1 SUMMARY OF KEY TRENDS

The *APEC Energy Demand and Supply Outlook – 5th Edition* is designed to present policymakers with an understanding of the energy trends and issues facing the APEC region to the year 2035. With this goal in mind, this first chapter presents an overview of the most important trends that deserve the attention of policymakers. This chapter appears in place of the Executive Summary that would normally appear at the beginning of a report of this size.

KEY ASSUMPTIONS

The trends discussed in this chapter and throughout this report are shaped by some specific assumptions about the future. This section explains those assumptions and why we make them.

Business-As-Usual

As this report is being written, the energy policies of APEC governments continue to change rapidly. These changes are driven by at least six factors.

1. *Volatility in the oil market.* The first decade of this century saw a dramatic rise in world oil prices, followed by a precipitous drop in late 2008, followed by another rapid rise (see Chapter 3, Figure 3.2). Oil's price volatility has been damaging to businesses and consumers throughout the APEC region. Perhaps even more worrying, however, is that much of the price volatility has reflected tensions in the Middle East, which, if not resolved peacefully, could pose serious threats to oil supply security. Governments are, therefore, increasingly seeking policies that will reduce dependence on oil in general and imported oil in particular.
2. *Climate change.* Governments are seeking policies that will reduce greenhouse gas emissions in order to limit the damage from climate change. Since the production and use of energy accounted for more than two-thirds of greenhouse gas emissions on a world scale in 2010 (IEA, 2011a, p. III.47), these policies are likely to have a profound effect on the energy sector.
3. *Rapid growth of developing economies.* Developing economies, especially in the APEC region, have been remarkably successful in their pursuit of economic growth. While this growth has lifted hundreds of millions of people out of poverty and improved the lives of additional hundreds of millions in other ways, it has had the downside of turning these economies into major world-scale energy consumers and, in some cases, energy importers. Their governments are increasingly recognizing that their own policies will have a significant impact on world energy markets and world greenhouse gas emissions, which could have damaging impacts on their own economies along with others.
4. *The continuing economic crisis.* Despite the continuing growth in the developing economies, most of the developed economies of the APEC region continue to suffer from slow growth and high unemployment. When the last *APEC Energy Demand and Supply Outlook* was published in 2009, governments were attempting to address the problem partly through stimulus programs involving increasing government spending. However, because of increasing concern over the sustainability of the deficit spending involved, governments have been shifting their policies for combating the economic crisis. In addition to monetary policies, the new focus has been on finding ways to do more with less. In the energy sector, this has meant promotion of innovation, economic liberalization and reform, and reduction of taxpayer subsidies for both fossil fuels and renewables. Developing economies have also been attempting to secure their economic future by promoting many of these same policies.
5. *The Fukushima Nuclear Accident.* The tragic events at Japan's Fukushima Daiichi Nuclear Power Plant have provoked a review of policies on nuclear power throughout the APEC region.
6. *Advances in technology.* As detailed in various chapters of this report, energy technology continues to advance in nearly every area, including fossil fuel supplies, renewable supplies, 'smart grids', and more efficient vehicles and other energy-consuming devices. Each innovation requires appropriate policy responses if its full benefits are to be realized.

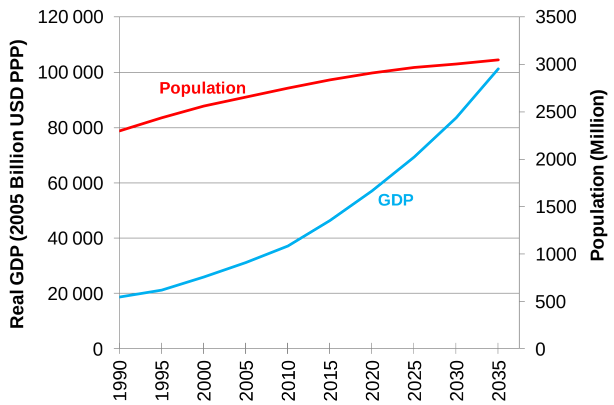
Clearly the policies of the future will not be business-as-usual. Yet what will they be? Given the uncertainties, the safe course would appear to be to assume 'business-as-usual' in our projections. Any other approach has a very real risk of 'counting our chickens before they are hatched'—that is, assuming policymakers do the right thing—resulting in an overly optimistic view of the current situation. Also, policymakers need an independent standard of comparison. Any projection that has built into it assumptions about what policymakers themselves are going to do in the future fails to provide this standard, and is likely to cause confusion.

So, except for the alternative scenarios that are considered, we assume business-as-usual throughout this report. The definition of business-as-usual includes existing policies. It also includes policies that are already being implemented; that is, any necessary legislation has already been passed and there is little uncertainty that the policy is really going to happen. On the other hand, the definition does not include 'targets', 'goals', or policy proposals that governments may have announced, but whose implementation is not yet certain or well defined.

GDP and Population

We assume that the APEC region will continue to enjoy economic growth and progress over the long term, especially in the developing economies. In developing economies, this will include increasing use of commercial fuels, increasing access to electricity, and increasing use of motorized vehicles for transportation. Figure 1.1 shows our specific assumptions about GDP and population for the APEC region as a whole.

Figure 1.1: Assumed APEC GDP and Population



Sources: Global Insight (2012) and APERC Analysis (2012)

Table 1.1 shows the assumed APEC GDP and population growth rates. Reflecting the growing GDP share of fast-growing developing economies, and recent demographic trends, it can be seen that GDP growth rates over the 25-year outlook period are assumed to be slightly higher than recent history, while the population growth rate is a bit lower.

Table 1.1: Assumed APEC GDP and Population Growth Rates

Growth	GDP (%)	Population (%)
1990—2005	3.4	1.0
2005—2010	3.6	0.7
2005—2030	4.0	0.5
2005—2035	4.0	0.5
2010—2035	4.1	0.4

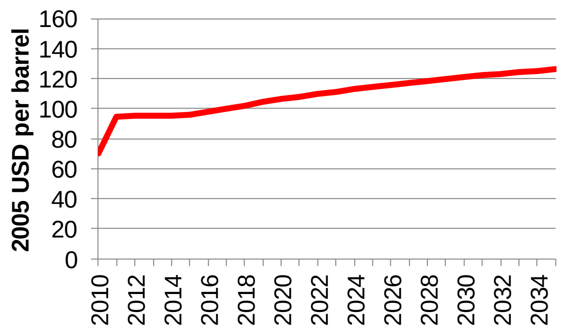
Sources: Global Insight (2012) and APERC Analysis (2012)

Oil Prices

Oil prices have been highly volatile since the oil shocks of the 1970s, and there is no reason to think that the future will be any different. There are many diverse opinions about the future of oil prices offered by well-informed people. Probably the most thorough, publicly available analysis of the long-term future of the oil market is that of the International Energy Agency (IEA) in their *World Energy Outlook 2011*. Their 'Current Policies Scenario' is based on assumptions similar to our business-as-usual assumptions. In this scenario, they assumed that the average IEA member crude oil import price would rise to USD 126/barrel in 2005 USD by 2035 (IEA, 2011b).

