementation of low-carbon interventions. Based on this understanding, the following interventions have been proposed:

<table>
<tr><th>Type of activity</th><th>Brief description</th><th>Intended audience</th></tr>
<tr><td rowspan="2">Training/ Workshop</td><td>• Dissemination of benefit and implementation guidelines for recommended interventions across each Government department.
• Guidelines on efficient energy use to be communicated to citizens</td><td>Government departments</td></tr>
<tr><td>• Training on proposed interventions to support in community outreach initiatives for awareness building or supporting implementation activities</td><td>Citizens, NGOs and private sector operating in sustainability space (eg.: Evergreen labs, IUCN,)</td></tr>
<tr><td>Media communications</td><td>• Design Behaviour change campaigns focused on specific user-groups and functional areas.
• The campaigns will help identify areas where emission reduction can be achieved by changing patterns of energy usage and waste management behaviour in residential, commercial buildings.
• Communication of benefits of efficient energy use & practices, waste segregation/recycling to achieve it through multiple media</td><td rowspan="2">Government Officials,
Communities
Citizens</td></tr>
<tr><td>Demonstration Model</td><td>• Introduce a demonstration model of Community-based forest management (CFM) in Phu Quoc in regards with the conservation and protection of Phu Quoc National Park</td></tr>
<tr><td>Household Business Model</td><td>• The legal and technical framework in Viet Nam and Kien Giang Province is being consolidated to encourage the introduction of rooftop solar PV at household scale through Feed in Tariff (FIT) and potential for Phu Quoc can be explored with a household scale business model.
• The capacity building is needed for multi stakeholders to make this model happen including government, private sector and citizens.</td><td>Government departmetn
Power Companies
NGOs
Citizens</td></tr>
</table>

Further elaboration of each set of intervention is given below, which provides detailed description of intervention, an implementation plan and accompanying case study exemplifying implementation concept.

3. Training / Workshop

3.1. Description of concept

The objective of this intervention is to develop institutional capacity as well as capacity of non¬government agencies to support assessment and implementation of low-carbon interventions.

A. For Government bodies

Government bodies in this respect entails specific departments within municipality organization like Town planning, Waste management etc. which be required to implement the interventions provided as part of project output. Accordingly, the indicative areas where trainings need to be imparted are given below:

- Developing Zero-Energy Guidelines and integration with municipal bye-laws
- Developing TOD System and urban traffic planning
- Developing Zero Waste concept for Phu Quoc
- Financing options for low-carbon interventions

The trainings can be in the form of

- Short-term, long-term, regular, refresher, face-to-face/online courses, etc. for different subjects, industries and fields
- Demonstration models, organizing sightseeing activities, learning experiences, ..
- Organizing exchange courses, seminars, workshops,
- Integrating in general education programs, various forms of information and communication, entertainment activities, art, advertising campaigns, etc.

B. For non-government organizations

Phu Quoc Municipality can collaborate with non-governmental organizations to extend citizen outreach possibilities as well as support responsible Government agencies in implementation. The Municipality can connect with NGOs operating in Viet Nam focusing on sustainable development and can contribute to the identified interventions for low-carbon model town for Phu Quoc.

An example of sustainable development-oriented NGO is IUCN, which operates in Viet Nam and undertakes implementation of sustainable development initiatives in nature conservation and waste management, apart from other areas.

The Municipality can engage with similar NGOs and undertake workshops to apprise representatives from such organizations on the initiatives planned for Low-Carbon development in Phu Quoc and probable methods to deliberate on how the organizations can assist in implementation.

3.2. Implementation Plan

A step-by-step approach for implementation of Training/workshops aimed at enhancing capacity is given below:

1. Conduct a rapid assessment of the areas where internal departments and other Government institutions require assistance in developing capacity for planning, implementing and subsequent operations of the identified Low-Carbon interventions. Typical areas that can be focused on are as follows:

   A) Explanation of low-carbon interventions and key actions required for implementation of intervention

   B) Compilation of processes and approvals along with most probable turnaround time, to support planning of infrastructure interventions

   C) Financing low-carbon infrastructure projects - process for exploring multi-lateral funding, Government funding and compilation of market-based financing options like public-private partnership

2. Identify external agencies (i.e. beyond Phu Quoc City) that are required to be involved in the project lifecycle like power distribution company (for Floating and Ground mount, rooftop Solar PV), local transport department (for TOD system, EV related initiatives), public works department (for wastewater management), environmental protection authority (for high efficiency waste incinerator) etc.

3. Undertake rapid assessment of knowledge requirements of identified agencies for conveying importance of low-carbon interventions for Phu Quoc, key requirements for successful operation of the interventions and expected role of the agencies

4. Development of annual Training Plan that provides details on the areas where training will be provided, brief of training contents, target audience, sequencing of training events and tentative schedule

5. Additionally, identify non-government organizations (like IUCN, Evergreen Labs, Action for the City) or private organizations operating in target areas of the LCMT concept (i.e. Buildings, Untapped energy, Renewable energy, Greenery and Waste Management, Climate Change Response). Identify and develop workshop materials to convey proposed role of these agencies in the interventions and seek input on support that can be provided by the agencies.

6. Integrate workshop for external agencies and develop a combined Training and Workshop Plan, which will be utilized for budget and human resource allocation.

7. The municipality can choose to engage a specialized agency for delivery of the Training and Workshop plan including development of requisite materials and delivery according to the schedule. Alternately, Municipality can nominate internal resources for delivery of the Training and Workshop Plan.

3.3. Case study 1A:

Say no to plastic bags and waste separation at source in Cu Lao Cham, Hoi An City, Viet Nam

Objective	Reduce the use of plastic items, efficient waste management and use
Target	Citizens
Method / Approaches	• The authorities of Tan Hiep island commune have focused a lot of resources and been flexible in directing and implementing measures to deploy new rural construction in association with the protection and improvement of the environmental landscape. • In order to clean up non-biodegradable waste on the island, the International Union for Conservation of Nature (IUCN) connected with Forever Green Labs Consulting Co., Ltd (Evergreen Labs) in collaboration with the Hoi An city government, Cu Lao Cham Marine Conservation Management Board together to find solutions for sustainable waste treatment on the island.
Tools / Instruments	• Propaganda in residential areas • Insert “not use plastic bags” into the tourists’ guide contents, to control plastic waste from the departure point.
Implementation	• Originating from a movement to respond to the "say no to plastic bags" day in 2009, after 12 years of implementation, up to now, Cu Lao Cham, Tan Hiep island commune, Hoi An city (Quang Nam) is the only locality that has successfully implemented "Say no to plastic bags" and is also the first locality in the economy to commit to saying no to plastic straws. • The authorities of Tan Hiep commune have persevered in doing every step, from campaigning, persuading, and sanctioning, creating conditions for people to develop their livelihoods, guiding tourism as well as protecting the landscape and environment. • Tourism businesses also show responsibility, seriously implement, remind visitors to participate, many businesses and social organizations inside and outside the city also enthusiastically contribute to sponsor alternative ecological bags. plastic bags with quantities up to thousands of pieces. • In Cu Lao Cham, all kinds of organic waste are put in separate bins, Hoi An City organizes environmental trucks to collect on alternate days, the days of the week are divided, and the garbage collection truck also has an identification color to People know which days to collect organic waste and which days to collect non-biodegradable waste. This waste is then taken to the garbage factory and continues to follow the process, the organic waste is composted for reuse.

