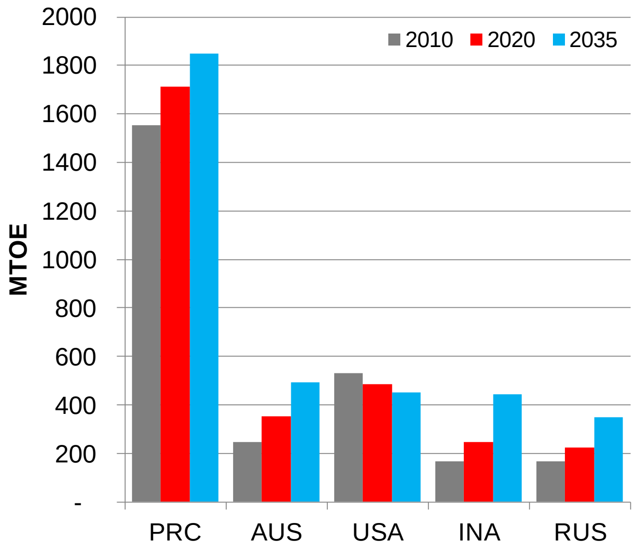
13 COAL SUPPLY

COAL PRODUCTION

Under business-as-usual (BAU) assumptions, coal production in the APEC region will continue to grow by 0.9% per year during the outlook period. It will amount to 3703 million tonnes of oil equivalent (Mtoe) in 2035 or about 37% more than in 2009. All 15 existing coal producing economies will continue to produce coal, while Papua New Guinea may start some minor production.

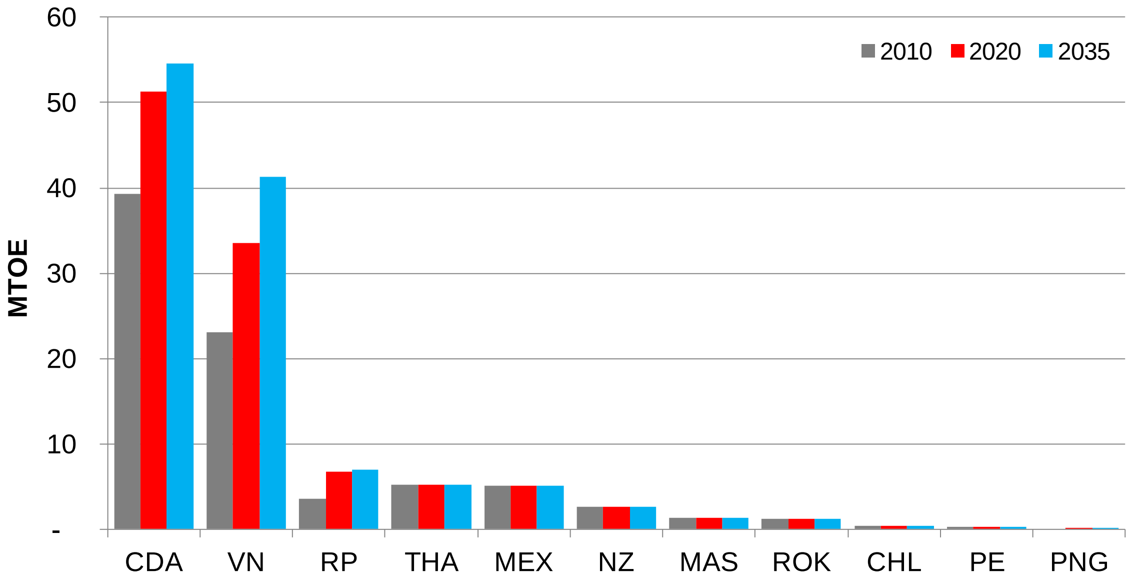
The five major coal producing economies (China, Australia, United States, Indonesia and Russia) are projected to maintain their 97% share of APEC's coal production throughout the forecast period. China will continue to be the major coal producing economy not just among the APEC economies, but worldwide. Production in China will be 1849 Mtoe in 2035, or about 50% of the APEC region's production; it was 57% in 2009.

Figure 13.1: Projected Coal Production in Mtoe, Major Coal Producing Economies



Source: APERC Analysis (2012)

Figure 13.2: Projected Coal Production in Mtoe, Other Economies



Source: APERC Analysis (2012)

