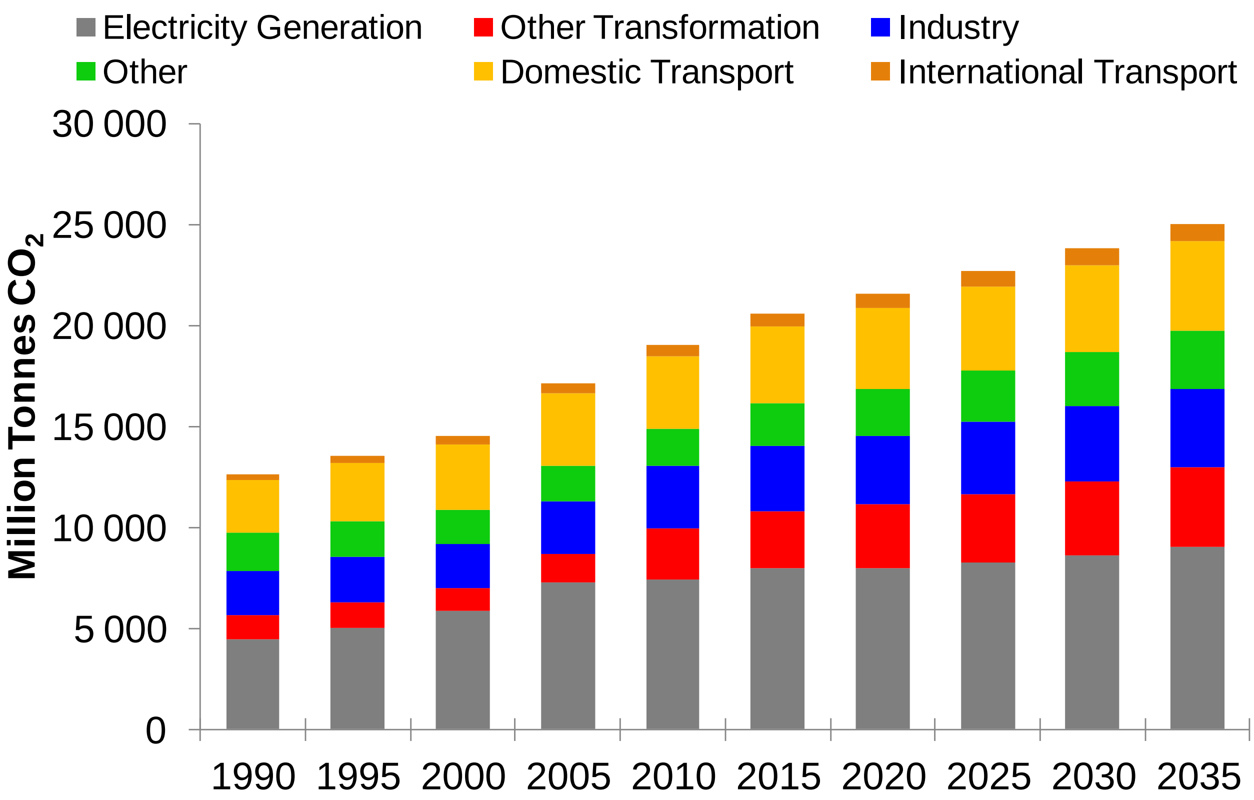
16 CARBON DIOXIDE EMISSIONS

The APEC region's CO_2 emissions from fuel combustion are projected to rise by about 32% between 2010 and 2035 (see Figure 16.1). These emissions pose a threat to humanity, to the environment, and to the economies of the APEC region and the world. This chapter discusses the details of these emission projections and their implications for policymakers.

APERC has modelled only the emissions of carbon dioxide (CO_2) from fuel combustion. As noted in Chapter 1, in 2009 CO_2 emissions from fuel combustion accounted for 89% of energy-related greenhouse gas emissions worldwide on a CO_2-equivalent basis, and these energy-related emissions in turn accounted for about two-thirds of total greenhouse gas emissions on a CO_2-equivalent basis (IEA, 2011, p. III.45). Non-CO_2 energy emissions are difficult to model because they depend not just on the quantity of fuel burned, but also on details of the conditions under which the fuel was burned or escaped into the environment (IPCC, 2006).

Figure 16.1: APEC Projected Business-as-usual CO_2 Emissions from Fuel Combustion