3.4. Case study 1B:

Building a green lifestyle in schools and in communities in Hanoi, Hue, Da Nang and Ho Chi Minh City: Initiatives to reduce emissions and reduce the impact of climate change

Objective	Since 2009, Action for the City has been working with the volunteer club "EcoTeams" to build green living models in the community, towards change. Unsustainable shopping and consumption habits, especially in urban areas, through changing individuals' behavior, thereby helping to reduce emissions, contributing to climate change reduction. This is an activity within the framework of the project "Building capacity on climate change for Vietnamese civil society organizations" sponsored by the Embassy of Finland.
Target	Community Adolescence
Method / Approaches	Approach: Aware - Act - Advocacy Implementation activities: Activities of Eco teams are closely followed the behavior change process: (i) Initial assessment and measurement of behavior change, (ii) Re-evaluate and measurement; and (iii) Summary of the results.
Tools / Instruments	Seminars and talks Organizing events, extracurricular activities
Implementa tion	Groups are trained on topics of green living, emission reduction such as electricity consumption, water consumption, waste, shopping, health and personal relationships,... Specifically including : Living Green in the Community - EcoTeams has been established in 10 communes and wards in Hanoi, Hue, Da Nang and Ho Chi Minh City, including 1,000 participating households with sustainability topics introduced in turn for EcoTeams groups. • When EcoTeam groups operating in a neighborhood reach a large enough number, they will form their own Green Living Club so that they can carry out activities on a wider scale in the community. • Living Green in School - Middle school students are guided in groups, the maximum number of members in each group is 12 people, through extracurricular activities each week. Through these activities, the children also attracted family and friends to participate and support. Organize events and youth rallies to respond to and connect with other international events, such as 350.org and Earth Hour. Organizing green festivals and ecological fairs. Organize campaigns and presentations for the community on topics related to sustainable development (eg on the topic of vegetarianism). Organize the program “Smart housewives” to encourage reuse of plastic bags. Organize workshops and training activities for young people on the above specific issues, and issues on emission reduction, environmental protection and sustainable development

4. Behaviour change campaign on Energy Conservation and Energy Efficiency

4.1. Description of concept

A comprehensive program that assesses and identifies opportunities for emissions savings that can be achieved through behavioural change in consumers and utilize suitable public outreach platforms to affect the change. The campaign aims to gradually change in energy consumption habits by sustained communication of benefits of behavioural change, along with requisite knowledge tools and psychological reinforcement through public outreach. This outreach can be achieved through print media and community outreach programs communicating key financial benefits and responsibilities of citizens.

Energy conservation involves using less energy by adjusting your behaviors and habits. Energy efficiency involves using technology that requires less energy to perform the same function. Economical and efficient use of energy means the application of managerial and technical measures to reduce energy loss and consumption of devices and equipment while meeting demands and requirements of production and life (Law No. 50/2010/QH12 of 2011 on Economical and Efficient Use of Energy).

Improving the quality of energy use in the direction of saving and efficiency, conserving energy resources is an important solution in the energy security policy of the economy.

Effectively implementing energy-saving and conservation solutions will achieve the following goals:

- Economical and efficient use of energy makes an important contribution to ensuring and stabilizing energy Security of the economy, and at the same time contributing to the implementation of Viet Nam's commitment to the international community on reducing greenhouse gas emissions in the Nationally Determined Contributions (NDC) to the Paris Agreement on Climate Change;
- Forming habits of economical and efficient use of energy in all activities of society; reduce energy intensity in economic sectors and fields; Energy conservation has become a regular activity for key energy-using facilities and key economic sectors that consume a lot of energy; towards the goal of green growth and sustainable development;
- Mobilize all domestic and international resources to promote economical and efficient use of energy through the synchronous implementation of tasks, solutions for state management, technical support, and science-techonology research and product development, transforming markets, training and developing human resources, taking advantage of the experience and support of the international community in the field of economical and efficient use of energy.

4.2. Implementation

Implementation of such a behavioural change program will involve the following activities:

a. Propagating, disseminating and raising awareness for the community, promoting conservation, economical and efficient use of energy (as similar to #1)

- Strengthen communication and dissemination to raise awareness about economical and efficient use of energy in production, consumption and daily life. Develop topics and categories on economical and efficient use of energy and periodically publish on radio stations of districts, communes, townships and mass media. Mobilize people in the districts to participate in the annual Earth Hour campaign.
- Regularly update and improve the quality of information on the guidelines, policies and laws of the State in the field of economical and efficient use of energy; introduce advanced solutions and technologies associated with energy saving and energy efficiency on the local website.
- Organize training courses to raise awareness on economical and efficient use of energy for officials, civil servants, public

employees and businesses in the area.

b. Economical and efficient use of energy in industrial production enterprises

- Guide and require enterprises to apply standards, technical regulations and norms on energy use prescribed by competent economy agencies, choose to apply advanced production management processes and models, appropriate technological measures and technological equipment with high energy efficiency, using alternative forms of energy with higher efficiency in the production line.
- Organize demonstrations of management models, production technologies and energy-saving products, new energy and renewable energy. Guide businesses to gradually phase out vehicles and equipment with outdated technology and consume a lot of energy.
- Continue to advise and support businesses to build energy management and energy audit models; research, propose and implement solutions to save energy and efficiently for businesses.
- Encourage and support units and enterprises to invest in projects to upgrade, improve and rationalize technology in order to use energy economically.

c. Conservation, economical and efficient use of energy in construction works

- New energy-intensive projects must use new technologies, achieve and exceed energy efficiency. The key energy-using units fully perform the tasks of conservation, economical and efficient use of energy according to regulations.
- Guide, control and promote the design of construction works to ensure economical and efficient use of energy according to the National Technical Regulations on energy-efficient construction works (QCVN 09:2013/BXD) and guiding documents of the Law on Economical and Efficient Use of Energy.

d. Conservation, economical and efficient use of energy in transportation activities

- Propaganda and train to raise awareness on conservation, economical and efficient use of energy in the field of transportation, promote the use of other forms of energy (biofuels...) to replace traditional fuels system.
- Implement the integration of energy saving content in transportation development planning projects. Guiding the implementation of energy saving measures in project formulation and construction of transportation works in districts.

e. Conservation, economical and efficient use of energy in public lighting

- Replace high-capacity public lighting with low-power, high-efficiency LED systems on roads.
- Appraisal and approval of new projects and constructions of lighting systems using low-power and high-efficiency LED lights in the area.

f. Conservation, economical and efficient use of energy in the home

- Strengthen the implementation of propaganda programs, advertising and mobilizing people to use energy-saving lighting products (LED lights), solar water heaters, install solar power systems attic; use biomass/biogas energy for daily life.
- Coordinate in organizing and launching contests on energy saving in order to create a strong response to the use of high energy efficient household appliances, energy-labelled products in the household, to limit use large-capacity electrical equipment during peak hours.

