15 RENEWABLE ENERGY SUPPLY

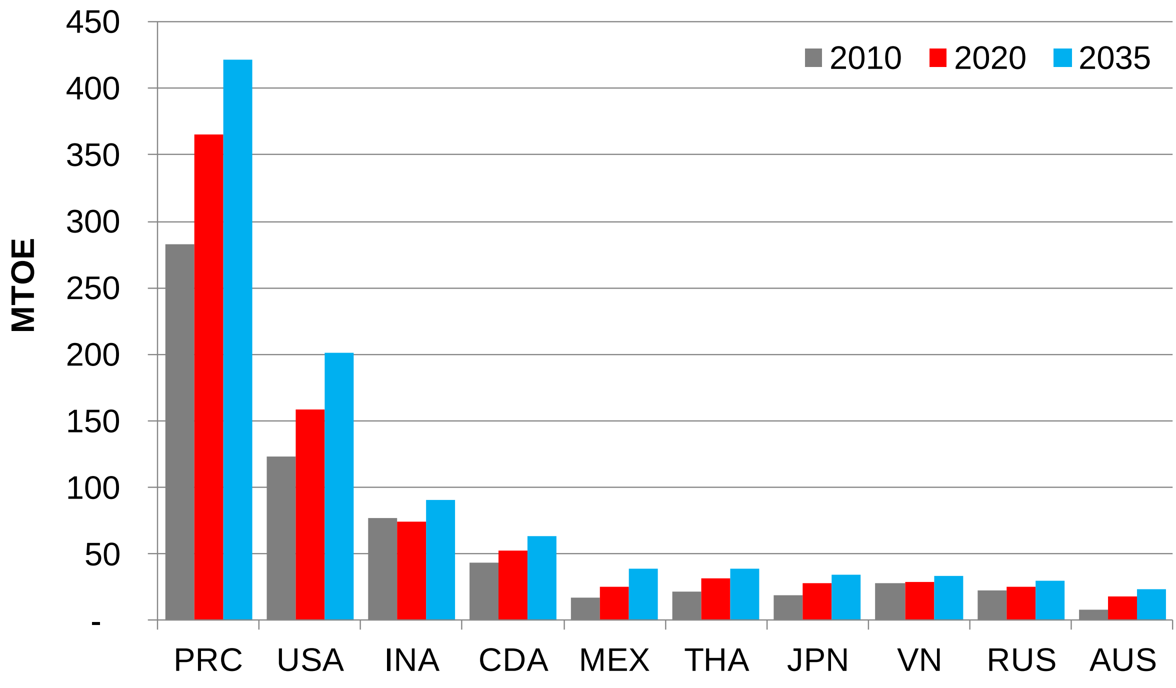
Renewable energy resources offer significant benefits for APEC economies. They are potentially secure, sustainable, and low in greenhouse gas (GHG) emissions. The quantity of resource potentially available is enormous.

Technological advancements have made it possible for APEC economies to harness more renewable energy resources, especially in the power generation sector. Spurred by these technological advances, coupled with existing supportive government policies, the contribution of renewable energy to the APEC region's energy supply is projected to grow over the outlook period under business-as-usual (BAU) assumptions—at an average annual rate of 1.8%, increasing from 684 Mtoe in 2010 to 1050 Mtoe by 2035.

China and the United States are expected to be the major contributors, making up over 50% of the total APEC primary renewable energy supply by 2035. At the same time, all APEC economies are expected to have some form of renewable energy contribution by 2035.

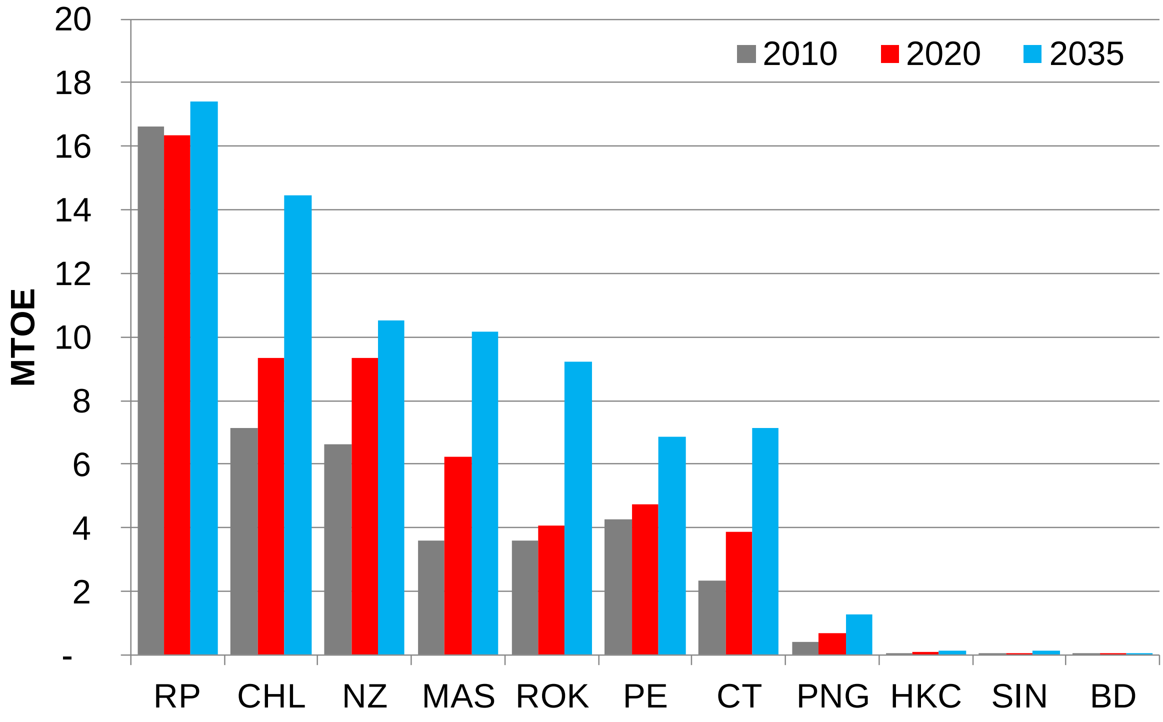
Figures 15.1 and 15.2 show the projected renewable energy supply for each APEC economy in the years 2010, 2020 and 2035. Note the difference in the scales of the vertical axis in the two figures.