As discussed in Chapter 3, we have adopted the IEA's oil price projection in this report. Figure 1.2 shows our oil price assumptions.

Figure 1.2: Assumed Oil Prices



Note: Actual data for 2010 and 2011.
Historical Data: *Energy Prices and Taxes* © OECD/IEA 2012b

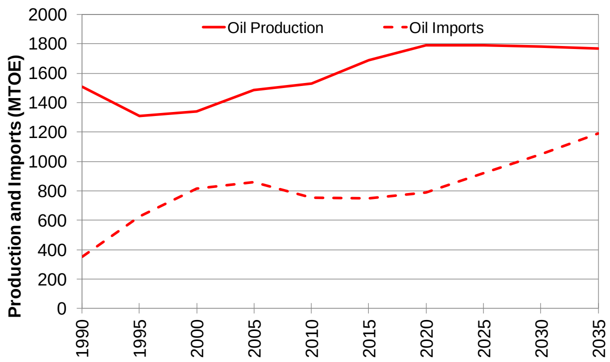
Having explained our key assumptions, the remainder of this chapter examines some expected key trends in the energy sector between now and 2035 that should be of concern to policymakers.

KEY TREND #1

Oil security remains a major threat to the economy of the APEC region

Since 1990, oil production in the APEC region has increased only slightly, while oil demand has risen significantly. As a result, oil imports into the APEC region have grown faster than production. Our business-as-usual projections, as shown in Figure 1.3, indicate that these trends will continue to 2035. Despite some significant increases in APEC's own oil production, the APEC region will become more dependent upon oil imported from outside the region.

Figure 1.3: APEC Total Oil Production and Net Oil Imports



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics* 2011 © OECD/IEA 2011a

This increasing dependency on oil imported from outside the region means that APEC economies may face at least four kinds of risks to their economies:

1. The availability of oil supplies could be threatened by political events in other regions, such as the Middle East and Africa.
2. The availability of oil supplies will depend upon the ability of national oil companies and multi-national oil companies in these other regions to make adequate investments.
3. As oil production becomes more concentrated in a few countries, oil prices will be increasingly influenced by the market power of the producing countries.
4. Increasing amounts of oil will need to be shipped over long distances, typically from the Middle East or Africa, which poses additional security risks.

The likely outcomes of APEC's import dependency are that:

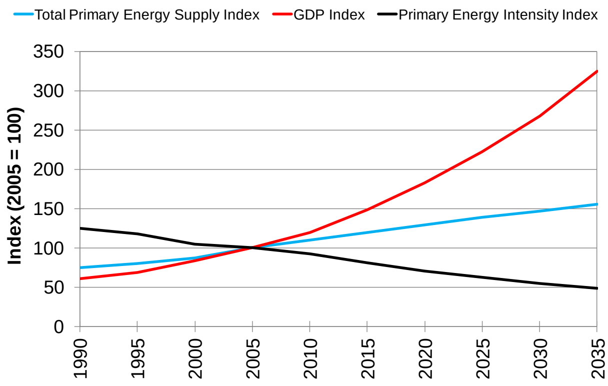
- Continued oil price volatility will be a near certainty.
- There will be significant risks of supply disruptions.
- Both of the above threaten the economic stability of APEC economies and the world.

KEY TREND #2

APEC's energy intensity goals will probably be met under business-as-usual

At their meeting in Sydney in September 2007, APEC leaders called for APEC economies to work toward achieving an APEC-wide regional aspirational goal of a reduction in energy intensity of at least 25% by 2030 (with 2005 as the base year) (APEC, 2007). The goal was revised upward in 2011 at the APEC Leaders' meeting in Honolulu, Hawaii to an improvement of 45% by 2035 (APEC, 2011) since it was becoming apparent that the APEC economies would easily surpass the original goal.

Figure 1.4: Change in APEC Primary Energy, GDP, and Energy Intensity



Source: APERC Analysis (2012)

By 2035, we would expect the APEC region primary energy supply to increase by about 53% compared to 2005, while GDP will increase by about 225%. As shown in Figure 1.4, the net impact will be a decrease in primary energy intensity of about 53%.

This improvement in energy intensity is significantly higher than past trends. Between 1990 and 2009, energy intensity declined at a rate of about 1.4% per year. Under our business-as-usual assumptions, between 2005 and 2035 it will decline at a rate of about 2.5% per year. This decline primarily reflects improvements in technology driven by market forces (including rising energy prices) and the impacts of existing government policies promoting energy efficiency.

KEY TREND #3

Business-as-usual is still environmentally unsustainable

The expected improvement in energy intensity is, unfortunately, not sufficient to put the APEC region on a path toward environmental sustainability. In fact, the best science suggests that the path we are on has a great probability of disastrous climate change consequences.

To understand why this is, we must first understand what science says needs to happen to greenhouse gas emissions to mitigate the risks of climate change. In fact, managing greenhouse gas emissions is a problem very different from managing other types of air pollution. With most air pollution, if the emissions can be stabilized, the impacts can be stabilized, and if the emissions can be reduced, the impacts will be reduced. This is not true of greenhouse gas emissions, since they build up cumulatively in the atmosphere and break down only over extremely long time periods (typically decades or centuries). Hence, only very large reductions in greenhouse gas emissions can stabilize the impacts.

Table 1.2 summarizes the challenges posed by climate change. It is taken from the Intergovernmental Panel on Climate Change (IPCC) *Fourth Assessment Report* (the Fifth Assessment Report is due for release in 2014). The IPCC is the scientific body set up by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP) to provide objective information about climate change (IPCC, 2012).

