Asia-Pacific
Economic Cooperation

Advancing Free Trade
for Asia-Pacific Prosperity

Final Report
Building Back Better: Energy Efficiency, Renewable Energy, and Energy Resiliency in the New Normal

APEC Energy Working Group

September 2023

Asia-Pacific
Economic Cooperation

Final Report

Building Back Better: Energy Efficiency, Renewable Energy, and Energy Resiliency in the New Normal

APEC Energy Working Group

September 2023

APEC Project: EWG 12 2021A

Produced by

Kathleen Purvis Roberts & Chanyaporn Bstieler

Scripps College
W.M. Keck Science Department
925 N. Mills Ave.
Claremont, CA 91711 US

King Mongkut's University of Technology Thonburi
126 Pracha-uthit Rd, Bangmod, Thungkru,
Bangkok 10140 Thailand

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

APEC#223-RE-01.9

TABLE OF CONTENTS

(This page is intended to be left blank)

ABBREVIATIONS

HW	Hybrid Work
WFH	Work From Home
EUI	Energy Use Intensity
MEPS	Minimum Energy Performance Standards
PIR	Passive Infrared (Sensor)
ESCO	Energy Service Companies
PV	Photovoltaic
EV	Electric Vehicle
EE	Energy Efficiency
RE	Renewable Energy
SDGs	Sustainable Development Goals
tCO_2e	Tonnes of carbon dioxide equivalent

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The US-led APEC-funded workshop titled "**Building Back Better: Energy Efficiency, Renewable Energy, and Energy Resiliency in the New Normal (EWG 12 2021A)"** was organized by Scripps College, California, United States, and King Mongkut's University of Technology Thonburi, Thailand. We hosted the three-day workshop at Chatrium Hotel, Bangkok, Thailand during 11-13 January 2023. Co-sponsoring APEC economies are Australia; Canada; Hong Kong, China; Chinese Taipei; and Thailand.

The project received funding from the Energy Efficiency and Low-Carbon Measures fund. The event was held under APEC Project: **The APEC Workshop Furthering University Collaboration to Support Data Gathering and Analysis in Energy Efficiency, Renewable Energy, and Energy Resiliency (EWG 12 2021A).** As the COVID-19 Pandemic was fading away, the organiser decided to take advantage of an in-person workshop, allowing face-to-face interaction among the attendees and a field trip in Bangkok as well. This decision was also in line with the participants' suggestions from the APEC-funded online workshop we organised last June 2021(EWG 06 2019A).

1.2 GOALS

APEC's Energy Working Group (EWG) and its subfora have identified a broad range of strategic goals to work towards from 2019-2023. They are in line with the APEC aspirational goals endorsed by APEC Ministers and Leaders to 1) double the share of renewables in the APEC energy mix from 2010 levels by 2030 and 2) reduce APEC's energy intensity by 45% from 2005 levels by 2035. These ambitious goals and projects require extensive data gathering and synthesis, in addition to the work the policymakers are already doing.

This project aims to identify and begin to ameliorate data gaps for policymaking in renewable energy, energy efficiency, and energy resiliency by work on current projects around *Reducing the Lighting Carbon Footprint in the Tropics* and *Energy Use and Resiliency for New Work Patterns and Lifestyles with the COVID-19 Pandemic.* It also aims to develop new collaborations and projects between EWG policymakers, research institutes, and university faculty.

The three-day workshop brought together policymakers from APEC member economies, faculty from universities in APEC economies, a researcher from APERC, and energy experts from the private sector to discuss energy data requirements and potential EWG/University collaborations. The event was tailored to include several sessions for the key themes described above with varying topics, such as expert presentations, case studies, break-out group discussions, and a field-trip to maximize learning and retention.

1.3 PROJECT OBJECTIVES

The project aims to:

1. Further develop a network of university faculty that provide data gathering and analysis to support EWG's needs and goals in collaboration with policymakers and researchers from institutes.

2. Communicate progress of collaborative projects developed during a virtual workshop held in June 2021 (EWG 06 2019A). Policymakers, participants from research institutes and faculty members will all be invited to participate in projects and/or provide feedback and input on the data gathering and research direction.

3. Develop ideas for new collaborations. Policymakers can share data needs that they have for developing energy policy, and all participants can discuss ideas for new projects that will fill these data gaps.

4. Incorporate energy resiliency and economic analysis into projects. A key part of policymaking is understanding the economic cost of different policy options, so participants will discuss how to include this into current and future research projects.

5. Identify best practices for communicating project results between the EWG policymakers, research institutes, and universities. This is critical for university faculty to understand key data and policy gaps for future research projects.

This publication is a final report of the workshop and comprises four chapters. Following the introduction, which presents the workshop's project goals and objectives, Chapter 2 describes key outputs of this project - the background report titled *"The Impact of Hybrid Work on Energy Efficiency and Resiliency in the Built Environment"* and the workshop (the participants and the methodology). The workshop agenda was divid-

ed into eleven sessions over three days, including a half-day boat trip to understand potential energy savings from the use of public transportation.

Chapter 3 compares the key outcomes with the project's objectives for three aspects: 1) Data gaps identified and needs from the policy-makers 2) Potential new collaborations and projects with common interests and 3) Awareness of women in energy fields and university students engagement in energy research projects.

Chapter 4 summarizes all presentations at the workshop and key issues derived from break-out group discussions, organised according to the workshop agenda (see APPENDIX A). The first part of the workshop included the policymakers' and APERC presentations, examples of current research that could be developed into collaborative projects, and the experiences of gender issues shared by women energy experts. The group discussions were divided into three groups - Reducing lighting carbon footprint in the tropics; Energy efficiency and resilient in transportation, and Renewable Energy. Finally, Chapter 5 concludes with key findings, follow-up activities, and potential future collaborations on the three themes mentioned above. A summary of the participant's evaluation (APPENDIX B) provides feedbacks and suggestions for organising a more efficient future workshop.

CHAPTER 2

THE BACKGROUND REPORT AND THE WORKSHOP

This chapter describes two key outputs of the project: the background report and the three-day in-person workshop. The background report was developed, written, and shared with the attendees prior to the workshop (see the full report in APPENDIX C). Since the COVID-19 Pandemic is constantly changing, the report aims to provide information on current circumstances as a framework for discussions about its impact on energy and resiliency at the workshop in January 2023. The onsite workshop went well and was an interactive event. It attracted policymakers, University faculty, and energy experts from 14 APEC economies who could contribute to and, at the same time, benefit from future collaborations that developed out of this workshop.

2.1 THE BACKGROUND REPORT

2.1.1 Introduction

This report is titled ***"Impact of Hybrid Work Energy Efficiency and Resiliency in the Built Environment"***. It provides background information for the APEC workshop held in Bangkok, Thailand, titled: ***"Building Back Better: Energy Efficiency, Renewable Energy, and Energy Resiliency in the New Normal (EWG 12 2021A)"***. The report was developed based on the results obtained from the 2-day online APEC-funded workshop in June 2021. Results from the previous workshop suggested exploring several themes further to provide better data gathering for achieving ambitious APEC energy goals. One of the main themes was the impact of the COVID-19 Pandemic on the changing work patterns and lifestyles (Figure 1); and how these changes may affect energy use and resiliency in the APEC economy.

> "***Hybrid Work*** means a combination of working onsite and spending some time away from the office"; and " ***Teleworking*** means the activity of working at home, while communicating to your office by phone or email, or using the internet". Definition of 'teleworking' by Cambridge Dictionary. (Cambridge University Press, n.d.)

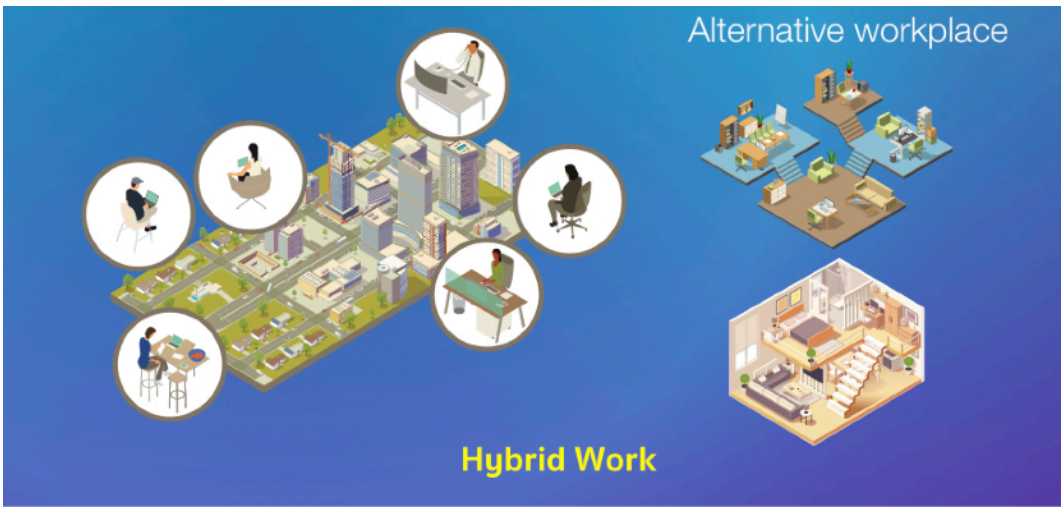

Figure 1: Hybrid work and alternative workplace

The background report focused on energy efficiency and renewable energy in the built environment and transportation sector, as they are closely linked to the new working and living patterns. Another central theme was reducing lighting's carbon footprint, taking advantage of advanced light sources (LED) and control technologies. In particular, daylighting in the tropics is of a concern, where daylight is abundant, but its use is still limited. Thus, this workshop emphasizes data required by policy-makers in the APEC economies that will inform energy policies and strategies and help achieve a green recovery from the setback and disruptions caused by the COVID-19 Pandemic.

2.1.2 Organization

This document obtained information from a review of reports by international organizations and research centers, surveys by private sectors in the commercial real estate industry and workplace consultants, and published articles in international journals, mainly from 2019-2022. The report comprises three main chapters:

1) Chapter One provides an overview of drivers for change and summarises how the new working and living patterns may impact the design and energy use at building and urban scales. It also presents an initial survey on efficient lighting strategies, including the employee preference for the workplace and lighting after the pandemic. **2) Chapter Two** presents the trends and factors affecting energy use in public, commercial, and residential buildings during the pandemic. It also reviews changes in economy-wide policies and strategies for renewable energy of APEC economies. **3) Chapter Three** shows a systematic review of energy use and trends in the transportation sector post-COVID. Finally, it recommends developing ideas for further discussions and assessment between policymakers, researchers, and experts at the upcoming workshop.

2.1.3 Key Findings

The following includes key findings from the literature reviews, divided into four parts. Details are as follow:

Resilience in the Built Environment: Drivers for Change

The disruptions caused by the complexities of the current global crisis significantly impact organizational dynamics and new ways of working and living. Organizations have faced external and internal risks in the past three years that have forced them to transform and adapt. Although some of these risks are not new and started to have a global impact before 2019, the pandemic has indeed accelerated and magnified its consequences.

- In addition to a global pandemic, *societal risks* include climate change, natural disasters like flooding and fire, and war or military conflict.
- Internal factors include *talent wars, the adoption of hybrid work, and the health and well-being* of the worker.
- Employees' expectations and priorities have shifted toward more *flexibility* in choosing where and when they work, *better work-life balance, and health and well-being*.

The New Working and Living Lifestyle

At the end of 2022, the pandemic was not yet over. Several surveys of business leaders and employees in different APEC regions, such as the US, Latin America, and Southeast Asia, suggest that the final model of working and living - where and how we work and live after the pandemic, is still an ongoing topic of discussion. However, some changes during the pandemic will be permanent, and to some extent, this new lifestyle certainly impacts the energy demand and resiliency in the built environment.

- *Hybrid work*, a combination of working onsite and spending some time away from the offices, is here to stay. Employees' ideal combinations are working remotely for 2-3 days and the rest in the office.
- The percentage of employees who prefer to work full-time remotely is much smaller but varies by region. Those in developing economies and, particularly, mothers with young children, tend to favor working from home.
- While employees still value human interaction and meetings with their colleagues and team managers onsite, reducing wasted time commuting and better work-life balance are among the main advantages of working remotely.

- One in five employees may leave their company shortly, and if they are back on the job market, they would prefer an organization that offers a flexible work model located near a public transportation hub.
- With a shifting focus on health and well-being, employees consider working for companies providing ergonomic furniture (including natural light and views) and nutritional food as benefits.
- Due to the talent wars and the continuing *Great Resignation* trend, employers are embracing this new demand for a flexible work model and still investing in improving workplace quality to attract and retain their talent.
- Despite the wide adoption of hybrid work, headquarters are still the focus of the office operation, with smaller satellite locations or shared working space on a flexible lease. However, organizations are not just renting *space* but require a *solution for productivity,* including flexible working and meeting facilities.
- Small talent-rich urban areas, as opposed to traditional urban cores, with good public space and transport connections, should be developed to attract employees looking for a better environment to live a good quality of life.

Impacts on Energy Demand and Resiliency

- As teleworking and hybrid work increases, the overall energy consumption in office buildings and transportation is reduced. While the energy demand was reduced in commercial buildings, such as offices, retail, and hospitality sectors, the energy use in residential buildings increased. These changes vary across the APEC region, reflecting not only the impact of weather conditions, but also socio-economic and cultural differences.
- The profile of peak energy demand for residential buildings shifted as most people were working and learning from home. Pre-COVID-19, the peak energy demand was in the evening when everyone was home and turned on the television and air-conditioning (AC). Peak energy demand now changed to the afternoon to early evening. The flexible work patterns allows movement from and distribution of energy consumption from the city centre to the suburb areas.
- Despite the major interruption on daily life and devastating economic impact on the global scale, the pandemic has temporarily restored the natural environment and improved the air quality. The small particles (PM10 and PM2.5) and other air pollution indicators decreased mainly due to much less transportation, construction, and industrial production.

Preference for Mode of Transport and Travel Behaviour

- Preference for active mobility options like biking, bike sharing, and walking has increased slightly before, during, and after the pandemic. However, this trend needs attention from planners to enable comfortable and safe passage. Even though bike-sharing is a shared mobility, due to the size of the network and accessibility of the vehicles, users may be able to have control over the possibility of contagion using individual sanitization before use.
- The perceived threat of shared mobility or public transit has negative perceptions both during and after the pandemic mainly due to the possibilities of contagion, inequitable access, and lack of personal control.

2.2 OVERVIEW OF THE WORKSHOP

2.2.1 Workshop Objectives

The workshop was a three-day onsite event to bring together energy policymakers from APEC economies, researchers from universities in APEC economies and APERC, and experts from energy-related fields in the private sector. The workshop included 1) presentations from the experts, energy policymakers, and university faculty; and 2) break-out group discussions on data requirements (particularly post-COVID-19 Pandemic, and discussion of possible collaborative projects to be developed during the next academic year. The policymakers, faculty, and experts from private sector brainstormed about potential future projects that will benefit both the EWG and the university partners.

2.2.2 The Participants

Since the COVID-19 pandemic is fading away, we decided to host this US-led, APEC-funded onsite in Bangkok, Thailand. The workshop occurred at Chatrium Hotel Riverside, 9:00-17:00 (GMT+7 time zone) on 11-13 January 2023. Sixteen speakers and 45 participants attended this three-day workshop. Speakers and participants included 36% policymakers, 48% researchers and University faculty, 16% energy experts from the private sector, and graduate students from fourteen APEC economies. Approximately 60% were male, and 40% were female participants. These included Australia; Brunei Darussalam; Chile; Hong Kong, China; Indonesia; Japan; Malaysia; Mexico; the Philippines; Singapore; Chinese Taipei; Thailand; The United States; and Viet Nam. Due to budget and personal reasons (sudden illness and prior engagement), speakers from Australia; Hong Kong, China; Mexico; and The United States participated online via Zoom platform.

2.2.3 Methodology

The background report, described in section 2.1, was distributed via email to all participants prior to the onsite workshop in Bangkok, Thailand. At the end of 2022 and early 2023, the COVID-19 Pandemic and its disruptive impacts on people's lives and energy use in the built environment and transportation sectors were still dynamic. Thus, this report provided the current context at the time as a common framework for the speakers and participants to consider during the group discussions on energy efficiency and resiliency.

The first day (Wednesday, 11 January 2023) started with an introduction and discussion of objectives of the workshop. This was followed by a welcome speech. There were four sessions, focusing on an overview of the APEC energy goals and activities, data collections and energy refocus for the post-COVID-19 period, and finally a presentation of the case studies on energy resilience in commercial buildings. Each presentation was approximately 20 minutes, followed by a Q&A session. In addition to the presentations, groups in the first breakout session discussed policymaker needs and further ideas around data gathering and analysis: 1) to achieve energy resiliency in buildings and transportation; 2) to reduce lighting carbon footprint; and 3) to achieve renewable energy goals. Finally, the organiser summarised the key issues from presentations and discussions from the first day. See **Figure 3** for main activities at the workshop.

The second day (Thursday, 12 January 2023) started with a brief summary of key points from the first day, and an overview of the day two's activities and goals followed. There were two sessions; the first was a series of presentations on the impact of hybrid work on energy use and resilience in buildings and transportation, and the second one was a group discussion, emphasising data collection. The morning session was complemented by a boat trip (see section 2.3) along canal networks in west Bangkok to experience one of the collaborative projects, promoting the use of clean energy and low impact transportation. The second day ended nicely with a complimentary dinner on the Chaophraya River supported by EnviroLab Asia, Claremont Colleges.

The last day (Friday, 13 January 2023) began with a recap of the main ideas learned from the second day, including the field trip. There were five sessions emphasising the two themes. The first session focused on the energy efficiency and resiliency policy implications and recommendations. The second was sharing experiences on gender issues related to the energy sector and exchanging ideas about developing collaborative projects. Finally, the project overseer gave closing remarks and invited all participants to contribute to the workshop evaluation and, if interested, continue their involvement with the follow-up online meetings.

Figure 3 Expert presentation, Q&A session, and group discussions

2.3 The Boat Trip: Clean Energy and Sustainable Transportation

The traffic issues in Bangkok not only waste energy, but also harm the economy and the environment. Thus, we purposely chose solar-powered boats and the route along the canals (see Figure 3) that had intersections with mass transit networks. This was discussed during the presentation in Session 5 by Dr. Ampol Karoonsoontawong (KMUTT, Thailand) and focused on the proposed canal transit network for west Bangkok.

To reduce the traffic and air quality problems in the city centre, in 2019 the Bangkok Metropolitan Administration (BMA) launched a policy to promote more convenient and seamless connections between road transport, mass transit (i.e., overground and underground trains), and water transport. The city proposed new routes of boat services at some main piers in west Bangkok connecting people who use buses and other popular road vehicles (such as motorcycle-taxis and micro-buses), sky trains, and underground trains.

There are over 1,000 canals in the Bangkok Metropolitan area, and the total length of these canals is around 2,600km. In the past, these canal networks had prominent socio-economic and cultural roles in Thai society. They were the main thoroughfares for transportation of people and goods; they were also essential for agriculture and households' everyday life. They also served as recreational areas and venues for cultural and religious events. However, most are not in use and the conditions deteriorated.

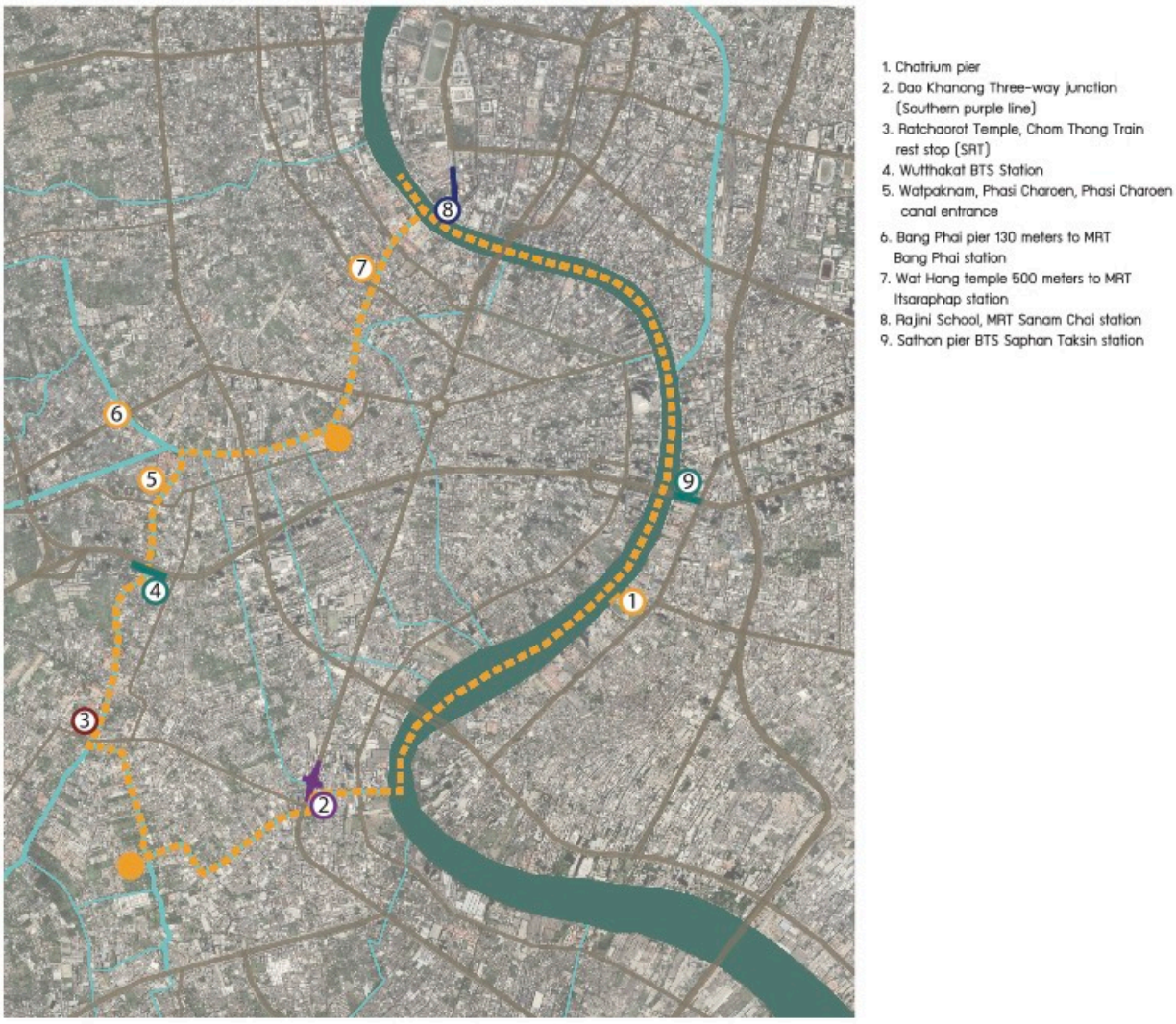

Figure 4: Route of the field trip by solar-powered boats along the Chao Phraya River and the canals of Western Bangkok.

Due to rapid urbanisation and construction of new concrete road networks, major developments have turned their back to the canals. As a result, water quality and living conditions of the communities along the canals deteriorated. In addition, water gates have been built at the intersections between the river and the canals to manage the daily water levels and during the annual flooding period in Bangkok. These watergates prevented the water transport services that used to serve daily commuters using long-tail boats traveling from their home along the canals to main piers on the river. To experience the reminiscence of old ways of life on the water and current problems, we started our boat trip on the afternoon of day two.

Environmentally conscious drivers picked up the participants in three solar-powered boats from the hotel pier and traveled slowly from the Chao Phraya River into Dao Kanong Canal. Each boat can accommodate up to 8-10 people and had at least one local

host who can provide useful information to the participants. They converted the original diesel-engine boats, commonly used by the famous *'long-tail'* boats, to solar PV and batteries (see Figure 4). They are a group of seven operators, each owning 1-3 boats. There are only a few of these boats, but they all believe this sustainable approach is better for their local tourism business and the environment in the long term. In addition to using renewable energy, these boats run quietly and emit no fumes, producing no noise or air pollution compared to their counterparts, the long-tail boats. Particularly after the COVID-19 Pandemic, more tourists prefer to travel in smaller groups and would like to reduce their environmental impact while traveling and enjoying new experiences.

Figure 4 The solar-powered boats

Figure 5 The boat at the watergate

The participants experienced how the existing canal networks could be integrated with local public transportation - for example, motorcycle-taxis, mini-buses, and tuk-tuks - and mass transit systems such as local trains (see Figure 6), skytrains and underground trains. There are also canal-side paths along the waterways, promoting micro-mobility and non-motorised transportation (i.e. cycling and walking).

Figure 6 The local train

Figure 7 The boat vendors

Another objective of this trip is to demonstrate how a research collaboration between the university, local authorities, and communities can contribute to more sustainable transport and better environmental quality. The participants also experienced the old way of life and local culture, such as the boat vendors selling seasonal fruits and street food (see Figure 7). After some 40 minutes, the boats stopped for a short break at *Rachaorot Temple* in Jomthong District, established since the Ayudhaya Period over 300 years ago and later renovated with exquisite fusion of Thai and Chinese arts and architectural style. In Thailand, the temple ground serves as a public space for religious and community events as well as recreational activities. The provision of public lighting is therefore important for functional and cultural purposes.