Figure 15.1: Projected Renewable Energy Supply, Larger Supplying Economies



Source: APERC Analysis (2012)

Figure 15.2: Projected Renewable Energy Supply, Smaller Supplying Economies

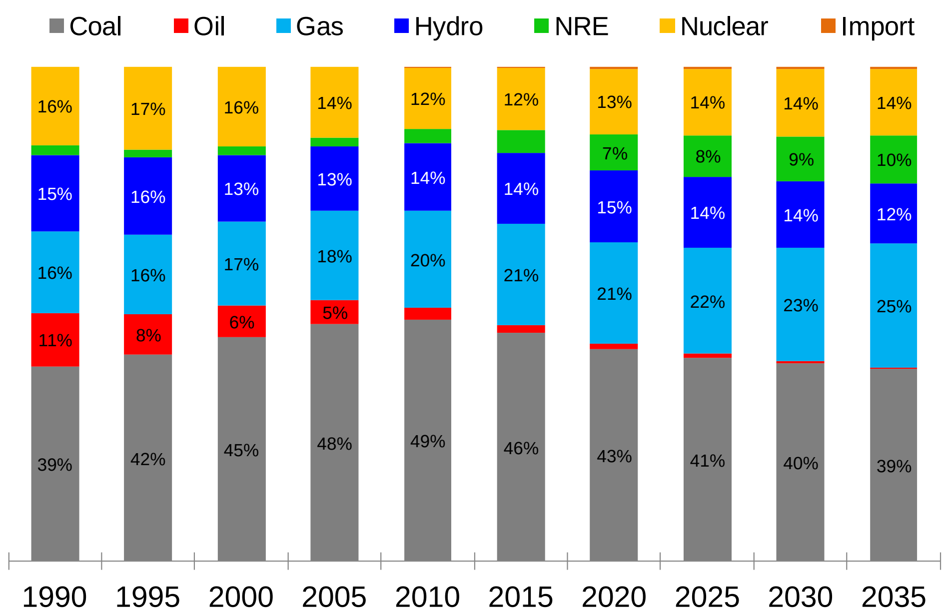


Source: APERC Analysis (2012)

RENEWABLE ENERGY IN THE ELECTRICITY GENERATION SECTOR

As APEC economies strive to minimize greenhouse gas emissions and air pollution, more renewable energy power generation capacity is being developed to counter the harmful effects of fossil fuel combustion. Figure 15.3 shows the renewable energy share (including hydro and new renewable energy) in the power generation mix will increase over the outlook period from 17% in 2010 to 22% by 2035. In APERC's terminology, new renewable energy (NRE) is understood to mean all renewable energy other than hydro.

Figure 15.3: APEC Region Electricity Generation Mix (1990–2035)



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

The Role of Hydro in Electricity Generation

Use of renewable energy resources is not new in the APEC region. New Zealand, Canada and Peru used hydropower—mostly large-scale hydro—to generate more than half of their total electricity needs in 2010. Large-scale hydropower is a mature technology with generally favourable economic viability.

Further development options for large-scale hydro are limited in many APEC economies, as the best sites have already been developed. In addition, large-scale hydro has substantial social and environmental effects, such as dislocation of large numbers of people, loss of considerable amounts of productive land, and downstream impacts including diversion of water and trapping of silt. Hydro reservoirs may also emit methane, a potent greenhouse gas. However, the Intergovernmental Panel on Climate Change (IPCC) notes that for most hydro projects, lifecycle assessments have shown low overall net greenhouse gas emissions (IPCC, 2007, p. 274).

Total hydropower capacity in the APEC region is projected to increase from 532 GW in 2010 to 732 GW in 2035 under BAU assumptions. Accordingly, hydropower generation will increase at an annual average rate of 1.5% from 1840 TWh in 2010 to 2690 TWh in 2035. As shown in Figure 15.3, the share of hydro in the electricity generation mix will fluctuate between 12-15% over the outlook period. Since electricity production is growing faster than the primary energy supply growth, the share of the total primary energy supply coming from hydropower generation will increase from 2.1% in 2010 to 2.3% in 2035.

The Role of Non-Hydro Renewable Energy in Electricity Generation

NRE generation capacity is projected to grow rapidly in the APEC region over the outlook period, at an average annual rate of 7.3%. The growth in NRE capacity will be driven by existing supportive policies, as well as by rapidly declining costs. Wind energy is expected to be the technology with the greatest increase in capacity.