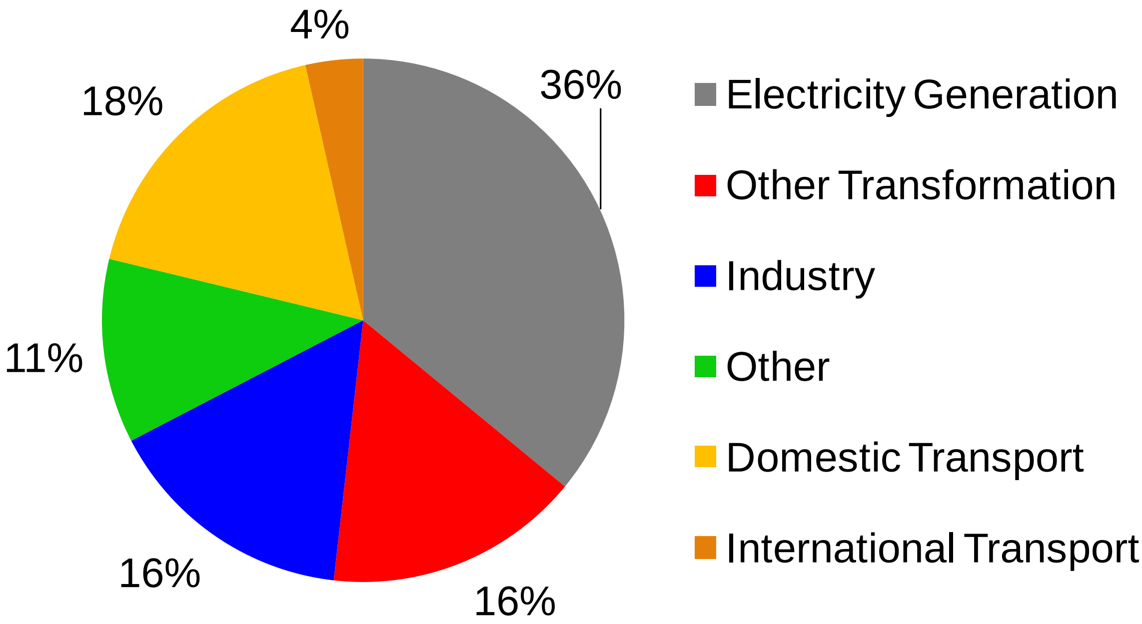


Source: APERC Analysis (2012)

CO_2 EMISSION RESULTS

CO_2 emissions from APEC economies are projected to increase under our business-as-usual (BAU) assumptions from 19.0 billion tonnes in 2010 to 25.1 billion tonnes in 2035. Electricity generation alone (Figure 16.2) will account for 9.0 billion tonnes, or about 36% of these emissions in 2035. Domestic transport at 4.4 billion tonnes or about 18% is in second place. 'Other Transformation' (which includes refineries and other energy sector own use, heat generation, and hydrogen generation) at just under 4.0 billion tonnes or 16% is almost tied for third place with Industry at a bit more than 3.9 billion tonnes (16%).

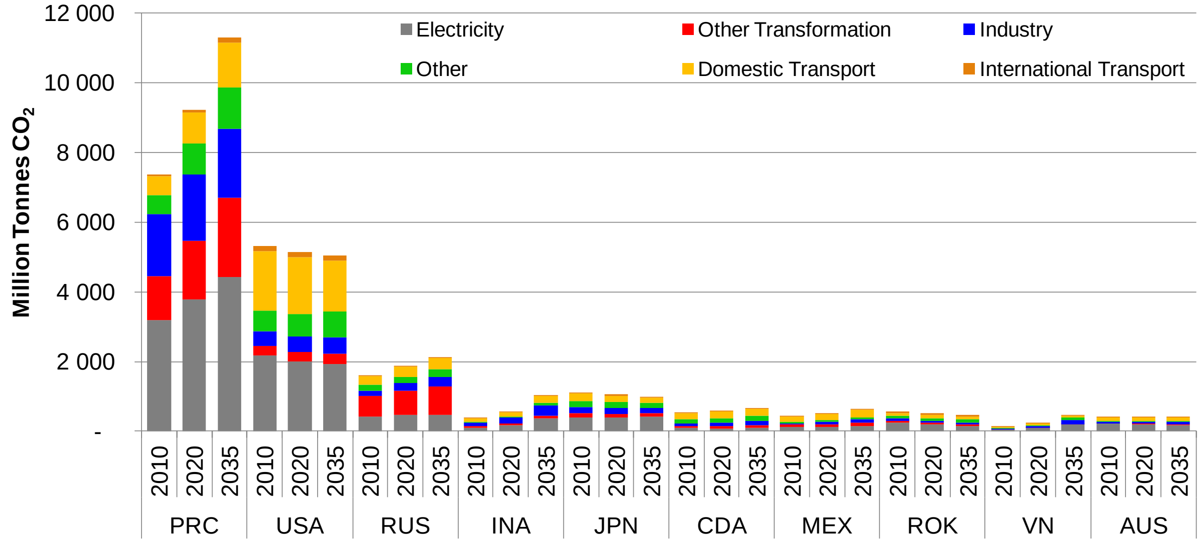
Figure 16.2: APEC Projected Shares of CO_2 Emissions from Fuel Combustion by Sector in 2035



Source: APERC Analysis (2012)