The participants in the first boat, many of whom are lighting experts focusing on reducing lighting carbon footprints, did observe the pole lights in the temple. They are typical 3-meter high poles with glass lampshades (see Figure 8a-8c) and conventional light sources (i.e. compact fluorescents and mercury vapour lamps). Although the light poles are nicely design for the cultural context and some already have LED light bulbs, they tend to have low efficiency due to diffuse light distributions. The local authority should consider using LED technology with a lens that would control light distribution on both horizontal and vertical surfaces. The common practice of LED lamp replacement only will not take full advantages of this new light source and control technologies.

Figure 8 The public lighting at the temple

After the break, we took the local train from nearby the temple to *Talad Plu*, a famous food market three stops away. This train line runs from Mahachai, the area famous for the wholesale seafood and fresh markets, west of Bangkok, to *Wong Wien Yai* Station - now also served with the BTS skytrain.

The original route used to go further from *Wong Wien Yai* to the river, where goods and produce from agricultural areas are delivered to main ports, then transferred to other parts of Thailand by boats. This local train is still popular among the locals due to relatively low costs, such as students and families with children, who mainly take short rides. *Talad Plu* as the BTS skytrain station is very central, only 4 stops from the *Taksin Bridge* Station, the main pier and the start of Bangkok's central business district (Sathorn and Silom area).

At the market, a number of riders from various companies (e.g., Grab and Line-man) waited to pick-up ready-made food from the famous street vendors and restaurants. Similar to other economies in Southeast Asia, such as the Philippines, Malaysia, and Indonesia, the food and essential household products delivery service has dramatically increased during the COVID-19 pandemic lockdowns. Although, there is no longer restriction on travel and visits to food and beverage outlets, this scenario may suggest that people still avoid dining in at the restaurants and rely on home delivery services, thus reducing their journey to retail outlets. However, to understand the real impact of this lifestyle change on energy use for daily journeys, especially by private vehicles, we would need more data.

After letting the participants observe local lifestyles and patterns of transport at the market, the boats picked us up again from the pier and continued our journey back to the river and then the hotel.

2.4 Summary

In summary, this chapter gives details of the materials and methodology of conducting the three-day workshop, including the boat trip on the river and canals. It also describes the distribution of the workshop participants from fourteen economies and how they contribute to the workshop activities and objectives. The following chapter will present the key outcomes of the workshop as a result of the presentations, group discussions, and, finally, the follow-up meetings of new collaborations on potential collaborative projects.

CHAPTER 3
KEY OUTCOMES

This chapter presents key outcomes compared with the objectives of the workshop in the following three aspects: 1) Data gaps identified and needs from the policymakers; 2) Potential new collaborations and projects with common interests; and 3) Awareness of women in energy fields and university students engagement in energy research projects. While they are the primary outcomes of the three-day workshop, potential new partnerships and projects, in particular, are being developed from the ongoing exchange of ideas- both online and onsite meetings.

3.1 Data Gaps Identified and Needs From the Policy-makers

This section summarises the group discussions, and we organized them in two aspects. The first is data required for supporting energy efficiency in the building and transportation sectors from the first two groups, and the other is data for promoting renewable energy and resiliency from the last group.

3.1.1 Energy Efficiency in Building and Transportation Sectors

As the APEC economies share 'Green' common goals, and the lighting and cooling systems are major contribution to the electricity use in the tropics. The group discussed the benefits of data collection (e.g. occupancy data in buildings and outdoor public spaces) and best practices in design and operation in this hot-humid region. They proposed collective activities - a collaboration on data collection to establish baseline activity and energy use in these systems before and after the COVID-19 pandemic. This time-based activity data will be valuable, for example, to inform how to adjust light levels of street lighting to reduce energy use, while maintaining safety and security.

For office buildings post-COVID-19, this data should support a provision of flexible space arrangement, lighting, and cooling (as opposed to centralised systems) that can optimise the electricity use, employee' comfort, and work performance. Data on occupancy and energy use in industrial buildings and large retail outlets is also important to optimising design and operation for energy efficiency. This is due to the impact of COVID-19 and digital transformation; many factories are replacing staff with automation and increasing online shopping may leave large shopping malls with less customers. These changes can have an effect on energy use for cooling per square meter.

Regarding the relationship between teleworking and carbon neutrality, the participants agreed that there is a need to collect more comprehensive data to understand the real impact of new work patterns and energy-related behavior in residential buildings, workplaces, and transportation. As illustrated in the initial studies of Dr. Ichinose (Japan) and Dr. Diaz (The Philippines), summarised in Chapter 4, these patterns and the extent to which they will impact the energy efficiency measure in both sectors and each economy might differ.

Thus, the participants proposed the development of a common survey with short (8-10) questions to share and collect baseline data to compare. Each economy could integrate this survey into the existing data collection channels. For example, through surveys, Thailand and the Philippines collect data on electricity use in residential buildings, which may need updating.

Regarding the best practices in building system design and operation, the economies can share design recommendations and guidelines, information on available technology and performance, and education and training materials. For example, designing and implementing adaptive street lighting would require information of appropriate light source characteristics (e.g., correlated colour temperature (CCT) and illuminance), control types, and energy sources (main electricity or solar-power). The participants also suggested that there should be recorded training materials and best practices can be shared and, through local contact and partner in different economy, they can be translated into local languages.

3.1.2 Renewable Energy and Resiliency

According to the renewable energy group discussions moderated by Dr. Katie Purvis-Roberts (The United States), the following are data gaps and needs identified:

1. The potential area on rooftops for solar PV installation
2. Data about end-of-life treatment for solar panels when they have to be replaced.
3. Resource assessment for bioenergy implementation.

    a. Private control of land, making it difficult to obtain missing datas.

    b. Fuel security - Identifying land for growing crops near bioenergy plants for shorter transportation to power plants

    c. Data about land most suitable for growing bio-crops that are close to the power plant

d. Data about the impact of fuel bio-crops on food security

e. Competition for land with other potential uses

f. Identifying the fastest growing plants (e.g., Napier grass) to produce for bio-crops for energy

4. Data about the increase in the storage of electricity

a. Figure out how to increase PV and wind energy generation with an additional storage capacity

b. Data about costs of energy storage

c. Information about which technologies would work best, and potential improvements

3.2 Potential New Collaboration and Projects with Common Interest

This part describes potential new collaborations and projects with common interests among the participants. These are from each of the three breakout group discussions at the workshop: 1) Reducing lighting carbon footprint for the tropics; 2) Decreasing energy use and improving urban transportation in Thailand and the Philippines; and 3) Investigating effective models for the promotion of solar PV for communities in the APEC. Details are as follows.

3.2.1 Reducing Lighting Carbon Footprint in the Tropics

The first group members are interested in energy-efficient lighting (for indoor and outdoor applications) and daylight harvesting in the tropics. They are the university faculty, environmental consultants, and policymakers with expertise in lighting system design and technology and building physics and energy policies from Brunei Darussalam; Indonesia: Japan: Singapore: Thailand: and The United States. As most of them are from tropical economies in Southeast Asia, they focus on integrating daylight and artificial lighting to reduce the energy intensity and, at the same time, to increase the share of renewable energy for buildings used during the daytime.

After the workshop and during a few online and in-person meetings, a collaboration between lighting and building physics experts (from Japan; Singapore; and Thailand) has been formalized. Dr. Chanyaporn Bstieler (Thailand), the research project leader, invited Dr. Masayuki Ichinose, Department of Architecture and Building Engineering, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan Uni-

versity, Japan, and Dr. Szu-Cheng Chien, Singapore Institute of Technology (SIT), Singapore to collaborate on an ongoing project funded by the Thailand Science and Technology Research Agency. This research plan covers two years (2022-2024) and is titled: "Developing Lighting Innovation for Future Workplace." Currently, the first phase of the project (2022-2023) is funded, and the second phase (titled: "Development of Daylighting Integration for Future Workplace to Reduce Environmental Impact and Promote Well-being: A Case Study of Bangkok") is still under budget review.

This project aims to identify the new patterns of working and living in APEC economies in Southeast Asia post-COVID-19, and how they influence the development of lighting innovations that reduce lighting energy use while improving the lit environment for better health and well-being of the users. These include Indonesia; Malaysia; the Philippines; Singapore; Thailand; and Viet Nam - all of which are APEC members. Dr. Masayuki Ichinose has been invited as a research advisor to the project due to his extensive surveys in green office buildings in Southeast Asia and his graduate student's research on a similar topic conducted in Tokyo, Japan. This work was titled: "Indicators to Evaluate the Introduction of Telework Post-COVID-19 flexible work arrangements" and published in the Proceedings of Passive and Low Energy Architecture (PLEA) Conference Santiago 2022. He also gave permission to use the questionnaire employed in his work for this current employee survey in the APEC economies in ASEAN. The project leader will adjust some questions and then translate the questionnaire from Japanese into English and other official languages of each economy before distributing it.

Another data collection method is in-depth interviews with key stakeholders - such as heads of Human Resources in large companies, building facility managers, and policymakers. Dr. Szu-Cheng Chien agrees to introduce this research and coordinate with critical stakeholders in Singapore. We also discussed the possibility that SIT graduate students might incorporate these questionnaire surveys into their projects. This research has also been introduced to other participants in the group discussion; some from Indonesia and the Philippines would consider contributing to the questionnaire surveys.

Another possible partnership is with the USAID Southeast Asia Smart Power Program (SPP). Mr. Balaji MK and Dr. Amornwan Resanond, speakers at our workshop, are two key people for the SPP project responsible for the increased deployment of advanced energy systems and clean and sustainable energy, respectively. There was a follow-up meeting after the workshop (May 2023), where they invited Dr. Bundit Fungthamasan, Dr. Pipat Wiwatworakul, and Dr. Chanyaporn Bstieler (JGSEE and KMUTT, Thailand) to join their year three annual work plan meeting in June 2023. The purpose was to exchange ideas and discuss possible collaborations on reducing lighting energy use by developing lighting design standards and specifications for LED streetlights and lighting and cooling energy use in airport buildings.

Finally, the last potential collaboration regarding lighting is between The United States and Thailand and involves developing demand-response lighting codes and standards. After Dr. Michael Siminovitch's presentation, the Ministry of Energy, Thailand's representative, expressed her interest in establishing a lighting standard to take advantage of today's advanced LED and lighting control technologies. These include, for example, daylight sensors, motion sensors, and PIR sensors that can reduce the light intensity or switch off depending on the available daylight or the actual use of that space. Since Dr. Siminovitch has experience in current lighting practices in offices, education, and some industrial buildings in Thailand, he agrees that this approach would be possible and timely as the technologies have become more affordable and easier to operate. A meeting to explore the possibility of working together will be arranged around mid-August 2023 when he is in Bangkok.

3.2.2 Sustainable Transportation

The urban and transportation group members have common interests in exploring two issues further. These are the impact of COVID-19 on energy use in the transportation sector in APEC economies and a comparative study on challenges and opportunities to utilize water transportation in Bangkok and Manila. Dr. Crispin Diaz (The Philippines) has conducted an initial survey among the commuters in Metro Manila to understand the changing behavior due to the COVID-19 pandemic. After an online communication and exchange of ideas, there was also a suggestion to modify this survey and combine it with other questions about work methods and energy use in buildings mentioned in the section above. We could develop a standard survey, then send it to many APEC economies and see variations in different locations.

Another project concerns the potential of water transportation to lessen the traffic problems in Bangkok and Manila, which would consequently reduce energy waste and air pollution. For Metro Manila, the *Pasig River,* which flows from the east toward Manila Bay in the west, has been identified as potential for water transportation. However, current services could be more extensive and perhaps more reliable to attract people. Also, there were problems with inconvenient connections and high costs.

On the other hand, water transportation in Bangkok offers a variation of boat services on the Chao Phraya River and in some canals, as seen during the boat trip on day two. Conducting a comparative study between Manila and Bangkok would help gain valuable insights into the challenges and opportunities associated with water transportation in both cities. Dr. Diaz and Dr. Budhimethee will organize an online meeting to discuss and develop these two projects in detail. These two possible projects would improve urban transportation while reducing energy use and environmental impacts.

3.2.3 Investigating effective models for community-based Solar PV in the APEC

Another possible new renewable energy and resiliency project will focus on investigating practical approaches to support community-based solar PV in the APEC economies. Dr. Norashikin Ahmad Ludin (Malaysia) and Dr. Katie Purvis-Roberts (The US) led the working group and proposed an initial idea for collaboration on solar PV, developed from the group discussions at the workshop. Subsequently, the group extended to include Dr. Bundit Fungthammasan, Dr. Athikom Bangwiwat, and Dr. Worajit Setthapun (Thailand). The members exchange information on current situations of solar energy for communities and rooftop projects in Malaysia and Thailand.

Many homeowners in Malaysia are facing an increased electricity bill, as the current subsidy will be reduced stage by stage by the end of 2023. The support only applies to the B40 group under the income generation classification, so most people living in the urban community will no longer be eligible for the subsidy. As a result, many have considered installing solar rooftops to reduce electricity bills. However, the investment cost is still the main barrier.

Meanwhile, in Thailand, there are many incentives and supporting schemes to promote the use of solar rooftop PV. However, the details of these supports are varied and perhaps needed to be better understood by the public. Previous solar home projects also faced maintenance issues after the installation by the real estate developer. Another issue is the current community solar energy project that allows private companies to invest, install solar PV in the community, then sell the electricity to the residents. As a result, the residents have no ownership of solar energy generation and do not benefit from the lower costs of electricity generated in their community.

As solar PV projects gain more popularity, especially during the COVID-19 pandemic and recent energy crisis, there seemed to be effective models to support community-based solar PV implemented in other APEC economies. So this group has developed an outline for a new concept note to seek funding from the APEC's EWG in 2024. The group leaders also plan to invite other possible partners from Chile to collaborate, then develop potential case studies. The proposed main activities will include focus group discussions, workshops, and policy dialogue with, for example, policymakers, regulators, utilities, community leaders, and installers. The project will identify different types of barriers, conduct barrier validation and analysis, and then propose a policy recommendations.

3.3 Awareness on Women in Energy Fields

This APEC project raised awareness of women in the energy fields by inviting prominent female speakers and encouraging other female attendants to take essential

and visible roles at the workshop. For example, fourteen female attendants served as speakers and moderators. At the workshop's beginning, the PO invited Dr. Geri Richmond, the Under Secretary for Science and Innovation at the Department of Energy (The United States), also a distinguished female scientist, to deliver her inspiring opening speech (recorded) to the workshop participants. She emphasized the importance of promoting more females in science and energy fields, new collaborations, and integrated efforts to achieve the APEC's ambitious energy goals. Subsequently, President Suzanne Keen, Scripps College (The United States), also gave her welcome remarks and encouraged the participants to join efforts between the policymakers, the university faculty, and the students.

There were also two dedicated sessions on gender issues related to the energy sector (Session 8) and the energy project's impact on education and students' interest in clean energy (Session 9). Session 8 was moderated by Dr. Bstieler (Thailand) and had two female speakers from universities in Malaysia and Thailand, and the last speaker, Dr. Amornwan Resanond, a private consultant (Deloitte, Thailand).

Dr. Norasikin Ahmad Ludin (Malaysia) illustrated the gender disparity in career advancement within the science and energy sectors, with women holding fewer high-level positions than men. Several factors contribute to this gap, including challenges in maintaining work-life balance, gender stereotypes associated with women in these fields, and limited access to training and career progression opportunities. In 2022, however, there was distinguishable progress in Malaysia, where women now hold 40% of senior leadership positions. This positive change is attributed to businesses in the energy sector adapting to new challenges and opportunities arising from the post-COVID-period. The companies have introduced flexible working patterns and committed to diversity and inclusion at work over the past year.

Dr. Norasikin Ahmad Ludin also addressed the gender issue in society through her current project. The work aims to strengthen women's roles in the innovative sustainable energy and cooling sector to address poverty and household dynamics through a gender-based study about energy and cooling access, to improve health and well-being, to develop financing for gender-sensitive energy cooling solutions, and to support awareness raising activities such as education and sharing platforms.

The second speaker, Dr. Jirawadee Polprasert (Thailand), referred to section 5 of the UN's SDGs on gender equality and addressed the gender-related energy challenges in Thailand. The gender issue encompasses various domains, such as household energy, electricity accessibility and pricing, renewable energy technology options, energy-efficient household management, and the social implications of significant energy infrastructure projects. To close the gender gap, she proposed the following steps to con-

nect domestic and international efforts, empowering women from the bottom up, providing targeted funding, improving access to networks, and implementing supportive policies for gender equality.

Dr. Resanond addressed the crucial role of gender equality and social inclusion (GESI) for sustainable development. She presented a case study for implementing this concept for public EV transport policy formulation in Nakornratchasrima Province (Korat), a major city in northeastern Thailand. She also emphasized the data collection sampling and methods, such as interviews and field surveys, that included women, children, older people, persons with disabilities (PWD), and marginalized groups.

After this session, there were contributions from Ms. Elvira Gelindon (APERC) and Dr. Michael Siminovitch (The US). Ms. Gelindon added that women researchers play a crucial role in data collection, as they can gather more profound insights during individual interviews. According to her experience in the energy sector, she perceives no gender bias, as the office where she previously worked in the Philippines comprises numerous young female researchers. In order to improve the gender issue in the energy sector, Dr. Siminovitch proposed that incorporating evidence-based practices and objective indicators could contribute to advancing the problems of gender issues in the workplace. For instance, research conducted in the United States reveals that organizations led by female CEOs tend to achieve greater success. Therefore, the proposal should focus on examining the underlying mechanisms and identifying what factors contribute to this phenomenon and why.

3.4 University Faculty Works with Data on Energy Projects and Impact on Education and Developed Interest for Student in Pursuing Clean Energy Work

This section summarises the university faculty projects from Session 9 and draws from other presentations that also engaged students in energy data collection to illustrate the benefits of this approach to education and developing student interests in clean energy work. Dr. Norasikin Ahmad Ludin (Malaysia) shared the experience of collecting data on selected solar farms with students from Indonesia; Malaysia; and Thailand. The project investigated the Dynamic Life Cycle Assessment (LCA) & Life Cycle Cost Analysis (LCCA) of Distributed Energy Systems. This research has led to new networks and collaborations with domestic and international agencies. The students who participated also benefit from presenting at conferences and joint research. Her Ph.D. student is also investigating this research topic.

Dr. Szu-cheng Chien (Singapore) addressed the importance of raising students' awareness of creating a sustainable environment. For Singapore, the hot-humid climates offer an excellent opportunity to use daylight to reduce electricity use while improving occupants' visual comfort and productivity. One of his research focuses is the integration of daylighting and other building systems, and the project usually involves students. He also shared the program that the Singapore Institute of Technology (SIT) used to align the student's understanding of sustainability. The Sustainable Education Programme consists of 4 groups of integrated modules– projects, data workshops, guest lectures, and internships. This systematic learning approach has built the necessary knowledge and skill sets for the students to advocate for clean energy projects and innovate for a sustainable future.

Prof. Katie Purvis-Roberts (The US) and Dr. Kanjanee Budhimethee (Thailand) shared their collaborative project on developing a commuter boat network on Bangkok canals. The goal is to investigate different locations along the canals suitable for creating a network of commuter boats and propose new facilities. KMUTT graduate students in Bangkok collected water and air samples, while undergraduate students in Claremont analyzed the data. Subsequently, KMUTT students incorporated the environmental data into their design concepts and proposed small design projects to facilitate the boat service, such as a new pier and smart lighting as air quality indicators along the canals. Students in this joint class learned about the challenges of collecting and analyzing real-world environmental data and created evidence-based design solutions accordingly. Claremont students, in particular, got very interested in the idea of solar boats.

In addition to the presentations in this session, others also engage their students in energy data collection. For example, Dr. Wan Yun Hong (Brunei Darussalam) investigated the energy consumption and CO_2 emission of lighting for commercial buildings in Southeast Asia. She assigned her students to collect data on lighting energy consumption in commercial buildings, particularly the university library, where they regularly use it. The study also compared the energy use between artificial lighting and a combination of daylight in the library. This engagement could make them more aware of renewable energy choices and the impact on the building energy intensity.

Dr. Masayuki Ichinose (Japan) shared his project on the impact of hybrid work on energy consumption and CO_2 emission in Tokyo and its implication for green building design. This work also involved his undergraduate student, who was accepted to present and published in the proceedings of the PLEA international conference (2022) titled: "Indicators to Evaluate the Introduction of Telework Post-COVID-19 flexible work arrangements". This student has now pursued her graduate study and continued investigating the similar impact of hybrid work on energy use.

3.5 Summary

This chapter describes the main outcomes of the workshop. Time-based occupancy and activity data in residential buildings, workplaces, and transportation are needed to support energy efficiency in buildings and transportation sectors. Feasibility studies for generating solar power, land use, and appropriate crops for biomass are required to promote renewable energy and resiliency.

As a result of the interaction at the workshop and further exchanges of ideas, some participants with common interests created new partnerships and initiated collaborative projects. Finally, it illustrated that the workshop successfully raised awareness of gender equality in energy fields and that student engagement in energy data collection has a beneficial impact on their interest in clean energy further education and practice.

CHAPTER 4
SUMMARY OF PRESENTATIONS

This chapter summarises nineteen presentations given by the policymakers, university faculty, and energy experts over three days. The summaries are organised into four groups as follow: 1) Overview of the APEC energy goals, data collection, energy policy refocus for the post-COVID-19; 2) Case studies on energy efficiency and the impact of hybrid work on energy use in buildings and transportation; 3) Renewable energy and resiliency and policy implications; and 4) Gender issues related to the energy sector.

4.1 APEC energy goals, data collection, and energy policy refocus post-COVID-19

Session 1: Dr. Cary Bloyd (United States) Pacific Northwest National Laboratory. ***Overview of APEC Renewable Energy, Energy Efficiency, and Energy Resiliency Activities.***

Dr. Bloyd gave an overview of the APEC structure, clean energy mandate, and current projects supported by the Expert Group on Energy Efficiency and Conservation, the Expert Group on New and Renewable Energy Technologies, and the APEC Energy Resiliency Task Force. The Energy Working Group is supported by eight sub-fora groups. APEC Leaders and energy ministers provide clean energy goals. The goals (set in 2015) are to reduce aggregate energy intensity by 45 percent by 2035 and double renewable energy in the regional energy mix from 2010 levels by 2030 to achieve sustainable and resilient energy development within the Asia-Pacific.

The APEC host economy sets annual themes and priorities, and the theme for the 2023 US host year is: “Creating a Resilient and Sustainable Future for All.” The US has identified three priorities:

1. Interconnected: Building a resilient and interconnected region that advances broad-based economic prosperity.
2. Innovative: Enabling an innovative environment for a sustainable future.
3. Inclusive: Affirming an equitable and inclusive future for all.

Dr. Bloyd also gave examples of current projects supported by the APEC Expert Groups and, more specifically, the projects that universities in APEC economies are conducting to help define future APEC energy options.

Session 2: Data Collections for Energy Policy Post COVID-19

Moderator: Dr. Chanyaporn Bstieler

Ms. Elvira Gelindon: Research Fellow, APERC (Japan). ***APEC Energy Overview: APEC twin goals and a lot more.***

Ms. Gelindon gave an overview of the APEC Energy Overview produced annually by APERC since 2000. Two types of data are collected: the social and economic indicators (WB) and the energy data submitted by the member economies. Where possible, the APEC Overview uses data provided by Experts Group on Energy Data and Analysis (EGEDA) and Energy Statistics and Training Office (ESTO) for consistency. The APEC Energy Overview objectives are: 1) To share the latest information on energy-related government policies of member economies; 2) To provide up-to-date information and insights to policymakers and researchers in the region; and 3) To promote the use of EGEDA/APEC data. Until 2014, APEC's progress towards its goal of reducing energy intensity was incorporated in the Executive Summary. In 2017, the report also included the analysis on doubling the share of renewable energy (RE) goal. Thus, the APEC Energy Overview became a platform for monitoring progress of APEC's two goals.

The APEC energy supply trend decreased from 2019-2020 due to reduced economic activities during the COVID-19 lockdowns. While APEC electricity generation during 1990-2020 had a compound annual growth rate (CAGR) of 3.1%, from 2019 to 2020 growth was only 0.2%, most probably due to COVID-19 lockdowns. The share of renewable energy increased to almost 25% in 2020 from 1990 level, mainly from hydropower, wind, and solar. APEC's final energy consumption showed an increased CAGR from 1990-2020 but likewise decreased during pandemic. By type of fuel, oil consumption dropped 10.1% from 2019 to 2020. The transport sector took the brunt declining 11.4% from 2019 to 2020 due to travel restrictions imposed during pandemic. Energy consumption in the services sector likewise declined by 6% from 2019 to 2020 as the place of work activity shifted from offices to residential. Historically, both final and primary energy intensities decreased substantially from 1990-2020. CO_2 emissions has the biggest year-on-year decline in 2020.

In conclusion, Ms. Gelindon shared that if this trend on final energy consumption continues, APEC's aspirational goal of reducing energy intensity by 45% from 2005 to 2035 is likely achievable. Likewise, efforts should be sustained to achieve APEC's aspirational goal of doubling the share of renewable energy from 2010 to 2030. Finally, she suggested that we closely monitor the energy efficiency and renewable energy trends after 2020, post-pandemic energy consumption. Next steps for the APEC Energy Overview is to include discussion on energy transition, in view of the global race to carbon neutrality and the enhanced collaboration with IEA, for the May 2023 publication.