The long-term future of NRE, however, is likely to be based on solar energy. Solar is a rapidly advancing technology, which is easily scalable and distributable. Solar manufacturing costs, particularly for solar photovoltaic (PV) systems that directly convert sunlight into electricity, have declined rapidly as a result of advances in technology and from manufacturing economies of scale. Like computer chips, solar PV is a semiconductor technology that is amenable to the application of advanced science and engineering. It is expected that solar PV costs will continue to decline more quickly than those for mechanical and thermal technologies. Historically, solar PV has competed with concentrated solar power (CSP), which concentrates sunlight to produce heat. However, owing to its versatility in both small and large-scale applications, as well as its more rapidly declining costs, solar PV can be expected to lead the long-term growth in solar generation installations in the APEC region.

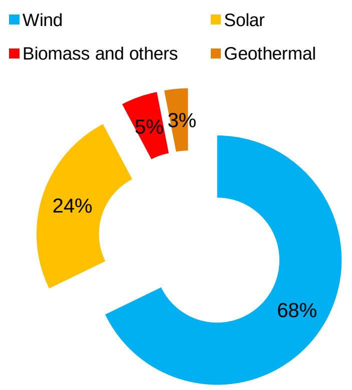
Module production costs for solar PV have declined sharply in recent years (IHS Consulting, 2012). Silicon module costs have declined from USD 4.50 per watt in the year 2000 to below USD 1.00 per watt in late 2011 (LBNL, 2011; IHS Consulting, 2012). Early estimates for module costs at the end of 2012 suggest they may be as low as USD 0.50 per watt. These cost estimates are for low-efficiency modules, but they serve as a good indication of the rapidly improving economics of PV solar. In the future, an increasing focus will be on reducing costs for the balance of the PV system other than the modules themselves, such as costs associated with installation and grid connection. Because of the decline in module costs, the balance of the PV system now typically accounts for two-thirds of total PV installation costs (LBNL, 2011).

Unsubsidized solar PV costs are expected to become competitive with the retail price of electricity in many regions as early as 2020—this is known as 'grid parity' (IEA, 2010). The economics of solar PV is especially attractive in places where electricity demand peaks on hot days when sunshine is likely to be most intense, which describes many APEC economies. Once the economics of solar are firmly established and cost competitive with conventional generation technology, growth in NRE should accelerate.

The NRE growth projections in this Outlook are founded on the plans of the individual APEC economies. It is likely that these projections do not consider the rapidly declining costs of NRE, particularly for solar PV. Therefore the NRE growth projections across APEC are conservative in nature.

From 2010 to 2035, it is projected that a total of 677 GW of NRE generation capacity will be installed in the APEC region under BAU assumptions. The likely breakdown (by energy source) of NRE generation capacity added from 2010 to 2035 is shown in Figure 15.4. It is expected that wind will dominate, followed by solar, biomass and others, and geothermal. In APERC terminology, 'biomass and others' means combustible renewable sources, which comprise solid biomass, liquid biomass, biogas, industrial waste and municipal waste.

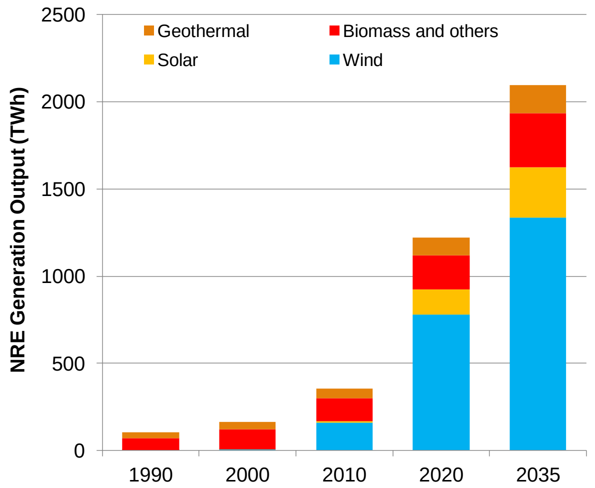
Figure 15.4: NRE Capacity Additions in APEC by Energy Source (Total for 2010–2035)



Source: APERC Analysis (2012)

Electricity generation output from NRE sources will increase dramatically from 355 TWh in 2010 to 2095 TWh in 2035. Figure 15.5 shows the growth in NRE electricity generation output by energy source. As with capacity additions, wind dominates, contributing 64% of the NRE generation mix. 'Biomass and others' is the second largest contributor at 15%, followed by solar (14%) and geothermal (8%).

Figure 15.5: NRE Electricity Generation in APEC by Energy Source (1990–2035)

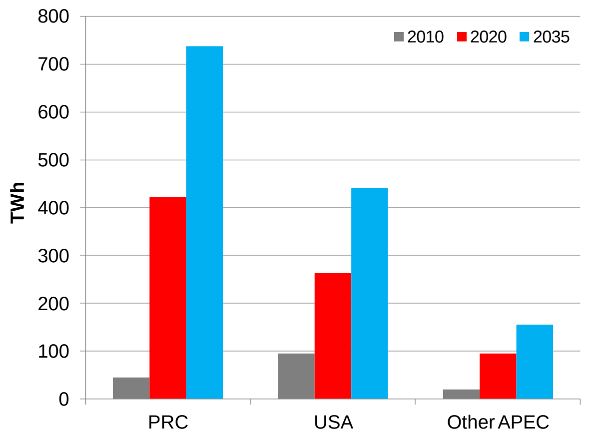


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

Wind Power Generation

Figure 15.6 shows the breakdown of wind generation by economy. By 2035, China leads in the output of electricity generated from wind energy, reaching around 738 TWh. This is followed by the US on about 440 TWh. Together China and the US account for around 88% of wind-based generation output across the APEC region.