Table 1.2: Climate Change Stabilization Scenarios

Category	CO_2 concentration at stabilisation (2005 = 379 ppm)[b]	CO_2-equivalent concentration at stabilisation including GHGs and aerosols (2005=375 ppm)[b]	Peaking year for CO_2 emissions[a,c]	Change in global CO_2 emissions in 2050 (percent of 2000 emissions)[a,c]	Global average temperature increase above pre-industrial at equilibrium, using 'best estimate' climate sensitivity[d,e]	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only[f]	Number of assessed scenarios
	ppm	ppm	year	percent	°C	metres	
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	0.4 – 1.4	6
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	0.5 – 1.7	18
III	440 – 485	535 – 590	2010 – 2030	-30 to +5	2.8 – 3.2	0.6 – 1.9	21
IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	0.6 – 2.4	118
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	0.8 – 2.9	9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	1.0 – 3.7	5

Notes (from IPCC):

a) The emission reductions to meet a particular stabilization level reported in the mitigation studies assessed here might be underestimated due to missing carbon cycle feedbacks (see also Topic 2.3).

b) Atmospheric CO_2 concentrations were 379 ppm in 2005. The best estimate of total CO_2-eq concentration in 2005 for all long-lived GHGs is about 455 ppm, while the corresponding value including the net effect of all anthropogenic forcing agents is 375 ppm CO_2-eq.

c) Ranges correspond to the 15th to 85th percentile of the post-TAR scenario distribution. CO_2 emissions are shown so multi-gas scenarios can be compared with CO_2-only scenarios (see Figure 2.1).

d) The best estimate of climate sensitivity is 3°C.

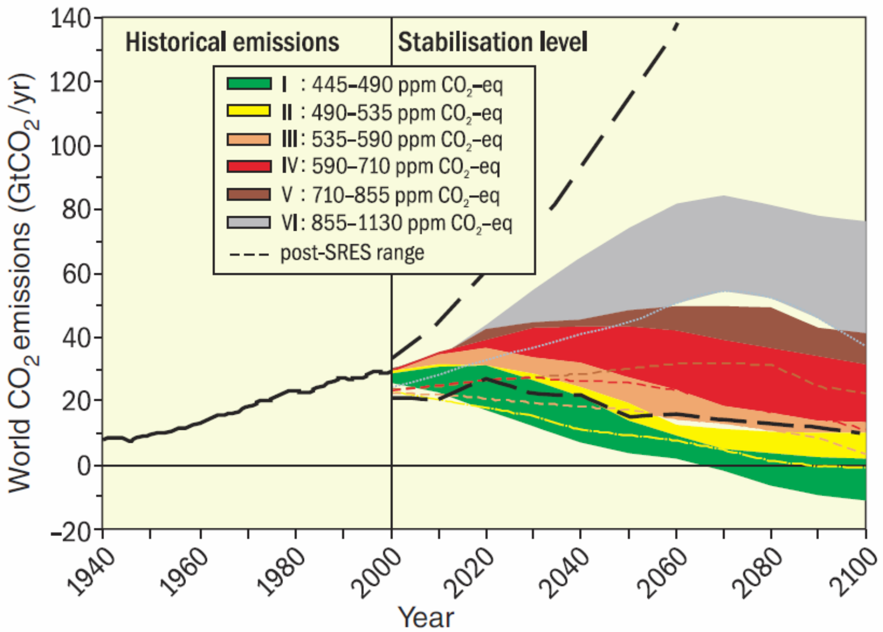
e) Note that global average temperature at equilibrium is different from expected global average temperature at the time of stabilization of GHG concentrations due to the inertia of the climate system. For the majority of scenarios assessed, stabilization of GHG concentrations occurs between 2100 and 2150 (see also Footnote 30).

f) Equilibrium sea level rise is for the contribution from ocean thermal expansion only and does not reach equilibrium for at least many centuries. These values have been estimated using relatively simple climate models (one low-resolution AOGCM and several EMICs based on the best estimate of 3°C climate sensitivity) and do not include contributions from melting ice sheets, glaciers and ice caps. Long-term thermal expansion is projected to result in 0.2 to 0.6 m per degree Celsius of global average warming above pre-industrial. (AOGCM refers to Atmosphere-Ocean General Circulation Model and EMICs to Earth System Models of Intermediate Complexity.)

Source: IPCC (2007), Table 5.1, p. 67

The table shows five possible scenarios for greenhouse gas emissions. Category I, which limits the average global temperature increase to 2.0–2.4 degrees Celsius, requires concentrations of greenhouse gases in the atmosphere to stabilize at a level of 445–490 ppm of CO_2-equivalent. To achieve stabilization at this level would require global CO_2 emissions in the year 2050 to be reduced by 50–85% compared to the year 2000, with global CO_2 emissions peaking between the years 2000 and 2015. The green range in Figure 1.5 illustrates the path of emissions under such a scenario.

Figure 1.5: CO_2 Emissions for a Range of Stabilization Levels



Source: IPCC (2007), Figure 5.1, p. 66

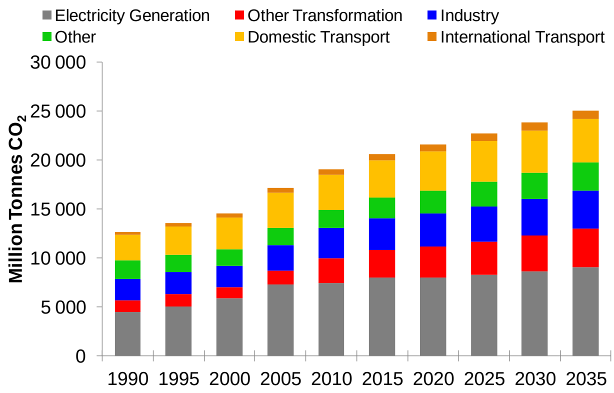
The impacts of climate change are wide-ranging, complex, and vary by location. A fair summary of the IPCC's assessment of the impacts of climate change is that there is a mixture of beneficial and damaging impacts in the 2.0–2.4 degrees Celsius range of warming. Beyond this, most impacts turn out to be damaging, some significantly so. These include:

- rising sea levels—by the 2080s many millions more people are likely to experience coastal flooding each year, especially in the low-lying mega deltas of Asia (IPCC, 2007, p. 48)
- declines in global food production potential (IPCC, 2007, p. 48)
- future tropical cyclones (typhoons and hurricanes) becoming more intense (IPCC, 2007, p. 46 and Table 3.2, p. 53)
- widespread loss of glaciers and snow cover, reducing water availability, hydro potential, and changing the seasonality of water flows in regions supplied by melt water from major mountain ranges (Hindu–Kush, Himalaya, Andes), where one-sixth of the world population currently lives (IPCC, 2007, p. 49)
- adverse health impacts, including increased diarrhoeal, cardio-respiratory, and infectious diseases (IPCC, 2007, p. 51)
- increases in rainfall in some wet, tropical areas, including East and South–East Asia, accompanied by decreases in rainfall in many semi-arid areas including the western United States; drought-affected areas are expected to increase in extent (IPCC, 2007, p. 49)
- widespread damage to coral reefs and their dependent species, including Australia's Great Barrier Reef, due to ocean acidification (IPCC, 2007, pp. 50–51)
- greater frequency of extreme weather events, including heat waves and heavy precipitation (IPCC, 2007, Table 3.2, p. 54).
- widespread extinctions of wildlife: 20–30% of species assessed so far are at risk of extinction if global average warming exceeds 1.5 to 2.5 degrees Celsius relative to 1980–1999 levels; as global average warming exceeds 3.5 degrees Celsius, this rises to 40–70% of species assessed (IPCC, 2007, p. 54).