Ir Prof. Harry Lai (Hong Kong, China) Principal Advisor/Carbon Neutrality, EMSD, Government of the Hong Kong, China. ***Achieving Carbon Neutrality In Collaboration with Universities and Research Institutions.***

Ir Prof. Lai first reviewed global developments in achieving carbon neutrality, including the Intergovernmental Panel on Climate Change (IPCC) established in 1988 and the United Nations Framework Convention on Climate Change (UNFCCC) formed in 1994. He then presented Hong Kong, China's goal, targets and strategies to achieve carbon neutrality before 2050. Electrical and Mechanical Services Department (EMSD) contributed to achieving the said carbon neutrality goal mainly via the Energy Efficiency & Conservation (EE&C) route, which included setting up the Energy Efficiency Office in 1994, mandatory and voluntary energy efficiency labeling schemes, building energy codes, building energy efficiency and district cooling services ordinances, and assisting to formulate the energy saving and climate action plans.

Apart from the EE&C plan, other carbon neutrality-related issues under study would include, amongst others, renewable energy, carbon capture, net-zero energy buildings, and green transport. EMSD's Support Framework for Carbon Neutrality comprised a Steering Committee and a Carbon Neutrality Group, leading the Energy Work Group, District Cooling System Work Group, and Hydrogen Team to collaborate with universities and research institutions to conduct the study.

Potential areas of collaboration were:

- To keep abreast of high-end developments of new decarbonization technologies globally
- To facilitate the Government's understanding of the latest technologies
- To assist in the formulation of forward-looking policies
- To provide training opportunities for future leaders of relevant Departments

Examples of collaboration with universities and researchers included smart thermostat for fan coil units, and solar hydrogen via Photocatalyst by City University of Hong Kong; performance of PV panels in local environment, and energy storage system with retired vehicle batteries by Hong Kong Polytechnic University; sustainable smart campus as a living lab by Hong Kong University of Science and Technology, etc. Besides, the E&M AI Lab was launched to support the development of Big Data and AI applications for Building E&M Facilities to combat future challenges, including smart city initiatives, while focusing on Data Hub, Semantic AI, and Platform.

Finally, he concluded by quoting the IEA Report: Net Zero by 2050 that we should drive a huge leap in clean energy innovation as most of the reductions in CO_2 emissions through 2030 would come from technologies already in the market. But in 2050, almost half of the emission reductions would come from technologies currently in demonstration or prototype phases. Hence, major innovative efforts must take place this decade to bring these new technologies to the market in time.

Session 3: Energy Policy Refocus for the Post-COVID-19 Era
Moderator: Dr. Chanyaporn Bstieler

Ms. Shu-mei Peng. (Chinese Taipei) Senior Executive, Bureau of Energy, Ministry of Economic Affairs, Planning Division. ***Chinese Taipei's Energy Policy and Development in the New Normal.***

Ms. Peng presented Chinese Taipei's Energy Consumption under COVID-19 and the net zero transition in the economy. The energy mix in Chinese Taipei is imported energy (nearly 98%) and local (only 2.3%), mainly from biomass and waste. The industrial sector is the largest energy consumption (62.3%), while the transportation sector is the second largest (14.4%). Chinese Taipei's economy is export-oriented. During the COVID-19 pandemic, domestic energy consumption increased by 5.1% compared with 2019, while the Industrial sector increased by 9.4%. The impact of the lockdown on other major sectors included transportation reduced by 4.4%, residential increased by 8.1%, and services declined by 1.2%.

Regarding the net zero transition in Chinese Taipei, Chinese Taipei's goal is to achieve Net Zero Energy goals by 2050. Net Zero transition strategy in Chinese Taipei includes (from low carbon to no carbon) decreasing the import of low carbon fuel while increasing the share of indigenous energy (renewable energy) by 60% and planning to improve power system integration and power storage.

Key strategies include energy-saving through strengthening laws and regulations and expanding the scope of incentives and assistance. In addition, the economy will promote renewable energy, focusing on solar and wind power development. The solar PV development target is 20GW by 2025 with an offshore wind power target of 5.6GW by 2025. The rapid expansion of solar PV, based on the mapping of domestic land area inventory and technology forecast, shows an estimated solar energy potential in 2050 of between 40-80GW. This is subject to technology advancements(i.e., module efficiency). The solar PV pathway focuses on R&D in advanced battery technology, grid integration, and recycling.

Two demonstration projects of offshore wind farms generated a total of 237.2MW. The process has three steps: demonstration, potential site selections, and zonal development. The economy also involves developing innovative energy technologies, such as baseload geothermal and marine energy are prioritized, with the expansion of biomass energy. It will also expand the production of hydrogen. Energy storage development concerns the grid, power generation, and end-users (mandatory renewable energy and energy storage for large electricity users). Finally, for energy resiliency, the aim is to strengthen grid resilience. She concluded that:

1. Chinese Taipei has been promoting energy transition policies promoting green energy, increasing natural gas, reducing coal-fired, and achieving nuclear-free since 2016, and has caught up with the worldwide agenda of net-zero emissions.

2. Transitioning to zero carbon will focus on developing renewables and innovative energy technologies (e.g., hydrogen). In addition, the economy plans to expand the energy-storage facilities to ensure power supply stability while improving energy efficiency and conservation implementation to utilize natural resources better and thereby reduce carbon emissions.

3. Under the new normal, the energy transition policy toward a net-zero future is essential to optimize energy structure and strengthen energy security.

Mr. Daniel Collin G. Jornales. (The Philippines) Supervising Science Research Specialist EE&C Program Management and Technology Promotion Division Energy Utilization Management Bureau Department of Energy, the Philippines. ***Energy Policies of the Philippines for the Post-Pandemic Era.***

This presentation gave an overview of the energy demand outlook of the Philippines and the impact of the COVID-19 pandemic on the future scenario. After the energy demand declined in 2020, total final energy demand increased and returned to its pre-pandemic levels in 2023, continuing its growth trajectory with 38.7MTOE in 2024. Growth in total final energy demand rebounds in 2021, then normalizes by 2022 to 2024, moving in parallel with economic growth. He presents policies on energy efficiency, renewable energy, and energy resiliency.

Adopting Energy Resiliency in Planning and Programming prompts the energy sector to mitigate the potential impacts of disasters, and promotes planning and investment in energy resiliency to ensure the economy's energy infrastructure continues to deliver while anticipating and reducing vulnerabilities. The RE Act aims to accelerate the development of the economy's renewable energy resources, including biomass, solar, wind, hydro, geothermal, and ocean energy sources, including hybrid systems. The Energy Efficiency and Conservation (EEC) Act institutionalizes energy efficiency and conservation, enhances energy use, and grants incentives to energy efficiency and conservation projects.

The introduction of Designated Establishments (DEs), referring to private entities identified as energy-intensive industries from the commercial, industrial, and transportation sectors, aims to increase energy efficiency. Other strategies included the design guidelines, particularly Building Envelope, Mechanical and Electrical Systems (thermal performance, ventilation, and high efficiency), and the launch of the Energy Efficiency

Excellence (EEE) Awards (a total of 24 awardees in 2022). As of 2021, the EE projects implemented by ESCO resulted in an energy saving of 7.65MKWh.

The government also encourages and promotes the energy-conserving design of buildings and their services to reduce the use of energy with regard to the cost-effectiveness, building function, comfort, health, safety, and productivity of the occupants. This strategy covers new buildings and their systems and any expansion or modification of existing facilities with connected electrical loads of at least 112.5kWh or at least 10,000m^2 Total Gross Floor Area (TGFA). Other strategies included the design guidelines, particularly the mechanical systems (high efficiency and clean air), and the launch of the Energy Efficiency Excellence Awards (a total of 24 projects in 2022).

Ms. Sutthasini Glawgitigul. (Thailand) Chief of Energy Cooperation Section, Strategy and Planning Division Department of Alternative Energy Development and Efficiency. *Thailand Energy Policy Refocus for the Post-*COVID-19 *Era.*

This presentation addressed the effects of the COVID-19 pandemic on the energy sector in Thailand. The energy demand declined, and there was a shift in energy use due to reduced income and supply chain disruptions. In 2022, the overall energy consumption increased by 3.2%. The primary consumption trends in 2023 have also gone up by 2.7%. The direction of energy policy in 2023 addressed three goals: energy security, a carbon-neutral goal in 2050, and Net Zero Emission in 2065. Thailand's energy policy comprises four dimensions.

Dimension 1: Energy creates stability for a low-carbon society. This dimension includes, for example, a domestic energy plan, grid modernization, and EV investment.

Dimension 2: Energy to strengthen the economy. This aspect involves developing financial tools to promote energy conservation, implementing the Building Energy Code (BEC) in the public sector through the Energy Service Companies (ESCO) mechanism, and promoting electricity generation from renewable energy.

Dimension 3: Energy to reduce inequality and improve life quality. This element specifically addresses using biomass and biogas from energy crops for communities and local economy, sustainable island and remote areas, and support for vulnerable groups through public welfare schemes.

Dimension 4: Organizational Development for Service Providers. This aspect involves, for example, providing services to the National Energy Information Center and analyzing and designing digital technology systems to increase efficiency in energy business regulation.

Dr. Wahyu Sujatmiko. (Indonesia) Specialist Engineer-Directorate for Settlement and Housing Engineering Development-Directorate General of Human Settlements. ***Indonesia Green Building Regulations.***

Dr. Sujatmiko presented the development of green building policies, regulations, and implementation in Indonesia. In 2030, Indonesia predicts that Green House Gas (GHG) emissions will increase by more than 1,500MtCO_2, and the economy aims to achieve Net Zero Emissions by 2060. Indonesia established a green building roadmap and strategies to overcome challenges, involving building research and innovation, and developing Green Building Standard Conformity Test Equipment. The Ministry of Public Works and Public Housing (MPWH) was responsible for preparing and developing the Green Building Performance Assessment/Rating.

Green building regulations require *Green Building Performance Assessments* for new and existing buildings, community neighborhoods, as well as new and existing green space. The assessment parameters include site management, energy and water efficiency, indoor air quality, waste management, and wastewater management. To date, many commercial and public buildings are certified as Green Buildings. Indonesia's new capital city is among several projects preparing for Green Building Certification.

During the planning stage, the Green Building Simulation Support is available, for example this includes fire safety simulation. Strategies to promote the implementation of Green Building Policies include capacity building through training and providing a transition period, accelerating the implementation by local Government, and improving the assessment parameters. The economy also supports green building research and innovation, such as a prototype of low-carbon apartments incorporating the hybrid approach, a combination of active and passive design.

Mr. Joan Manuel Romero Ubiergo and Ms. Priscilla Leufuman. (Chile) Ministry of Energy, Chile. ***Energy Policy Refocus for the Post*-COVID-19 *Era.***

In March 2020, the Chilean Government declared a state of emergency and implemented quarantine measures. As a result, public and private companies adopted remote work policies. The economy established several measures to monitor electricity consumption and energy demand to ensure energy supply throughout the logistic chain and prioritize worker health and safety.

During the state of emergency, various sectors experienced reduced electricity demand, particularly the commercial sector. Additionally, suspending electrical consumption during peak hours in the summer aimed to support families, economic activity, and employment. The Government also implemented a contingency plan to provide

support during this challenging time, benefiting over 3,000,000 low-income Chilean families by covering their energy bills. Furthermore, the Government allocated USD5 million towards renewable energy and energy efficiency projects.

Chile aims to achieve Carbon Neutrality by 2050 through four key aspects:

- Increasing the share of renewable energy and phasing out coal power plants
- Promoting energy storage and electromobility (the principle of using electric propulsion for a wide range of transportation types)
- Emphasizing hydrogen technologies
- Implementing energy efficiency measures

In 2021, the approval of the energy efficiency law marked an important step in this direction. The law includes provisions for institutionalizing energy efficiency, implementing energy management systems in industries, establishing energy labeling for buildings, and setting efficiency standards for vehicles. Chile also incorporates the process of public participation in energy policy. There is an ongoing discussion within the working group comprising the Minister of Energy, representatives from the public sector, and the National Energy Commission.

4.2 Case Studies

Session 4: Case Studies on Energy Resilience in Commercial Buildings
Moderator: Dr. Katie Purvis-Robert
Prof. Michael Siminovitch (The United States) Rosenfeld Chair, California Lighting Technology Center, UC Davis. ***Experimental research and data collection to inform energy policies in California.***

Dr. Siminovitch presented the vision for California that aims for a 15% reduction in GHG emissions, and "The 100 Percent Clean Energy Act of 2018," or Senate Bill 100 (SB 100) that, requires 100% electricity created by zero-carbon resources by 2045. The University of California set a goal to achieve Carbon Neutrality by 2025. Buildings account for almost 40% of The US's carbon emissions. Achieving zero-net-energy buildings would require government policy, new technologies, best practices, and reducing wasted energy. Wasted energy is commonplace and represents more than 50% decarbonization opportunity. He highlighted a gap between an ideal building's energy use profile and the energy use in real buildings, where unoccupied buildings tend to use the same energy as those occupied.

However, translational research can drive policy through laboratory research, demonstration, training, and codes and standards. But currently, policy goals need to be mapped to strategy, addressing the lack of standards and effective regulations, and educational programs. Dr. Siminovitch also suggested that we need building monitoring data to realize these energy-saving opportunities and to understand where and when energy is used in lighting. He shared examples of how data from research and demonstration projects help drive building standards, a mandatory measure leading to actual energy savings.

For example, his study found 75% of energy-saving opportunities in common spaces, particularly corridors, stairwells, bathrooms, and large parking lots. This data informed the following policies in California: a policy requirement for residential sensors (2005) and load shedding, with and without adaptive lighting controls (demand response). Sensor-based commercial building standards (2019) require corridors and hallways with bi-level control (lights to 50% power on vacancy, automatically to 100% on occupancy, with sensors) and contribute to 40% savings.

Prof. Masayuki Ichinose. (Japan) Tokyo Metropolitan University. ***The impact of hybrid work on energy consumption and CO_2 emission in Tokyo and its implication for green building design.***

Dr. Ichinose gave a brief overview of the history and future scenarios of energy consumption as well as CO_2 emission in Asia. These scenarios call for more rigorous energy efficiency measures in the building sector, resulting in wider adoption of international and local voluntary 'green building' labeling schemes throughout the region. These include LEED (Leadership in Energy and Environmental Design), one of the most widely used green building rating systems worldwide.

However, Dr. Ichinose and his local collaborators conducted field measurements and questionnaire surveys in certified green buildings in tropical APEC economies, such as Singapore; Thailand; and Viet Nam. They found an insignificant relationship between the designed energy performance and the actual energy use intensity (EUI). The occupant survey also revealed physical symptoms from too low-temperature settings and other discomfort due to poor indoor environmental quality control. Therefore, he proposed that the economies require real energy data and occupant surveys from occupied buildings to incorporate into future green building assessments.

Finally, he presented the results from his investigation (Tsukahara et al., 2022) on the impact of hybrid work on the overall energy-saving potential for building and transportation sectors, using an insurance company in Tokyo as a case study. The study con-

sidered the number of employees who occupied the office and the frequency and cost of travel to work in the office. The results indicated the data types needed for the economy to decide on hybrid work policies and still benefit from energy savings.

Prof. Wan Yun Hong. (Brunei Darussalam) Universiti Brunei Darussalam. ***Energy consumption and CO_2 emission of lighting for commercial buildings in Southeast Asia.***

Dr. Wan Yun Hong presented her research investigating an appropriate approach for estimating energy consumption, CO_2 emissions, and electricity cost of lighting in commercial buildings in Southeast Asia. The aim was to suggest a lighting decarbonization pathway and support the global ambition of net zero emissions. Although some 80% of lighting in Asia-Pacific is covered by the Minimum Energy Performance Standards (MEPS), accelerating the adoption of high-efficiency light-emitting diodes (LED) would significantly reduce the energy intensity and lighting carbon footprint (IEA, 2022).

The first study (Hong & Rahmat, 2022) compared building energy intensity (BEI), lighting energy use, CO_2 emissions, and electricity cost among six commercial building types in Brunei Darussalam; Malaysia; Singapore; and Thailand. The results suggested that retail paces are the largest contributor to lighting carbon footprint. In addition to adopting LED, integrating daylight and appropriate lighting control strategies would increase lighting energy savings potentials. The second study (Hong & Rahmat, 2021) investigated models for estimating energy-saving prospects of different lighting designs and control scenarios. She suggested that the best model for estimating lighting energy consumption was the multiple non-linear regression model (MNLR).

Session 5: The Impact of Hybrid Work on Energy Use in Buildings and Transportation

Moderator: Prof. Szu-cheng Chien

Prof. Crispin Emmanuel D. Diaz. (The Philippines) School of Urban and Regional Planning, University of the Philippines – Diliman. ***Hybrid work and transportation mode choices in Metro Manila: an initial survey.***

Dr. Diaz presented the results from his initial survey on the relationship between hybrid work and transportation mode choices in metro Manila. Telecommuting, the practice of working from home, using the internet, email, and the telephone, allows

employees to avoid travel costs and time spent traveling. Thus we expect the reduction in energy use to correspond to decreasing pollution. Based on estimates, current telecommuting arrangements save, on average, PHP159.64 per week per employed person and 103.49minutes per week per employee. Local studies suggest that the "commute time reduction" will likely be used by people for resting, spending more time with family, and leisure. Retaining telecommuting, *where possible*, can significantly impact the quality of life.

However, this initial study has the following limitations. The survey may underrepresent some occupations. Actual telecommuting arrangements may change, with employers making further adjustments to boost productivity. While telecommuting allows people to avoid transport costs, the survey needed to verify if they stayed home to do their remote work. Telecommuting may induce additional expenditure related to energy and material use at home (instead of at the office); the survey did not inquire on "new" activities or practices or changes in the allocation of time to various activities within a working day (and possible energy implications). Travel cost-saving estimates did not account for potential reductions resulting from congestion relief (based on the premise that fewer people on the road will reduce traffic volumes).

Dr. Ir. Rizki A. Mangkuto. (Indonesia) IPM Building Physics Research Group. Faculty of Industrial Technology, Institut Teknologi Bandung. ***Towards 'Locally-Relevant' Daylight Metrics in the Indonesian Context.***

Dr. Mangkuto addressed the benefits of daylight to our visual performance, health, and well-being, but at the same time, daylight also directly contributes to thermal comfort and heat gain, particularly in tropical buildings. Daylighting design in the tropics requires an accurate assessment of its visual and thermal impact on the buildings, which is still challenging. Currently, we rely on lighting modeling, computer simulations, and real measurements to evaluate the visual and thermal performance of lighting design and energy use. Therefore, daylight metrics suitable for the local context in Indonesia are essential to predicting indoor lighting quality.

His ongoing research includes daylight modeling and simulations in elementary schools, passive design optimization of building envelops, building-integrated photovoltaic (BIPV) facade optimization, and daylight evaluation and simulation in a room with a kinetic facade. He also compared the advantages and disadvantages of different daylight metrics and sky models. While detailed results vary, he suggested that *useful daylight illuminance* (UDI) can be a good predictor of indoor daylight availability in the tropical context. Further study is investigating variables due to the different microclimates of various locations in Indonesia.

Prof. Ampol Karoonsoontawong (Thailand) Faculty of Engineering, King Mongkut's University of Technology Thonburi (KMUTT). ***Sustainable transportation: the proposed canal transit network for west Bangkok.***

Dr. Karoonsoontawong presents the development of water transport systems in the Bangkok Metropolitan Area that is consistent with Thailand's 20-year strategies (2018-2037) and emphasized the promotion of a water transportation network, conservation of clean canals and rivers, and canal and river tourism. The study presents the criteria for classifying rivers and canals, the type of boat, and pier sizes for developing a water transportation network map (W-MAP). The objective is to investigate possible canal boat transportation routes, pier locations, pedestrian paths, and connections between piers and existing public transport stations in Western Bangkok and forecast the canal boat transportation demand by applying the existing travel demand model incorporating the proposed canal boat transportation system.

He points out the benefit of water transport, which is that travel costs and construction prices are cheaper than land travel by road. Also, the challenges in urban travel and transportation services, such as balancing efficient travel and transportation services with environmental friendliness, safety, and energy savings, provides the possibility of creating sustainable urban travel and transport methods in megacities with an increasing number of people, mobility efficiency, sustainable, and inclusive for users of all ages.

The researcher categorized the potential of 108 canals in Bangkok for transportation into three types; the first type can be used for water travel and the second group has potential but needs some improvement, while the last group has no potential. The results suggested that future travel patterns in the west of Bangkok have developed rapidly according to the development of public transportation projects, but are not connected to the public transport system on the ground and grow without clear direction.

Dr. Karoonsoontawong addressed the importance of stakeholder involvement in the development of policies to support water travel. It is also important for parallel studies to create new alternatives to the public transport system and the process of collecting sampling data in waterfront areas, both the physical aspects of the canal route, water quality, air quality, activities, and quality of life of riverside communities in 4 districts of western Bangkok (Khlong San, Thon Buri, Chom Thong, and Thung Khru).

The research also includes maps showing the potential of using the canal to connect to travel in west Bangkok, the environmental quality and vibrancy of weekdays, community and quality of life satisfaction, and proposes six different routes from the stakeholder surveys. Future work is proposed for the canal transit network in west Bangkok: studying the piers on the proposed six routes with high passenger demands on the connections to nearby bus/rail stations, estimating a new mode choice model that

separately considers the proposed canal boat transportation mode, and evaluating the environmental impacts of the proposed canal boat system in western Bangkok.

Notes from the event presentations and discussions:

Energy use in the Asian economy's transportation is a significant contributor due to rapid industrialization, urbanization, and increased vehicle ownership. Thailand's data shows the need to address transportation energy use, and water transportation can play an important role in the transportation energy policy of the APEC region. By promoting an intermodal transport system integrated with waterways, APEC can encourage the development of infrastructure and logistics systems that facilitate seamless intermodal connectivity, alleviate pressure on congested roads and reduce energy consumption in the transportation sector.

APEC economies can advance sustainable, efficient, and reliable coastal and inland waterway transport by developing low-emission vessels, optimizing routes and scheduling to minimize fuel consumption, and investing in infrastructure to support environmentally friendly water transport. APEC can foster research and innovation in water transportation technologies and practices by encouraging collaborative research projects, sharing of best practices, and facilitating technology transfer to accelerate the development and adoption of energy-efficient and sustainable solutions in the maritime sector. This activity can involve partnerships between governments, industry stakeholders, and research institutions to drive technological advancements.

It is important to recognize that the significance of water transportation may vary across different APEC economies depending on geographical characteristics, trade patterns, and infrastructure development. Therefore, specific policies and strategies related to water transportation should consider each economy's unique circumstances and priorities within the APEC framework.

Session 7: Energy Resiliency and Policies Implications

Moderator: Prof. Michael Siminovitch

Prof. Thang Nam Do. (Australia) Australian National University. *Harnessing solar and wind for sustainable cross-border electricity trade in the Greater Mekong Subregion.*

From 1995 to 2016, the Greater Mekong Subregion (GMS) annual electricity generation increased by 430%, reaching 775TWh, mainly relying on hydro and coal power, which is an unsustainable pathway that leads to many environmental consequences, e.g., biodiversity loss, fishery, and sediment losses, increased droughts and salt intrusions, air pollution, and climate change.

Potential solutions exist for more sustainable methods of generating and storing electricity in the GMS. Generating electricity from wind and solar energy is complementary on a seasonal basis. Thus, wind and solar with short-term, diurnal energy storage should be enough, as 25,500GW solar PV and 1,100GW onshore wind at sites would far exceed current electricity generation, plus there is good potential offshore wind in Viet Nam and Guangxi. Furthermore, the Levelized Cost of Energy (LCOE) for solar PV and onshore wind fell by about 85% and 56% between 2010–2020. And for the low environmental impact energy storage solution is off-river pumped hydro energy storage, which also reduces risks of insufficient water availability for dam operation in some seasons.

However, some strategies exist to implement solutions in the region, enabling community participation in decision-making, developing regional high-voltage direct-current super grids, crediting systems to verify and validate 'sustainable' electricity, and boosting regional electricity trade.

Mr. M.K. Balaji. (Thailand) Director, Advanced Energy Systems, USAID's Southeast Asia's Smart Power Program: ***Southeast Asia Energy Transition From RE Power and Policy***

The primary goals of USAID's Smart Power Program encompass three key objectives:

- Deploying Advanced Energy Systems
- Mobilizing financing
- Increasing regional energy trade by 5% in Southeast Asia within five years

This program aims to strengthen energy security in Southeast Asia by establishing transparent and open energy markets, promoting energy trade, and transforming the energy sector to ensure widespread access to clean, reliable, and affordable energy. The technology readiness level (TRL) of generation, transmission, and distribution, as well as energy utilization, is quite mature, ranging from 8 to 10, signifying that these systems have been fully integrated into commercial designs and are ready for market implementation.

USAID conducts comparisons across various dimensions of the energy landscape in economies across Southeast Asia, including the level of policy support, regulatory and fiscal support, natural resource potential, stage of market development, and status of investment and access to capital. The statistics indicate that investing in existing envi-

ronmental resources is more feasible than creating new ones, resulting in lower investments for Singapore and Malaysia than the overall investment in this region. There are noticeable trends in startup investment facilitated by environmental, social, and governance funds, blended finance, and green bonds. However, challenges arise from a need for more understanding of the clean energy sector by financiers and startups, a scarcity of appropriate capital options, limited monetization alternatives, and high transaction costs associated with clean energy investments.

Essential indicators for environmental startups encompass the number of new energy startups, research laboratories, universities, and networking assets, including startup events, incubators, capacity-building initiatives, supporting organizations, and environmental entrepreneurship.