Figure 15.6: Wind-based Generation Growth, Top Two and Other APEC Economies (2005–2035)



Source: APERC Analysis (2012)

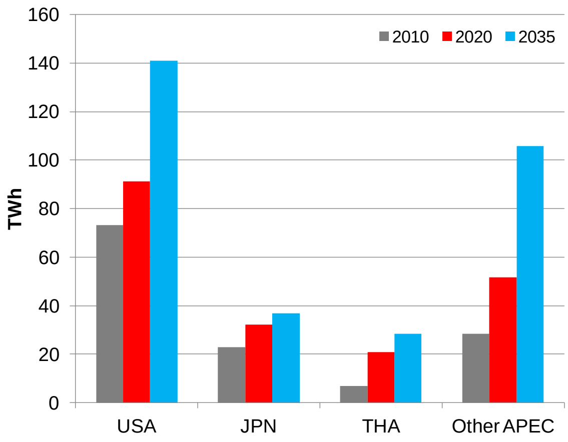
Biomass Power Generation

Biomass feedstock fuels used for electricity generation include forest wood and residuals, industrial waste, municipal waste and landfill gases. The most scalable biomass fuel source is from forests, where much of the projected growth in biomass generation in the APEC region will be sourced. Biomass has an increasing role as a feedstock for direct use in electricity production but also as a feedstock that is blended with coal to reduce GHG emissions.

Biomass is also expected to play an increasing role in improving energy security, as well as reducing emissions throughout APEC economies. The APEC-wide average annual growth rate in biomass generation is 3.5% over the outlook period.

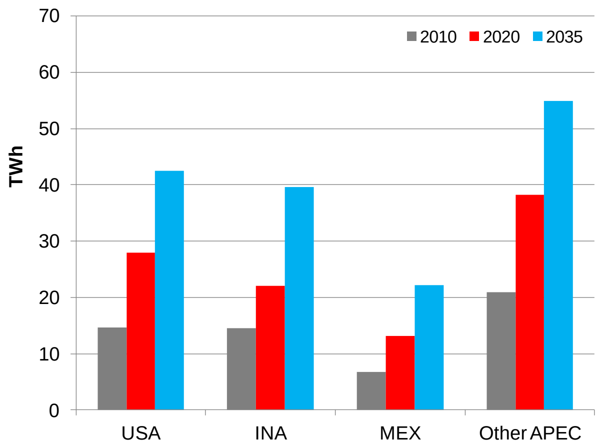
For the US, biomass use is vital to meeting many of the State Renewable Portfolio Standards for emission reductions (US EPA, 2012). Over the outlook period, the US will see rapid growth in biomass-based generation, with an average annual growth of 2.7%.

Figure 15.7: Biomass-based Generation Growth, Top Three and Other APEC Economies (2005–2035)



Source: APERC Analysis (2012)

Figure 15.8: Geothermal-based Generation Growth, Top Three and Other APEC Economies (2005–2035)



Source: APERC Analysis (2012)

Geothermal Power Generation

In some APEC economies, geothermal is one of the most economically attractive NRE sources. A major advantage of geothermal energy is that it can provide dependable base-load power generation. However, the potential for geothermal development in APEC is limited by its resource potential. Only around half of all APEC economies will have a geothermal capacity exceeding 300 MW by 2035 under BAU assumptions.

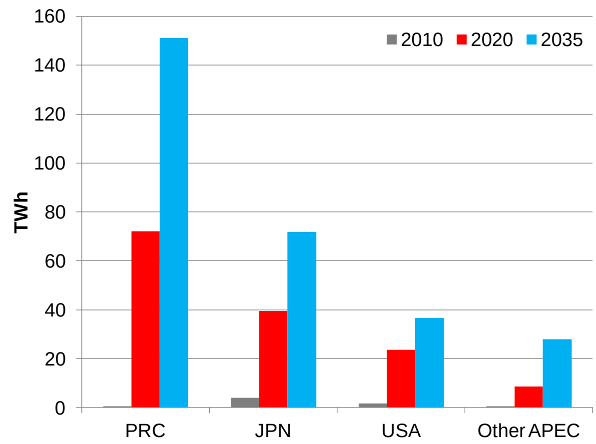
In the APEC region geothermal power generation is expected to grow at around 4.2% per year over the outlook period. The United States will lead the growth in geothermal-based generation, reaching 43 TWh in 2035, followed by Indonesia and Mexico. Australia, Chile and Japan are also likely to see modest growth in geothermal power generation.

Owing to its small electricity demand and attractive geothermal resources, the share of geothermal generation in New Zealand will reach 19% of its total generation in 2035—the highest in the APEC region.

Solar Power Generation

As discussed earlier, solar technology is advancing rapidly. From a base of near zero in 2010, solar-based electricity output (lead by China, Japan and the US) will reach over 288 TWh in 2035. This is an average annual growth rate of 16%.