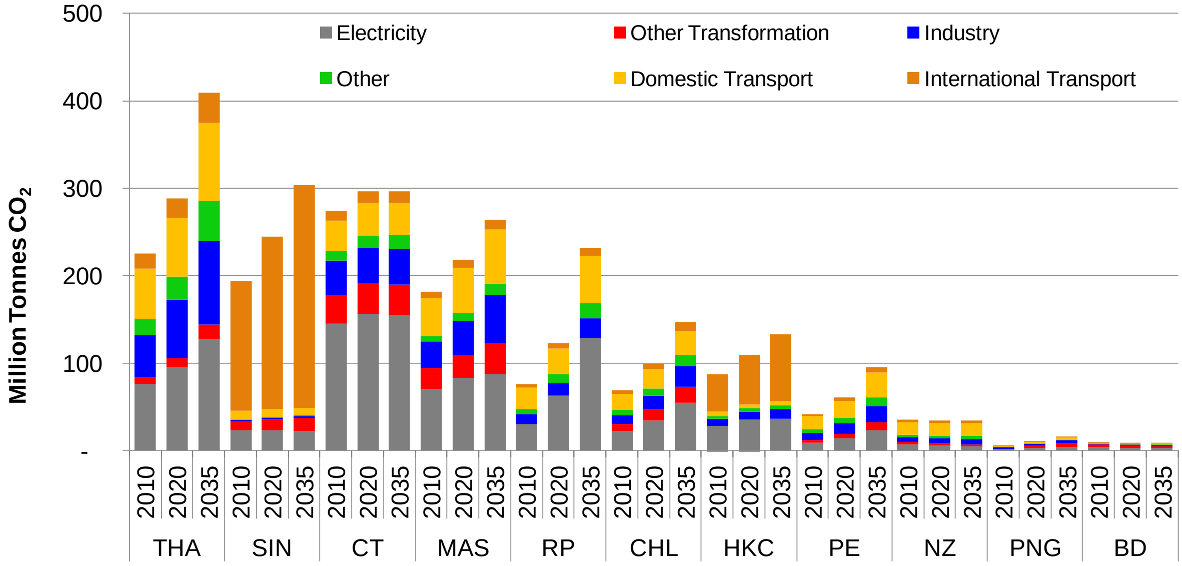
As shown in Figure 16.3 and Figure 16.4 (note the difference in scales between the figures), the importance of each sector in contributing to emissions varies considerably by economy. However, in 13 of the 21 APEC economies, electricity will be the leading source of CO_2 emissions in 2035.

Figure 16.3: CO_2 Emissions from Fuel Combustion by Sector, Higher Emitting Economies



Source: APERC Analysis (2012)

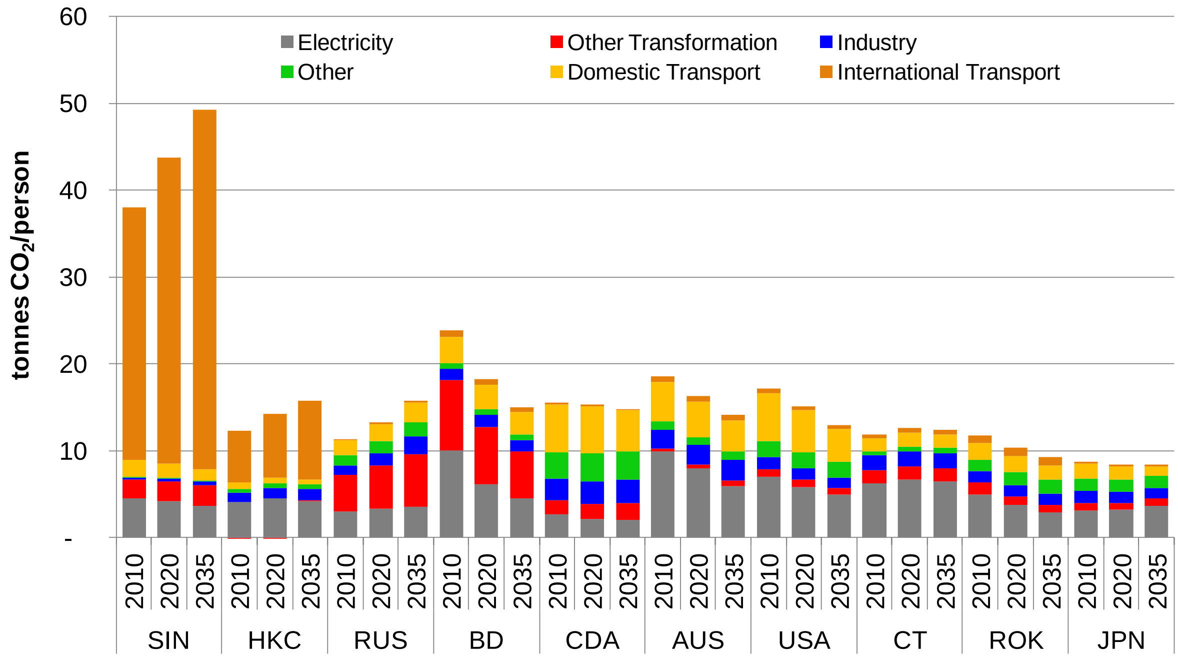
Figure 16.4: CO_2 Emissions from Fuel Combustion by Sector, Lower Emitting Economies