4.3 Gender Issues Related to the Energy Sector

Session 8: Gender Issues Related to the Energy Sector

Moderator: Dr. Chanyaporn Bstieler

Prof. Norasikin Ahmad Ludin (Malaysia) Solar Energy Research Institute (SERI) National University of Malaysia. ***Women Empowerment in the Energy Sector.***

Statistics reveal a gender disparity in career advancement within the science and energy sectors, with women holding fewer positions than men. For instance, women comprise only 32% of the energy workforce, with 45% occupying administrative roles and only 28% in technical positions. Several factors contribute to this gap, including challenges in maintaining work-life balance, particularly during maternity, gender stereotypes associated with women in these fields, and limited access to training and career progression opportunities.

A panel discussion on career pathways and opportunities for women in the energy sector and circular economy businesses in Malaysia revealed that in 2022, there had been notable progress in women's representation within companies. They now hold 40% of senior leadership positions, including roles on the director board, energy policy decision-makers, engineers or technicians, and CEOs. This positive change is attributed to businesses in the energy sector adapting to new challenges and opportunities arising from the post-COVID-19 era, including the climate crisis, energy security concerns, and increasing prices. The companies have introduced flexible working patterns and committed to diversity and inclusion over the past year.

Closing the gender gap in the energy sector's work environment requires a strong commitment from the government, industry, and stakeholders to foster equal opportunities for women and promote best practices in inclusive work culture. Moreover, provid-

ing professional training and mentoring programs is vital for women's career development. The ongoing work is to strengthen women's roles in the innovative sustainable energy and cooling sector to address poverty and household dynamics through a gender-based study on energy and cooling access, to improve health and wellbeing as temperature affects men and women differently, to develop financing gender-sensitive energy cooling solution, and to support awareness raising activities such as education and sharing platform.

Dr. Jirawadee Polprasert (Thailand) Faculty of Engineering. Naresuan University. ***Gender Issue Related Energy Sector.***

Sector 5 of United Nations Sustainable Development Goals is about gender equality, aiming to achieve gender equality by 2030. Key definitions related to the topic include sex, gender, gender equality, gender mainstreaming, empowerment of women, and gender parity/balance. The issues concerning equality and energy issues are basic human rights, education, health, and access to jobs and livelihoods for women and men. Therefore, gender equality is an intrinsic human right to narrow the gaps in wellbeing between men and women and an instrument for economic development, productivity, family welfare, and the establishment of inclusive institutions.

Gender-related energy challenges in Thailand encompass various domains, such as household energy, electricity accessibility and pricing, renewable energy technology options, energy-efficient household management, and the social implications of major energy infrastructure projects, including displacement, resettlement issues, immigration concerns, inequitable benefit sharing, and land-related concerns.

Finally, the author proposed the following next steps to help make society more inclusive and fair for everyone:

- Connecting domestic and international efforts.
- Empowering individuals from the bottom-up.
- Providing targeted funding.
- Improving access to networks.
- Implementing supportive policies for gender equality.

Dr. Amornwan Resanond (Thailand) **Director, Clean and Sustainable Energy, Southeast Asia's Smart Power Program.** ***GESI Implementation: A Case Study of Public EV Transport Policy Formulation in a City, Thailand.***

Promoting gender equality and social inclusion (GESI) is crucial for sustainable development as it benefits everyone equally. GESI mainstreaming involves:

- Considering the impact of planned actions on all individuals and incorporating diverse perspectives in designing.
- Monitoring and evaluating policies and programs across political, economic, and societal domains.

There are four levels of GESI mainstreaming: Level 0 - non-compliance (GESI unaware) when the project fails to identify different needs and impacts for women and marginalized groups. Level 1 - minimum compliance (voice) when the project addresses women's and marginalized groups' basic needs and vulnerabilities. Level 2 - empowerment (choice), when women and marginalized groups are equally involved in decision-making in the project. Level 3 - transformation (control), when women and marginalized groups have active control over resources.

In the case of Korat City in Thailand, the team incorporated GESI into formulating the Public Electric Vehicle (EV) policy. The process begins with transport surveys that ensure the inclusion of women, persons with disabilities (PWD), and marginalized groups, comprising 50% of the survey population. These surveys gather preferences for transport behavior through questionnaires and conduct focus groups to understand the condition of transitioning to the proposed e-bus system. Additionally, a field survey of infrastructure identifies potential issues that may impact the safety and accessibility of women, children, older people, and PWD. The project involves data collection and analysis of travel routes of local citizens, with a particular focus on women, which will inform the development of transportation policies.

CHAPTER 5
CONCLUSIONS AND NEXT STEPS

This report summarises the activities and key findings from the US-led APEC-funded workshop titled "**Building Back Better: Energy Efficiency, Renewable Energy, and Energy Resiliency in the New Normal (EWG 12 2021A)."** The three-day workshop in Bangkok, Thailand, from 11-13 January 2023, comprised 22 presentations, four group discussions, and a half-day boat trip. Forty-five speakers and participants from 14 APEC economies actively participated in the workshop: policymakers, university faculty, graduate students, and energy experts from APERC and the private sector. The main findings include data required to support the policymakers, energy policy recommendations, new partnerships, and four potential collaborative projects. Finally, it presents the next steps each working group will take to develop project proposals and obtain funding for further activities.

5.1 Main Findings

5.1.1 Data Required for Policymakers

1. Time-based activity and occupancy data for non-residential buildings and main public spaces requiring area lighting
2. Hybrid work and travel patterns and energy use in residential and office buildings and transportation sectors
3. Assessment of energy performance and lighting quality for new lighting and control technologies for commercial buildings and public lighting
4. Potential areas and feasibility study of small-scale solar energy projects and disposal of expired solar panels
5. Bio-mass appropriate crops for each economy and land use models to ensure food security
6. Available technologies and cost of the energy storage systems for solar PV and wind energy, and the improvement of new technologies for higher efficiency and capacity

5.1.2 Policy Recommendations

1. **Energy use patterns monitoring policy.** APEC economies shall require newly built and renovated buildings (over certain usable areas) to install some level of monitoring that provides data on energy use, including daily and seasonal patterns. The data will provide insights for policymakers about energy management and energy-saving opportunities.

2. **Assess the net energy use and make informed Work from Home (WFH) policy decisions.** APEC economies shall assess the net energy use in the building and transportation sectors, resulting from the new work and travel patterns after the COVID-19 pandemic. This project would contribute to establishing WFH policies that would help APEC economies to achieve energy efficiency and resiliency goals and, at the same time, reduce environmental impact.

3. **Provide an enabling mechanism in solar energy management.** APEC economies shall provide enabling means for solar energy installation and management for small-scale projects, such as individual homes and communities. The economies should conduct a feasibility study of new solar projects and provide financial and technical support. The energy regulations should allow private homeowners and local communities to own, produce, and use their clean electricity. The economies shall have a clear strategy for the disposal of solar panels and batteries after the end of life.

4. **Require training for energy professionals and education for youth.** The APEC economies shall require energy practitioners to implement energy policies to complete a comprehensive training path. Additionally, the economies shall encourage schools to integrate fundamental knowledge of energy and electricity consumption and cost into compulsory education.

5. **Reduce gender disparity in energy-related careers and policies.** Regarding gender equality in the energy sector, APEC economies shall provide appropriate training opportunities and implement supportive working policies to reduce career gaps for women in energy-related fields. The economies should also incorporate women's requirements and behavior in the energy policy formation.

5.2 New Collaborations and Potential Projects

5.2.1 Reducing Lighting Carbon Footprint in the Tropics

Experts in building physics, energy policy, and lighting from Brunei Darussalam; Indonesia; Japan; the Philippines; Singapore; Thailand; and The United

States have common interests in integrating daylight and artificial lighting to reduce the energy intensity and, at the same time, to increase the share of renewable energy for buildings used during the daytime. Another new partnership between KMUTT and the USAID Southeast Asia Smart Power Program (SPP) was also developed. The followings are potential collaborative projects:

- The second phase (2023-2024) of the research project funded by the Thailand Science and Technology Research Agency was titled: *"Development of Daylighting Integration for Future Workplace to Reduce Environmental Impact and Promote Well-being: A Case Study of Bangkok"*. This forms part of a three-year research plan on *"Developing Lighting Innovation for Future Workplace",* led by the Lighting Research and Innovation Centre, KMUTT.
- The energy experts from USAID Southeast Asia Smart Power Program (SPP) and KMUTT are exploring new collaborations and funding schemes to develop lighting design standards and specifications for LED streetlights and lighting and cooling energy use in airport buildings in Thailand, and then may expand to Indonesia.
- The representative from the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, Thailand, is interested in developing demand-response lighting codes similar to the California standards proposed by the California Lighting Technology Center, University of California Davis (The US). These advanced lighting codes will allow the economy to utilize LED and lighting control technologies fully.

5.2.2 Sustainable Transportation

A new collaboration between the Philippines and Thailand was developed, and the key members agreed to explore two potential research projects to reduce energy use and environmental impacts from the transportation sector post-COVID-19 pandemic. These are the following:

- Dr. Crispin Diaz (The Philippines) proposed an online survey to investigate the APEC economies' changing work and travel behavior post-COVID-19. The survey questions can be modified from his initial study in Metro Manila. As this project has common objectives as the one proposed by the energy in buildings group, the two groups will explore the best way to combine both aspects into the same survey.

- Dr. Kanjanee Budhimethee and Dr. Ampol Karoonsoontawong (Thailand), and Dr. Crispin Diaz (The Philippines) will develop a joint proposal to conduct a comparative study on challenges and opportunities to integrate water transport in Bangkok and Manila's sustainable transportation plan. They will focus on the City of Bangkok's plan to link different modes of transportation with boat services in the *Chao Phraya River* and canals in west Bangkok and the *Pasig River* in Manila.

5.2.3 Investigating effective models for community-based Solar PV in the APEC

For renewable energy and resiliency, a new collaboration has been established between Dr. Norashikin Ahmad Ludin (Malaysia), Dr. Katie Purvis-Roberts (The United States), Dr. Bundit Fungthammasan, Dr. Athikom Bangwiwat, and Dr. Worajit Setthapun (Thailand). The following outlines the new project proposal developed for obtaining funding from the APEC's Energy Working Group in late 2023.

The project will assess the available areas for solar power generation and the most effective models to support small and community-based solar PV installations. The main activities will comprise case studies, focus group discussions, workshops, and policy dialogue with key stakeholders from the public and private sectors, including community representatives, in the APEC economies. Figure 5.1 shows the diagram of a community-based solar PV installation and connection to the main grid.

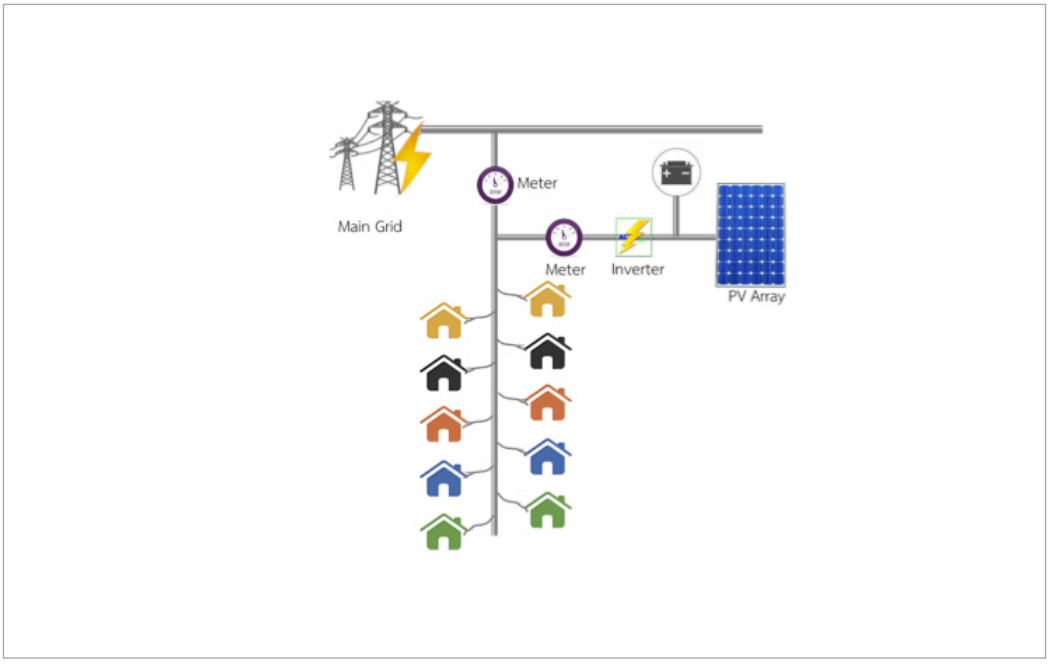

Figure 5.1 Community-based solar PV installation and Grid Connection

5.3 Next Steps

According to the potential new project concepts described above, each project has lead members who will coordinate further online and, in some cases, onsite meetings to discuss and develop the proposals to obtain the necessary funding. As some proposals are part of a long-standing research plan that is already funded, the project leaders can integrate the new collaboration more easily than the ones newly established. The following are planned activities in the coming months:

- Modification of the questionnaire surveys created by Dr. Ichinose and Dr. Diaz and combined with questions on workplace lighting by Dr. Bstieler for investigating the impact of new work and travel patterns on energy use in six APEC economies in Southeast Asia.
- Developing proposals for creating lighting standards and common specifications for LED streetlights and lighting and cooling best practices for airports in developing economies in collaboration with USAID Southeast Asia Smart Power Program and consultation with relevant public sectors and other regional agencies, such as Thailand’s Department of Airport, Ministry of Transportation and the ASEAN Centre for Energy (ACE).
- Organising a meeting between Dr. Michael Siminovitch (California Lighting Technology Center, the United States) and the representative of DEDE, Thailand, and exploring the possibility of collaborating on establishing an advanced lighting standard for demand-response in commercial and industrial buildings.
- Developing a proposal for a comparative study on challenges and opportunities to integrate water transport in Bangkok and Manila's sustainable transportation plan. Appropriate funding in Thailand or the Philippines will need to be identified.
- Developing a concept note for APEC's EWG funding to assess the potential of solar power generation and the most effective models to support small-scaled and community-based solar PV installations in the APEC developing economies.

5.4 Conclusion

In conclusion, this three-day APEC-funded workshop titled *"Building Back Better: Energy Efficiency, Renewable Energy, and Energy Resiliency in the New Normal (EWG 12 2021A)"* was a successful and interactive event where speakers and expert par-ticipants from 14 economies attended. The workshop also reached the project objectives of identifying data gaps required by policymakers to achieve the APEC's aspirational energy goals, establishing new collaborations, and developing potential new projects to realize these projects. Finally, it also raised awareness on reducing the gender gap for women in energy-related careers and involvement of women's behavior and opinion in forming energy policies.

REFERENCE

Cambridge University Press. (n.d.). Teleworking. In *Cambridge dictionary*. Retrieved April 16, 2023 from https://dictionary.cambridge.org/dictionary/english/teleworking

Hong, W.Y. & Rahmat, B.N.N.N. (2022). Energy consumption, CO_2 emissions and electricity costs of lighting for commercial buildings in Southeast Asia. *Scientific Reports*, 12, 13805.

Hong, W.Y. & Rahmat, B.N.N.N. (2021). Lighting energy consumption estimation models for a library building with different lighting scenarios. *2021 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE) on 8-10 December* 2021, Brisbane, Australia. Piscataway, New Jersey, United States: IEEE, pp. 1-5.

IEA (2022). Lighting, IEA, Paris Available from: https://www.iea.org/reports/lighting (Accessed on 30 April 2023).

Tsukahara, S., Ichinose, M., Ogata, M. & Alkhalaf, H. (2022, November). Indicators to evaluate the introduction of telework: post-COVID-19 flexible work arrangements. [Paper presentation]. In *PLEA SANTIAGO 2022: Will the cities survive?*. 36th PLEA-Conference of Sustainable Architecture and Urban Design (Chile), Santiago (pp. 454-459). PLEA Association.

APPENDIX A

WORKSHOP AGENDA

Asia-Pacific
Economic Cooperation

AGENDA

Building Back Better: Energy Efficiency, Renewable Energy, and Energy Resiliency in the New Normal (EWG 12 2021A)

11-13 January
2023
Bangkok, Thailand

Organizer: Scripps College, California, United States

Event held under APEC Project: The APEC Workshop Furthering University Collaboration to Support Data Gathering and Analysis in Energy Efficiency, Renewable Energy, and Energy Resiliency (EWG 12 2021A)
Sponsoring Economy / Project Overseer: The United States, Professor Kathleen Purvis-Roberts
Co-sponsoring APEC economies: Australia; Canada; Hongkong, China; Chinese Taipei; and Thailand

Funded by Energy Efficiency and Low-Carbon Measures

AGENDA

DAY 1 - 11 January 2023 (Wednesday)	
09:00-09:10	**Introduction** - Overview and Goals Dr. Katie Purvis-Roberts and Dr. Chanyaporn Bstieler 1. Welcome speech 2. Goals/Instructions for workshop & Agenda 3. Group photo
09:10-09:20	**Welcome:** • **Dr. Geri Richmond, Under Secretary at the Department of Energy** (The United States) - (recorded) • **President Suzanne Keen, Scripps College** (The United States) (recorded) • Representative of the President, King Mongkut's University of Technology Thonburi (Thailand)
09:20-09:40	**Session 1: Dr. Cary Bloyd** (United States) Pacific Northwest National Laboratory- Overview of APEC Renewable Energy, Energy Efficiency, and Energy Resiliency Activities.
09:40-10:10	**Introduction of workshop participants** 1. Introductions 2. Share your name, role in your organization, what are data needs or projects for Energy Efficiency, Renewable Energy, and/or Energy Resiliency in your economy
10:10-10:30	Coffee Break
10:30-11:30	**Session 2: Data Collections for Energy Policy Post COVID-19** Moderator: Dr. Chanyaporn Bstieler **1. Ms. Elvira Gelindon:** Research Fellow, **APERC** (Japan) **2. Ir Prof Harry Lai:** Principal Advisor/Carbon Neutrality, EMSD, Government of the Hong Kong SAR (Hong Kong, China)
11:30-12:30	**Session 3: Energy Policy Refocus for the Post COVID-19 Era** Moderator: Dr. Chanyaporn Bstieler 1. **Ms. Shu-mei Peng,** Senior Executive, Bureau of Energy, Ministry of Economic Affairs, Planning Division (Chinese Taipei) 2. **Ms. Sutthasini Glawgitigul,** DEDE, Ministry of Energy (Thailand) 3. **Mr. Daniel Collin G. Jornales,** EE&C Program Management and Technology Promotion Division, Energy Utilization Management Bureau, Department of Energy (The Philippines) 4. **Mr. Joan Manuel Romero Ubiergo,** Ministry of Energy (Chile)
12:30-13:30	Lunch Break

13:30-14:45	**Session 4: Case Studies on Energy Resilience in Commercial Buildings** Moderator: Dr. Kathleen Purvis-Roberts 1. **Prof. Michael Siminovitch,** Rosenfeld Chair, California Lighting Technology Center, UC Davis (The US) - *Experimental research and data collection to inform energy policies in California.* 2. **Prof. Masayuki Ichinose,**Tokyo Metropolitan University (Japan) - The impact of hybrid work on *Energy consumption and CO_2 emission in Tokyo and its implication for green building design* 3. **Dr. Wan Yun Hong,** Universiti Brunei Darussalam (Brunei Darussalam) *Energy consumption and CO_2 emission of lighting for commercial buildings in Southeast Asia.*
14:45-15:00	Coffee Break
15:00-16:00	Breakout groups to discuss policy maker needs and further ideas around data gathering and analysis 1) to achieve energy resiliency in buildings and transportation 2) to reduce lighting carbon footprint 3) to achieve renewable energy goals
16:00-16:30	Summary of discussions from the day

DAY 2 - 12 January 2023 (Thursday)	
09:00-09:10	Recap of Day 1 and Day 2 goals
09:10-10:30	**Session 5: The Impact of Hybrid Work on Energy Use in Buildings and Transportation** Moderator: **Prof. Szu-cheng Chien** 1. **Prof. Crispin Diaz** (The Philippines): *Hybrid work and transportation mode choices in Metro Manila: an initial survey.* **2. Prof. Rizki A. Mangkuto** (Indonesia): *Daylighting research and data collection in Indonesia.* 3. **Prof. Ampol Karoonsoontawong** (Thailand): *Sustainable transportation: the proposed canal transit network for west Bangkok.*
10:30-10:50	Coffee Break
10:50-12:00	**Session 6: Group discussion on data collection for energy use and resilience in building and transportation sectors**
12:00-13:30	Lunch Break
13:30-16:30	**Field trip: Bangkok's sustainable transportation network** Traffic problem in Bangkok does not only waste the energy, it also has a negative impact on the economy and the environment. This boat trip, powered by solar energy, goes through Bangkok's canals and mass transit networks, promoting the use of micro-mobility and non-motorised transportation. It aims to demonstrate how a research collaboration between the university, local authorities and communities can contribute to a more sustainable transportation and better environmental quality.
17:30 - 20:00	*Welcome Dinner (Supanniga Eating Room, Tha Tien)*

DAY 3 - 13 January 2023 (Friday)	
09:00-09:10	Recap of Goals for Days 1-3
09:10-10:10	**Session 7: Energy Resiliency and Policies Implications** Moderator: Prof. Michael Siminovitch 1. **Prof. Thang Nam Do (Australia):** *Harnessing solar and wind for sustainable cross-border electricity trade in the Greater Mekong Subregion* 2. **Dr Wahyu Sujatmiko (Indonesia)** Ministry of Public Works and Public Housing: *Indonesia's Green Building Regulations.* 3. **M.K. Balaji (Thailand)** Director, Advanced Energy Systems, USAID's SE Asia's Smart Power Program**:** *Southeast Asia Energy Transition From RE Power and Policy*
10:10-10:30	**Coffee Break**
10:30-11:15	**Session 8: Gender Issues Related to the Energy Sector** Moderator: Dr.Chanyaporn Bstieler 1. **Prof. Norasikin Ahmad Ludin** (Malaysia) University Kebangsaan Malaysia 2. **Dr. Jirawadee Polprasert** (Thailand) Naresuan University 3. **Dr. Amornwan Resanond** (Thailand) Deloitte Thailand
11:15-12:15	**Session 9: Faculty Presentations About How Working with Data on Energy Projects Has Impacted Education and Developed Interest for Student in Pursuing Clean Energy Work** Moderator: Dr. Chanyaporn Bstieler 1. **Prof. Norasikin Ahmad Ludin** (Malaysia) 2. **Prof. Katie Purvis-Roberts and Dr. Kanjanee Budhimethee** (The US and Thailand) 3. **Prof. Szu-cheng Chien** (Singapore)
12:15-13:30	Lunch Break
13:30-15:00	**Session 10: Group Discussion to develop new ideas for collaborative projects between policymakers, research institutes, and university faculty members in the APEC Region** 1. Reducing Lighting Carbon Footprint in the Tropics: Moderated by Prof. Michael Siminovitch (The US) 2. Impact of New Work Patterns and Lifestyles on Energy Use and Resiliency: Moderated by Prof. Cris Diaz 3. Achieving Renewable Energy Goals and Energy Resilience (Moderated by Prof. Katie Purvis-Roberts)
15:00-15:15	Coffee Break
15:15-16:15	**Session 11: Policy Recommendations for APEC economies to address based on workshop discussions and topics** 1. Prioritization of data gaps in renewable energy, energy efficiency, and energy resiliency and recommendations for how to fulfil these needs. 2. Summary of policy implications of Light Carbon Footprint and New Work Patterns and Lifestyles projects. 3. Identification of key projects to work on based on needs across the APEC region that will benefit the most economies.
16:15-16:45	Closing Remarks

APPENDIX B

SUMMARY OF THE EVALUATION

This section summarises the workshop evaluation survey which we distributed a link to the evaluation form via email to all participants at the end of the workshop and twice after the event to collect as many evaluations as possible. We received 24 responses (37.5% are female and 62.5% are male) from 45 participants. The survey comprised twenty questions and statements and was divided into two types: the first provided five multiple choices - with an option to provide additional comments, and the other were open-ended questions. Overall, most of the respondents agree and are satisfied with the workshop objectives, materials, methods of delivery, and outcomes. Most also reported that they learned new knowledge, and participating in the event motivated them to explore new collaborations with other economies. Details are as follows:

Nearly 80% of the respondents strongly agree, and 20% agree that the workshop's objectives were clearly defined. More than half (54%) strongly agree, and 46% agree that the project achieved its objectives. Seventy-one percent strongly agree, and twenty-nine percent agree that the agenda items and topics were relevant. Almost 80% strongly agree, and 21% agree that the content was well-organized and easy to follow. Half (50%) of the respondents strongly agree, and the other half (50%) agree that the workshop sufficiently addressed gender issues.

Almost all respondents (92% strongly agree and 8% agree) are confident that the speakers, experts, and moderators were well-prepared and knowledgeable about the topic. They find the materials distributed useful (58% strongly agree and 42% agree). While more than 90% agree that the time allowed for each session is enough, 8% felt that the time for each presentation with Q&A session could be longer. There are also suggestions that group discussions could be placed at the end of each day.

Some 92% consider this project very much and most relevant to them and their economy, particularly because of the workshop's main theme of identifying data needed for renewing energy policies and strategies after the COVID-19 pandemic. In their views, the project's achievements include

1. Exchanges of information (e.g., energy-related regulations and standards) and new knowledge from other disciplines and economies;

2. Alignment of the energy goals and action items between the economies; and

3. network between policymakers and academics for future collaborations and possible new projects.