Figure 15.9: Solar-based Generation Growth, Top Three and Other APEC Economies (2005–2035)

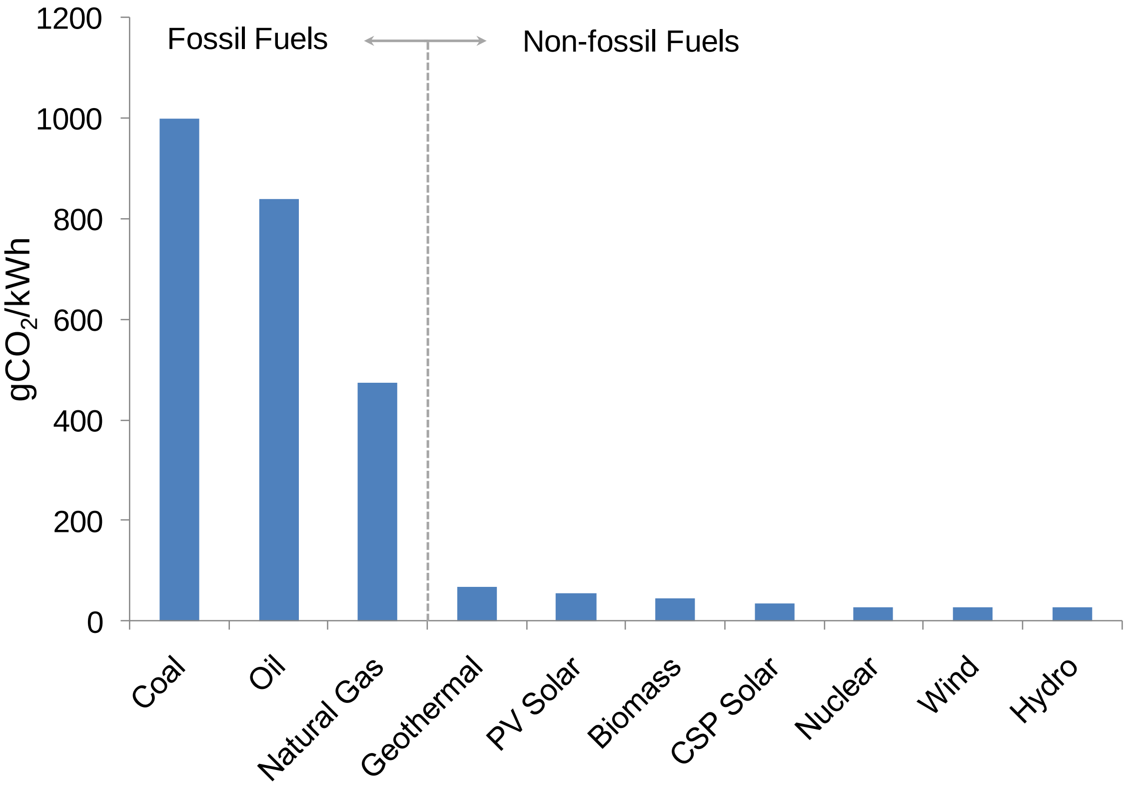


Source: APERC Analysis (2012)

Lifecycle Emissions of Renewable and Non-Fossil Electricity Generation

While the energy security benefits of electricity generation from renewable and non-fossil energy sources are readily apparent, there are often misunderstandings as to whether it offers significant reductions in greenhouse gas emissions on a lifecycle basis. Obviously, renewable and non-fossil generation, as the names suggest, use non-fossil energy sources. However, since the technology to extract this energy often involves an extensive upfront investment in manufacturing and construction, net emissions benefits must consider all stages of development and all production inputs. The World Nuclear Association (WNA) and Intergovernmental Panel on Climate Change (IPCC) have each summarized the findings from a comprehensive number of different research analyses. Based on these two sources, the median lifecycle emissions for each generation technology were estimated and are shown in Figure 15.10.

Figure 15.10: Median Lifecycle Emissions Estimates, by Electricity Generation Technology