Source: APERC Analysis (2012)

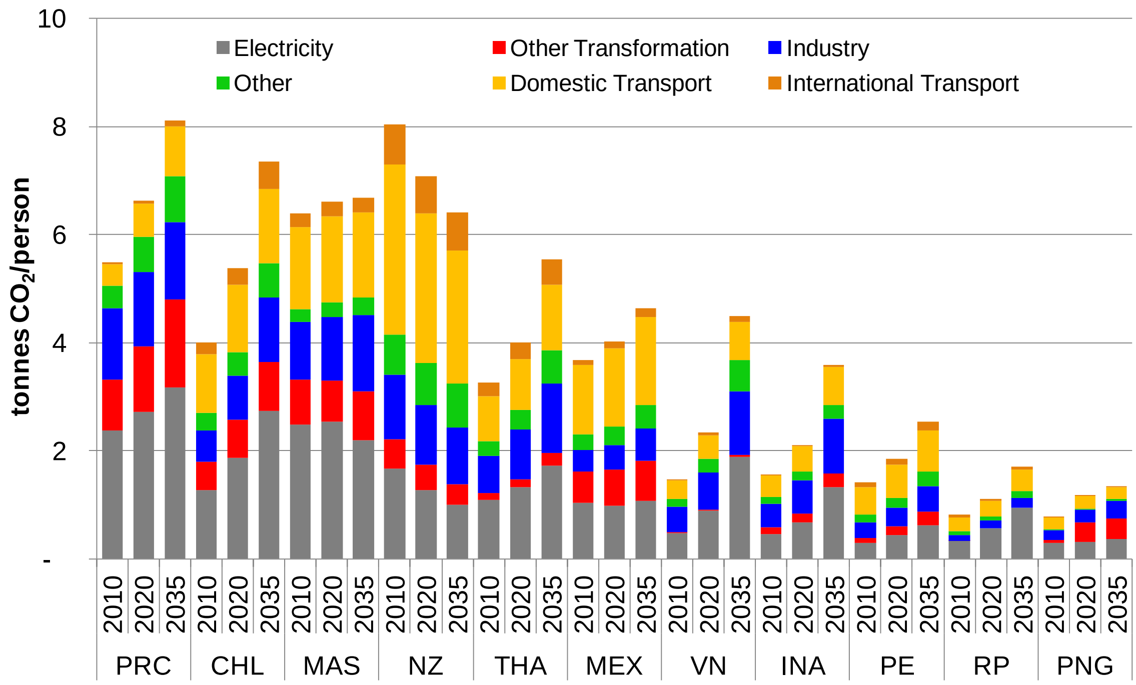
Considering emissions on a per capita basis paints a somewhat different picture of who is responsible for these emissions. As shown in Figure 16.5 and Figure 16.6, it is the APEC's more developed economies that have the highest per capita emissions, although emissions per capita in the developing economies are also rising rapidly. Singapore and Hong Kong have high emissions from international transport due to their role as major shipping and air transport hubs.

Figure 16.5: CO_2 Emissions per Capita from Fuel Combustion by Sector, Higher Per Capita Emission Economies



Source: APERC Analysis (2012)

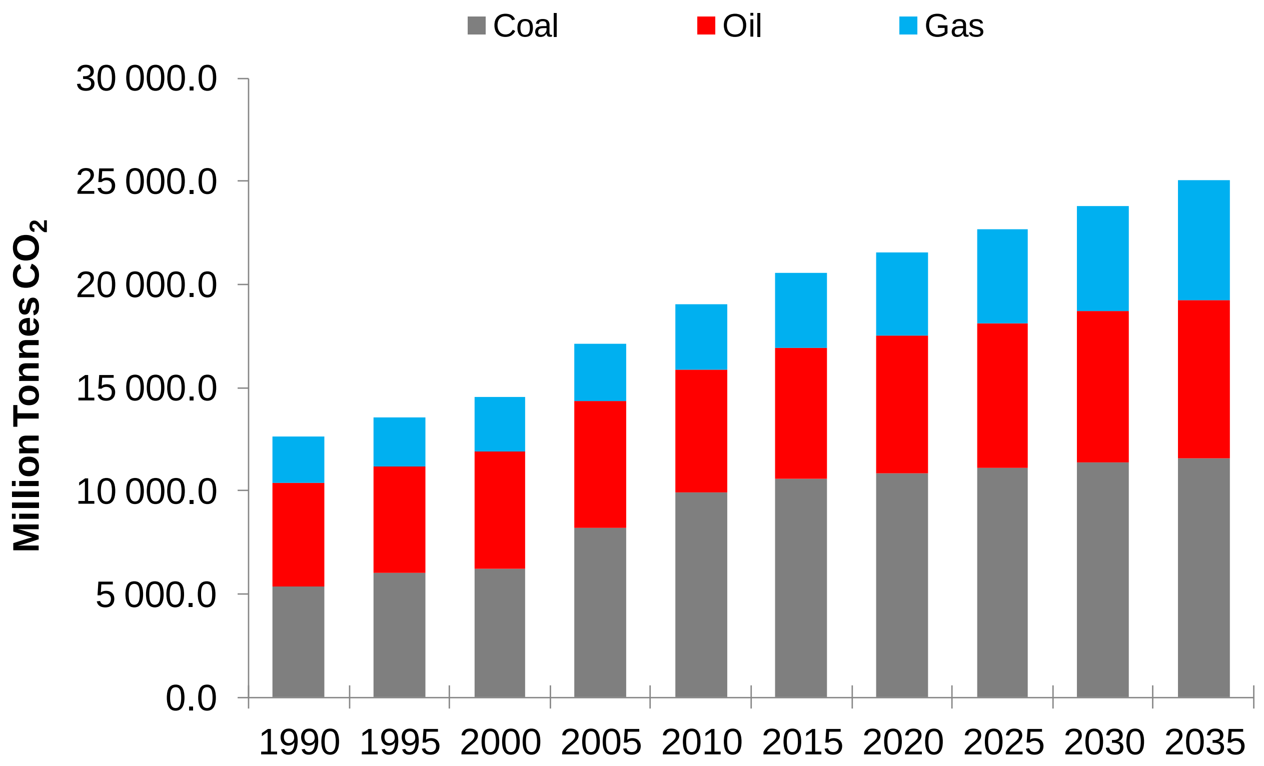
Figure 16.6: CO_2 Emissions per Capita from Fuel Combustion by Sector, Lower Per Capita Emission Economies