The respondents rated their knowledge of the topic after the workshop higher than before the event. Seventy-five percent of the respondents indicated that the workshop impacted their interest in collaborating with other organizations, and two-thirds are extremely likely to explore the possibility of new collaborations. There are interests in collaborating with or learning more about other organizations between policymakers (Indonesia; the Philippines; Chinese Taipei; and Thailand), research institutes (APERC and IEA), and university faculties in other economies. For example, the Ministry of Energy, Thailand, is interested to learn more about the advanced lighting standards developed by the University of California, Davis (The US); the Ministry of Public Works and Public Housing, Indonesia and the Ministry of Energy, the Philippines are open to exploring new collaborations with multiple universities and economies.

The respondents plan to apply the project contents and knowledge gained from the workshop at their workplace. These include:

- Developing new policy initiatives on energy efficiency and revising existing regulations (such as WFH policies and green building standards),
- Organizing the training about developing the renewable energy project in Thailand and SE Asia
- Developing the core technical concerns when selecting the street lighting technology
- Improving surveys and procedures for data collection to investigate the impact of WFH on energy use in buildings and transportation
- Harmonizing green building standards and Minimum Energy Performance Standards (MEPs)

Many respondents suggested that APEC could disseminate the outcomes of this project and support more of this workshop that brought together policymakers and researchers from energy-related fields. They also recommended that the APEC could support cooperative data collection as identified at the workshop, which can inform energy policies in each economy. Finally, the respondents proposed some improvements to the workshop, such as adding a writing proposal at the end and making a roadmap for each topic discussed to monitor and evaluate the project's progress and effectiveness regularly. This will allow for any necessary adjustments to ensure the project is meeting its objectives.

APPENDIX C

BACKGROUND REPORT

Asia-Pacific Economic Cooperation

SCRIPPS THE WOMEN'S COLLEGE

King Mongkut's University of Technology Thonburi

BACKGROUND REPORT

Impact of Hybrid Work on Energy Efficiency and Resiliency in the Built Environment

Bstieler, C., Chaloeytoy, K., Kaoshik, R., Budhimethee, K., and Purvis-Roberts, K.

Prepared for the APEC:Workshop

BUILDING BACK BETTER: Energy Efficiency, Renewable Energy,and Energy Resiliency in the New Normal

11-13 January 2023
Chatrium Riverside Hotel, Bangkok,Thailand

EXECUTIVE SUMMARY

Background

This report provides background information for the upcoming US-led APEC-funded workshop held in Bangkok, Thailand, **from 11-13 January 2023**. The workshop is titled: "Building Back Better: Energy Efficiency, Renewable Energy, and Energy Resiliency in the New Normal (EWG 12 2021A)". The report has been developed based on the results obtained from the 2-day online APEC-funded workshop in June 2021, which brought together policy-makers and academics from 16 economies. Results from the previous seminar suggested exploring several themes further to provide better data gathering for achieving ambitious APEC energy goals.

One of the main themes was the impact of the COVID-19 pandemic on the changing work patterns and lifestyles; and how these changes may affect energy use and resiliency in the APEC economy. We are focusing on energy efficiency and renewable energy in the built environment and transportation sector as they are closely linked to the new working and living patterns. Another central theme was reducing lighting's carbon footprint, taking advantage of advanced light sources (LED) and control technologies. In particular, daylighting in the tropics is of a concern, where daylight is abundant, but its use is still limited. Thus, this workshop emphasizes data required by policy-makers in the APEC economies that will inform energy policies and strategies and help achieve a green recovery from the setback and disruptions caused by the COVID-19 pandemic.

Organization

This document obtained information from a review of reports by international organizations and research centers, surveys by private sectors in the commercial real estate industry and workplace consultants, and published articles in international journals, mainly from 2019-2022. The report comprises four main chapters: **1) Chapter One** provides an overview of drivers for change and summarises how the new working and living patterns may impact the design and energy use at building and urban scales. It also present an initial survey on efficient lighting strategies, including the employee preference for workplace and lighting after the pandemic. **2) Chapter Two** presents a trend and factors affecting energy use in public, commercial, and residential buildings during the pandemic. It also reviews changes in domestic policies and strategies for renewable energy of APEC economies. **3) Chapter Three** summarises a systematic review of energy use and trends in the transportation sector post-COVID-19. Finally, it recommends developing ideas for further discussions and assessment between policymakers, researchers, and experts at the upcoming workshop.

Resilience in the Built Environment: Drivers for Change

The disruptions caused by the complexities of the current global crisis significantly impact organizational dynamics and new ways of working and living. Organizations have faced external and internal risks in the past three years that have forced them to transform and adapt. Although some of these risks are not new and started to have a global impact before 2019, the pandemic has indeed accelerated and magnified its consequences.

- In addition to a global pandemic, *societal risks* include climate change, natural disasters like flooding and fire, and war or military conflict.
- Internal factors include *talent war, the adoption of hybrid work, and the health and well-being* of the worker.
- Employees' expectations and priorities have shifted toward more *flexibility* in choosing where and when they work, *better work-life balance, and health and well-being*.

The New Working and Living Lifestyle

At the end of 2022, the pandemic has yet to be over. Several surveys of business leaders and employees in different APEC regions, such as The US, Latin America, and Southeast Asia, suggest that the final model of working and living - where and how we work and live after the pandemic is still an ongoing topic. However, some changes during the pandemic will be permanent, and to some extent, this new lifestyle certainly impacts the energy demand and resiliency in the built environment.

- *Hybrid work*, a combination of working onsite and spending some time away from the offices, is here to stay. Employees' ideal combinations are working remotely for 2-3 days and the rest in the office.
- The percentage of employees who prefer to work full-time remotely is much smaller but varies by region. Those in developing economies and, particularly, mothers with young children tend to favor working from home.
- While employees still value human interaction and meetings with their colleagues and team managers onsite, reducing wasted time commuting and better work-life balance are among the main advantages of working remotely.
- One in five employees may leave their company shortly, and if they are back in the job market, they would prefer an organization offering a flexible work model located near a public transportation hub.
- With a shifting focus on health and well-being, employees consider working for companies providing ergonomic furniture (including natural light and views) and nutritional food as benefits.
- Due to the talent war and the continuing *Great Resignation* trend, employers are embracing this new demand for a flexible work model and still investing in improving workplace quality to attract and retain their talents.
- Despite the wide adoption of hybrid work, headquarters are still the focus of the office operation, with smaller satellite locations or shared working space on a flexible lease. However, organizations are not just renting *space* but require a *solution for productivity,* including flexible working and meeting facilities.
- Small talent-rich urban areas, as opposed to traditional urban cores, with good public space and transport connections, should be developed to attract employees looking for a better environment to live a quality life.

Impacts on Energy Demand and Resiliency

- As teleworking and hybrid work increases, the overall energy consumption in the buildings and transportation seems to be reduced. While the energy demand reduced in commercial buildings, such as offices, retail, and hospitality sectors, the energy use in residential buildings increased. These changes vary across the APEC economy, reflecting not only the impact of weather conditions, but also socio-economic and cultural differences.
- The profile of peak energy demand for residential buildings shifted as most people were working and learning from home. Pre-COVID-19, the peak was in the evening when everyone was home and turned on the television and air-conditioning (AC), which it is now changed to the afternoon to early evening. The flexible work patterns allow movement from and distribution of energy consumption from the city centre to the suburb areas.
- Despite the major interruption on daily life and devastating economic impact on the global scale, the pandemic has temporarily restored the natural environment and improved the air quality. The small particles (PM10 and PM2.5) and other air pollution indicators decreased mainly due to much less transportation, construction, and industrial production.

Preference for Mode of Transport and Travel Behaviour

- Preference for active mobility options like biking, bike sharing, and walking has increased slightly before, during, and after the pandemic. However, this trend needs attention from planners to enable comfortable and safe passage. Even though bike-sharing is a shared mobility, due to the size and accessibility of the vehicles, users may be able to have control over the possibility of contagion using personally sanitization before use.
- The perceived threat of shared mobility or public transit has negative perceptions both during and after the pandemic mainly due to the possibilities of contagion, inequitable access, and lack of personal control.

CHAPTER 1
CHANGING WORK PATTERNS AND LIFESTYLES

1.0 INTRODUCTION

In the past three years, every aspect of life including living, working, and learning are disrupted according to multiple waves of corona virus outbreaks. According to the World Health Organisation (WHO 2022), we are approaching the end of COVID-19 pandemic as the number of new cases and deaths steadily declined. Despite the expert forecast (2022) that there will be new waves towards the winter months of 2022 and early 2023, it will be a slower pace and not as severe. Currently, November 2022, the pandemic appears to be coming to an end and will become an endemic disease with vaccines to provide enough public immunity. Each economy has relaxed restrictions against travel and social gathering; life has started to return to the 'next normal'. Although where and how we work and live after the pandemic has not yet settled, it is clear that some changes will be permanent. These new lifestyles will certainly have an impact on the energy demand and resiliency in each economy.

This chapter reviews reports and studies on the changing work patterns, as to when, where, and how we work now and in the future. In particular, it focuses on how the *'hybrid work'* has evolved in the APEC region and how the future forecast will influence the requirements for space and support facilities in buildings. To some extent, these changes in work patterns will result in different scenarios of energy use in offices and residential buildings.

1.1 NEW WORKING AND LIVING PATTERNS

" ***Hybrid Work*** means a combination of working onsite and spending sometime away from the offices"; and " ***Teleworking*** *means the activity of working at home, while communicating with your office by phone or email, or using the internet".* Definition of 'teleworking' by Cambridge dictionary.

Asia-Pacific

Over the last three years, a number of surveys and research that attempts to better understand 'hybrid work' in practice, including the viewpoints from both employers and employees on this issue. In PwC's latest Global Workforce Hopes & Fears Survey (July 2022), nearly 18,000 employees in the Asia-Pacific participated. Results are inline with other International studies: *hybrid work is here to stay.* The survey shows that, on average, the proportion of employees who want to work *remotely, hybrid, and in person* varies across the Asia-Pacific region, which is similar to the global survey. The distribution of preference for these three types of work varies across economies.

Figure 1.1 shows a summary of responses from 10,930 Asia-Pacific employees who state that their job can be done remotely from home. Factors affecting these preferences include, but are not limited to, type of business, type of job, demographics (age and gender), and local connections. Although economies included in this study are not all APEC members, many represent major APEC economies and show great differences between the developed and emerging economies.

For example, the average percentage of employees who want to work remotely in China and Indonesia are 10% and 11%, while it is 34% and 39% in Australia and New Zealand respectively. This study also highlighted the different perception and plan of each generation during the next 12 months. It shows that Generation Z and Millenials are more concerned about their future work than the older generations. These results shows that the physical office will still be central to work.

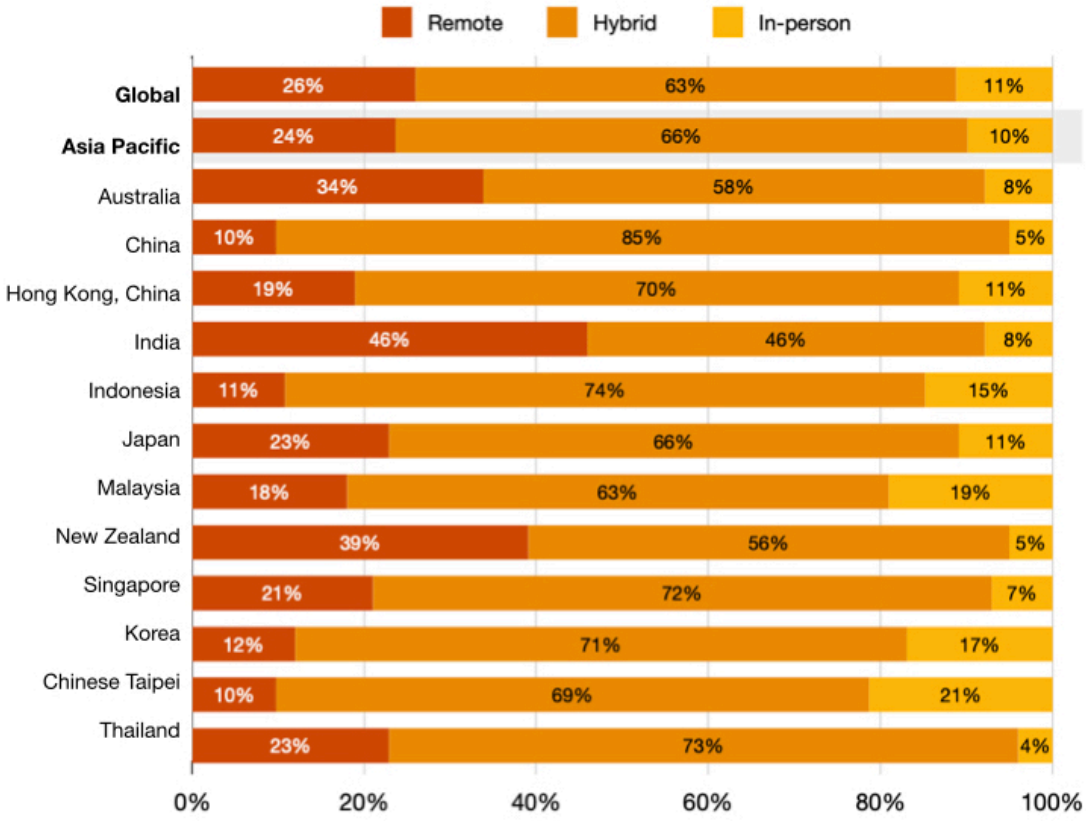

Figure 1.1 Preference modes of work in the next 12 months
(Source: PwC's Global Hopes & Fears Survey, July 2022)

Latin America

According to the Redefining work models in Latin America (2022), WeWork and HSM surveyed more than 10,000 business leaders and executives in Latin America (Argentina, Brazil, Chile, Colombia, Mexico, and Peru). The results highlighted new priorities these corporations needed to overcome one of the most challenging times. It helps us understand the pandemic's impacts on offices and work dynamics in the APEC economies in this region, namely Chile, Mexico, and Peru - representing 25% of survey respondents.

The results highlight the importance of human contact. During the lockdown period and remote work, some 70% of the respondents rated the interaction with colleagues and team managers as the aspect missed the most (in-person company meetings and physical workspace were only missed 25% and 26% respectively). Among the benefits of in-person activities, integration between departments and employees of the same organization was emphasized by 70% of the respondents. According to 42% of respondents, the ideal setup would be to work remotely three days a week, followed by 28% who prefer to work in this scheme up to two days a week.

There has been greater adoption of hybrid work recently as it helps separate professional and personal life, which 45% of the respondents considered a benefit of working onsite. The perception of distractions and interruptions during office work remains a crucial point of attention (highlighted by 42% of the respondents, though in Chile, the average drops to 38%). The majority (62%) prefer the possibility of a stipend to work from home or a shared workspace; 31% would be willing to give up at least one benefit in exchange for the freedom to choose his/her own work environment.

Many companies follow large corporations, such as Google, which continue to invest in physical offices. The physical space promotes team interaction and innovation and creates a greater sense of identity. Among the top three main benefits of the home office are reduced commuting time (99%) and operating costs, e.g., office rental, maintenance, and cleaning (71%) and time management (61%). At the same time, the main challenges of the in-person work model are time wasted with travel and commuting (99%) and distractions in the workplace (42%). In terms of productivity, the respondents rated the hybrid model (4.5), remote (4.3), and in-person 4.0) on a scale of 5.0. Two-thirds (75%) of the respondents feel safe returning to in-person activities.

Forty-one percent of the companies have moved to smaller offices, while only 23% have moved to a larger office, 28% remain unchanged, and 18% closed their offices. Ninety percent of the companies have moved to the same area as the previous one. Multiple work models have decentralized commuting flows and distributed work environments among neighborhoods and cities. This trend might be beneficial to companies and to the urban configuration itself. The proximity of the workplace to public transport emerges as a common need for all economies and positions (leaders and non-leaders) - 82%.

Organizations require a hybrid and flexible future - not a 'space' provider but a 'service and solution provider'- for productivity. Hybrid work, the new work model had significant impacts on the structure, configurations, and lease agreements of Latin American offices. The organizations in Peru, in particular, had 45% of their operations moved to smaller properties, and 54% of these changes resulted in more flexible lease agreements. Thus, the flexible lease agreements suggest that each organization may not want to invest heavily to improve its physical work environment. On the other hand, this could be an opportunity for real estate providers, including coworking spaces, to attract corporate clients by offering a better quality work environment.

The region's executives assessed the cost-benefit of different models of operation and lease of work environments in the post-pandemic period. More than half (52%) perceived that the future office is not a single location but a network of spaces and services. The network should comprise spaces designed for specific tasks, including focused work, team brainstorming, customer presentations, employee training, and meetings. In addition to office spaces, 40% of the respondents valued having common spaces for socializing. More than one-third (38%) see the value of more flexible terms of the lease length and the versatility of the environments. One-third (33%) also valued the ability to customize their lease flexible space with their brand's visual identity.

Some 22% rated the ability to own their workspace and outsource to a third party for operational management, facilities, and hospitality. One-fifth of the respondents (21%) agreed that tenants want more than 'space' to work; they are looking for a productivity solution to help them attract and retain the best talent. The majority of leaders were open to future disruptions. Three-quarters (75%) of the respondents see similarities between the on-demand cars of mobility applications and on-demand workspaces.

The ideal portfolio of services and infrastructure to engage professionals in the future of work requires *comfort, stability, and interactivity*. The surveys suggested that offices for the post-pandemic period should be improved or adapted to meet the new demands of the workforce.

These include ergonomic furniture (and lighting) as part of the new order of structure, benefits, and facilities, as well as the space infrastructure itself. The perception of value for studios to produce institutional content, such as live streaming and webinars, is declining. This is particularly the case for Chile, where demand was mentioned by 46% of respondents. Meeting rooms with a structure for virtual meetings are valued by some 75% of respondents who work in in-person and hybrid modes.

Three-quarters (75%) of respondents feel safe returning to the office, considering spaces with rigid safety protocols, use of masks, and distancing. For job benefits and perks, health insurance and quality food services are highly valued as crucial factors for attracting and retaining talent for 80% and 75% of respondents.

Surveys and studies from other APEC economies also suggest similar findings that would impact the location, space requirement, and physical design of the future workplace.

- The number of days working remotely and in the office vary across the region and types of organisation. Not all types of organisation can adopt hybrid work, and not every function in the same organisation can work remotely. Usually the professional employee can work away from the office, but not those who need to provide services for their customers. These include frontline and operational workers.
- While the majority would prefer some degree of hybrid work, two extreme cases include the employees who want to work remotely the whole week, and those who no longer want to work from home (almost 30% and 21% respectively, in The US).
- There are demographic differences between these two groups. While those who want to work remotely are mainly female employees with young children living in the suburb, the others who want to come back to work in the office are those young and single professionals living in small apartments in the city center.
- Surveys in multiple economies, such as the US and Latin America, found that employees who can work remotely at least part of the week are happier and more efficient. In particular, meetings with up to four people can be done effectively online with no need to commute. However, meetings and conference calls with up to 10 people or more are better off in-person.
- While some companies may want to give full flexibility to the employees to choose when and where they work, experts in business management have two concerns. The first is that given a choice, some workers, especially women with young children, may want to work from home and this might lead to inequality when it comes to promotion, comparing to young single males who work onsite closer to the boss. Secondly, given a choice for which day to work from home, most people would choose Monday and Friday, leaving the office empty on those two days while completely full on others. This scenario will not help the company to provide space and facility management effectively. It will also have an effect on energy use.
- Most companies are trying to improve their working environment in the office to attract and retain top talent. Workplace consultants carried out surveys to investigate what the employees expect from their workplace and their motivation to go to work in the office. These in-

clude clean air, access to natural elements, such as daylight and views, personalised workstations, adjustable lighting, and other hygienic factors.

- Generally, the employees demand office design that supports better health and well-being, while providing comfort and personalised environment as they work from home. An important motivation to come to work in the office is doing work that requires focus.
- According to these surveys and studies, it seems that after the pandemic ends in the future, space requirements and occupation rates may decrease as a result of permanent hybrid work. Studies in 2022 by Microsoft Asia and SAP (two large tech and software cooperates with offices in Australia; Japan; Singapore; and India) confirm that hybrid work will be permanent, and the office space and facilities need to be rethought and redesigned to facilitate these new work patterns. Companies will still open new offices in other locations. Space requirements for each location may decrease, but they will maintain the investment in a proper renovation to provide a high quality workplace to attract and retain their talent.
- Jones Lang LaSalle (JLL), Future of Work Survey (2022) conducted a survey that included over 1,000 respondents, covering part of APEC economies, including Canada; China; Japan; Singapore; and the US. The results suggest that corporate real estate (CRE) decision-makers are considering long-term transformation of their real estate portfolios to continue beyond this global pandemic. They consider the period from 2022 to 2025 as a critical ***window of opportunity*** for companies to redefine their workplace strategies and to create flexible, tech-enabled, future-proof real estate portfolios.

1.2 RESILIENCE IN THE BUILT ENVIRONMENT

The disruptions and changes caused by the complexities of the current global crisis significantly impacts organizational dynamics and new ways of working and living. The JLL Global Research Report (2022) suggests that we understand the drivers for change better and proposes how organisations can achieve resilience in the built environment. Organizations have faced external and internal risks in the past three years that have forced them to transform and adapt. Although some of these risks are not new and started to have a global impact before 2019, the pandemic has indeed accelerated and magnified its consequences. In addition to a global pandemic, *societal risks* include climate change, natural disasters like flooding and fire, and wars or military conflict can also impact the way we work.

Figure 1.2 Resilience in the built environment

- Internal factors include *talent war, the adoption of hybrid work, and the health and well-being* of the worker.
- Employees' expectations and priorities have shifted toward more *flexibility* in choosing where and when they work for *better work-life balance and health and well-being*.

The JLL report (2022) proposes that resilience in the built environment relies on an ecosystem which is complex and ambiguous. To be resilient, we must consider factors across a network of interconnected entities that support and rely on each other to sustain shocks and disruptions. It is an ecosystem built around Enterprise resilience, Societal resilience, and Personal resilience (See Figure 1.2).

1.3 THE EMPLOYEE EXPERIENCE AND FOCUS ON WELLBEING

1.3.1 The Employee Experience and Wellbeing

Since before the COVID-19 pandemic, studies on the employee experience have suggested an increased awareness and demand for a work environment that supports health and wellbeing. Jeanne C. Meister (2018), a leading HR advisory firm Future Workplace surveyed 1,614 North American employees about what elements of office design contribute to a great employee experience. The study found that access to natural light and views of the outdoors ranked as the number one attribute of the workplace environment, overtaking more fashionable office 'perks,' such as treadmill desks, nap pods, and onsite fitness. Most employees felt they did not have enough daylight and felt negatively towards windowless space. Some felt the workplace should improve indoor air quality (IAQ). This survey suggested that the employee highly valued fundamental and essential physical elements of their working environment.

Enhancing employee experience has become a priority for more organizations worldwide. The COVID-19 pandemic has put pressure on both employers and employees. Due to the competitive market for talent, especially specialized skill workers in high demand, companies need to provide what would contribute to the total experience of their employers. This greater emphasis on the employer experience is used to attract and retain promising talent with them for the long term. WTW, an international business consultancy, conducted the Employee Experience Survey from the end of March to April 2021. The respondents are 1,550 employers operating in a local market, regionally, and worldwide, representing 9.45million employees from eight different industries. These include, for example, manufacturing, financial services, general services, IT and telecom, healthcare, and energy and utilities.

While most organizations expect to arrive at their final new work patterns beyond 2022, they anticipate that in three years, some 25% of their employees will work as a mixture of onsite and remote working. This hybrid workforce is in addition to the 19% who will mainly work remotely. The findings suggested much greater awareness of enhancing employer experience as a priority after the pandemic, at least for the next three years, due to the negative impact of the pandemic. Some 35% of the respondents reported decreasing productivity as an issue, and 50% agreed that the pandemic hurts employees' physical and mental health. Only 52% of the employees, compared to 92% of organizations, reported enhancing employer experience as their priority before and after the pandemic. The report also acknowledges challenges in enhancing employee experience after this significant disruption and uncertainties. To overcome these challenges, the report highlighted three areas organizations should focus on in the *new reality of work, wellbeing, and total rewards*. Sixty-three percent of organizations recognize the need to prioritize employee wellbeing to enhance the overall positive experience.

The focus on wellbeing is in line with other studies that suggest thriving in the future workplace; employees demand a working environment that contributes to their physical and mental health. As a result of this, there are wellness and productivity implications. These findings support a larger trend of the growing importance of employee wellbeing. According to Gallup's most recent iteration of the State of the American Workplace poll, more than half of employees report better overall well-being as "very important" to them. In the same survey, work-life balance and overall well-being were determined to be the second most important factors when choosing to work for an organization. When employees are fulfilled in all aspects of their well-being, this leads to increased employee engagement and increases individual performance.

1.3.1 The Role of Daylight on Wellbeing

There has been a greater interest in the health effects of daily light exposure that should follow the natural cycle of daylight. In addition to the visual benefits of daylight as a light source for seeing and performing visual tasks, its dynamic intensity and spectrum throughout the day is one of the main time-keepers for human circadian rhythms that regulate our body main biological functions. These include, for example, the modulation of core body temperature and the secretion of hormones such as melatonin that synchronises our sleep-wake cycle and cortisol that modulates stress and alertness.

Since the discovery of the third type of photoreceptors in the human retina and the emerging knowledge on the non-image forming (NIF) effects of light through the circadian rhythms has contributed to renewed interest in daylighting research and design practice. This discovery provides a better understanding of how the provision of daylight and artificial lighting during the design process plays a critical role in regulating the secretion of hormones, such as melatonin and cortisol, and changes core body temperature during a 24-hour cycle. There are wellness and productivity implications too.