4.3. Case study:

Plan on conservation, economical and efficient use of energy in Binh Xuyen district, Vinh Phuc, Viet Nam

Objective	Conservation, economical and efficient use of energy
Target	Officials, Citizens
Method / Approaches	Develop a plan on economical and efficient use of energy in Binh Xuyen district
Tools / Instruments	Physical visits to cities which have already implemented measures for conservation, economical and efficient use of energy as well as to cities which are interested
Implementation	Propaganda and dissemination to raise people's awareness, promote conservation, economical and efficient use of energy, and protect the environment • Develop and periodically broadcast thematics and columns on energy saving on loudspeakers of districts and communes and townships. • Maintain and update propaganda information on energy saving on the website of Binh Xuyen district • Design, print, distribute leaflets, posters, propaganda posters, instructions on saving electricity and energy • Organize training courses to raise awareness on energy saving for households, agencies and units in the district • Organize contests and extracurricular activities on energy saving for schools in the district Conservation, economical and efficient use of energy in public lighting, offices of districts, communes and townships • Replace lighting equipment in offices of District Party Committees, District People's Committees, agencies, units, People's Committees of communes and townships by energy-saving appliances labeled with energy • Invest and replace high-capacity public lighting bulbs on district-managed roads with energy-saving LED bulbs Conservation, economical and efficient use of energy in the home • Organize and launch contests and contest programs "Electricity saving families" in communes and towns; • Support application model, installation of biogas or biogas cellars, solar water heaters in households; • Distributing propaganda leaflets; • Hanging posters, banners, slogans. Enhance the role of State management on Conservation, economical and efficient use of energy • Develop regulations on local mechanisms and policies on management of investment activities and economical and efficient use of energy. • Organize groups to study and exchange experiences on conservation, economical and efficient use of energy in other localities

5. Demonstration Model of Community-based Forest Management to Phu Quoc

5.1. Description

Community-based forest management (CFM) is one of the popular forest management methods in Viet Nam and exists in parallel with other management methods such as forest management of the state forestry production and business system, and private forest management. In fact, there are many different manifestations of this forest management method, which further affirms the role of community forest management such as: forests and forest land are recognized and managed by the community in a long time; forests and forest land used for forestry purposes are assigned by local authorities to the community for stable and long-term management and use; forests and forest land used for forestry purposes by state organizations (forestry farm, Management Boards of special-use forests and protection forests, project management boards) contracted to communities to protect and zone and new planting under contract of forest; forests and forest land of households and individuals who are members of the community self-associate themselves into community groups (groups of households) that jointly manage to create strength to protect, support, and exchange work in forestry activities.

Up to now, Viet Nam has a basic legal and policy framework for CFM development, which is reflected in two major laws (Land Law 2003 and Law on Forest Protection and Development 2004) and other legal documents. This legal and policy framework shows the basic points such as the community is the forest owner, the forest user has full or incomplete legal status depending on the conditions of each community and forest object. assigned or contracted. Communities are allocated land, forests, and receive long-term forest contracts when meeting the provisions of applicable laws and policies. Communities enjoy rights and perform obligations when participating in forest management in accordance with the law. Over the years, many programs and projects on CFM of the Government and international organizations have been implemented across the economy with great success. The lesson learnt can be applied to Phu Quoc throught a demonstration model.

5.2. Implementation Plan

Phu Quoc City Government and Phu Quoc Nature Park Management Board will take the following steps to realize a CFM model in Phu Quoc Island.

Step 1: Establish a working group to develop a CFM model

- Expected stakeholder participation
- Communicating with stakeholders about the establishment of a working group
- Meeting to establish working group

Step 2: Identify the villages participating in the CFM model

- Make a list of villages expected to participate
- Meeting to discuss and agree on the criteria for selecting villages to participate in the model.
- Evaluation and selection of villages participating in the model
- Make a list of villages participating in the model

Step 3: Reach out to the community

- Working with local authorities and people to build models
- Conduct community meeting to collect basic information
- Synthesize collected information

Step 4: Organize training on CFM

- Organize training on Community-based Forest Management

Step 5: Establish a village-level Forest Management Board, group of forest protection households and develop a convention on CFM

- Meeting to discuss and agree on the following contents: establishment of a village-level Forest Management Board; establishment of groups of forest protection households; CFM convention
- Submit the Convention to the Commune People's Committee for approval
- Dissemination of the content of the Convention

Step 6: Make a CFM plan

- Review reports on forest status, forest resources, status of forest protection and development
- Meeting to make CFM plan and plan for monitoring and evaluation of CFM

Step 7: Implement, monitor and evaluate the CFM plan

- Implement planned activities
- Hold a meeting every 6 months to evaluate the results of the implementation of the CFM plan
- Share the results of building a CFM model to stakeholders.

5.3. Case study:

Community based forest management in Ban Ve, Yen Na Commune, Tuong Duong District, Nghe An Province, Viet Nam

Objective	Improve awareness of protection and sustainable use of natural forest. Strengthen the participation of local people in the use of natural forest, in partnership with other stakeholders. Improve livelihoods through income generation for local people.
Target	Citizens
Method / Approaches	Collect and analyze secondary information Discussion groups
Tools / Instruments	Venn Diagram Village mapping Village development history Route survey (transect walk)
Implementation	Criteria for selecting members of the Forest Management Board in Ban Ve, Yen Na commune, Tuong Duong district, Nghe An province • Good healthy • Enthusiastic, with a high sense of responsibility • Have experience in forest management • Have management knowledge and skills • Good reporting skills • Have time to participate in community work • There are no illegal acts related to forest protection and development. • Do not drink alcohol. Forest Management Board of Ban Ve, Yen Na commune, Tuong Duong district, Nghe An province is responsible for: • Propagating and disseminating to local people about the Law on Forest Protection and Development. • Monitoring the implementation of regulations of the forest protection group • Develop a forest protection plan • Monitoring forest protection activities • Contact and coordinate with Yen Na Commune People's Committee, Tuong Duong Protection Forest Management Board to carry out forest protection activities • Report to Yen Na Commune People's Committee on forest protection situation Ban Ve protection group, Yen Na commune, Tuong Duong district, Nghe An province is responsible for • Coordinate with Ban Ve Forest Management Board to develop forest protection plan; • Develop a plan for patrolling and protecting forests; • Report to Ban Ve Forest Management Board on the results of forest protection patrol; • Organizing meetings to implement forest protection activities; • Coordinate with Ban Ve Forest Management Board to carry out forest protection activities; • Directly carry out forest protection activities; • Coordinate with Ban Ve Forest Management Board to generate revenue for forest protection activities and share benefits from the revenue. • Coordinate with Tuong Duong Forest Management Board to implement coordinated activities on livelihood development and forest protection (such as: planting trees in open forests, grazing goats and buffaloes in protection forests...). • Mobilize local people to participate in forest fire prevention and fight against illegal activities. • Assign households that have farms near protection forests to protect forests.

6. Business model of household solar power scheme

6.1. Description of concept

The grid-connected solar power system for households has solar panels that absorb sunlight and convert it into DC current; this current will be converted into clean power by the inverter to power electrical appliances, help many households save significantly on monthly electricity costs. On the other hand, small-scale grid is usually solar panels installed on the roofs of households or offices can be an alternative to the utility scale and households can be financially benefitted through FIT with connected to the grid of the economy by selling out surplus power volume.