Source: APERC Analysis (2012)

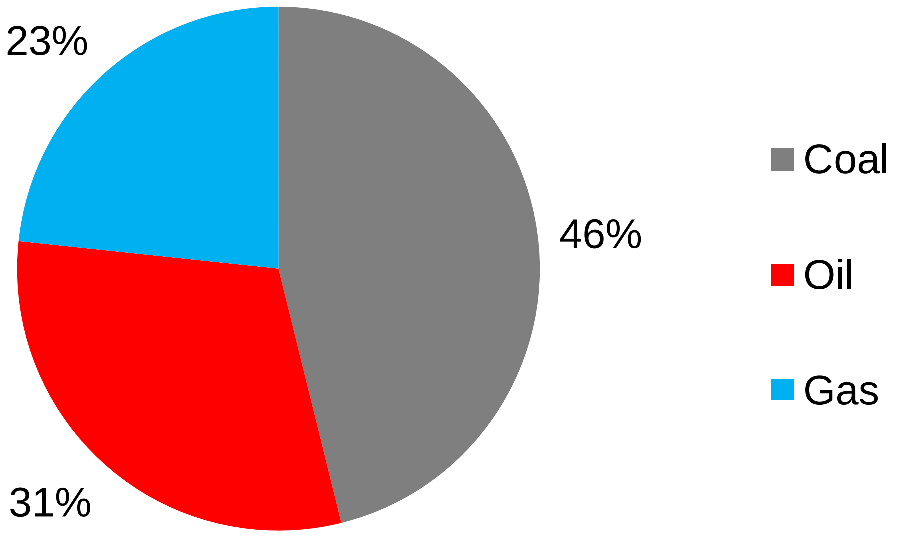
Among the fossil fuels, coal is projected to provide the largest contribution to APEC's primary energy supply by 2035. As it is also the most carbon intensive of the fossil fuels, coal not surprisingly contributes the most to CO_2 emissions. Coal contributes 46% of greenhouse gas emissions in 2035, whereas oil and gas contribute 31% and 23%, respectively (Figures 16.7 and 16.8).

Figure 16.7: APEC Projected BAU CO_2 Emissions from Fuel Combustion, by Fuel



Source: APERC Analysis (2012)