Researchers from Cornell University (Hedge, 2022) have found that workers with natural daylight in their office environments reported a 51% drop in the incidence of eyestrain, a 63% drop in the incidence of headaches, and a 56% reduction in drowsiness. Optimization of natural light, therefore, would be beneficial not only to reducing electricity use, but also to improve the overall health and wellbeing of the worker. The study also found that the absence of natural light and outdoor views hurts the employee experience. Over a third of employees feel that they don't get enough natural light in their workspace. About 47% of employees admit they feel tired or very tired from the absence of natural light or a window at their office, and 43% report feeling gloomy because of the lack of light. According to a Northwestern Medicine neurologist and sleep specialist (ZEE, 2022), there is increasing evidence to support exposure to natural light, particularly in the morning. This would be beneficial to health via its effects on mood, alertness, and metabolism. Especially for workers, who as a group are at risk, as they usually spend most daytime hours indoors without the exposure to bright light needed for their circadian rhythms. A proper daily light exposure to natural and bright artificial lighting, with appropriate spectrum and timing, would also have a positive impact on mental health and sleep quality.

1.4 CONCLUSION

This chapter presents main findings on changing working and living patterns from major APEC economies and how these changes might impact the energy use and resilience in the physical workplace and urban settings. These include the global adoption of the hybrid work model and factors that organisations would have to concern regarding the provision of physical workplaces to attract and retain their talent. This is mainly due to the changing expectation and new focus of employees on the work-life balance, health, and wellbeing. Finally, it provides some evidence that the provision of daylight and views out could reduce energy use and, at the same time, improve the employee health and wellbeing.

CHAPTER 2
THE COVID-19 IMPACT ON ENERGY USE AND RENEWABLE ENERGY

2.0 INTRODUCTION

The global COVID-19 pandemic caused massive disruption to the building sector worldwide, creating uncertainty regarding restrictions to economic activities. The lockdown policies from government administrations and public cooperations, such as stay-at-home orders, quarantine state, social distancing, and isolation of confirmed patients at high risk, have prompted a full-time home-based activity. Thus, buildings' energy consumption significantly changed during the pandemic, which modified the energy landscape and its mitigation efforts in the post-pandemic era.

Previous studies analyzed energy use patterns according to the building types, since occupants' behavior and lifestyle significantly influenced building use. The following provides an overview of how energy use in public and residential buildings changed due to the pandemic and other socio-economic factors.

2.1 IMPACT ON BUILDING ENERGY USE

2.1.1 Decreasing Building Energy Use

The sudden disturbance in energy use in 2020 during the global pandemic is the largest in the last 70 years. Global energy demand in 2020 decreased by 6% compared to 2019 (IEA, 2020). The decrease in energy demand for public buildings was mainly due to measures implemented during the temporary closures with restrictions (GABC, 2021). These included reduced opening hours and a limited number of users while practicing the work-from-home policies. This period of low or no occupancy can be challenging for building energy patterns, as the deviation from normal operations may decrease energy demand.

The pandemic forced organizations to adapt and experiment with work-from-home policies to keep their operations running while maintaining their employees' safety. Over 80% of all global workplaces were partly or fully closed after COVID-19's first wave (Chen et al., 2020). The lockdown period presents an opportunity to examine energy reduction patterns in vacant public buildings under those restricted conditions. For example, Deiss et al. found a 10.3% in energy reduction in commercial buildings in The US compared to before the COVID-19 period. Duarte and Cortiços performed energy simulations in office buildings in China under the post-COVID-19 scenarios, resulting in upward and downward trends based on the climate zones. Su et al. compared the energy consumption patterns and indoor air quality of a large green commercial buildings in China and reported that the building energy consumption decreased by an average of 55.4% and the indoor air quality compliance rate increased. Kang et al. analyzed the impact of the lockdown on average electric consumption of buildings such as offices, hotels, and religious facilities in Korea and observed reductions of 1.36%, 7.00%, and 10.91%, respectively.

In Chile, the researchers (Sánchez-López et al., 2022) analyze the impacts of the first wave of COVID-19 (March to September 2020) on the electricity demand of residential, commercial, and industrial buildings. They obtained hourly data from 230 thousand smart meters of residential and commercial consumers in 32 communes of Santiago. The results show that the electricity demand in commercial buildings significantly declined and that the restricted measures most affect the hospitality and construction sectors.

Educational buildings also experienced energy use reduction as faculties, researchers, and students had limited access to on-campus facilities. For example, Geraldi et al. assessed the impact of the lockdown on electric use of municipal buildings such as health centers, administrative buildings, elementary schools, and nursery schools in Brazil and saw reductions of 11.1%, 38.6%, 50.3%, and 50.4%, respectively. Chihib et al. measured the impact of the temporary closure of different facilities categories on energy consumption at a university in Spain. During the pandemic-related lockdown in 2020, compared to electricity consumption in 2019, the most significant reduction was found in supporting facilities like libraries, while the research category had a minor decrease.

Gui et al. investigated changes in energy use during the COVID-19 lockdown at a university in Australia. The results suggest that energy use was 16% lower than in a typical academic year. López-Sosa et al. evaluated the electricity consumption of 13 public state universities in the state of Michoacan in Mexico and reported savings in consumption between 10-90% and carbon footprint reduction potentials. Nasir et al. measured the electricity consumption in the research complex at a university in Malaysia during the lockdown in 2020 and found it was 11% lower than the typical year (2019).

Gaspar et al. also assessed the impact of the lockdown on energy consumption in 83 academic buildings at a university in Spain; their results revealed a 19.3% decrease compared to the post-COVID period. In Thailand, Chaloeytoy et al. (2022) found that energy use in a leading university during the pandemic year was 35.50% lower than in the pre-pandemic year. The results align with the previous research in Spain; the research facilities had less energy use reduction than classrooms and supporting facilities. It is important to note that despite the low occupancy and activities during the lockdown and closure, the remaining systems (heating, ventilation, and air conditioning - HVAC) and power plug loads or servers still consume a substantial amount of electricity.

2.1.2 Increasing Building Energy Use

In 2020 the global pandemic caused almost all organizations to implement the work-from-home model; as a result, energy demand shifted from the commercial, industrial, and transportation sectors into the residential sphere (Chen et al., 2020). As discussed in the first chapter, a hybrid work model will remain part of the new working and living lifestyle - at least for knowledge workers. This combination of remote and onsite work will undoubtedly impact the energy use in residential buildings now and in the future. Although the final formula for the hybrid work model is still developing, we can learn how the extreme scenarios during the first waves of COVID-19 increased home energy use and shifted the peak load demand.

In Australia, the residential electricity demand during the lockdown in March 2020 increased by 14% compared to pre-lockdown (Farrow, 2020). In Chile, Sánchez-López et al. (2022) found that the energy demand of residential consumers increased throughout the first wave and was independent of the weather. Moreover, this growing demand in 32 different Santiago communes reflected residential consumers' socio-economic background. In Europe, after a 13% decline below the five-year average in April, cross-sector electricity demand partly recovered during the summer months (IEA, 2021b). In New Zealand, electricity demand from the industrial sector fell while the residential market rose, and it was the only sector where consumption surpassed the 2019 levels (MBIE, 2021). In the UK, statistics showed that midday residential energy consumption increased by about 30% (BBC, 2020). In the US, electricity consumption in the residential sector increased by 20% (DiSavino, 2020).

The lockdown has caused the residents to use more energy for daily activities (Villeneuve et al., 2020). Many residences have been transformed into office settings for workers or classroom environments for students. While working and learning from home, people use computers, laptops, lighting, and other appliances typically used in their offices and schools. Moreover, imposing severe restrictions on outdoor entertainment activities has caused people to find alternatives within their homes, increasing energy consumption (Abdeen et al., 2021). Many studies draw on evidence from these behavioral interventions to report changes in energy patterns. In addition to individual research focus on each economy, Krarti and Aldubyan conducted a systematic analysis of energy demand data and indicated that electricity consumption has shifted from commercial buildings and manufacturing facilities to the residential building sector.

For example, Abdeen et al. found a 12% increase in household electricity consumption from 500 homes in Canada when comparing 2020 to 2019. Another study by Rouleau and Gosselin found a 46% increase in electricity use in social housing in Canada during the lockdown period. In The US, Kawka and Cetin surveyed 225 housing units from 2018 to 2020 based on the resident's income groups and found the effect of household income on the increased electricity demand. The results suggested the most significant increase of 66.9% in the lowest household income group, while the middle-income group experienced the least. In Indonesia, Novianto et al. (2022) collected energy data through online questionnaires from more than 1,000 households; they found that the number of family members, the use of air conditioning, and the use of kitchen appliances significantly contributed to the increase in electricity.

Interestingly, the work-from-home lifestyle has also shifted peak demand in the residential sector. As millions of people stayed at home, the changes in routines modified the intensity of peak times from returning home from work or early evening hours into the daytime (Aweh & Goldstein, 2019). Li et al. predicted residential electricity use during the daytimes on weekdays while practicing work-from-home under the lockdown period in The US. The researcher predicted that 9am - 5pm residential electricity usage on weekdays would be 15% – 24% higher than under prior, pre-pandemic conditions. This forecast could lead to substantially higher utility costs for residents. Moreover, the residential hourly peak demand between 12pm and 5pm on weekdays could be 35% – 53% higher than that under pre-pandemic conditions.

2.1.1 Suburban migration of energy density

The impact of the pandemic on the energy sector is an inherently geographical process at the urban scale as it is likely to be site-specific, varying according to socio-economic and urban structure, geographic context, and institutional or cultural change (Kanda & Kivimaa, 2020). During the lockdown and subsequent restricted measures, most employees worked from home, typically in suburban communities, and some even moved back to their hometowns away from the city. As a result, energy consumption patterns changed to reach deeper into the rural and peri-urban areas.

Rowe et al. used night-time light satellite imagery from December 2019–June 2020 across 50 of the world's largest urban conurbations to estimate spatiotemporal changes in urban energy consumption in response to COVID-19. The results highlighted the diversity of changes in energy consumption between and within cities. The dominant narratives of a shift in energy demand away from dense urban areas to suburban communities reflect widespread and more localized geographical changes across the urban landscape. This trend suggested the "*suburbanization*" of energy demand in several urban contexts during the early phases of COVID-19 as the dominant spatial pattern of energy usage as lockdowns continued. Moreover, the significant change is in

the shape of the load profiles during the daytime as household schedules, and daytime mobility patterns change.

There is an urgent need for employers to develop new working policies and consider their energy impact. With a transfer from urban agglomerations to smaller areas, teleworking can cause much more significant decreases in energy use (O'Brien & Yazdani Aliabadi 2020; Whitaker 2021). However, when deciding on stipends for work-from-home expenses, employers must remember that teleworkers may have increased energy bills. Government policymakers may consider incentivizing occupancy adaptability of all buildings (Ouf, O'Brien & Gunay 2019). Additionally, the pandemic has indicated the need for a reliable localized energy supply as the local power generation, with renewable sources like solar and wind at the forefront (Olabi et al., 2022). It will provide opportunities to connect household energy to the electric grid system within the areas. Meanwhile, private organizations or homes can sell their generated electricity back to energy companies or governments, which will be an essential element of future energy systems.

During the COVID-19 pandemic, home solar panel installations are growing in many economies. In 2021, The US Energy Information Administration reported a 34% increase in residential solar power installations in The US. The growth could be higher after The US President has recently signed a law that includes a 30% solar tax credit. According to Pew Research Center's January (2022) survey, 39% of the US homeowners - particularly those in the West - seriously considered installing solar panels over the past year.

2.2. IMPACT ON RENEWABLE ENERGY

As the pandemic limited economic activities, pollutant emissions have declined, and environmental damage has also fallen in most areas. The lockdown has postponed vital negotiations on global environmental governance with respect to climate change (OECD, 2020). On the other hand, the adverse effect of the pandemic can convert the negative impacts into a great opportunity for renewable energy implementation, expected to be the only energy source to grow during the pandemic, in contrast to fossil fuels and nuclear. IEA (2021) forecasted that the renewable capacity additions would achieve double-digit growth in 2019 after stalling the year before, and expected to grow in 2020 before declining in 2021, but not halting. The world saw the share of renewable energy in electricity substantially increase at record levels due to a mixture of past policies, regulations, incentives, and innovations embedded in the power sectors of many forward-thinking economies (Mojarro, 2020). The following section provides an outlook on renewable energy development during and after the global pandemic.

2.2.1 Growing awareness of the environment and renewable energy

Despite major disruptions in every aspect of life, the pandemic has positively impacted the environment. Several lockdowns and restricted mobility in most economies, with people not able to travel around, resulted in decreasing global energy demands. Consequently, greenhouse gas emissions were reduced by more than 5% (Gili, 2020). Air pollution (such as nitrogen dioxide and carbon dioxide emissions) decreased in many regions (McMahon, 2020). This trend is an opportunity for structural reforms for climate strategies. With more awareness of the environment and renewable energy impacts, energy mitigation strategies and policy recommendations in the post-COVID-19 era should take advantage of this to become more innovative and sustainable over the long term.

Improving air quality can maximize the amount of sunlight reaching the earth, reaching the solar panels in photovoltaic (PV) systems and leading to increased energy production. Watts and

Kommenda observed a decrease in atmospheric pollution during the pandemic. Naderipou et al. found that implementing the Movement Control Order (MCO) law in Malaysia reduced environmental pollution, especially air pollution. Greenhouse gas emissions, 8MtCO_2 eq. from January 2020 to March 2020, was reduced to <1MtCO_2 eq. for April and May. Reducing both GHG emissions and pollutant gases allowed more sunlight to reach photovoltaic panels, increasing the renewable energy generation in the economy. On the other hand, it is essential to note that the pandemic has resulted in some negative impacts due to the increased medical waste and high consumption of sanitizing chemicals, which put a significant burden on wastewater and solid waste management systems.

2.2.2 Transition to renewable sources

Under the lockdown, the pace of the transition was fast-tracked, as the radical substitution of clean sources (such as wind and solar) for fossil fuels happened in a short period of unprecedented pandemic situations. This transition is an opportunity to become less dependent on fossil fuels (Olabi, 2022), while shifting to distributed energy generation using local and renewable sources to decarbonize and decentralize power generation systems that do not require pricey and logistically challenging transmission networks to achieve the goal of total energy access and sustainability (Apanada, 2020).

At the same time, the lack of capital investment, manufacturing facilities, and supply chain disruption seriously affected the renewable energy sector. Many companies slowed the transition to sustainable energy or green and low-carbon energy progress due to the global decline in economy-driven demand (Hosseini, 2020). However, several economies registered new records for renewable sources and saw their share in electricity substantially increase. In the US, renewable energy outputs have passed coal for the first time in 130 years, while the UK hit a record for solar generation (Mojarro, 2020). Renewable energy made significant progress with accelerated growth due to overwhelming research activities, technology advancements, and supporting policies in the sector. The pandemic experience has demonstrated that developing renewable and sustainable energy in future infrastructure is a safe strategy (Hosseini, 2020). In terms of policies, most economies formulated strategies to ensure the sector's development globally (Olabi, 2022). The following provides examples from some of the APEC economies.

Australia – Australia has announced plans to shift away from fossil fuels to renewable sources such as offshore wind farms, hydropower facilities, and solar panels, which accounted for 32.5% of the economy's total electricity generation in 2021, an increase of almost 5% compared to 2020, according to the Clean Energy Council, a non-profit industry body (Mercer, 2022). For solar energy in particular, the Australian Renewable Energy Agency (ARENA) considers the next-generation grid-scale batteries pivotal to this transition, with inverter technology that can maintain grid stability without the need for coal and gas generators. In October 2022, ARENA announced AUD200 million in grant funding for the Community Batteries for Household Solar Program. This new program aims to deploy community batteries across Australia, allowing households to store and use the excess power they produce. In December 2022, the agency announced its plan to support eight grid-scale battery projects across Australia. These projects represent a tenfold increase in grid-forming electricity storage capacity currently operational in the National Electricity Market (NEM).

Brunei Darussalam - Brunei Darussalam's energy sector focused on reducing dependency on imported fuel products while continuing to generate products for export. The economy has developed renewable resources, particularly PV and waste-to-energy, to target its share of the power generation mix from renewable energy to at least 10 percent by 2035. The government also plans to introduce policy and regulatory frameworks that will stimulate investment by the

government and the private sector in developing and deploying renewable energy (Energy and Industry Department of Prime Minister's office, 2016).

Canada – Canada generates a large share of its electricity from renewable sources, including hydro generation. Near-term (2018-2023) changes to capacity are primarily based on renewable energy projects that are under construction or have been completed or proposed by the National Energy Board (NEB, 2017), while the Energy Futures series includes long-term projections of the Canadian energy system focus on a net-zero energy system (CER, 2020). During COVID-19, however, the projects under development suffered the most, particularly hydropower plants, as the pandemic restricted travel to remote areas and made it more challenging to find the human resources to carry out the projects.

Chile – New renewables, solar and wind, have become more relevant, while hydro has decreased in prominence. The government is working with companies to suspend coal and gas plants to reach 60% renewables by 2035 and 70% by 2050. Green hydrogen has begun to increase interest among governments, as there is a task force addressing potential uses (Baker & McKenzie, 2020).

China – China has had substantial growth in renewables. The economy is gradually shifting its policy focus from large, central plants to distributed energy, agricultural energy, building-integrated energy, offshore wind, and floating PV. According to the Renewable Energy Law, renewable energy will be a high portion of the energy system and developed on a large scale in a market-oriented way. China is determined to become carbon neutral by 2060 (Hove et al., 2021).

Hong Kong, China – The government published its Climate Action Plan 2050 to eliminate the use of coal for electricity generation by 2035. The economy aims to become more innovative and sustainable over the long term, with small-scale renewable energy systems installed at government buildings and increased renewable energy. Property and transport sectors present significant opportunities to reduce the city's carbon footprint, as the pandemic has positively affected attitudes toward digital transformation, technology adoption, and data sharing (KPMG, 2022).

Indonesia – The economy has set an overall target to have modern renewables provide 23% of the total primary energy supply by 2025 and 31% by 2050. According to IRENA (2017), investments need to accelerate rapidly to achieve this goal. Indonesia's Ministry of Energy and Mineral Resources (MEMR) has developed a roadmap for 2030, highlighting ways to increase the uptake of renewable energy beyond the economy's present policies and plans to increase the share of renewable energy.

Republic of Korea – In recent years, the economy has experienced significant change by increasing the share of renewable energies in the overall energy mix. The greater interest in the potential of renewable energy and the long-run impact of sustainable business gained popularity. In order to keep the promise of safe and clean energy, the expansion of renewable energy contribution to the energy mix is pivotal (World Energy Council, 2022)

New Zealand – The share of total energy supply from renewables was at its highest since reporting started in 1990. The percentage of modern renewables in final energy consumption increased to 28.4%.

Papua New Guinea – The government has set the ambitious goal of reaching 70% access to electricity by 2030 and becoming fully carbon-neutral by 2050. It is already working to implement the National Electrification Rollout Plan for the economy with support from development partners, emphasizing the development of renewable energy to cut down on the use of fossil fuels. It is also evident that energy has great potential to become a significant catalyst for welfare improvements and economic prosperity in the economy (NRI, 2022).

The Philippines –The Philippines Climate Change Commission has called for economic recovery to build climate resilience. This appeal includes supporting low-carbon technologies, eco-construction and design policies, research and development for ecological purposes and natural capital investment for ecosystem resilience and regeneration, including reducing dependence on large fossil fuel power plants and shifting to distributed energy generation using local, renewable sources (Apanada, 2020).

Singapore – Singapore will continue to harness its "four switches" of energy, namely natural gas, solar energy, regional power grids and emerging low-carbon alternatives. By 2030, solar energy - Singapore's second switch - is expected to supply around 3% of the economy's total electricity consumption (Tan, 2020).

Chinese Taipei – The solar sector is performing greatly in the short term of 2020 despite the pandemic. Combined growth in the solar and wind sectors would enable Chinese Taipei to meet its energy target of 65% non-hydro power renewables by 2030.

2.3. CONCLUSION

Buildings energy use changed during the COVID-19 pandemic due to the temporary closure, with restrictions on opening hours, and limitations on the number of users because of the stay-at-home policies. Studying building use patterns shows a direct correlation between occupancy conditions and building types; for example, energy consumption in commercial buildings decreased due to limited economic activities, while those in residential and healthcare buildings increased during an extended stay with home-based activities. This caused an energy density transfer from urban agglomerations to smaller, more suburban areas.

Many residents switched to working or undertaking education from home, which has become a "new normal" lifestyle in the post-pandemic era. Households may increase their expenditures by using air conditioning and kitchen appliances with longer running times. These home-based activities have also shifted peak demand. Thus, planning for future residential energy use during the weekdays should be further discussed. Policies from governments or organizations may want to consider incentivizing occupancy adaptability. Upgrading the energy efficiency of government or private facilities, such as retrofitting, training, and accreditation could also support better energy management.

Should the world continue to follow this pattern of work or study, energy demand for domestic purposes is likely to surge. Thus, medium-sized localized power generation systems need to be developed to serve local electric utilities in suburban areas (Olabi, 2022). As clean energy sources spread during the pandemic, renewable energy, such as solar and wind, could be required to be incorporated with microgrid systems in the area as a localized grouping of electricity generation. This could provide an opportunity for energy reforms and policy recommendations to shift away from fossil fuels and raise environmental awareness with a target on carbon neutrality. Moreover, it could also create jobs to support the energy sector in the economic recovery process after the pandemic. Intelligent policies with the government's support could convert the negative impacts of the pandemic into tremendous opportunities for the world's sustainable energy development toward renewable energy in the long run.

CHAPTER 3

POST-COVID TRENDS IN TRANSPORTATION SECTOR

3.0 INTRODUCTION

The new working and living lifestyles post-COVID-19 also impact energy use in the transportation sector worldwide and influence the development of alternative modes of transport. During the peaks of this global pandemic, travel restrictions and lockdowns resulted in reduced mobility, particularly in public transportation and energy use. At the same time, many new mobility modes are being introduced, such as electric vehicles, zero-emission vehicles, e-bikes, bike-sharing, and ride-hailing platforms, due to concerns about using public transport and rising energy prices. Based on systematic literature reviews, this section focuses on preferences for alternative modes of transportation and electric or zero-emission vehicles over internal combustion engine vehicles to achieve energy efficiency, sustainability, or resilience.

This review followed the systematic literature protocol, which included finding, screenings, and assessing 474 articles and then narrowing the analysis down to the most relevant 19 articles. Subsequently, a content analysis was conducted to extract the narratives responding to the research question and validated evidence. Eight out of 19 articles promoted alternative active mobility such as bicycle, biking, and bike sharing, while the same number of articles mentioned negative preferences towards shared/public transport. Analysis also show patterns emerging in travel behaviors, other pollution-related findings, and support for alternative transportation. Finally, this study suggests that future research should widen the investigation on alternative transport or mobility by including different modes. These include water transport or mobility, for an equitable and ubiquitous system, especially in developing economies with the distinctive urban fabric and existing transportation infrastructure.

3.1 RESEARCH QUESTION AND FRAMEWORK

Current development in urban mobility is transforming towards carbon neutrality (Hepburn, et al., 2021). Various modes of transportation are going greener, including bio-diesel vehicles to solar buses. The most significant changes are happening in personal mobility, where passengers are adopting electric vehicles over other alternative fuel vehicles.

This research aims to identity themes within recent findings on the preferences of electric vehicles (EV) and zero-emission vehicles (ZEV) over internal combustion engine vehicles (ICEV) concerning the pandemic related teleworking, work-from-home and/or for achieving energy efficiency, sustainability, or resilience. This study limits its search to the academic literature and original research conducted in APEC member economies.

This research aims to answer the following question:

Are post-pandemic situations such as teleworking and working from home favoring electric vehicles or equivalent zero-emission vehicles over ICE vehicles in the APEC economies to achieve energy efficiency, sustainability, and resilience?

3.2 METHODOLOGY

The methodology of this systematic review is described in Major et al. (2010). This study follows the SPICE framework proposed by Booth (2004) as suggested to be suitable for social science and healthcare research (Systematic reviews: Formulateyourquestion, 2022).

Table 1: SPICE Framework for this research

Aspects	Keywords
Situation	COVID-19, pandemic, post-COVID, post-pandemic, epidemic, plague, outbreak, lockdown, hybrid work, teleworking, work from home, remote work, rebound, counter urbanization,
Population	APEC Economies: Australia; Brunei Darussalam; Canada; Chile; People's Republic of China; Hong Kong, China; Indonesia; Japan; Republic of Korea; Malaysia; Mexico; New Zealand; Papua New Guinea; Peru; The Philippines; The Russian Federation; Singapore; Chinese Taipei; Thailand, The United States; Viet Nam
Intervention	ICE, Internal Combustion Engine Vehicles, Fossil Fuel Vehicle, Petrol Vehicle, CNG, NGV, LPG, Diesel vehicle
Comparator	EV, Electric Vehicle, e-Bike, e-Cycle, e-scooter, electric car, electric bus, ZEV, or EZEV,
Evaluation	policy, planning based on energy efficient, efficiency, alternative, alternate, resilient, resilience, sustainable, sustainability

3.2.1 Search Strategies

Following the framework described above, the search strategies were devised for five well-known databases as listed in Table 2 for search strategies. There were limitations on how many keywords could be used, even in the advanced search options of many databases (IEEE, 2022), and some had a restriction on Boolean connectors (Elsevier, 2018). Therefore, this study included carefully selected keywords in the search strategies to avoid discrepancies across the selected databases. Since the population was seldom mentioned in the keywords, title or abstracts, this aspect was manually screened during the funneling process (Vassar, Atakpo, & Kash, 2016).