Cooperative efforts to reduce emissions at the global level remain a work in progress. There does, however, appear to be a consensus that climate warming should be limited to 2 degrees Celsius. This consensus was reflected in the Cancun Agreements adopted at the United Nations Framework Convention for Climate Change (UNFCCC) Conference of Parties in Cancun, Mexico in December 2010, which called for holding "the increase in global temperature below 2 degrees Celsius" (UNFCCC, 2010, p. 3). The UNFCCC enjoys near universal membership, with 194 member countries plus the European Union (UNFCCC, 2012).

This need to dramatically reduce emissions may be contrasted with the business-as-usual projection of APEC region CO_2 emissions from fuel combustion, shown in Figure 1.6. CO_2 emissions from fuel combustion accounted for about 89% of greenhouse gas emissions from energy and for over 60% of greenhouse gas emissions from all sources worldwide on a CO_2-equivalent basis in 2010 (IEA, 2012a, p. III.47).

Figure 1.6: APEC CO_2 Emissions from Fuel Combustion



Source: APERC Analysis (2012)

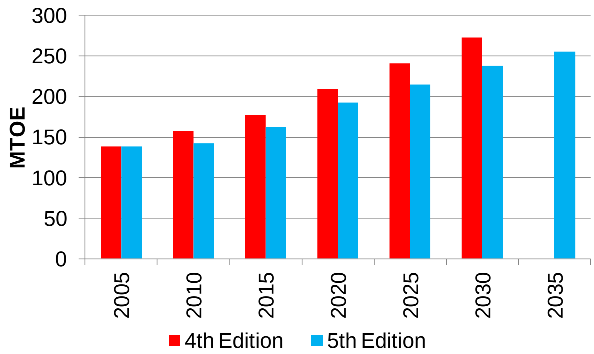
The figure shows that APEC region CO_2 emissions from fuel combustion are expected to rise by about 32% between 2010 and 2035. The threat these emissions pose to humanity, to the environment, and to the economies of the APEC region and the world certainly make it one of the greatest challenges facing the region.

KEY TREND #4

Nuclear development slows down, but not by much

As noted above, the Fukushima Nuclear Accident in Japan has caused the APEC economies that use nuclear power, or are considering using nuclear power, to reassess their policies. Nuclear safety regulation is being reviewed and upgraded in all APEC economies with nuclear power. These safety reviews will necessarily cause some delays and slow-downs in nuclear power development. However, except in Japan itself and Chinese Taipei, all the evidence suggests that the outcome over the long term will not be a lot different from what would have happened if the accident had not happened. Figure 1.7 shows a comparison of APERC's projection of nuclear electricity output in our previous *APEC Energy Demand and Supply Outlook – 4th edition* and this *Outlook– 5th Edition*. It can be seen that the differences are not large.

Figure 1.7: APEC Nuclear Output



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics* 2011 © OECD/IEA 2011a

Why is this the case? Based on the information available to APERC, all APEC economies with existing nuclear power plants plan to continue to operate them as originally planned, with the possible exceptions of Japan and Chinese Taipei. All APEC economies that were planning new nuclear plants, again with the possible exception of Japan and Chinese Taipei, also appear to be proceeding with their plans, subject only to the safety reviews mentioned above.

In Chinese Taipei and especially in Japan, there is a great deal of uncertainty regarding the future of nuclear power. At the time of writing this report, most nuclear power plants in Japan have been shut down pending a comprehensive nuclear safety review. When and whether they will resume operation is not clear. It will be up to the Japanese government that was newly elected in December 2012, to sort out Japan's nuclear policy going forward. In this report, we have assumed that the existing nuclear plants will resume operation, but there will be no new nuclear plants in Japan and no life extensions for existing plants beyond their 40-year life. So nuclear will effectively be slowly phased out in Japan over the outlook period.

In Chinese Taipei, the existing nuclear plants continue to operate, and work continues on two units currently under construction. However, the government has announced a policy of not granting life extensions for the existing units and of shutting down the oldest two units once the two units currently under construction are completed. As a result, we assume that nuclear output in Chinese Taipei will drop to about half of its 2009 level by 2035.

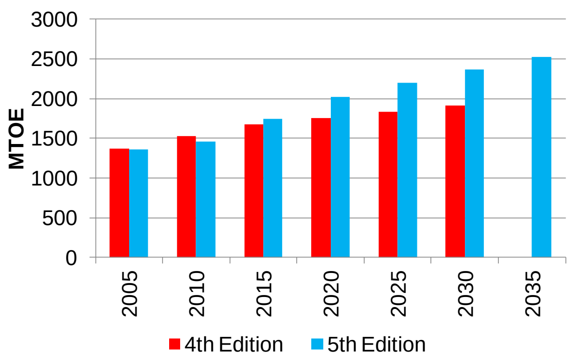
KEY TREND #5

Gas production growth speeds up, and could challenge coal

As discussed in Chapter 12, the growing production of unconventional gas, especially in the US and Canada, has far exceeded expectations of only a few years ago. This is primarily the result of new technology for producing shale gas, including horizontal drilling and hydraulic fracturing. Although this development was anticipated and discussed in the 2009 *APEC Demand and Supply Outlook – 4th Edition*, the technology has continued to prove itself in the real world over the interim.

Figure 1.8 shows the projected APEC gas production in our previous *APEC Energy Demand and Supply Outlook – 4th Edition* and this *Outlook – 5th Edition*. It can be seen that our projected gas production is now significantly higher after 2015.