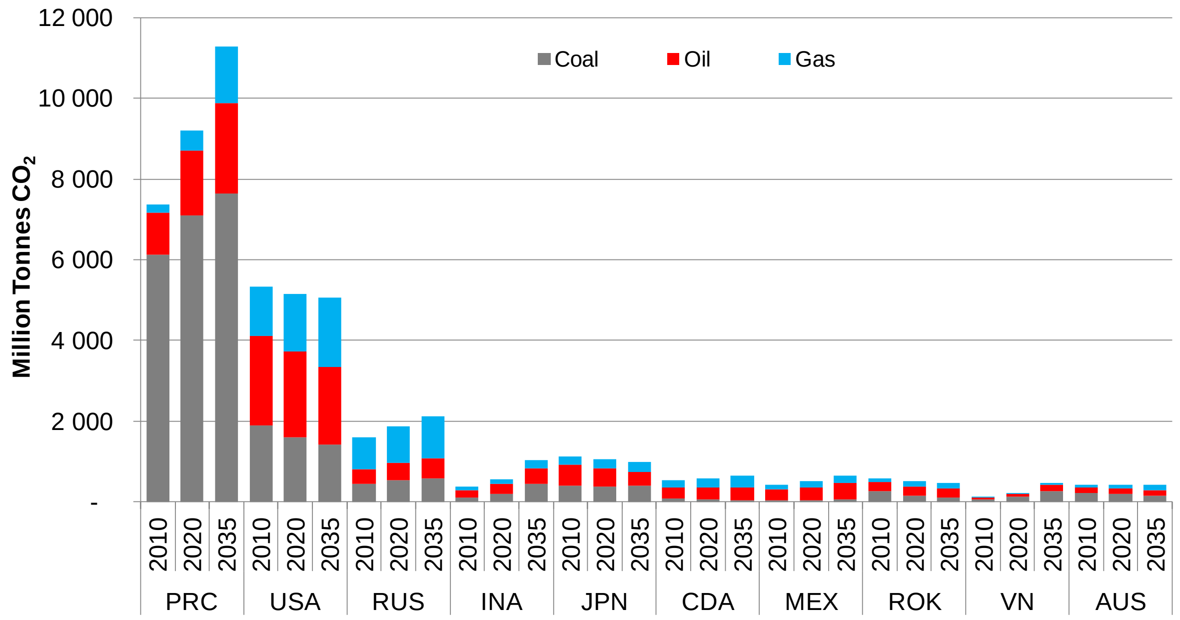
Figure 16.8: APEC Projected Shares of CO_2 Emissions from Fuel Combustion by Fuel in 2035



Source: APERC Analysis (2012)

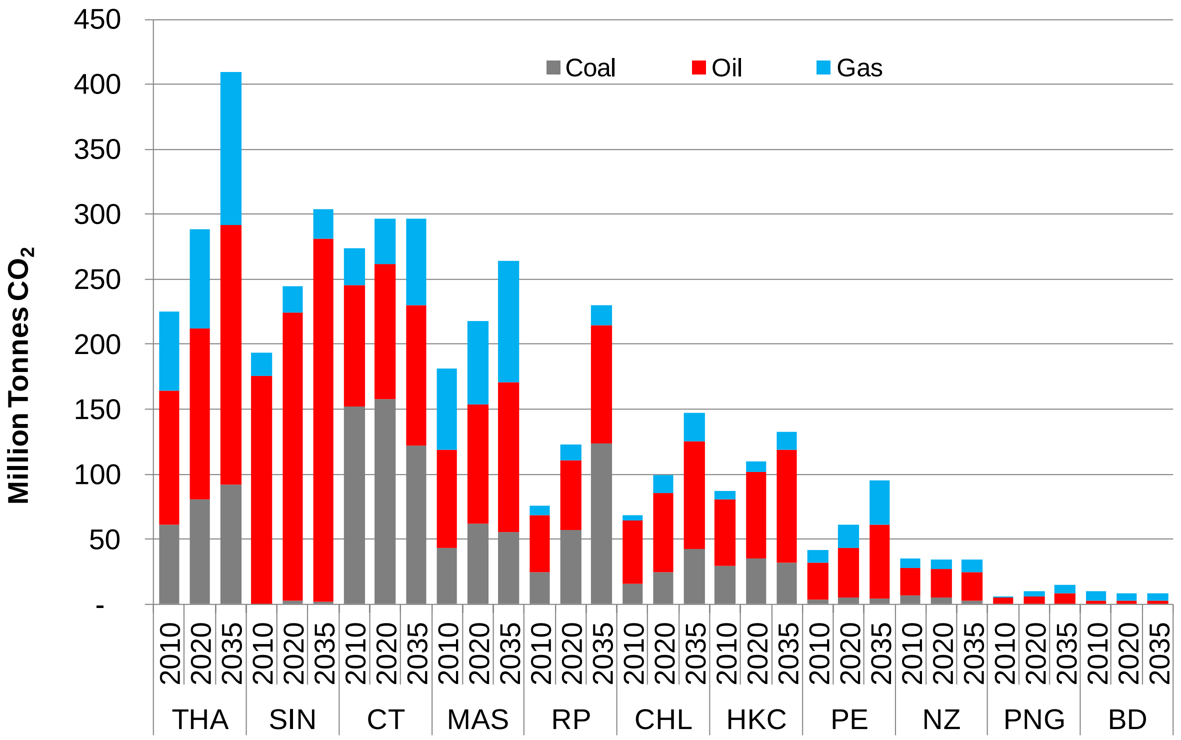
However, as shown in Figure 16.9 and Figure 16.10, the share of the three fuels in CO_2 emissions varies dramatically among the economies.

Figure 16.9: CO_2 Emissions from Fuel Combustion by Fuel, Higher Emitting Economies



Source: APERC Analysis (2012)

Figure 16.10: CO_2 Emissions from Fuel Combustion by Fuel, Lower Emitting Economies



Source: APERC Analysis (2012)

In 2009, the APEC economies accounted for about 60% of world CO_2 emissions from the combustion of fossil fuels (calculated from IEA, 2011, pp. III.45–49). It is, therefore, no exaggeration to say what happens in APEC will largely determine what happens in the world. As discussed in Chapter 1, the best science is saying that the world needs to make dramatic reductions in greenhouse gas emissions to avoid potentially disastrous climate change consequences. This need for reductions stands in stark contrast with the 32% increase in CO_2 emissions from fossil fuel consumption between 2010 and 2035 under our BAU scenario. Clearly, the BAU projection is incompatible with APEC's commitment to "…prevent dangerous human interference with the climate system" (APEC, 2007).