3.2.2 Selection Criteria

The inclusion criteria for primary studies included the following:

- Publications reporting on the policy or planning using case studies, as opposed to theoretical research, on electric or zero-emission vehicles are included.
- Papers that involve an empirical study or have a ‘lessons learned’ (experience report) element are included.
- Where several papers have reported the same study, only the most recent article will be included. Most publications included in this section are from 2020 onwards.
- Grey literature (such as technical papers or government reports) will be accepted if relevant.
- All literature will have its subject within APEC member economies.

Table 2: Search Strategies for databases

Database	Search Syntax	Remarks on filters used
Science Direct	(teleworking OR “work from home”) AND (resilient OR sustainable) AND (mobility OR "electric vehicle" OR "zero emission vehicle" OR "internal combustion engine vehicle")	[search field: Title, abstract or author-specified keywords] [review articles, research articles, open access, 2020-2023]
Google Scholar	(teleworking OR “work from home”) AND (resilien* OR sustainab*) AND (mobility OR "electric vehicle" OR "zero emission vehicle" OR "internal combustion engine vehicle")	[2020 - 2023, patents and citations excluded]
Pubmed	((("hybrid work") OR (teleworking) OR ("work from home") OR ("remote work")) AND ((resilien*) OR (sustainab*)) AND ((mobility) OR ("electric vehicle") OR ("zero emission vehicle") OR ("internal combustion engine vehicle")))	[Text availability: Abstract, Free Full Text, Full Text, English, 2020-2023]
Scopus	(teleworking OR "work from home") AND (resilient OR sustainable) AND ("electric vehicle" OR "zero emission vehicle" OR "internal combustion engine vehicle"))	[TITLE-ABS-KEY] [PUBYEAR > 2019] [Selected Document Type: Article, Conference Paper, Review, Book Chapter]
IEEE Explorer	(teleworking OR “work from home”) AND (resilient OR sustainable) AND (mobility OR "electric vehicle" OR "zero emission vehicle" OR "internal combustion engine vehicle")	[Years: 2020-2022]

This literature review excluded publications written in languages other than English and those that only provided abstracts. Subsequently, the researcher created a set of questions as a checklist for the quality assessment of each publication (Dyb˚a & Dingsøyr, 2008). The first two questions are used to screen out non-academic papers. Simultaneously, the researcher extracted relevant data to contribute to understanding the subject matter and answering the research question. For data extraction, the researcher employs a reference manager (Endnote X9.3.3. in combination with Microsoft Excel 2019, Google Doc, and Microsoft Word 2019) to manage, assess, and mark the articles found through the search strategies. The findings extracted from selected papers are then presented in a tabulated format and narrative analysis. The results are as follows.

3.3 PREFERENCE FOR MODE OF TRANSPORT AND TRAVEL BEHAVIOUR

3.3.1 Screening Results

This research aims to address the planners' and policymakers' interests. Therefore, it included publications in journals related to transportation, urban planning, or policy-making among the APEC members. After applying the search strategies to the advanced search options of selected databases, it derived a total of 474 full papers. However, most of these papers were later removed as some were duplicated, and others needed more relevant keywords. Finally, the detailed analysis presented here used twelve articles addressing APEC populations. Figure 2 shows the network map of topics found in 79 articles, and Figure 3 shows the network map of keywords from selected articles (general terms removed).

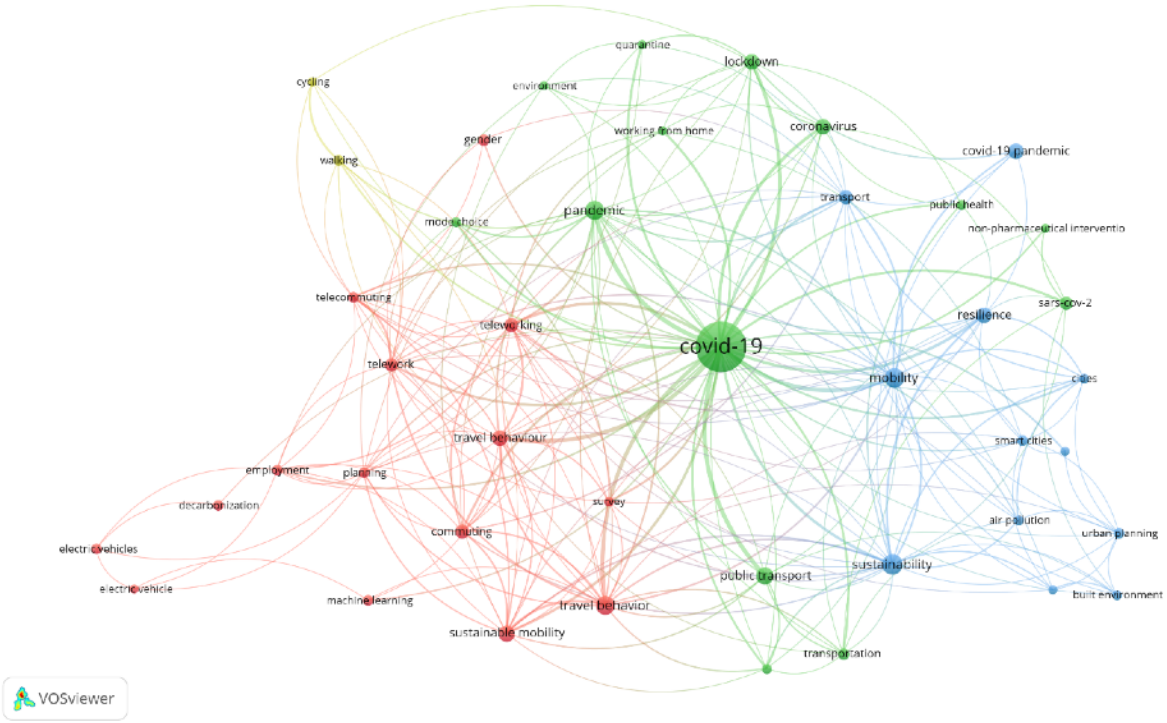

Figure 2: Network map of topics found in 79 articles

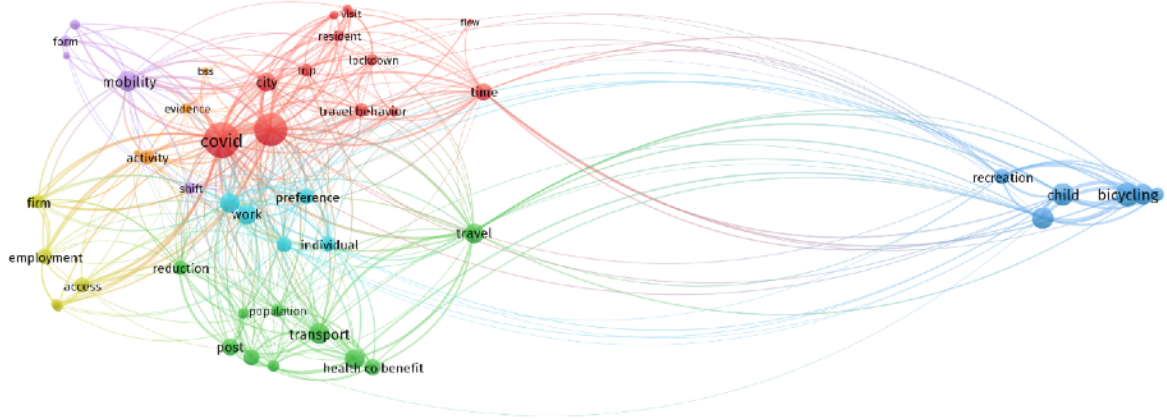

Figure 3: Network map of keywords from selected articles (general terms removed)

3.3.2 Narrative Analysis

It is noteworthy that most of the selected literature (see Table 3) draws their cases and direct relevance from articles published in the recent past, if not contemporary. The few articles referred to also suggested that bicycle or bike-sharing will be a prominent mode of mobility in the future, based on their research, such as (Pucher & Buehler, 2008), and (Campbell & Brakewood, 2017). An interesting study investigated the pandemic's impact on mobility concerning Indonesia's socio-economic factors. This study revealed that people who significantly reduce their mobility could be characterized as prosperous, residing in urbanized areas with formal sectors, employed in the manufacturing or tourism industry, with relatively higher education, and digitally connected. The research suggests that developing economies should address the gap in their digi-

tal infrastructure by providing access as far and wide to prepare their people for pandemic-like situations (Khoirunurrofik, Abdurrachman, & Rachmanto, 2022).

A scenario study in Changzhou, China, suggested that people preferred bicycles or private cars over shared or public transportation during the pandemic. The use of bicycles correlated with reducing CO_2 and other pollutants (Zhang & Zhang, 2021). In another city of Huzhou, looking at the travel behavior of patients, they found that people preferred bicycling over public transportation during the pandemic. They also suggested that bicycling can be related to better fitness and well-being of commuters (Yang, et al., 2021).

Table 3: Description of the selected research articles

Author	Situation	Mode1	Mode2	Aim	Economy	Method
Khoirunurrofik, et. al. 2022	Travel behavior	-	-	Socio-Economic impact on travel	Indonesia	Regression, Scatter Plot
Zhang and Zhang 2021	New Normal	Bicycle and Car	Shared, Public Transport	CO2 Reduction	China	Scenario, (+- 10%)
Yang et. al. 2021	Travel behavior	Bicycle	Public Transport	Fitness & Wellbeing	China	Recommendation
Lu et. al. 2022	Transportation Decarbonization	Near Zero	IGT and MEV	Better health benefits	China	Scenarios
Xu et. al. 2022	BMV Collisions	Bicycle	Motor Vehicle	Increased Safety	Hong Kong, China	Empirical (Bayesian)
Li, Ha and Lee 2022	Travel behaviour	Public Transport	Cars	Study long term impact of COVID	Korea	Hist gradient boosting model
Lee and Finerman 2021	Travel Behavior,	-	-	Study pollution reduction due COVID lockdown	Korea	Panel regression model
Kawaguchi, Kitao and Nose 2022	Work from Home	-	-	WfH adaptation and its impact on company sales	Japan	Heterogeniety in descriptive stats.
Arimura et. al. 2020	Travel Behavior	-	-	Changes in Population Density	Japan	Geo-spatial regression
Dilley et. al. 2022	Counter-Urbanization	-	-		Japan	Critical Analysis
Mayo et. al. 2021	Travel behavior	-	-	Changes in purpose for traveling	The Philippines	Visualization, Multi Logic Regression
Sersli et.al. 2021	Bicycling	Recreational Bicycling	Transportatio n Bicycling	Study Demography	Australia	Multilevel logistic regression
Vecchio et. al. 2022	Delivery Ridership in Pandemic	Delivery Ridership	-	Risks in Delivery Ridership	Chile	Interviews, Survey Triangulation
Teixeira and Lopes 2020	Choice, Behaviour	Bike sharing	Subway	Resilience	The US	GIS, ridership
Wang et. al. 2022	Travel behaviour	-	Public Transit	Equity	The US	Regression Model
Shamshiripour et. al 2020	Travel behaviour	-	-	Public dynamics during and after COVID	The US	Descriptive stats. Visualization
Sevtsuk, et al., 2022	Travel behaviour	-	-	Travel pattern by SEI groups	The US	Spatial analysis
Koon et. al. 2022	Mobility disability	-	-	Travel options for disabled	The US	Descriptive stats, content analysis
Fatmi, Orvin and Thirkell 2022	Work from Home choices	-	-	Assess long term impact of WfH post COVID	Canada	RPOL model

Research in Beijing, China, employed five scenarios of the transportation situation, namely a) Business as Usual (BAU), b) Increased Green Transport (IGT), c) More Electric Vehicles (MEV), d) IGT+MEV, and e) Near zero. They modelled IGT with walking, cycling and public transport, MEV with three types of electric vehicles: battery electric vehicle, plug-in hybrid, and range extender electric vehicles. For the "Near Zero" scenario, the researcher used the combination of IGT and MEV with 100% electrification of all cars and a gradual reduction of the number of passenger vehicles to near zero by 2050 (Lu, et al., 2022). While all four latter scenarios resulted in a decrease in CO_2 emissions, the "Near Zero" scenario promised much better health benefits.

There is also evidence that changing transportation modes contribute to better environmental quality. A study in the Republic of Korea compared travel patterns of Seoul and Daegu provinces in 2019 and 2020 with the pollution data of these two regions over two years and analyzed them by a panel regression model. It shows that for every 1% of decreasing commuting flows, there was a significant drop in pollution levels of PM2.5 by 0.11%, PM10 by 0.17%, NO2 by 0.14%, and CO by 0.09% (Lee & Finerman, 2021). Another research project investigated the long-term impact of the pandemic in Seoul, Korea, using a hist gradient boosting model and other machine learning tools. The results indicate a) travel in Seoul decreased unevenly, b) consumer, service, and foreign tourism continue to be affected, c) neighborhoods with higher car ownerships and higher female residents show long-term weaker resilience of their public transport, and d) short-distance commuters and commuters to city centers returned to public transport in the second year (Li, Ha, & Lee, 2022).

An economy-wide survey in Japan focusing on specific companies linking sales and hours work with publicly available data from Google Community Mobility Report. This study found that a 10% reduction in mobility reduced sales by 2.8% and hours worked by 2.1%. However, the companies that adopted work-from-home before the pandemic could mitigate term sales by 55% and hours worked by 35%. Moreover, engaging more short-term remote workers helped reduce the negative impact on sales and hours worked. They finally suggested that adopting to work from home benefits can be realized at a public scale reducing the burden of subsidy of labor hoarding (Kawaguchi, Kitao, & Nose, 2022).

A spatial mobility and demographic study in Sapporo, Japan, looked at the population distribution and density variations during the pandemic. They found that population distribution and concentration significantly decreased on weekdays after the second emergency declaration, with minimum change during the weekends and holidays. Interestingly, population distribution was concentrated primarily in the downtown areas. This study suggests that the residents of Sapporo reduced their mobility in cohorts with the Japanese government announcements during the pandemic (Arimura, Ha, Okumura, & Asada, 2020).

A critical review of literature and policies on counter-urbanism in Japan, a trend during the beginning of the pandemic, indicates that there are two faces to this phenomenon. One supported by the public organization is the "furusato" - idealization of the countryside/hometown, and another is the rustic rural reality – "inaka" is still contrary to the generally perceived prosperity – keeping 29% of Japanese in Tokyo. While idealization has been catalyzed during the pandemic, this study suggested that more systemic measures are needed to mediate between the two faces of this phenomenon (Dilley, Gkartzios, & Odagiri, 2022).

Another research project in the city of Santiago, Chile, investigated the aspect of digital injustice towards the riders working for delivery apps using a series of interviews and surveys before and during the pandemic. It revealed that the riders face critical danger apart from the tireless work routine. The riders considered this type of work as very risky (42% before compared to 69% during the pandemic), prone to road accidents (80%), aggressive clients (76%), stressful

daily targets (52%), and fear of contagion (76%). It emphasized the need for a spatial dimension of fairness to mitigate the impacts of injustice delivered within the digital platforms (Vecchio, Tiznado-Aitken, Albornoz, & Tironi, 2022).

In The US, a comparative study between the Citi Bike Sharing and NYC Subway ridership over February and March 2019 versus 2020 found that bike-sharing ridership is more resilient than subways. They also found that bike rides were longer in 2020, and there was a modal shift from the subway to bike sharing during February-March 2020 (Teixeira & Lopes, 2020). Researchers in another study used smartphone location data points in North Carolina to track the travel patterns of residents in three socio-economic statuses (low, medium, and high). They found that low and medium-SES residents were frequenting retail and offices during the lockdown, putting them in a vulnerable position. They suggested that policymakers should facilitate safe and convenient transportation, especially in public transit, for people of low SES (Wang, Kaza, McDonald, & Khanal, 2022).

In Chicago, Illinois, a preference survey was carried out, coupled with Illinois Department of Public Health (IDPH) data as of June 2020, to understand peoples' travel behavior during the pandemic and its future prospects. The results revealed a significant drop in public confidence in shared mobility (such as shared taxi, shared bike, and shared e-bike) and public transit due to the threat of contagion. However, part of the people sampled still used public transit, while most people preferred private cars, private bikes, and walking to be safer. The research recommends that the transportation system be more equitable to enable safe travel for people who may not have access to a private vehicle (Shamshiripour, Rahimi, Shabanpour, & Mohammadian, 2020).

Another study covering multiple cities in The US (Sevtsuk, et al., 2022) found a mobility gap between the high and low socio-economic index (SEI) groups across the economy. The people in the low SEI group would travel short distances within their respective city blocks, while those in the high SEI group would make trips to the parks, healthcare providers, and retail spaces even before the pandemic. Transit-served and walkable neighborhoods benefited the high SEI people more than the low SEI group. This result suggested that the built environment influences not only the mobility but also the well-being and resilience of the various groups of SEI differently (Sevtsuk, et al., 2022).

Yet another survey-based mixed method study found that people with mobility disabilities faced another challenge during the pandemic regarding transportation restrictions compared to pre-pandemic times. Their main concerns were a) fear of contagion, b) difficulty embarking/disembarking, and c) access to reliable/effective choices given that none could bike and some had limitations with wheelchair use. Thus, transportation modes should consider giving all-time access to people with disability providing safety and convenience (Koon, et al., 2022)

In the Central Okanagan region of British Columbia, Canada, residents of large dwellings, away from urban centers, with children, having higher incomes, and living in highly residential areas showed an inclination towards working from home. This trend also resonates with female participants even though they showed less interest in working from home. This research also confirmed that residents of areas with alternative transportation, such as more extended bike lanes or sidewalks, showed less preference for working from home. They suggested that local authorities plan transits options to accommodate the work schedules (Rahman Fatmi, Orvin, & Thirkell, 2022).

This narrative analysis discusses various common themes: travel behavior or patterns, work from home, and choices/preferences. To examine preference of electric vehicle or zero emission vehicle over internal combustion vehicles, it may be necessary to look for evidence (see Table 4) the selected literature provides. The evidence table shows that most of the authors of the selected articles reviewed favor bicycles as opposed to public transit. Since these articles examined travel

behavior in conjunction with the work-from-home practices prevalent during the pandemic, it may be said that public transit modes need reconsideration for preparing for such global phenomena, especially in the Asia Pacific region.

Table 4: Evidence table of the select articles reviewed

Author	Economies	Theme	Supports EV/ ZEV	Over ICEV
Khoirunurrofik, et. al. 2022	Indonesia	Travel behaviour	-	-
Zhang and Zhang 2021	China	New Normal	Bicycle, Car	Share/Public Transit
Yang et. al. 2021	China	Travel behavior	Bicycle	-
Lu et. al. 2022	China	Transportation Decarbonization	Bicycle and EV	ICEV
Xu et. al. 2022	Hong Kong, China	BMV Collisions	Bicycle	Motor Vehicle
Li, Ha and Lee 2022	Korea	Travel behavior	-	Public Transit
Lee and Finerman 2021	Korea	Travel Behavior,	-	-
Kawaguchi, Kitao and Nose 2022	Japan	Work from Home	-	-
Arimura et. al. 2020	Japan	Travel behavior	-	-
Dilley et. al. 2022	Japan	Perception vs. Population	-	-
Mayo et. al. 2021	The Philippines	Travel behavior	-	Public Transit
Sersli et.al. 2021	Australia	Bicycling	Bicycle	-
Vecchio et. al. 2022	Chile	Inequity	-	-
Teixeira and Lopes 2020	The US	Choice, behavior	Bike Sharing	Public Transit
Wang et. al. 2022	The US	Travel behavior	-	Public Transit
Shamshiripour et. al 2020	The US	Travel behavior	Car, Bike, Walk	Shared/Public Transit
Sevtsuk, et al., 2022	The US	Travel behavior	-	-
Koon et. al. 2022	The US	Travel behavior (of Disabled)	Private Car	Public Transit
Rahman Fatmi et. al. 2022	Canada	Work from Home choices	Bike Lanes	Public Transit

3.3.3 Preference for Alternative Transport

The previous reviews provide a clear picture of the general preference for using bicycles while moving away from public transit. Private cars were also preferred in two cases, though it needed to be clarified if these vehicles were either electric or zero-emission vehicles. Walking is another mode considered safer than shared/public transit during the pandemic. Internal combustion engine vehicles or motor vehicles were less preferred in the two articles. Thus, there is a clear preference for active transport such as bicycle, bike-sharing, and walking over shared or public transport primarily due to the threat of contagion, safety, access, and personal control.

The literature highlighted above casts light on several issues, and further discussion may help synthesize the findings and suggestions put forward by the reviewed articles. This section is organised according to the following themes:

Preference for active mobility options like biking, bike sharing, and walking has increased slightly before, during, and after the pandemic. However, this trend needs attention from planners to enable comfortable and safe passage. Even though bike-sharing is a shared mobility, due to the size and accessibility of the vehicles, users may be able to have control over the possibility of contagion using personally sanitation before use.

The perceived threat of shared mobility or public transit has negative perception during and after the pandemic mainly due to the possibilities of contagion, inequitable access, and lack of personal control.

3.3.4 Travel Behaviour

Travel Behavior, the most common theme in the literature reviewed, reveals the following:

High socio-economic groups in the west (particularly in the US) were open to travel during the pandemic (Koon, et al., 2022), (Sevtsuk, et al., 2022), and (Shamshiripour, Rahimi, Shabanpour, & Mohammadian, 2020). On the other hand, people in this category were reluctant to travel in the east such as China; Indonesia; Japan; and the Philippines. (Dilley, Gkartzios, & Odagiri, 2022), (Khoirunurrofik, Abdurrachman, & Rachmanto, 2022), (Mayo, Maglasang, Moridpour, & Taboada, 2021), and (Yang, et al., 2021).

There is a similarity in terms of equity across the articles, suggesting that people with lower socio-economic status or limited options for personal mobility had to opt for public transit or any other mode of transport to meet their daily goals (Wang, Kaza, McDonald, & Khanal, 2022), (Mayo, Maglasang, Moridpour, & Taboada, 2021), (Khoirunurrofik, Abdurrachman, & Rachmanto, 2022). This factor also relates to the inequity generated by the digital delivery platforms, as noted by (Vecchio, Tiznado-Aitken, Albornoz, & Tironi, 2022) in Santiago.

In general, people will prefer to commute less if not necessary because the pandemic has catalyzed the culture of working from home, online shopping, and delivery services, and also created a negative perception of crowded places.

Pollution, mainly air pollution, has decreased due to the reduction of travel in many places such as Changzhou (Zhang & Zhang, 2021), Huzhou (Yang, et al., 2021), New York City (Teixeira & Lopes, 2020), Seoul and Daegu (Lee & Finerman, 2021). This improvement supports the argument that electric vehicles may lead the way to net or near-zero-emission transportation, as envisioned by Lu, et al. (2022).

Evidence from this systematic review supports the introduction of alternative transport in the global east (Zhang & Zhang, 2021) (Yang, et al., 2021) (Lu, et al., 2022) and (Lee & Finerman, 2021). It is also beneficial in the global west, as noted by (Sersli, Turrell, Burton, Brown, & Heesch, 2021), (Teixeira & Lopes, 2020), (Shamshiripour, Rahimi, Shabanpour, & Mohammadian, 2020) and (Rahman Fatmi, Orvin, & Thirkell, 2022). Even though China is seen as a global leader in bike-sharing, followed by the Republic of Korea and Japan, the difference may be because the bike sharing is not as ubiquitous and equitable in the east as it is in the west, especially in Europe (Shaheen, Guzman, & Zhang, 2010).

Synthesis of findings

The pandemic has exposed the vulnerabilities of shared mobility and public transit, which will continue into the near future. There is an inclination towards active mobility catalyzed dur-

ing the pandemic due to its benefits on health, accessibility, and zero emissions. Based on their socio-economic status and available choices, people are making conscious preferences when it comes to their travel behavior, which may not only be limited to choosing the transportation modes but also deciding to travel, which may further impact urban mobility. More emphasis will be given to reducing pollution while planning transportation modes in the future to ascertain achieving global sustainability goals. In the process, it will be necessary to reevaluate the alternative transportation scenarios to be more accessible and equitable, especially in developing economies.

3.4 CONCLUSION

This literature review shows that the mobility and transportation sectors will fundamentally change after the pandemic. There will be more preference for personal or active mobility, while shared and public transit will have to be reconsidered due to its perceived threat of contagion, emission, and access. Travel behavior may have patterns based on socio-economic status, where people of lower socio-economic status choosing shared and public transport may look for more equitable and accessible options.

Generally, people will travel less compared to the past due to digitization, telecommuting, working from home, and online shopping, which became more familiar during the pandemic. Pollution reduction will be a significant agenda in transportation, limiting the use of internal combustion engine vehicles, which may be replaced by electric or zero-emission vehicles coupled with biking or walking. Alternative transport will be encouraged more in developing economies which may need to have it equitably ubiquitous.

This research points out that the transportation sector in APEC economies needs to consider the changes brought forth by the pandemic to plan a future sustainable and resilient system. Using alternative or active mobility like bicycles in developing economies should provide more equitably ubiquitous. Finally, achieving the global sustainable development goals should be kept in mind to execute the infrastructure plans in the future.

Future studies should bring other alternative transport, such as water-based mobility and transportation, because it seems to be a promising area of interest given the imminent sea level rise (Tannum & Ulvensøen, 2019). Especially in Bangkok, Thailand, there have been plans to execute extensive water-based transportation utilizing its canal network with the Chao Phraya river system (OTPP, 2021).