At household level, the solar power system does not take up too much space, so it only takes a small space on the roof or terrace (not shaded) to be installed, safe to enjoy many practical benefits from green energy.

The socio-economic and environmental impacts of the grid-connected solar power system for households as follow:

- Reduce exploitation and use of fossil fuels;
- Impact on people's lives and social security (create jobs, taxes for the locality...);
- Ensure local electricity demand for economic development and social needs;
- Reduce greenhouse gas emissions;
- Promote the development of science and technology;
- Impact on ecosystems and biodiversity (negligible);
- Generation of solid waste, dust and pollutants that degrade environmental quality (mainly in the construction and demolition phase).

The legal and technical framework in Viet Nam and Kien Giang Province is being consolidated to encourage the introduction of rooftop solar PV at household scale through Feed in Tariff (FIT) and potential for Phu Quoc can be explored with a household scale business model.

6.2. Implementation Plan

a. Policies, Institutions, investment

- The guidelines and orientations for the development of solar power; Mechanism to support buying and selling prices; State needs to develop preferential policies to encourage households to actively participate in household-scale solar power installations; Mechanisms and policies to support the development of this energy source; Policies and laws on renewable energy…
- Prioritize allocating capital from the city budget to implement plans and programs to promote the development of solar power for households in each 5-year period;
- Create favorable conditions for solar power investment projects to enjoy loan interest support.
- Each locals develops its own support mechanisms, integrates and coordinates with Viet Nam's general mechanisms and policies, promotes the development of the solar power market in each province and city.

b) Development of human resources, science and technology

- Localize solar power technology, develop specialized research and training programs, develop standards and regulations on exploitation and use of solar power;
- Improve the management capacity of rooftop solar power development at management agencies and local authorities in order to unify goals, orientation and development roadmap in each period, synchronously at all management levels. ;
- Organize tours and extracurricular activities related to the field of renewable energy, solar energy, etc.
- Enlist the support of the international effort to combat climate change, reduce emissions of greenhouse gases, elaboration of plans to cooperate with organizations and international organizations in the development of human resources on solar power, raising awareness and operating experience in the field of solar power.

c) Improve the efficiency of Economy management

- Develop plans and programs to promote household solar power development in the 5-year period and annual plans to implement support solutions, evaluate effectiveness, build and adjust development roadmaps accordingly.
- Develop a close coordination mechanism between departments, branches and local authorities in project management and appraisal, construction licensing, supervision of solar power investment activities;
- Strengthen the management in the field of investment and development of solar power, publicize the survey results and map of the technical potential of solar power technology for investors and people to facilitate the investment and installation process.

d) Investment promotion, supply and demand connection, development cooperation

- Take advantage of foreign ODA and non-governmental funding sources to research and support businesses in the city to have the opportunity to access preferential loans and technical support in the field of roof solar power investment;
- Strengthen communication, propaganda, organize seminars on policies, mechanisms of the Economy, cooperation models to develop effective roof solar power to raise the awareness of businesses and people about benefits of using clean energy, solar energy, contributing to promoting the development of roof solar power;
- The Economy and local authorities need to focus on promoting communication and propaganda about the application of renewable energy in general and solar power in particular, raising public awareness, helping people understand the practical benefits of solar power…
- Communication about successful solar power installation projects, models, and pilot programs, widely propagate and popularize, and built trust for households and communities.
- Promote the organization of conferences and seminars to connect supply and demand between industrial production establishments, trade and service centers, agricultural production, people and units providing models and solutions for technology and finance in the field of solar power to effectively exploit the potential of solar power development.
- Encourage the active participation of the community. Households are the main energy users, without the participation and joint implementation, it will be difficult for policies and goals to develop solar power.

6.3. Case study:

Rooftop solar energy in 100% households in An Hao commune, Tinh Bien district, An Giang

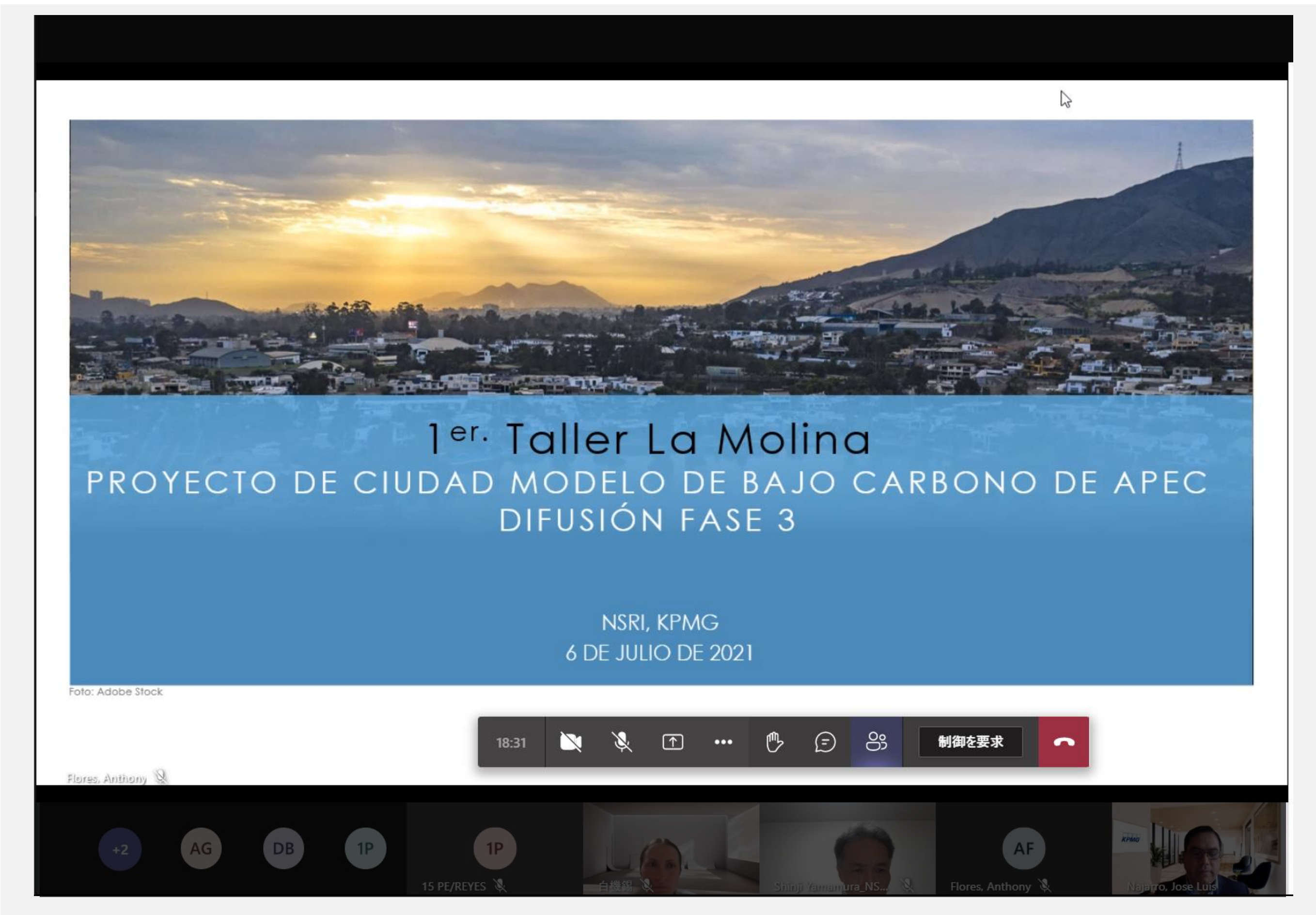
Objective	Develop and exploit effectively household-sccale solar pwoer
Target	Citizens
Method / Approaches	To meet the needs of the community, Green Innovation and Development Centre (Green ID) co-operates with the An Giang Green Energy Management Board with the financial support of Bread for the World has developed the project to increase access to energy for the people, brought electricity to people in remote, difficult areas.
Tools / Instruments	• Physical visits to households which have already implemented the rooftop solar power as well as to households which are interested
Implementation	• Piloting the development of a mechanism to support investment in solar power in the area; • Develop mechanism to support buying and selling prices; Economy needs to develop preferential policies to encourage households to actively participate in household-scale solar power installations; • Development of human resources, science and technology; • Raise community awareness about the practical benefits that solar power brings; • Communication about successful solar power installation projects, models, and pilot programs, widely propagate and popularize, and built trust for households and communities; • Take advantage of foreign ODA and non-governmental funding sources to research and support businesses in the city to have the opportunity to access preferential loans and technical support in the field of roof solar power investment.