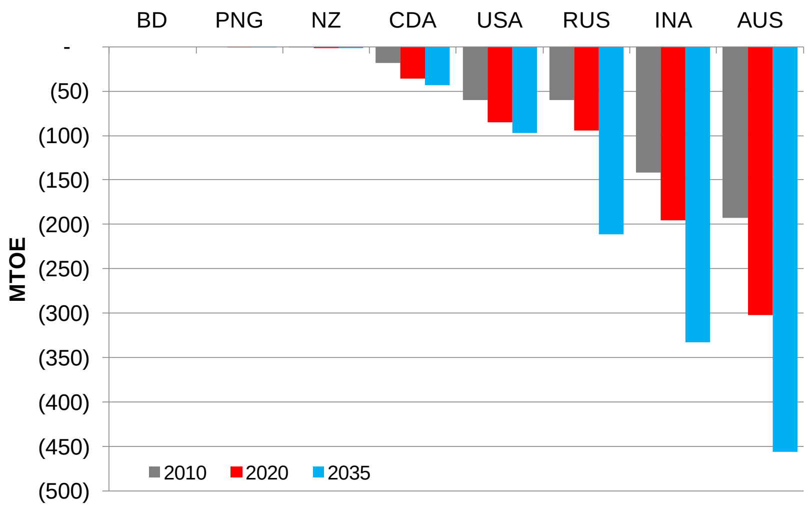
COAL IMPORTS AND EXPORTS

The APEC region is likely to be a net coal exporting region. Australia, Indonesia, Russia, United States and Canada will be able to supply 1046 Mtoe of coal to the international market in 2035. Papua New Guinea and New Zealand may start some minor export.

Figures 13.3 and 13.4 show that by 2035 there will be seven net coal exporting economies in APEC, and 13 more APEC economies that are net importers of coal. Brunei Darussalam is projected to have no production, consumption, imports, or exports of coal during the outlook period.

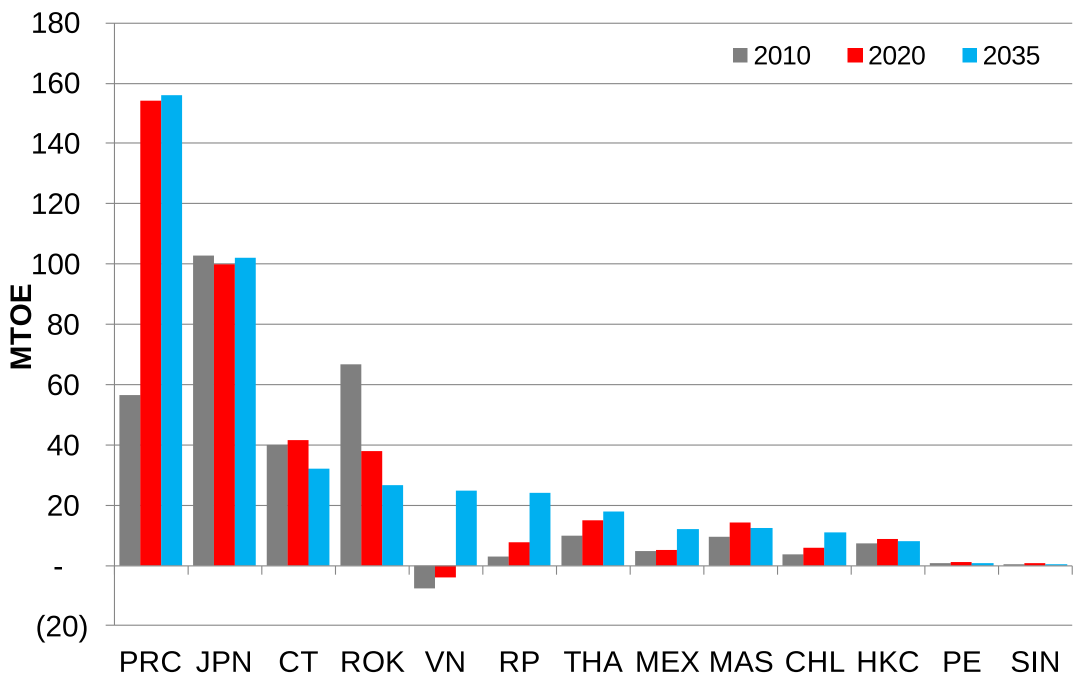
The largest coal importing economies are China, Japan, Chinese Taipei and Korea. Coal imports by Japan are projected to decline in the 2020–2035 period. China will be a large and growing net importer of coal, but imports will supply only about 5% of its demand in 2035. Viet Nam will become a net coal importer after 2020.

Figure 13.3: Projected Net Export (-) of Coal, APEC Coal Exporting Economies, in Mtoe



Source: APERC Analysis (2012)