THE WAY FORWARD

Finding ways to make large reductions in greenhouse gas emissions in fast-growing economies, such as those of the APEC region, is a challenge that ranks among the greatest of our times. CO_2 is an inherent product of fossil fuel consumption; unlike toxic air pollutants, it cannot be eliminated with improved combustion technology. There are fundamentally only three ways to reduce CO_2 emissions: use less energy, switch to less-emission-intensive energy sources, or find a way to capture and permanently store the CO_2. Given that under our BAU projections the APEC region will depend upon fossil fuels for over 80% of its primary energy supply in 2035, each of these alternatives will involve huge changes.

While this study has not attempted a detailed analysis of alternatives, there are some general recommendations that emerge from the analysis presented here.

1. *Educate*. Dealing with a challenge the size of the climate change problem will require a serious commitment from a lot of people. Policymakers will need support and cooperation from their stakeholders and constituents if effective policies are to be agreed upon and adopted. This kind of support and cooperation will only come if those stakeholders and constituents understand the magnitude of the challenge and the consequences of an inadequate response. Since climate change is a challenge that will have to be dealt with over a time span of decades, it makes sense to insure that young people are appropriately educated on climate change science, technology, and institutions in schools of all levels. And no opportunity should be lost to educate their elders as well.
2. *Promote energy efficiency*. As discussed in Chapter 4, there are a variety of market barriers preventing the most efficient use of energy resources. Removing these barriers, or adopting policies to offset them, can often simultaneously reduce emissions, reduce costs, and promote energy security. Improved energy efficiency is likely to be the quickest and least-cost first line of attack on the climate change problem.
3. *Promote energy research*. As discussed in Chapter 15 and others, there are a variety of promising low-emission energy supply technologies, including various types of renewable energy, carbon capture and storage, and advanced nuclear. Technology can also improve energy efficiency using advanced vehicles, smart grids, better communication as an alternative to transportation, and in many other ways. The cheaper and more convenient that emissions-reducing technology can be made, the easier it will be to deal with the challenges of climate change. Technology will be especially important over the longer term, since once the economic emission reductions from the technology available today have been achieved, further reductions will require new technology.
4. *Put a price on emissions*. As noted in Chapter 4, a major market failure results from the fact those who emit greenhouse gases pay no cost for the damage they are doing. Some kind of scheme for putting a price on emissions, such as an emissions cap and trade program, or a carbon tax, would address this market failure. Some low-emission technologies, such as carbon capture and storage, can probably never be cheaper than conventional technology, while others may take a long time to get there. A price on emissions will pave the way for low-emissions technology to move from research to commercialization.

   An economy could avoid a loss of competitiveness to their industry by levying the emissions price on the emissions embedded in what is consumed, rather than on the emissions from production. Such an approach might make a price on emissions more politically acceptable (see the sidebar 'Did the Kyoto Protocol Get It Backwards?' in this chapter).

5. *Cooperate*. Climate change is a global challenge. No one economy can deal with it alone. Trade is a key example of where cooperation will be required, but there are a number of others, including infrastructure development, financial mechanisms, regulatory frameworks, research and development, information sharing, and education and capacity building (APERC, 2008). APEC could play an important role in many of these areas.

MODELLING CO_2 EMISSIONS

Projecting CO_2 emissions from combustion is, in principle, simple if we know the amount of each fuel to be combusted: just multiply the quantity of each fuel combusted by the emission factor (CO_2/unit of fuel) for that fuel. The emission factor for each fuel is a fixed chemical property of the fuel.

In practice, data limitations make these calculations more uncertain. There are many types of coal, many types of oil and oil products, and even natural gas may vary slightly in chemical composition. However, because of limitations on data and model complexity, APERC projects the demand for only three generic fossil fuels: coal, oil, and gas. So what to do?

One approach would be to use the worldwide average emission factor for each of these three generic fossil fuels. These may be calculated by dividing worldwide CO_2 emissions from that generic fuel by worldwide demand. Such a calculation (using data from IEA, 2011, pp. II.7–16) yields the following generic emission factors for the year 2009:

- Coal—3.8293 million tonnes CO_2/Mtoe
- Oil—3.0179 million tonnes CO_2/Mtoe
- Gas—2.3972 million tonnes CO_2/Mtoe.

These emission factors are broadly consistent with the default emission factors for combustion given in the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006, Table 1.4). (The IPCC's figures are given in TJ/Mtoe; given there are 41 868 TJ/Mtoe (IEA, 2012), the emission factors above would imply average CO_2 emissions of about 91 500 kg/TJ for coal, 72 081 kg/TJ for oil, and 57 300 kg/TJ for gas.)