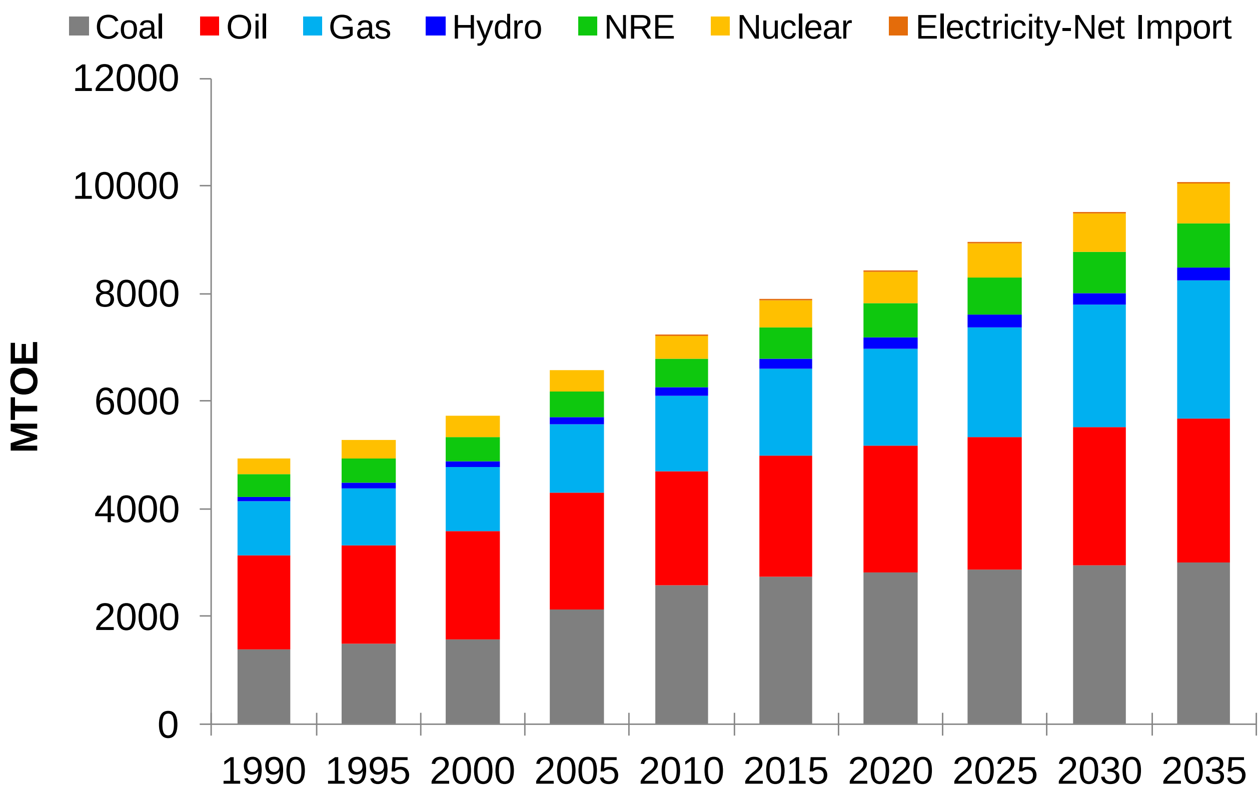
Sources: Adapted from WNA (2011) and IPCC (2011, p. 732)

Figure 15.10 illustrates the clear divide in lifecycle CO_2 emissions between fossil and non-fossil generation. Among fossil fuels, natural gas generation has the lowest lifecycle emissions, while geothermal and PV solar have the highest lifecycle emissions of the non-fossil fuels. (In earlier years, PV lifecycle emissions were noticeably higher than shown in Figure 15.10. However, advances in manufacturing and technology have now reduced PV solar lifecycle emissions estimates to levels comparable with other renewable energy technologies.) Overall, CO_2 emissions on a lifecycle basis for both geothermal and PV solar are less than natural gas by more than a factor of 6.

DIRECT USE OF NRE

The NRE share of the total APEC primary energy supply was 7.3% (530 Mtoe) in 2010. Of this, about 80% was used directly, rather than converted to electricity. In 2035, the NRE share is projected to have increased to 8.1% (818 Mtoe), of which about 41% is expected to be used directly. NRE resources are currently dominated by biomass, and this is expected to remain the case in 2035.

Figure 15.11: APEC Region Total Primary Energy Supply Mix (1990–2035)



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

NRE Use in the Residential Sector

NRE utilization in the APEC region varies depending on the resources and technology available. Biomass resources such as wood, animal dung and agricultural residues have been used for many centuries for residential cooking, space heating and lighting. These fuels are still widely used by the poor in some less developed areas of the APEC region, where commercial fuels are too expensive or unavailable. The use of residential biomass may have negative impacts, especially in terms of severe indoor air pollution, which causes diseases and respiratory problems. Gathering of biomass may reduce the fertility of the land. In addition, residential biomass use may also lock people, especially women and children, into poverty, since time spent gathering fuel means reduced time for education and income-generating activities (APERC, 2009, p. 45).

In the APEC region, rising incomes, improved availability of commercial fuels and urbanization will likely work against the use of residential biomass. However, there are many uncertainties about residential biomass, starting with a lack of basic data: since most residential biomass is never traded commercially, it is not possible to survey producers or marketers.

It is likely that residential biomass will continue to be popular in the APEC region throughout the outlook period, given its affordability and availability, and the cultural preferences for wood fires and wood cooking. This need not be a cause for concern, as modern technology allows biomass to be produced in an environmentally sustainable fashion and to be burned cleanly and efficiently. It is important that government policies ensure that this modern technology gets applied, and that those who use residential biomass do so by choice, and not by poverty-driven necessity.

NRE Use in the Commercial and Industrial Sectors

More sophisticated methods are also being developed to extract energy cleanly and more efficiently from solar and geothermal resources, as well as from biomass, for non-power applications in the commercial and industrial sectors. These include:

- *Biomass energy.* The pulp and paper, forest products, food, and chemical industries are examples of industries that utilize biomass energy directly in their industrial processes by burning their own waste products. Biomass feedstock can now be transformed into more convenient solid, liquid or gaseous forms to generate heat for industrial processes and combined heat and power (CHP) systems (IPCC, 2011, p. 217).
- *Solar energy.* New buildings are being designed to effectively manipulate solar energy for heating, cooling and natural lighting. This method is called 'passive solar technology', whereas 'active solar technology' uses collectors with chemical, mechanical or electrical elements to collect, circulate and store heat from solar energy more effectively. A popular use for solar energy in Asian countries is the domestic solar water heater, which is a cost-effective system to generate hot water for bathing and washing.
- *Geothermal energy.* Direct applications of geothermal energy include space heating, bathing and balneology (therapeutic use of baths), horticulture (greenhouses and soil heating), industrial process heat and agricultural drying, aquaculture (fish farming) and snow melting (IPCC, 2011, p. 416).