Meeting Minutes

1. La Molina District, Lima, Peru

1.1. 1st Workshop

- Date: 6 July 2021
- Time: 23:00 – 25:00 JST, 09:00 – 11:00 PET
- Tool : Web Meeting (Teams)
- Participants: 12 Person`s (Ministry of Foreign Affairs, La Molina Municipality, KPMG Peru, KPMG India, NSRI)



1.2. 2nd Workshop

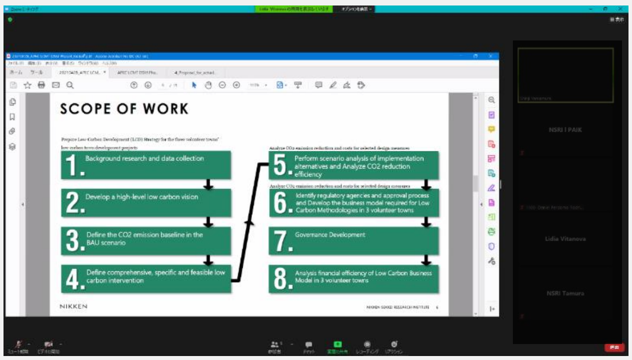
- Date: 17 September 2021
- Time: 23:00 – 25:00 JST, 09:00 – 11:00 PET
- Tool : Web Meeting (Teams)
- Participants: 15 Person's(Ministry of Foreign Affairs, La Molina Affairs, KPMG Peru, KPMG India, NSRI)

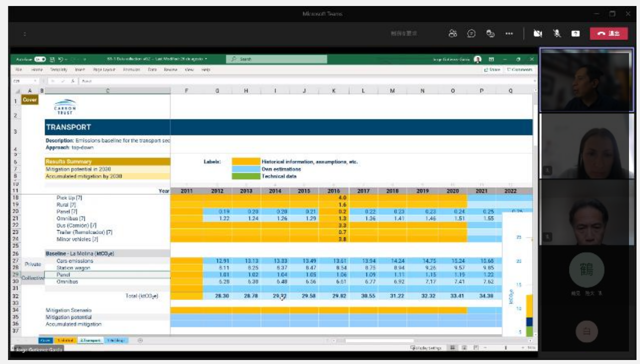
1.3. 3rd Workshop

- Date: 29 October 2021
- Time: 23:00 – 25:00 JST, 09:00 – 11:00 PET
- Tool : Web Meeting (Teams)
- Participants: 14 Person's (Ministry of Foreign Affairs, La Molina Municipality, KPMG Peru, Carbon Trust, NSRI)

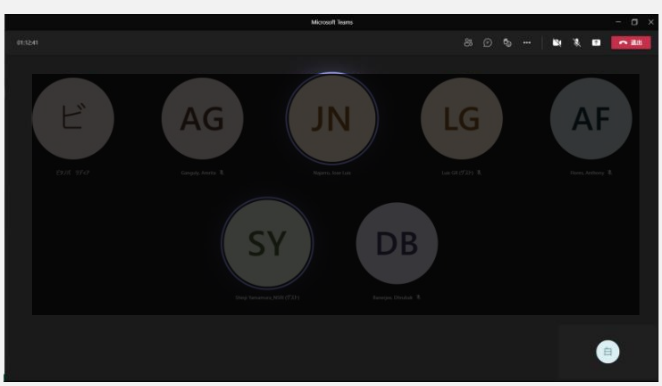
1.4. Advance Meeting and Discussions

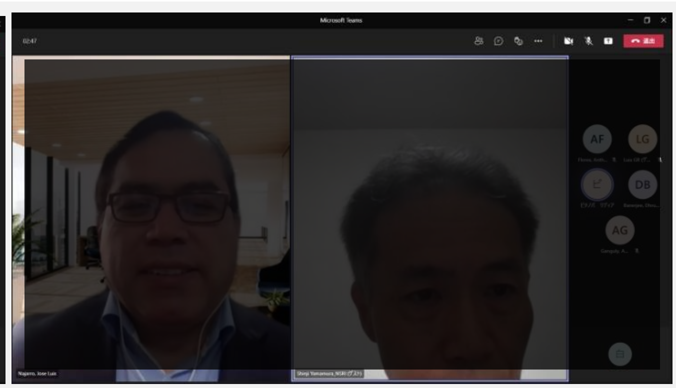
- Date: 17 May 2021; 7 September 2021; 29 October; 2 December 2021;
- Time: 08:00 – 10:00 JST
- Tool : Web Meeting (Zoom)
- Purpose: Kick-off meeting and data collection communication with Carbon Trust
- Participants: 6 Person’s (Carbon Trust, NSRI)





- Date: 9 June 2021; 15 June 2021; 22 June 2021; 30 June 2021
- Time: 01:00 – 02:00 JST
- Tool : Web Meeting (Teams)
- Purpose: Kick-off meetings and data collection discussion with KPMG
- Participants: 9 Person’s (Ministry of Foreign Affairs, La Molina Municipality, KPMG Peru, KPMG India, NSRI)