Figure 1.8: APEC Projected Gas Production



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics* 2011 © OECD/IEA 2011a

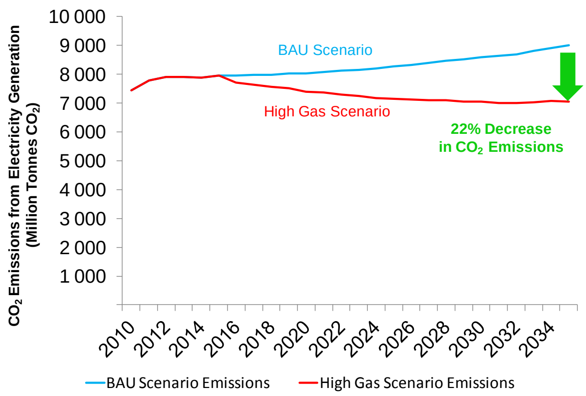
The business-as-usual scenario shown in Figure 1.8 does not include significant shale gas development outside North America and includes fairly conservative estimates of production from both conventional and non-shale-gas unconventional resources outside of North America. However, as discussed in Chapter 12, the conventional and unconventional gas resources of the Asia–Pacific region are immense. And with LNG prices in Asia several times as high as those in North America the economics of gas development outside of North America, as well as further gas development in North America for export, should be compelling.

With appropriate policies and regional cooperation, the APEC economies could use their gas resources to move toward a cleaner energy system, while promoting energy security and mutual prosperity. To illustrate some of the benefits that might accrue from removing the barriers to gas production and trade, APERC developed an alternative 'High Gas Scenario'. In the High Gas Scenario, APERC estimated the gas production that might be available without raising prices if existing constraints on gas production and trade were reduced. In this still-conservative scenario, gas production on an APEC-wide basis was about 30% higher compared to business-as-usual by 2035.

There are many ways the additional gas could be used in the APEC region, almost all of them positive in terms of economics, energy security, and/or the environment. Using gas to replace coal in electricity generation is an especially good option from a CO_2 emissions perspective, since gas-fired generation typically has less than half the CO_2 emissions of coal-fired generation per unit of electricity produced.

APERC therefore assumed the additional gas in the High Gas Scenario would be used to replace coal in electricity generation. As shown in Figure 1.9, the additional gas in the High Gas Scenario could reduce CO_2 emissions from electricity generation in 2035 by about 22% compared to business-as-usual. This implies an overall reduction in energy CO_2 emissions of about 8% compared to business-as-usual.

Figure 1.9: High Gas Scenario – Reduction in CO_2 Emissions from Electricity Generation



Source: APERC Analysis (2012)

It is important to recognize that, in some APEC economies, there is growing public concern over the environmental risks of unconventional gas development. These concerns will need to be addressed through better regulation if gas development is to win the public confidence it will need to deliver benefits like those illustrated in this scenario.

KEY TREND #6

New renewable energy (NRE) goes mainstream

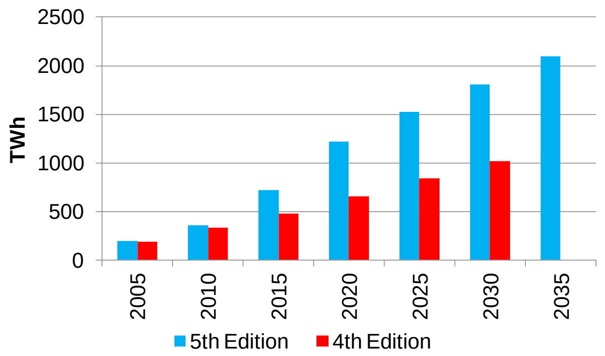
Two forces are driving new renewable energy (NRE) into the mainstream, especially in electricity production. The first is that many APEC economies are responding to the climate change challenges with policies to promote NRE development. These may include:

- feed-in tariffs under which electric utilities are required to buy electricity generated from renewables at a guaranteed price
- renewable portfolio standards, which require electric utilities to obtain a minimum fraction of their electricity from renewable sources
- carbon pricing, such as a tax on CO_2 emissions, which discourages the use of fossil fuels
- regulations limiting greenhouse gas emissions.

Some APEC economies are also promoting the use of biofuels in transportation through requirements that gasoline and diesel fuels have a minimum biofuel content.

The second force driving NRE into the mainstream is technological improvement that continues to reduce the cost and improve the performance of renewable energy. A number of APEC economies have been making substantial investments in research and development to improve renewable energy technology. Businesses and entrepreneurs also perceive a growing market for this technology and are responding with investments of their own. Reductions in the cost of solar photovoltaics (PV) have been especially impressive, with the cost of solar PV electricity now approaching the retail price of electricity in some cities.

Figure 1.10: APEC Projected Electricity Production from New Renewable Energy (NRE)



Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics* 2011 © OECD/IEA 2011a

Figure 1.10 compares projected electricity production from new renewable energy (NRE) sources in this *Outlook – 5th Edition* with that of the previous *Outlook – 4th Edition*. Reflecting the two forces discussed above, the figure shows a significant upward revision to projected APEC NRE supplies.

The growth in NRE projected in this *Outlook – 5th Edition* is impressive in percentage terms. This is especially true in electricity generation where NRE output will grow at an average of 7.4% per year over the outlook period, which is the fastest growth of any form of electricity generation. However, the overall role of NRE in energy supply remains modest under business-as-usual assumptions, even in 2035. Further expansion of renewable energy will be needed to meet the challenge of climate change.

An earlier APERC study (APERC, 2010, p. 82) concluded that the APEC region should have a non-fossil primary energy share of about 30% by 2030 if the APEC region is to contribute to stabilizing concentrations of greenhouse gases in the atmosphere at 450 ppm of CO_2-equivalent. This compares to a share of 18% by 2030 in our business-as-usual scenario. The same study also concluded that to meet this goal, APEC's low-carbon electricity generation share (which could include both nuclear and carbon capture and storage) should reach 60% by 2030. This compares to a share of 36% by 2030 in our business-as-usual scenario.