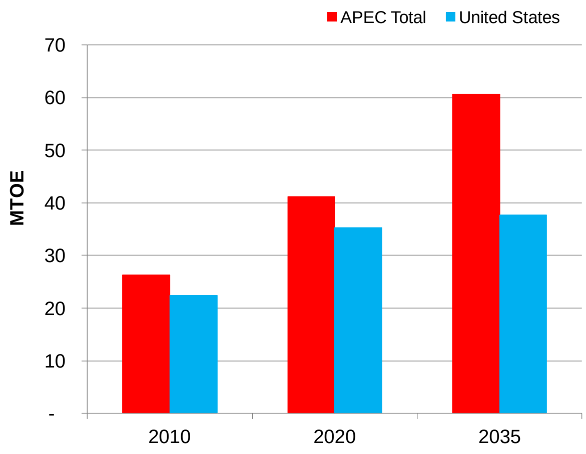
NRE Use in the Transport Sector

Biomass feedstock can be converted into liquid biofuels such as ethanol and biodiesel for use in road transportation. Ethanol today is made primarily from corn and sugar cane, while biodiesel can be produced from virgin plant oils, waste vegetable oil, animal fats, fish oil and algae (REN21, 2011, p. 31). These are categorized as first-generation biofuels.

While first-generation biofuels provide net energy benefits, when all associated emissions are accounted for, biofuels may produce more greenhouse gas emissions than they avoid. There are also added negative externalities in the form of rising food costs and damage to local ecosystems (APERC, 2009, p. 78).

Second-generation technology is expected to solve some of the problems of today's commercial biofuels. 'Cellulosic' biofuel can be made from almost any plant, as well as from forestry and agricultural residues and from city waste. It has even been reported that this advanced biofuel could help cut transport emissions by 80% (Renewable Energy World, 2011). However, due to the significant production and technological challenges, as of 2012 there is still no large-scale commercial production of second-generation biofuels. Many organizations are working, some with government support, to commercialize various pathways for producing cellulosic biofuels. Until these second-generation technologies are deployed, the increased energy security offered by biofuels comes at a high cost.

Figure 15.12: Biofuel Use in Transport Sector in APEC Economies



Source: APERC Analysis (2012)

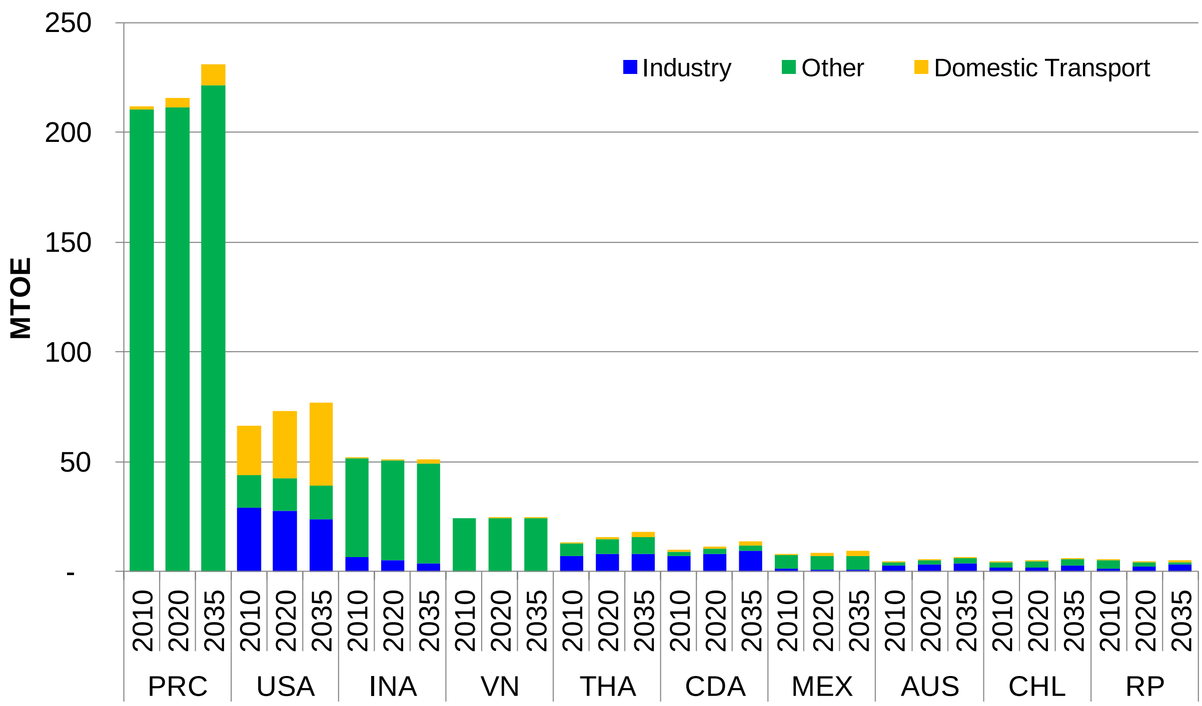
From Figure 15.12, it can be seen that the United States is the leading biofuel consumer in the APEC region, consuming up to 85% of the total 26 Mtoe biofuel demand in 2010. As other economies begin to adopt the technology, the United States share is expected to decline, reaching about 62% by 2035, with China taking up 15.5%, Thailand 4.5%, and Mexico 3.8%.