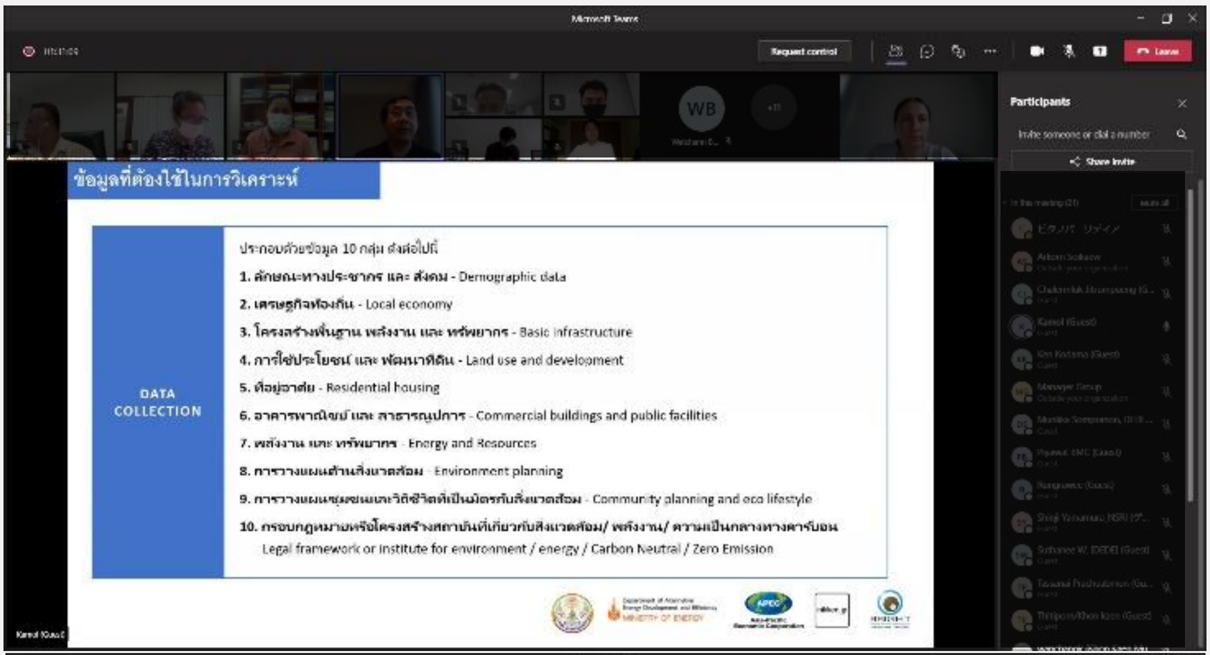


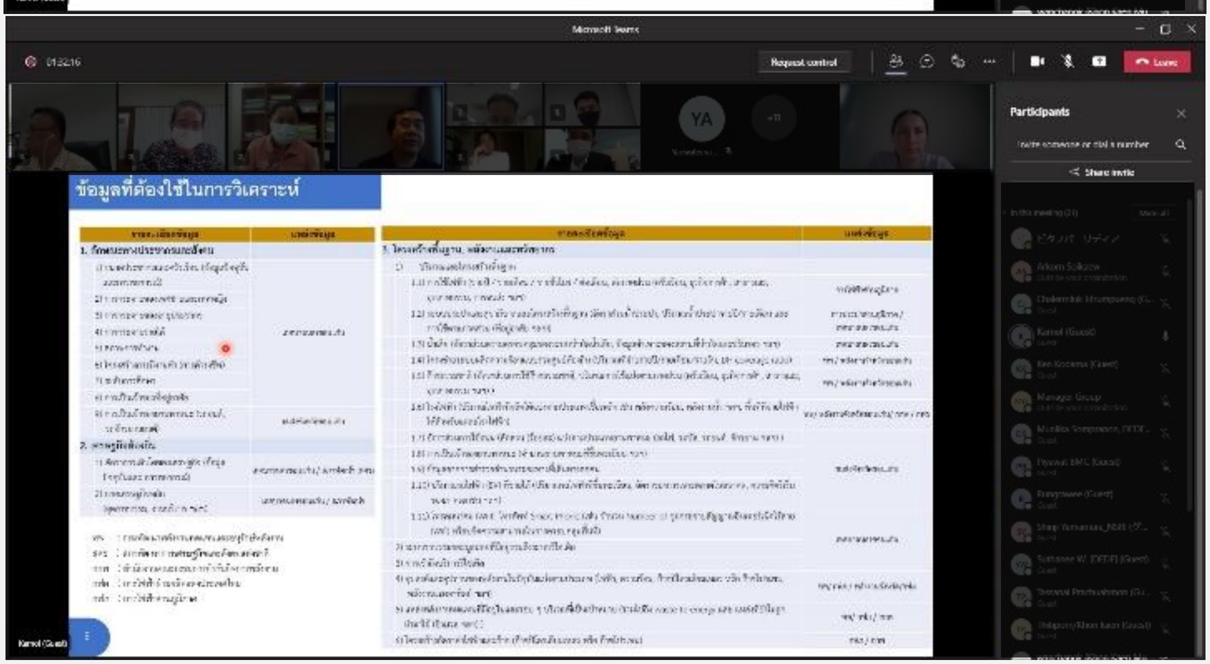


2. Kohn Kaen Municipality, Thailand

2.1. 1st Workshop

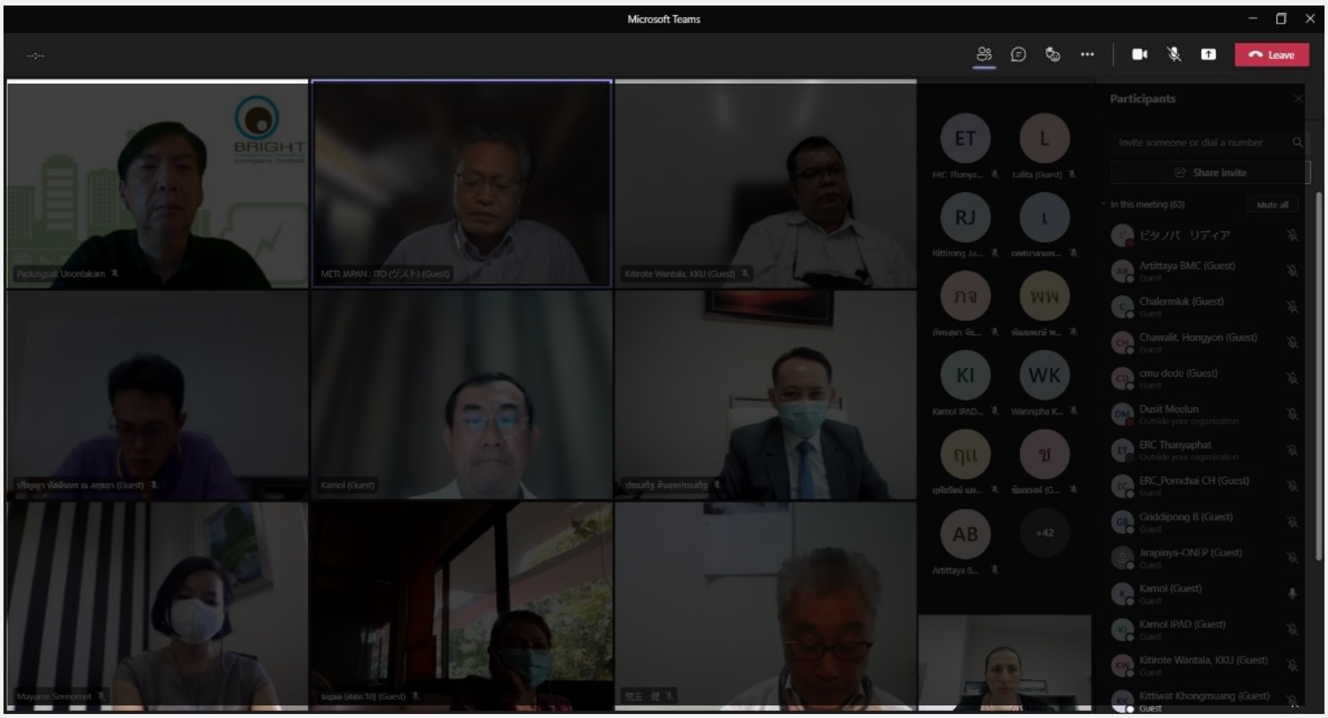
- Date: 22 June 2021
- Time: 17:00 – 19:00 JST
- Tool : Web Meeting (Zoom)
- Participants: 25 Person's (DEDE, Khon Kaen Municipality, BMC, NSRI)