KEY TREND #7

Big opportunities to improve efficiency, especially in transportation

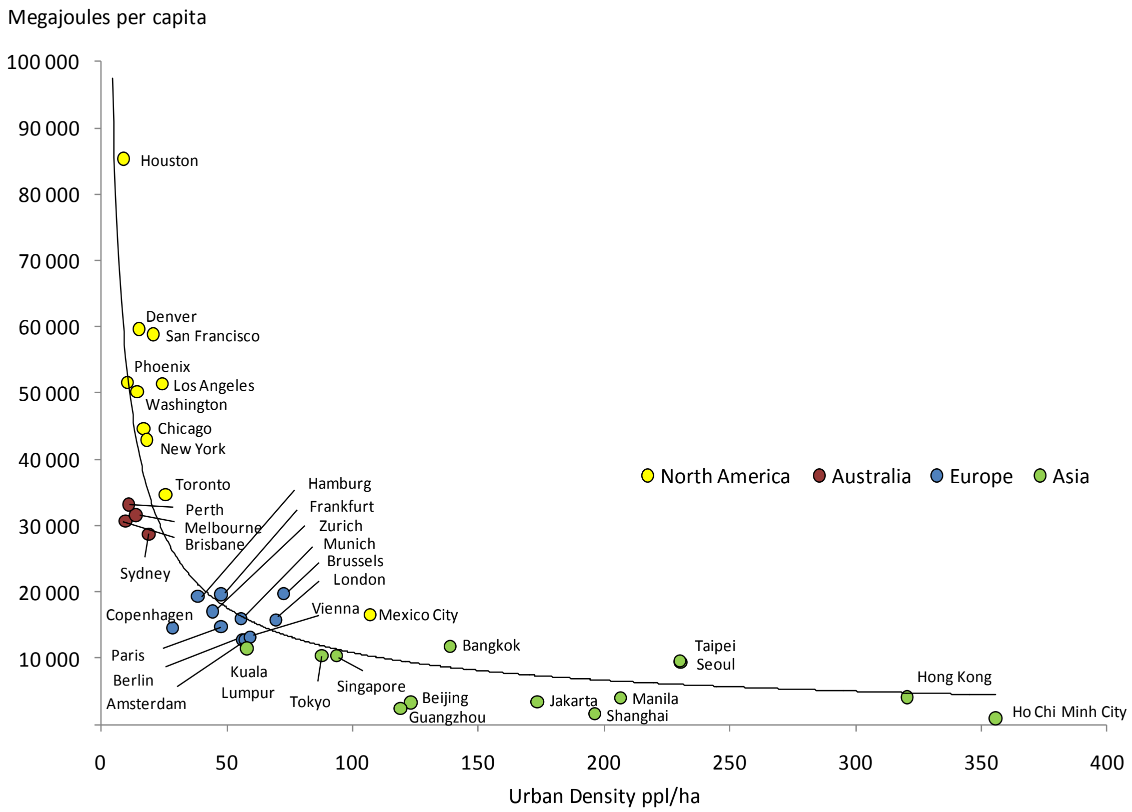
Improving energy efficiency remains the largest and cheapest opportunity to help create a more sustainable energy future. Although there are a set of market failures (discussed in Chapter 4) that tend to inhibit energy efficiency improvements, addressing these market failures offers a unique opportunity to protect the environment, help the economy, and save money for energy users all at the same time. This *Outlook – 5th Edition* closely examines two alternative approaches for improving energy efficiency in the transport sector: alternative urban development and alternative vehicle designs.

Alternative Urban Development Scenarios

The 'Alternative Urban Development' scenarios start from the observation that cities vary dramatically in their per capita energy consumption. It can be seen in Figure 1.11, for example, that per capita transport energy demand in Tokyo or Singapore is about one-seventh what it is in Houston. What if we could design future cities to be more like Tokyo or Singapore and less like Houston?

Of course, redesigning cities is a long-term undertaking. However, the APEC region will be doing a huge amount of city building over the next few decades. The United Nations (2009) estimates that the urban population of the APEC region will grow by 576 million people, or 38%, by 2035 compared to 2010. By 2050, the growth will be 782 million or 51%. And, of course, much of the existing building stock will also be replaced over this time. Clearly, the rapid growth of APEC's cities presents a unique opportunity to build them in an energy-efficient manner.

Figure 1.11: Per Capita Transport Energy Demand vs. Urban Density



Source: Adapted from IUPT/ISTP (1995)

Our model of the energy-saving potential for alternative urban development builds on the observed correlation between per capita urban transport energy use and urban population density that is clear from Figure 1.11. This is, however, a correlation, not necessarily causation. Urban planning can introduce transport-energy-saving design characteristics in a number of ways, including:

- diversity (better mix of land uses, improved jobs–housing balance)
- design (more street connectedness, greater pedestrian/bicycle friendliness)
- transport infrastructure (increased focus on transit over road and parking investments).

More compact cities (those with a higher population density) tend to have lower energy use than less dense 'sprawling' cities for at least three reasons:

1. *Direct effect.* Compact cities have shorter travel distances.
2. *Indirect effect.* Compact cities *tend* to have more of the energy-saving design characteristics discussed above.
3. *Reverse effect.* Cities with the energy-saving design characteristics discussed above *tend* to develop in a more compact way.

In short, building energy-efficient cities will require a full range of better planning decisions, not just higher population densities.

In our modelling, however, we take population density as an indicator of a city's energy efficiency. We ask, what if APEC cities could grow to be like today's higher density cities rather than like today's sprawling cities—like them in all ways, not just population density.

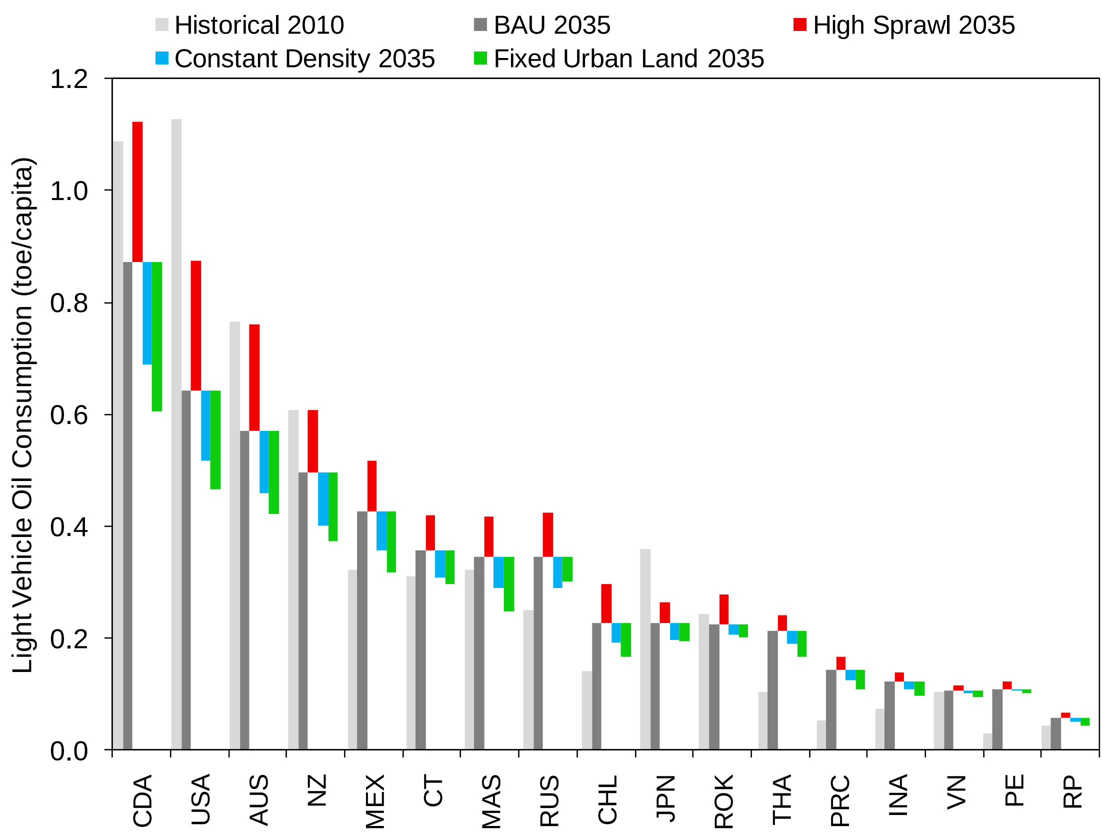
Specifically, we looked at four possible alternative futures:

1. *Business-As-Usual (BAU)*. In this scenario urban population density declines at a rate of 1.8% per year, consistent with current worldwide trends.
2. *High Sprawl*. In this scenario urban population density declines at 3.6% per year, or twice the current worldwide trend, consistent with the observed rate in some APEC cities.
3. *Constant Density*. In this scenario the urban population density remains constant, so cities expand in land area in proportion to their population growth.
4. *Fixed Urban Land*. In this scenario the land area of the city remains constant, with population expansion accommodated through growing 'up' rather than 'out'.

The impacts of these scenarios on urban transport energy use by 2035 could be quite dramatic, as shown in Figure 1.12. Note that the alternative urban development scenarios were not run for Brunei and Papua New Guinea due to lack of data, and were not run for Singapore or Hong Kong, China due to their natural geographical limitations.

Overall, the Constant Density scenario would reduce APEC urban transport oil product demand by about 16% by 2035 compared to business-as-usual; the Fixed Urban Land scenario would reduce it by 24%. On the other hand, the High Sprawl scenario would increase oil product demand by about 25% compared to business-as-usual.

Figure 1.12: APEC Light Vehicle Oil Demand Per Capita under Alternative Urban Development Scenarios



Source: APERC Analysis (2012)

Virtual Clean Car Race

Another way to improve transportation energy efficiency is by introducing alternative vehicle designs. The 'Virtual Clean Car Race' alternative scenarios looked at the impacts of introducing four alternatives to conventional internal combustion light vehicles:

1. *Hyper Cars*. These are conventionally powered vehicles with light carbon-fibre bodies and other energy-efficient features.
2. *Electric Vehicles*. These are 100% electric-battery-powered vehicles of otherwise conventional design.
3. *Natural Gas Vehicles*. These are compressed natural gas internal combustion vehicles of otherwise conventional design.
4. *Hydrogen Vehicles*. These are powered by fuel cells running on hydrogen; they are of otherwise conventional design.

We made the assumption in each of four sub-scenarios that each vehicle was introduced uniformly in each economy starting in 2013, with a new vehicle market share rising to 50% by 2020. While not intended to be realistic, these assumptions allow a straightforward comparison of the energy-saving potential of each vehicle type.

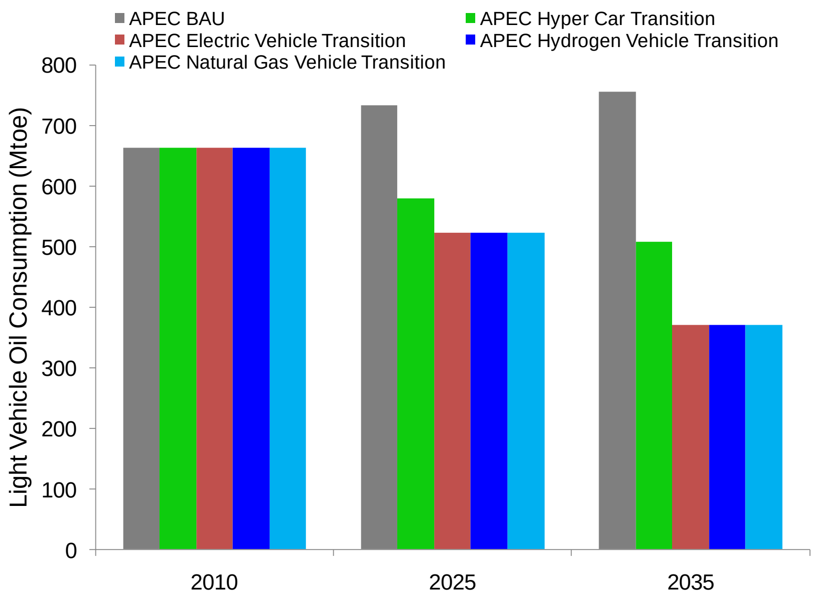
For the Electric Vehicle Transition scenario, we assumed the electricity came from the grid, with additional electricity produced from fossil fuels, either coal or gas, as projected by our electricity supply model. Hydrogen for the hydrogen vehicles was always assumed to be produced by reforming natural gas. We chose not to assume renewable sources were used to produce the additional electricity and hydrogen, since this would be counting the benefits of additional renewable energy supply as a benefit of electric or hydrogen vehicles, which it is not. There is considerable room in every APEC economy to add renewable energy supply without using hydrogen or electric vehicles at all.

The alternative vehicles could potentially provide two types of benefits:

- lower oil demand, thereby increasing energy security
- lower greenhouse gas emissions.

Figure 1.13 shows the impact of the alternative vehicles on oil products demand. It can be seen that by 2035, oil demand when using electric, natural gas, or hydrogen vehicles is about half what it would be compared to using conventional vehicles. This is not surprising, since these vehicles use no oil product for fuel and, by assumption, will constitute about half the vehicle fleet by 2035. Hyper cars also use significantly less oil product than conventional vehicles, reflecting their high fuel efficiency—more than twice that of a conventional vehicle.