These emission factors could be multiplied by the projected demand for each of the three generic fuels to project CO_2 emissions. This approach, however, fails to capture the differences in the mix of specific fuels used in each economy.

APERC, therefore, goes one step further, calculating a specific emission factor for each generic fuel for each APEC economy for the base year 2009. This is accomplished by dividing the economy's CO_2 emissions from each generic fuel (again from IEA, 2011, pp. II.7–II.16) by demand for that generic fuel. These emission factors thus take into account the specific mix of fuels in each economy. For the year 2009, modelled emissions are guaranteed to match actual emissions, since the emission factors were calculated from actual emissions. For future years, the mix of fuels in the economy could change somewhat over time, but this method should be a good approximation and probably about the best possible given the limitations of the demand models.

DID THE KYOTO PROTOCOL GET IT BACKWARDS?

Under the Kyoto Protocol, 37 developed economies and the European Union agreed to limit their greenhouse gas emissions over the five-year period 2008–2012 (UNFCCC, 2012). However, a post-2012 successor agreement with binding limits has attracted only meagre participation thus far (Washington Post, 2012). In many economies, there has been strong opposition to such binding emissions limits, and especially to the carbon pricing (carbon taxes or emission trading) that will probably be needed to enforce them.

The basic dilemma here is that any disparity in the regulation of emissions between economies, and especially in the price of carbon, will put the economy with the stricter regulations at a competitive disadvantage. And unless every economy in the world agrees to a common carbon pricing scheme—an unlikely outcome given the 'free-rider' advantages accruing to any economy that stays out of the agreement—there will always be disparities.

Energy-intensive industries, and their workers, tend to be politically powerful, and will demand that carbon pricing be abandoned, or at least that export-competitive industry be exempted or compensated, which significantly weakens the emission reduction impact. Governments are effectively forced to make a trade-off: climate protection vs. economic growth and jobs. When the policy question is posed in these terms, it is inevitable that climate protection will lose. No-one likes new taxes, but when they look like a tariff on your economy's own products that is not faced by foreign competitors, the difficulties can become overwhelming for even the most environmentally committed political leaders. Indeed, a 'race to the bottom' for weaker emission regulation would seem to be the natural outcome, and it largely has been.

What is happening here can be viewed as a classic market failure. Economic principles tell us markets work when consumers pay the full cost (including environmental costs) of the products they consume, and any departure from this principle produces 'market failures' that give people an incentive to behave in ways that are not in society's best interests. Yet under the Kyoto Protocol, with its limits on the emissions produced by each economy, the consumer can avoid paying the full environmental costs they are imposing on society by purchasing products from economies with weak emission regulation. The result is a classic market failure, which explains much of the difficulty in reaching and in implementing an agreement.

The alternative that avoids market failure is for each participating economy to pledge to limit the emissions embedded in what they *consume*, not what they *produce*. As with the Kyoto Protocol, the limits could be enforced in each participating economy through measures of their own choosing. Some kind of carbon pricing scheme, such as a carbon tax or emissions trading, but applicable only to domestic consumption, would be the obvious choice. The carbon price would, however, need to cover *all* domestic consumption, whether the product was produced domestically or imported. So it would need to be charged on imported products, and refunded on exported products.

With consumption-based emission limits, there would be no competitive benefit to the industries in an economy that does not participate in the agreement. The products of non-participating economies would have to bear the same carbon price when they are sold to participating economies as domestic products in those economies. This means, even if an economy chooses not to participate in the agreement, their industries would still face strong economic incentives to minimize the carbon embedded in their products if they wish to remain competitive in participating economies. Thus, the incentives facing each economy and their industries would be completely different from those under Kyoto-style production-based limits.

Such a proposal raises two obvious questions. The first is whether such a scheme would be legal under international trade agreements. The basic requirement of international trade agreements is non-discrimination. The border adjustments proposed here would meet this requirement, since imported products in each economy would be charged for carbon emissions in the same manner as domestically produced products (Horn and Mavroidis, 2011 and Khrebtukova, 2010). Today's value-added taxes, which are charged on imports and refunded on exports by many countries, have set a precedent for this (Lockwood and Whalley, 2008). Of course, the most logical way to avoid the risk of trade disputes over border adjustments for carbon pricing would be to explicitly incorporate the rules for them into international trade agreements (Barrett, 2011; Whalley, 2011).

The second question is whether the carbon accounting required by border adjustments could be implemented in the real world fairly and at reasonable cost. Clearly, there are accounting challenges in implementing such consumption-based emission limits, specifically in determining what the carbon content of a particular product is. These accounting challenges should be manageable, although full implementation would take time. Efforts already underway in this area include the Greenhouse Gas Protocol of the World Resources Institute and World Business Council for Sustainable Development (WRI/WBCSD, 2012) and ISO Standard 14067 (PCF World Forum, 2012).

This section is a short summary of Samuelson (2012), which should be consulted for a more detailed discussion of consumption-based emission limits.

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