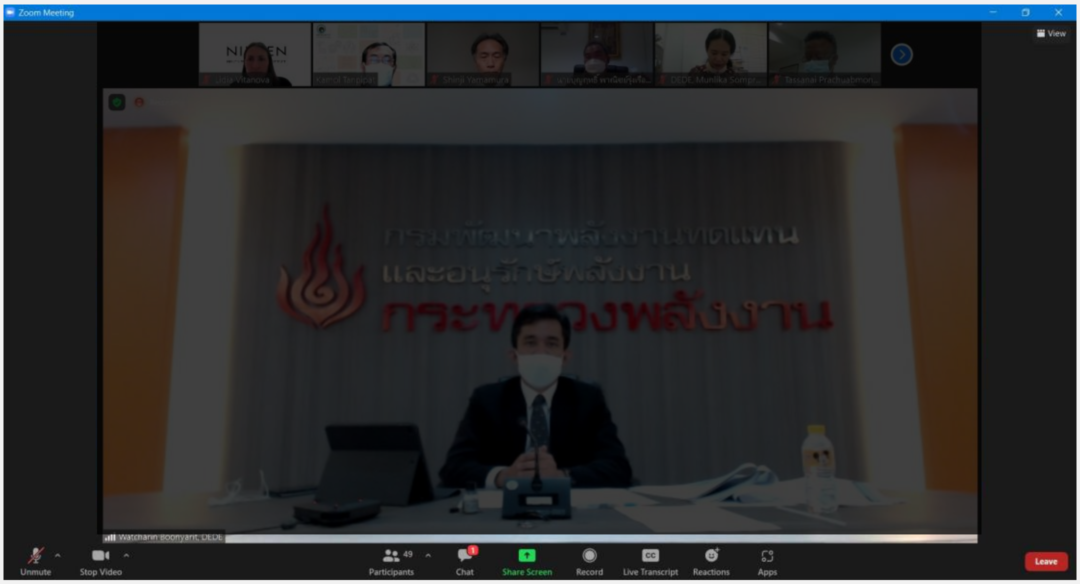
2.2. 2nd Workshop

- Date: 15 September 2021
- Time: 15:00 – 17:00 JST
- Tool : Web Meeting (Zoom)
- Participants: 56 Person's (DEDE, TGO, Khon Kaen Municipality, Khon Kaen University, OERC, ONEP, State Railway of Tailand, BMC, NSRI)



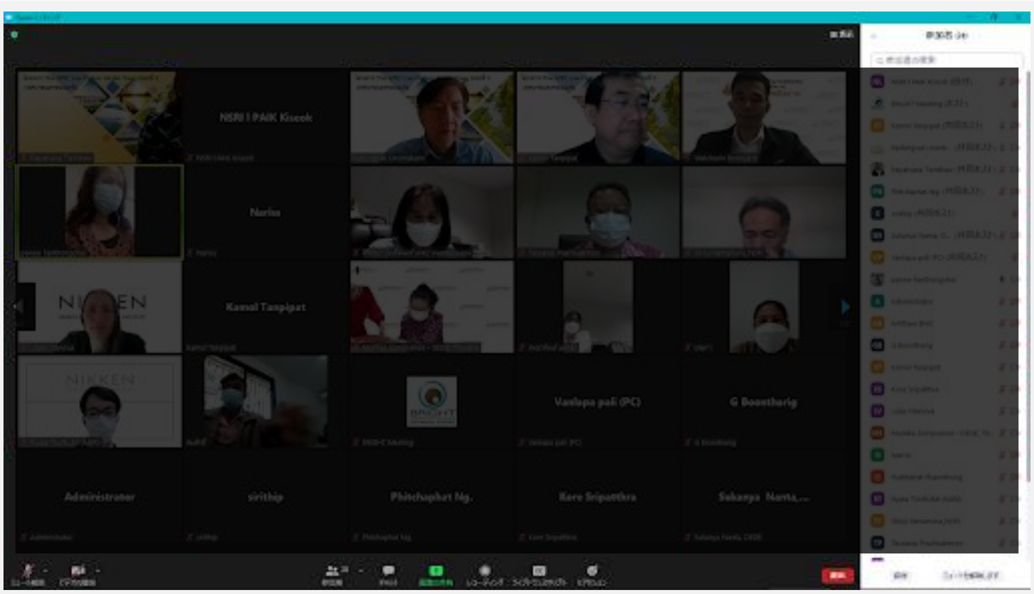
2.2. 3rd Workshop

- Date: 25 January 2022
- Time: 11:30 – 14:00 JST
- Tool : Web Meeting (Zoom)
- Participants: 42 Person's (DEDE, Khon Kaen Municipality, KKTT, EPPO, TGO, Khon Kaen University, BMC, NSRI)



2.3. Advance Meeting and Discussions

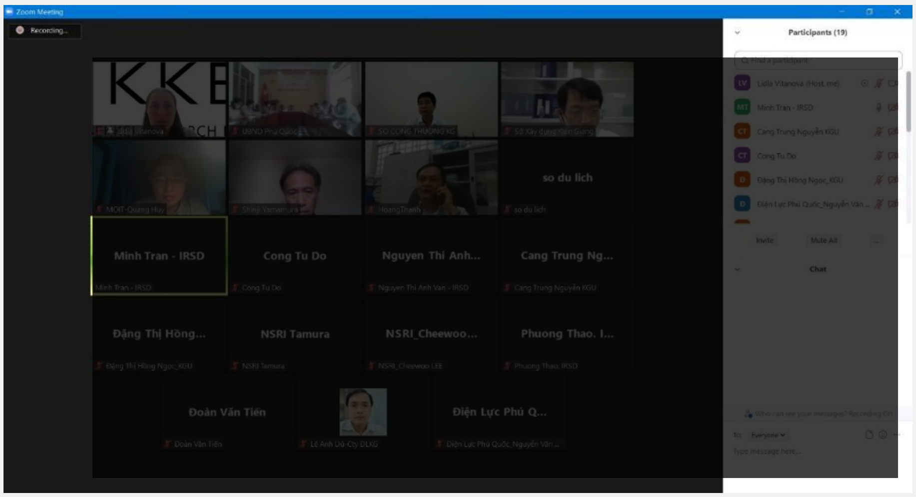
- Date: 20 April; 26 October; 28 October; 24 December 2021
- Tool : Web Meeting (Zoom)
- Purpose: Kick-off meeting; Capacity Building, DEDE and BMC discussions
- Participants: 11 Person's (DEDE, BMC, NSRI)