Projections for Direct Use of NRE in the APEC Region by Economy

Projections of direct use of NRE in APEC economies by sector are shown in Figures 15.13 and 15.14. As noted earlier, data on direct use of renewable energy is limited, so available data may not represent a complete picture of NRE utilization.

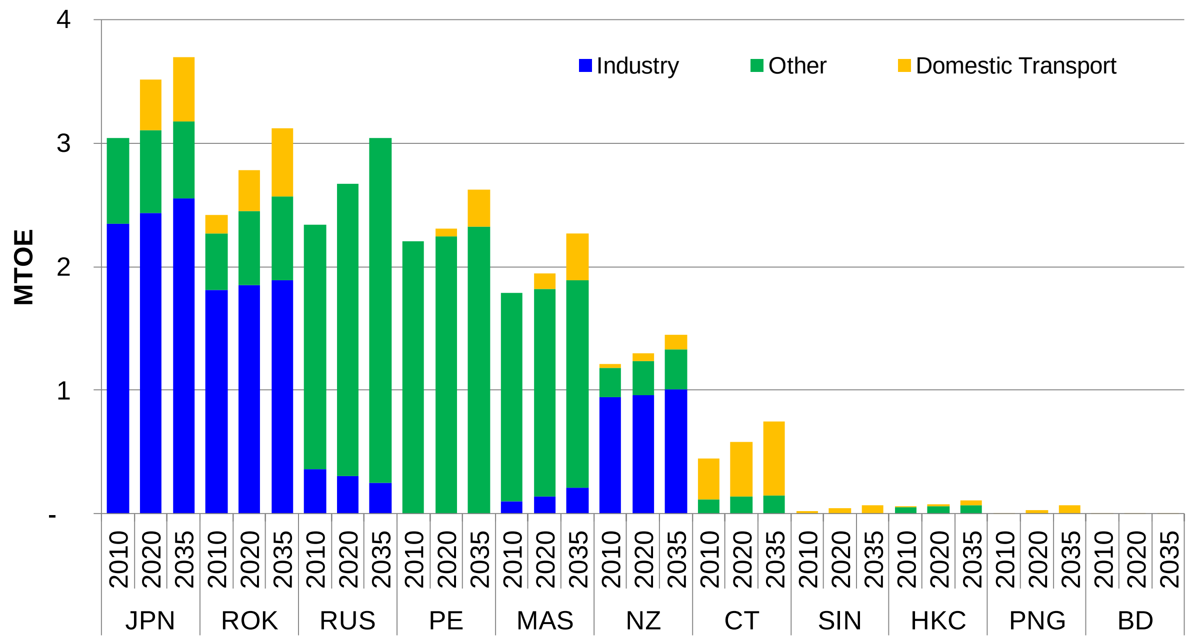
Overall, direct use of NRE will show an increase across all economies. Developing economies like China and Indonesia tend to use more NRE sources in the 'other' sector, while developed economies like United States, Japan and Korea use more NRE in industry. NRE use in the 'other' sector in developing economies would mostly be for residential biomass—with better access to commercial energy, biomass use in the residential sector would decline. However, this reducing trend in residential biomass use would likely be offset by the growth of modern NRE direct use technologies in the industry and transport sectors. By 2035, China will account for about half of NRE direct use in the APEC region, followed by South-East Asian economies (24%) and North American economies (19%).

Figure 15.13: Direct Use of NRE by Sector, Larger Supplying Economies



Source: APERC Analysis (2012)

Figure 15.14: Direct Use of NRE by Sector, Smaller Supplying Economies



Source: APERC Analysis (2012)

REFERENCES

APERC (Asia Pacific Energy Research Centre) (2009), *APEC Energy Demand and Supply Outlook 4th Edition, Volume 1*, www.ieej.or.jp/aperc/

IEA (International Energy Agency) (2010), *Technology Roadmap: Solar Photovoltaic Energy,* www.iea.org/publications/freepublications/publication/pv_roadmap-1.pdf

— (2011), *World Energy Statistics 2011,* retrieved from OECD/IEA CD-ROM Service.

IHS Consulting (2012), *Mapping Key Trends in Leading Global Renewable Power Markets*, presentation at the IHS Focus Forum on Emerging Energy Research, Japan, 30 August 2012.

IPCC (Intergovernmental Panel on Climate Change) (2007), *Fourth Assessment Report 2007: Mitigation of Climate Change,* www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter4.pdf

— (2011), *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change,* http://srren.ipcc-wg3.de/report

LBNL (Lawrence Berkeley Laboratory) (2011), *Tracking the Sun IV: A Historical Summary of the Installed Cost of Photovoltaics in the United States from 1998–2010,* http://eetd.lbl.gov/ea/emp/reports/lbnl-5047e.pdf

REN21 (Renewable Energy Policy Network for the 21st Century) (2011), *Renewables 2011: Global Status Report*, www.ren21.net

Renewable Energy World (2011), 'Second-Generation Biofuels Gain Traction but Growth Challenges Remain', 6 May, www.renewableenergyworld.com/rea/news/article/2011/05/second-generation-biofuels-gain-traction-but-growth-challenges-remain

US EPA (United States Environmental Protection Agency) (2012), *Carbon Pollution Standard for New Power Plants,* http://epa.gov/carbonpollutionstandard/index.html

WNA (World Nuclear Association) (2011), *Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources,* www.world-nuclear.org/uploadedFiles/org/reference/pdf/comparison_of_lifecycle.pdf