REFERENCES

Hybrid Work and Energy in the Built Environment

Abdeen, A., Kharvari, F., O'Brien, W., & Gunay, B. (2021). The impact of the COVID-19 on households' hourly electricity consumption in Canada. *Energy and Buildings, 250,* 111280. https://doi.org/10.1016/j.enbuild.2021.111280

Apanada, M.J. (2020). Clean Energy Can Help Southeast Asia Recover After COVID-19. https://www.wri.org/insights/clean-energy-can-help-southeast-asia-recover-after-covid-19

Asia Pacific Energy Research Centre (APERC). (2022). APEC Energy Overview 2022. https://aperc.or.jp/file/2022/9/2/APEC_Energy_Overview_2022.pdf

Aweh, A. & Goldstein, A. (2019). Alleviating peak demand challenges and improving customer affordability with time-varying rates. https://www.westmonroe.com/perspectives/point-of-view/alleviating-peak-demand-challenges-and-improving-customer-affordability-with-time-varying-rates

Baker & McKenzie. (2020). COVID-19 | Latin America Energy, Mining and Infrastructure Podcast Series. https://www.bakermckenzie.com/-/media/files/insight/publications/2020/05/baker-mckenzie--latin-america-power-amid-covid19.pdf?sc_lang=en&hash=96670D551251AD01DE8E460AD15F0C4E

The British Broadcasting Corporation (BBC). (2020). Coronavirus: domestic electricity use up during day as nation works from home. https://www.bbc.com/news/technology-52331534GABC

Broto, V.C. & Kirshner, J. (2020). Energy access is needed to maintain health during pandemics. *Nature Energy, 5*, 419–421. https://doi.org/10.1038/s41560-020-0625-6

Bhuiyan, M.A., An, J., Mikhaylov, A., Moiseev, N. & Danish, M.S.S. (2021). Renewable Energy Deployment and COVID-19 Measures for Sustainable Development. *Sustainability, 13*, 4418. https://doi.org/10.3390/su13084418

Chaloeytoy, K., Inkarojrit, V., & Thanachareonkit, A. (2022). Electricity Consumption in Higher Education Buildings in Thailand during the COVID-19 Pandemic. *Buildings, 12*, 1532. https://doi.org/10.3390/buildings12101532

Chen, C., Zarazua de Rubens, G., Xu, X., & Li, J. (2020). Coronavirus comes home? Energy use, home energy management, and the social-psychological factors of COVID-19, *Energy Research & Social Science, 68*, 101688. https://doi.org/10.1016/j.erss.2020.101688

Chihib, M., Salmerón-Manzano, E., Chourak, M., & Perea-Moreno, A.J. (2021). Manzano-Agugliaro, F. Impact of the COVID-19 Pandemic on the Energy Use at the University of Almeria (Spain). *Sustainability*, *12,* 1336. https://doi.org/10.3390/su13115843

Deiss, B.M., Herishko, M., Wright, L., Maliborska, M., & Abulencia, P. (2021). Analysis of Energy Consumption in Commercial and Residential Buildings in New York City before and during the COVID-19 Pandemic. *Sustainability, 13*, 11586. https://doi.org/10.3390/su132111586

DiSavino, S. (2020). COVID-19: America hasn't used this little energy in 16 years. https://www.weforum.org/agenda/2020/04/united-states-eneregy-electricity-power-coronavirus-covid19/

Duarte, C.C., & Cortiços, N.D. (2022). The Energy Efficiency Post-COVID-19 in China's Office Buildings. *Clean Technologies, 4,* 174–233. https://doi.org/10.3390/cleantechnol4010012

Eisen, J. (2021). COVID-19's Impact on Renewable Energy, 69 Kan. L. Rev. 775. https://scholarship.richmond.edu/cgi/viewcontent.cgi?article=2635&context=law-faculty-publications

Energy and Industry Department of Prime Minister's office. (2016). Brunei Darussalam Country Report. Energy Outlook and Energy Saving Potential in East Asia 2016. ERIA Research Project Report 2015-5, Jakarta: ERIA, 79-90.

Farrow, H. (2020). Commercial down v residential up: COVID-19's electricity impact. https://www.energynetworks.com.au/news/energy-insider/2020-energy-insider/commercial-down-v-residential-up-covid-19s-electricity-impact

Gaspar, K., Gangolells, M., Casals, M., Pujadas, P., Forcada, N., Macarulla, M., & Tejedor, B. (2022). Assessing the impact of the COVID-19 lockdown on the energy consumption of university buildings. *Energy and Buildings, 257*, 111783. https://doi.org/10.1016/j.enbuild.2021.111783

Geraldi, M.S., Bavaresco, M.V., Triana, M.A., Melo, A.P., & Lamberts, R. (2021). Addressing the impact of COVID-19 lockdown on energy use in municipal buildings: A case study in Florianópolis, Brazil. *Sustainable Cities and Society*, *69,* 102823. https://doi.org/10.1016/j.scs.2021.102823

Gili, R.M. (2020). Will environmental awareness increase after the COVID-19 pandemic?. https://www.caixabankresearch.com/en/economics-markets/activity-growth/will-environmental-awareness-increase-after-covid-19-pandemic

Global Alliance of Buildings and Construction (GABC). (2021). Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. GABC, Nairobi; Kenya. https://globalabc.org/sites/default/files/2021-10/GABC_Buildings-GSR-2021_BOOK.pdf

Gui, X., Gou, Z., Zhang, F., & Yu, R. (2021). The impact of COVID-19 on higher education building energy use and implications for future education building energy studies. *Energy & Buildings*, *251*, 111346. https://doi.org/10.1016/j.enbuild.2021.111346

Hoang, A.T, Nižetić, S., Olcer, A.I., Ong, H.C., Chen, W.H., Chong, C.T., Thomas, S., Bandh, S.A., Nguyen, X.P. (2021). Impacts of COVID-19 pandemic on the global energy system and the shift progress to renewable energy: Opportunities, challenges, and policy implications. *Energy Policy, 154,* 112322. https://doi.org/10.1016/j.enpol.2021.112322

Hosseini, S.E. (2020). An outlook on the global development of renewable and sustainable energy at the time of COVID-19. *Energy Research & Social Science, 68,* 101633. https://doi.org/10.1016/j.erss.2020.101633

Hove, A., Wenyun, Q., Kaiming, Z., Geres, P. & Yuzhao, L. (2021). Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). China Energy Transition Status Report 2021: Sino-German Energy Transition Project commissioned by the German Federal Ministry for Economic Affairs and Energy (BMWi). GIZ, Beijing; China.

International Energy Agency (IEA). (2020). Global Energy Review 2020: The impacts of the Covid-19 crisis on global energy demand and CO2 emissions. IEA, Paris; France. https://www.iea.org/reports/global-energy-review-2020n

International Energy Agency (IEA). (2021). Renewable Energy Market Update, IEA, Paris; France. https://www.iea.org/reports/renewable-energy-market-update-may-2022/renewable-electricity

Jiang, P., Fan, Y.E. & Klemeš, J.J. (2021). Impacts of COVID-19 on energy demand and consumption: Challenges, lessons and emerging opportunities. *Applied Energy, 285,* 116441. https://doi.org/10.1016/j.apenergy.2021.116441

Joseph, B. (2021). Assessing the Long-Term Impacts of COVID-19 on Electricity Consumption. *Nicholas Institute for Environmental Policy Solutions*. https://nicholasinstitute.duke.edu/sites/default/files/publications/Assessing-the-Long-Term-Impacts-of-COVID-19-on-Electricity-Consumption.pdf

Kanda, W. & Kivimaa, P. (2020). What opportunities could the COVID-19 outbreak offer for sustainability transitions research on electricity and mobility?. *Energy Research & Social Science, 68*, 101666. https://doi.org/10.1016/j.erss.2020.101666

Kang, H., An, J., Kim, H., Ji, C., Hong, T., & Lee, S. (2021). Changes in energy consumption according to building use type under COVID-19 pandemic in South Korea. *Renewable and Sustainable Energy Reviews, 148,* 111294. https://doi.org/10.1016/j.rser.2021.111294

Kawka, E. & Cetin, K. (2021). Impacts of COVID-19 on residential building energy use and performance. *Building and Environment*, *205,* 108200. https://doi.org/10.1016/j.buildenv.2021.108200

KPMG. (2022). Hong Kong's Connected Future. https://assets.kpmg/content/dam/kpmg/cn/pdf/en/2022/01/hong-kong-s-connnected-future.pdf

Krarti, M. & Aldubyan, M. (2021). Review analysis of COVID-19 impact on electricity demand for residential buildings. *Renewable and Sustainable Energy Reviews, 143,* 110888. https://doi.org/10.1016/j.rser.2021.110888

Li, L., Meinrenken, C.J., Modi, V. & Culligande, P.J. (2021). Impacts of COVID-19 related stay-at-home restrictions on residential electricity use and implications for future grid stability. *Energy and Buildings, 251*, 111330. https://doi.org/10.1016/j.enbuild.2021.111330

López-Sosa, L.B., Alvarado-Flores, J.J., Marín-Aguilar,T.N.J., Corral-Huacuz, J.C., Aguilera-Mandujano, A., Rodríguez-Torres, G.M., Morales-Máximo, M., Rodríguez-Magallón, M.C., Alcaraz-Vera, J.V., Ávalos-Rodríguez, M.L., Rutiaga-Quiñones, J.G., Rodríguez-Olalde, N.E., Flores-Armenta, M.C., & García, C.A. (2021). COVID-19 Pandemic Effect on Energy Consumption in State Universities: Michoacan, Mexico Case Study. *Energies*, *14*, 7642. https://doi.org/10.3390/en14227642

McMahon, J. (2020). Coronavirus lockdown likely saved 77,000 lives in China just by reducing pollution. https://www.forbes.com/sites/jeffmcmahon/2020/03/16/coronavirus-lockdown-may-have-saved-77000-lives-in-china-just-from-pollution-reduction/?sh=221f16ee34fe

Mercer, P. (2022). Australia Pledges Multi-Billion Dollar Renewable Energy Projects. https://www.voanews.com/a/australia-pledges-multi-billion-dollar-renewable-energy-projects-/6796061.html

Mojarro, N. (2020). COVID-19 is a game-changer for renewable energy. https://www.weforum.org/agenda/2020/06/covid-19-is-a-game-changer-for-renewable-energy/

Ministry of Business, Innovation and Employment (MBIE). (2022). Energy in New Zealand 2022, MBIE, Wellington; New Zealand. https://www.mbie.govt.nz/dmsdocument/23550-energy-in-new-zealand-2022-pdf

Naderipour, A., Abdul-Malek, Z., Ahmad N.A., Kamyab, H., Ashokkumar, V., Ngamcharussrivichai, C. & Chelliapand, S. (2020). Effect of COVID-19 virus on reducing GHG emission and increasing energy generated by renewable energy sources: A brief study in Malaysian context. *Environmental Technology & Innovation, 20,* 101151. https://doi.org/10.1016/j.eti.2020.101151

Nasir, S.N.S., Ludin, N.A., Radzi, A.M.S.M., Junedi, M.M., Ramil, N., Marsan, A., Mohd, Z.F.A., Roslan, M.R., & Taip, Z.A. (2022). Lockdown impact on energy consumption in university building. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-022-02507-z

The National Energy Board (NEB). (2017). Canada's Adoption of Renewable Power Sources. NEB, Alberta; Canada. https://www.cer-rec.gc.ca/en/data-analysis/energy-commodities/electricity/report/archive/2017-canadian-adoption-renewable-power/2017cnddptnrnwblpwr-eng.pdf

The National Research Institute (NRI). (2022). ENERGY SECTOR REFORM IN PAPUA NEW GUINEA: KEY FOCUS AND CHALLENGES. https://pngnri.org/images/Publications/Issue_Paper_38.pdf

Novianto, D., Koerniawan, M.D., Munawir, M. & Sekartaji, D. (2022). Impact of lifestyle changes on home energy consumption during pandemic COVID-19 in Indonesia. *Sustainable Cities and Society, 83,* 103930. https://doi.org/10.1016/j.scs.2022.103930

O'Brien, W. & Yazdani Aliabadi F. (2020). Does Telecommuting Save Energy? A Critical Review of Quantitative Studies and Their Research Methods. *Energy and Buildings, 225*, 110298. https://doi.org/10.1016/j.enbuild.2020.110298

Olabi, V., Wilberforce, T., Elsaid, K., Sayed, E.T. & Abdelkareem, M.A. (2022). Impact of COVID-19 on the Renewable Energy Sector and Mitigation Strategies. *Chemical Engineering & Technology, 45(4),* 558-571. https://doi.org/10.1002/ceat.202100504

Organization for Economic Cooperation and development (OECD). (2020). Environmental health and strengthening resilience to pandemics. https://unece.org/DAM/RCM_Website/OECD_Covid_env_health_brief_April_2020.pdf

Ouf, M.M., O'Brien, W., & Gunay B. (2019). On Quantifying Building Performance Adaptability to Variable Occupancy. *Building and Environment, 155*, 257-267. https://doi.org/10.1016/j.buildenv.2019.03.048

The Renewable Energy Policy Network for the 21st Century (REN21). (2021). Renewables 2021 Global Status Report. https://www.ren21.net/wp-content/uploads/2019/05/GSR2022_Full_Report.pdf

Renner, B., Cook J., Rogers S. (2021). Surprise Ingredients in the Post-pandemic Food Story: consumers Cooking up Concern for Restaurants' Return. https://www2.deloitte.com/us/en/pages/consumer-business/articles/food-service-restaurant-business-trends-post-covid.html

Rouleau, J. & Gosselin, L. (2021). Impacts of the COVID-19 lockdown on energy consumption in a Canadian social housing building. *Applied Energy*, *287*, 116565. https://doi.org/10.1016/j.apenergy.2021.116565

Rowe, F., Robinson, C. & Patias, N. (2022). Sensing global changes in local patterns of energy consumption in cities during the early stages of the COVID-19 pandemic. *Cities, 129,* 103808. https://doi.org/10.1016/j.cities.2022.103808

Sánchez-López, M., Moreno, R., Alvarado, D., Suazo-Martínez, C., Negrete-Pincetic, M., Olivares, D., Sepúlveda, C., Otárola, H., Basso, L.J. (2022). The diverse impacts of COVID-19 on electricity demand: The case of Chile. *International Journal of Electrical Power & Energy Systems, 138*, 107883. https://doi.org/10.1016/j.ijepes.2021.107883

Singh, V.K., Pedamallu, L.R.T. & Ziebell, A.C. (2017). Addressing Implementation Methods and Challenges for Energy Efficiency in Health Sectors of India, 3rd International Conference on Energy and Environment: bringing together Engineering and Economics (ICEE2017), Porto; Portugal.

Squire, M.M., Munsam, M., Lin, G., Telukdari, A. & Igusa, T. (2021). Modeling hospital energy and economic costs for COVID-19 infection control interventions. *Energy and Buildings, 242*, 110948. https://doi.org/10.1016/j.enbuild.2021.110948

Su, Y., Cheng, H., Wang, Z., & Wang, L. (2022). Impact of COVID-19 lockdown ion building energy consumption and indoor environment: A case study in Dalian, China. *Energy & Buildings, 263,* 112055. https://doi.org/10.1016/j.enbuild.2022.112055

Tan, A. (2020). Coronavirus: Pandemic's disruption of energy sector holds insights for a fossil fuel-free future. https://www.straitstimes.com/singapore/environment/coronavirus-pandemics-disruption-of-the-energy-sector-holds-insights-for-a

Tian, J., Yu, L., Xue, R., Zhuang, S. & Shan, Y. (2022). Global low-carbon energy transition in the post-COVID-19 era. *Applied Energy, 307*, 118205. https://doi.org/10.1016/j.apenergy.2021.118205

Türkes, M.C. & Vut, D.R. (2022). Telework: Before and after COVID-19. *Encyclopedia, 2,* 1370–1383. https://doi.org/10.3390/encyclopedia2030092

Villeneuve, H., Abdeen, A., Papineau, M., Simon, S., Cruickshank, C., & O'Brien, W. (2020) New insights on the energy impacts of telework in Canada. *Can. Public Policy, 47(3),* 460–477. https://doi.org/10.3138/cpp.2020-157

Watts, J., & Kommenda, N. (2020). Coronavirus pandemic leading to huge drop in air pollution (pp. 2–5). https://www.theguardian.com/environment/2020/mar/23/coronavirus-pandemic-leading-to-huge-drop-in-air-pollution

Whitaker, S.D. (2021). Did the COVID-19 Pandemic Cause an Urban Exodus?. *Federal Reserve Bank of Cleveland, Cleveland Fed District Data Brief.* https://doi.org/10.26509/frbc-ddb-20210205

The World Energy Council. (2022). COUNTRY COMMENTARIES: KOREA. https://www.worldenergy.org/assets/downloads/World_Energy_Issues_Monitor_2022_Korea_%28Republic%29_commentary.pdf

REFERENCES

Post -COVID-19 Trends in Transportation Sector

Arimura, M., Ha, T. V., Okumura, K., & Asada, T. (2020). Changes in urban mobility in Sapporo city, Japan due to the COVID-19 emergency declarations. *Transportation Research Interdisciplinary Perspectives*, 100212. doi:https://doi.org/10.1016/j.trip.2020.100212

Booth, A. (2004). Formulating answerable questions. In A. Booth, & A. Brice, *Evidence Based Practice for Information Professionals: A handbook* (pp. 61-70). London: Facet Publishing.

Campbell, K. B., & Brakewood, C. (2017). Sharing riders: How bike-sharing impacts bus ridership in New York City. *Transportation Research Part A: Policy and Practice*, 264-282. doi:https://doi.org/10.1016/j.tra.2017.04.017

Dilley, L., Gkartzios, M., & Odagiri, T. (2022). Developing counterurbanisation: Making sense of rural mobility and governance in Japan. *Habitat International, 125*, 102595. doi:https://doi.org/10.1016/j.habitatint.2022.102595

Dyb˚a, T., & Dingsøyr, T. (2008). Empirical studies of agile software development. *Information and Software Technology, 50*(9-10), 833-859.

Elsevier. (2018, April 16). Make the most of your access to ScienceDirect. Amsterdam,, Netherlands. Retrieved November 09, 2022, from https://www.elsevier.com/__data/assets/pdf_file/0004/671323/Training_Deck-ScienceDirect.pdf

Hepburn, C., Qi, Y., Stern, N., Ward, B., Xie, C., & Zenghelis, D. (2021). Towards carbon neutrality and China's 14th Five-Year Plan: Clean energy transition, sustainable urban development, and investment priorities. *Environmental Science and Ecotechnology, 8*, 100130. doi:https://doi.org/10.1016/j.ese.2021.100130

IEEE. (2022). *Command Search*. Retrieved from ieee.org: https://ieeexplore.ieee.org/Xplorehelp/searching-ieee-xplore/command-search

Kawaguchi, D., Kitao, S., & Nose, M. (2022). The impact of COVID-19 on Japanese firms: mobility and resilience via remote work. *International Tax and Public Finance*. doi:https://doi.org/10.1007/s10797-022-09749-7

Khoirunurrofik, K., Abdurrachman, F., & Rachmanto, U. N. (2022). Socioeconomic and policy determinants of mobility during COVID-19: Evidence from Indonesian cities. *Journal of Urban Management*. doi:https://doi.org/10.1016/j.jum.2022.07.003

Koon, L. M., Greiman, L., Schulz, J. A., Goddard, K. S., Nzuki, I. M., & Hall, J. P. (2022). Examining the effects of the COVID-19 pandemic on community engagement for people with mobility disabilities. *Disability and Health Journal, 15*(1(Suplement)), 101212. doi:https://doi.org/10.1016/j.dhjo.2021.101212

Lee, M., & Finerman, R. (2021). COVID-19, commuting flows, and air quality. *Journal of Asian Economics*. doi:https://doi.org/10.1016/j.asieco.2021.101374

Li, X., Ha, J., & Lee, S. (2022). Mobility Resilience of Commute Trips During The COVID-19 Pandemic in Seoul, Korea. In C. C. Wang, & S. Shirowzhan (Ed.), *7th International Conference on Smart Data and Smart Cities, SDSC 2022* (pp. 135-142). Copernicus Publications. doi:10.5194/isprs-annals-X-4-W3-2022-135-2022

Lu, C., Adger, W. N., Morrissey, K., Zhang, S., Venevsky, S., Yin, H., . . . Liu, Z. (2022). Scenarios of demographic distributional aspects of health co-benefits from decarbonising urban transport. *Lancet Planet Health, 6*, 464-474. doi:https://doi.org/10.1016/S2542-5196(22)00089-4

Major, L., Kyriacou, T., & Brereton, P. (2010). Systematic Literature Review Protocol: Teaching Novices Programming Using Robots. *IET Software, 6*(6), 502-513. doi:10.1049/iet-sen.2011.0125

Mayo, F. L., Maglasang, R. S., Moridpour, S., & Taboada, E. B. (2021). Exploring the changes in travel behavior in a developing country amidst the COVID-19 pandemic: Insights from Metro Cebu, the Philippines. *Transportation Research Interdisciplinary Perspectives*, 12. doi:https://doi.org/10.1016/j.trip.2021.100461

OTPP สนข. (2021). โครงการศึกษาจัดทำแผนพัฒนาการเดินทางทางน้ำในเขตกรุงเทพมหานครและปริมณฑล และการเชื่อมต่อการเดินทางรูปแบบอื่น กรุงเทพมหานคร. Office of Traffic Policy and Planning สำนักงานนโยบายและแผนการขนส่งจราจร. Bangkok: Ministry of Transport กระทรวงคมนาคม.

Pucher , J., & Buehler, R. (2008). Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. *Transport Reviews, 28*(4), 495-528. doi:https://doi.org/10.1080/01441640701806612

Rahman Fatmi, M., Orvin, M. M., & Thirkell, C. E. (2022). The future of telecommuting post COVID-19 pandemic. *Transportation Research Interdisciplinary Perspectives, 16*. doi:https://doi.org/10.1016/j.trip.2022.100685

Sersli, S., Turrell, G., Burton, N. W., Brown, W. J., & Heesch, K. C. (2021). Longitudinal associations between bicycling and having dependent children, in middle-aged men and women. *Preventive Medicine Reports*. doi:https://doi.org/10.1016/j.pmedr.2021.101479

Sevtsuk, A., Basu, R., Halpern, D., Hudson, A., Ng, K., & de Jong, J. (2022). A tale of two Americas: Socio-economic mobility gaps within and across American cities before and during the pandemic. *Cities, 131*, 104006. doi:https://doi.org/10.1016/j.cities.2022.104006

Shaheen, S. A., Guzman, S., & Zhang, H. (2010). Bikesharing in Europe, the Americas, and Asia: Past, Present, and Future. *Transportation Research Record: Journal of the Transportation Research Board, 2143*(1), 159–167. doi:https://doi.org/10.3141/2143-20

Shamshiripour, A., Rahimi, E., Shabanpour, R., & Mohammadian, A. (2020). How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago.

Transportation Research Interdisciplinary Perspectives, 7, 100216. doi:https://doi.org/10.1016/j.trip.2020.100216

Su, R., Xiao, J., McBride, E. C., & Goulias, K. G. (2021). Understanding senior's daily mobility patterns in California using human mobility motifs. *Journal of Transport Geography*, 103117. doi:https://doi.org/10.1016/j.jtrangeo.2021.103117

Tannum, M. S., & Ulvensøen, J. H. (2019). Urban mobility at sea and on waterways in Norway. *Journal of Physics: Conference Series 1357* (p. 012018). IOP Publishing Ltd. doi: 10.1088/1742-6596/1357/1/012018

Teixeira, J. F., & Lopes, M. (2020). The link between bike sharing and subway use during the COVID-19 pandemic: The case-study of New York's Citi Bike. *Transportation Research Interdisciplinary Perspectives, 6*. doi:https://doi.org/10.1016/j.trip.2020.100166

University of Bath Library . (2022, November 4). *Systematic reviews: Formulate your question*. Retrieved from The Library: https://library.bath.ac.uk/systematic-reviews/formulate-question

Vassar, M., Atakpo, P., & Kash, M. J. (2016). Manual search approaches used by systematic reviewers in dermatology. *Journal of the Medical Library Association, 104*(4), 302-304. doi: 10.3163/1536-5050.104.4.009

Vecchio, G., Tiznado-Aitken, I., Albornoz, C., & Tironi, M. (2022). Delivery workers and the interplay of digital and mobility (in)justice. *Digital Geography and Society, 3*, 100036. doi:https://doi.org/10.1016/j.diggeo.2022.100036

Wang, J., Kaza, N., McDonald, N. C., & Khanal, K. (2022). Socio-economic disparities in activity-travel behavior adaptation during the COVID-19 pandemic in North Carolina. *Transport Policy, 125*, 70-78. doi:https://doi.org/10.1016/j.tranpol.2022.05.012

Xu, P., Bai, L., Pei, X., Wong, S. C., & Zhou, H. (2022). Uncertainty matters: Bayesian modeling of bicycle crashes with incomplete exposure data. *Accident Analysis & Prevention*, https://doi.org/10.1016/j.aap.2021.106518.

Yang, Y., Cao, M., Cheng, L., Zhai, K., Zhao, X., & De Vos, J. (2021). Exploring the relationship between the COVID-19 pandemic and changes in travel behaviour: A qualitative study. *Transportation Research Interdisciplinary Perspectives*. doi:https://doi.org/10.1016/j.trip.2021.100450

Zhang, R., & Zhang, J. (2021). Long-term pathways to deep decarbonization of the transport sector in the post-COVID world. *Transport Policy, 110*, 28-36. doi:https://doi.org/10.1016/j.tranpol.2021.05.018