3. Phu Quoc District, Kien Giang Province Viet Nam

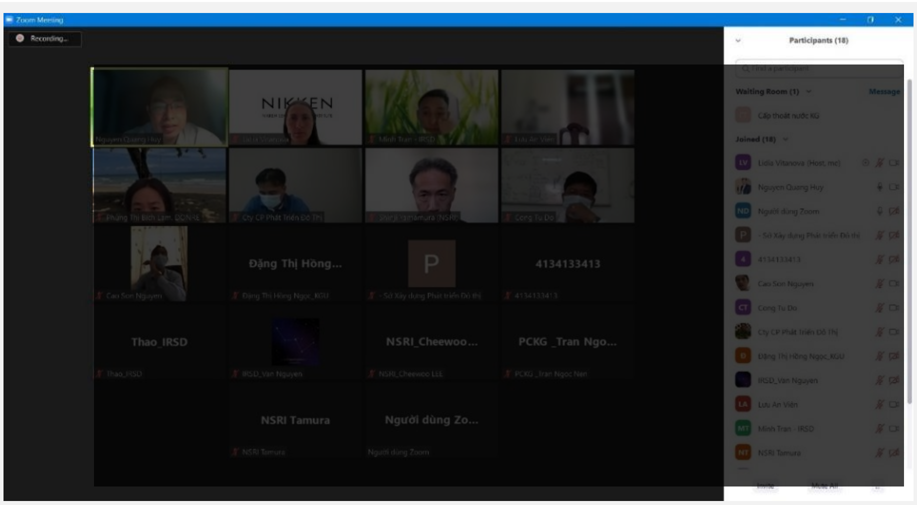
3.1. 1st Workshop

- Date: 26 August 2021
- Time: 10:00 – 14:00 JST
- Tool : Web Meeting (Zoom)
- Participants: 22 Person's (MOIT, Phu Quoc City People's Committee, METI, IRSD, NSRI)



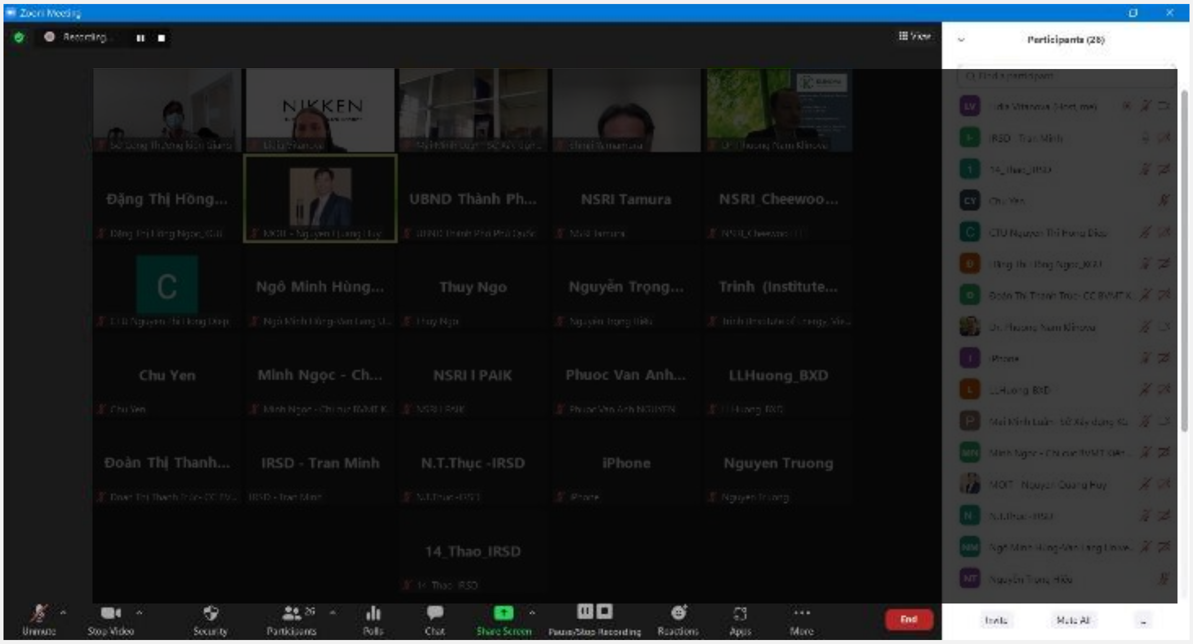
3.2. 2nd Workshop

- Date: 12 November 2021
- Time: 10:30 – 14:00 JST
- Tool : Web Meeting (Zoom)
- Participants: 22 Person's (MOIT, Kien Giang Province, Phu Quoc City People's Committee, IRSD, NSRI)



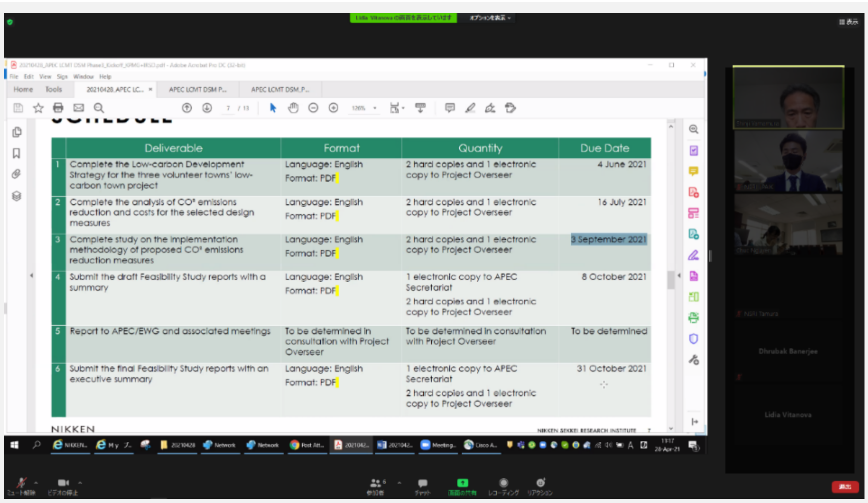
3.3. 3rd Workshop

- Date: 23 December 2021
- Time: 10:00 – 13:30 JST
- Tool : Web Meeting (Zoom)
- Participants: 21 Person's (MOIT, Kien Giang Province, Phu Quoc City People's Committee, Kien Giang University, Department of Science, Technology and Environment, Ministry of Construction , IRSD, NSRI



3.4. Advance Meeting and Discussions

- Date: 28 April 2021
- Time: 11:00 – 12:00 JST
- Tool : Web Meeting (Zoom)
- Purpose: Kick-off meeting with KPMG and IRSD
- Participants: 6 Person's (IRSD, KPMG India, NSRI)



FINAL REPORT

APEC Low Carbon Model Town (LCMT) Project Dissemination Phase 3

Asia-Pacific
Economic Cooperation

APEC Energy Working Group

February 2022