Figure 1.13: Impact of Alternative Vehicles on APEC Light Vehicle Oil Product Consumption



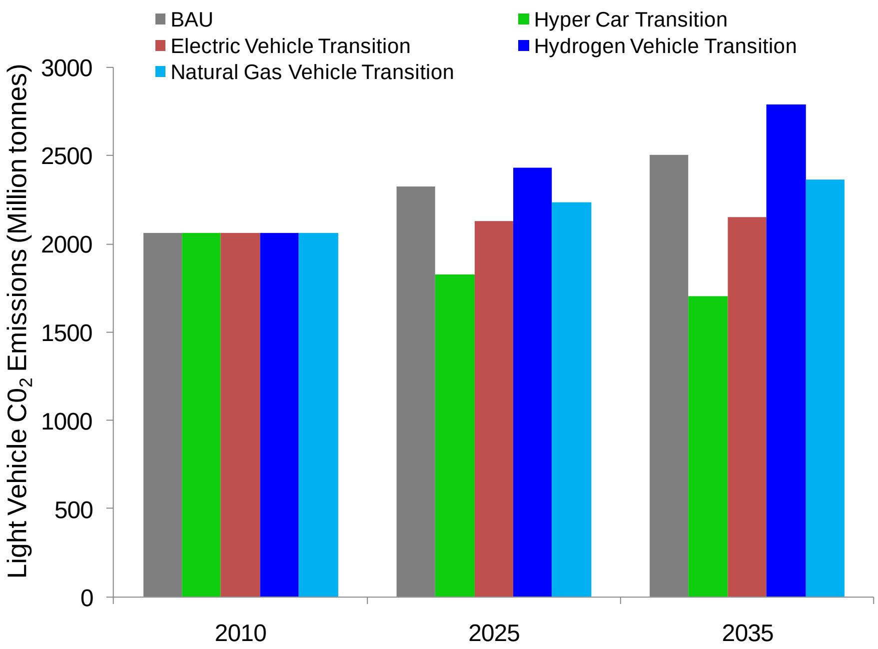
Source: APERC Analysis (2012)

Figure 1.14 shows the impact of the alternative vehicles on CO_2 emissions from fuel combustion. The figures shown include the additional emissions required to produce electricity for the electric vehicles and hydrogen for the hydrogen vehicles.

Here, the hyper cars are the clear winner, reflecting their efficiency, which is more than double that of a conventional vehicle. Since they make up about half the fleet in 2035, CO_2 emissions are about 32% lower than in the business-as-usual scenario. Natural gas vehicles offer a modest reduction in CO_2, reflecting the lower emission factor of natural gas compared to oil products. Electric vehicles also offer only a modest reduction in CO_2 emissions, reflecting our assumption that the electricity is produced from fossil fuels. The impacts of electric vehicles on CO_2 varied considerably between economies, with electric vehicles offering a larger reduction in emissions for those economies where natural gas, rather than coal, was the marginal source of electricity. Hydrogen vehicles turned out to be worse than conventional vehicles from a CO_2 emissions perspective, reflecting the inefficiencies of producing hydrogen from natural gas and then converting the hydrogen to electricity in the vehicle fuel cell.

Of course, the ideal vehicle would have the light weight and high efficiency of the hyper cars, combined with the reduced dependence on oil of any of the other three alternative vehicle types. Both technology paths should be pursued.

Figure 1.14: Impact of Alternative Vehicles on APEC Light Vehicle CO_2 Emissions from Fuel Combustion



Source: APERC Analysis (2012)

HAVE WE DEALT WITH A CHALLENGE LIKE CLIMATE CHANGE BEFORE?

The challenges posed by climate change can sometimes seem overwhelming to those of us who are attempting to do something about them. Avoiding a tragic outcome will require major, and potentially expensive, changes in government policies and technology in a number of sectors. The broad public will need education, both because public support will be required to make these changes happen politically, and because individual behaviour will need to change, too. And all of this needs to happen on a worldwide scale. Has anything like this been done before? The answer is a qualified 'yes'. There are many similarities between the challenges posed by climate change and the challenges posed by infectious diseases in the late nineteenth century.

It is easy to forget the threats that infectious diseases once posed, since no one today, at least in the developed economies, can remember the time when infectious diseases like tuberculosis, pneumonia, typhoid, cholera, scarlet fever, whooping cough, and diphtheria were both common and deadly. But in the United States, for example, in the 1870s and 1880s, one-fifth of all infants died in their first year of life, and even those who survived until adulthood faced a one-in-four chance of dying between the ages of 20 and 30 (Tomes, 1998, p. 25). Moreover, the disease rates were rising alarmingly in fast-growing cities.

Fortunately, at just this time, a new wave of scientific discovery was suggesting that a variety of micro-organisms, colloquially referred to as 'germs', were capable of causing diseases. Today, the germ theory of disease is one of the most widely known and widely accepted findings of science, but in the late nineteenth century, this was not yet the case. Indeed, to many at the time, it seemed rather radical to suggest that diseases were being caused by living organisms. As of 1880, the majority of the medical community found this whole concept hard to accept (Tomes, 1998, p. 27). From 1865 to 1895, Western medicine underwent a virtual civil war over the germ theory of disease. In Europe and the United States, the profession divided into hostile camps that debated in medical journals and textbooks. But by the 1890s, it had become scientific orthodoxy (Tomes, 1998, p. 28).

Inspired by the known value of smallpox vaccinations, many early converts to the germ theory of disease dreamed of developing vaccines or 'internal antiseptics' that could prevent or cure diseases. But, aside from a few exceptions like the rabies vaccine and the diphtheria antitoxin, such hopes for a silver bullet were repeatedly dashed (Tomes, 1998, p. 45). It was not until the 1930s and 1940s that sulfa compounds, penicillin, and other antimicrobial drugs were discovered. As with climate change today, the focus had to be on prevention.

And, as with climate change, prevention was a daunting and expensive task. It required a radical expansion of collective public health practices, including municipal sewerage systems, water purification, garbage collection, building codes, and food inspection. Indeed, our modern conceptions of government responsibility for public health date from the period from 1890 to 1930 (Tomes, 1998, p. 6).

Prevention also required private responses. Entrepreneurs, for one, saw opportunities in the germ theory of disease to promote modern plumbing, soaps, disinfectants, sanitary packaging, water filters, and so forth. Their advertisements, while sometimes exaggerated or inaccurate, still served an important educational role (Tomes, 1998, Chapter 3).

But this era also saw huge educational campaigns to change individual behaviour. In the United States, for example, this role was assumed by a wide variety of organizations, including municipal and state health departments, life insurance companies, women's clubs, settlement houses (organizations that provided charitable services to the poor), Boy Scouts and Girl Scouts, youth service organizations like YMCAs and YWCAs, and labour unions. The era happened to coincide with expanded educational opportunities for women, especially in social work, home economics, and nursing. Many women of this pioneer generation dedicated themselves to bringing the insights of "household bacteriology" to every homemaker (Tomes, 1998, pp. 9–10).

Today, we take all these changes for granted. As Tomes (1998, p. 2) puts it "The rituals of germ avoidance are so many and so axiomatic that we scarcely can remember when or where we first learned them". Yet for the people of the late nineteenth century, these must have seemed like huge and wrenching changes with high costs and uncertain benefits. But still they made it happen, and it can happen again.

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