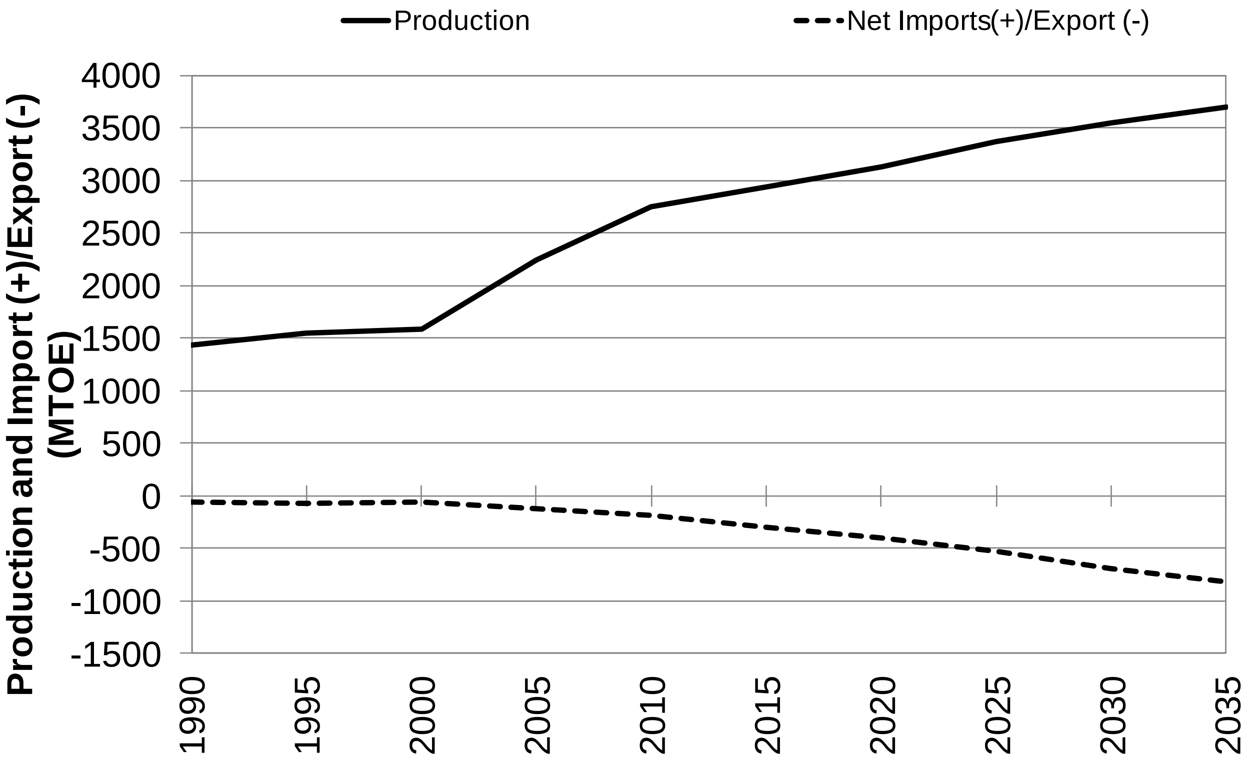
Figure 13.4: Projected Net Import of Coal, APEC Coal Importing Economies, in Mtoe



Source: APERC Analysis (2012)

As shown in Figure 13.5, net coal exports of the APEC economies are projected to increase from 122 Mtoe in 2009 to 715 Mtoe in 2035 under BAU assumptions. Note that negative net imports are exports.

Figure 13.5: Projected Production and Net Imports of Coal, all APEC Economies, in Mtoe

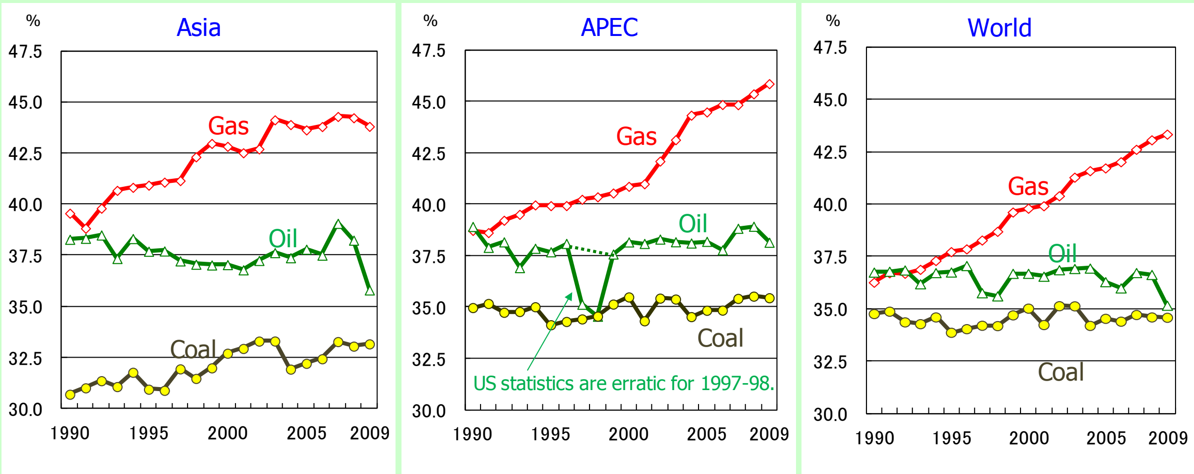


Source: APERC Analysis (2012)

IMPROVING THE EFFICIENCY OF COAL-FIRED ELECTRICITY GENERATION

In 2009, fossil fuels for electricity generation amounted to 38% of the world's total primary energy supply (TPES)—coal was dominant among them with a share of 47%. Thus, the efficiency of coal generation is a key for reducing greenhouse gas emissions. However, world coal generation efficiency has been hovering at around 35% for decades, while natural gas generation efficiency has improved remarkably as a result of combined cycle gas turbine (CCGT) technology. Due to the high cost of oil, oil generating plants are generally being phased out, with little new construction or replacement of plants being done.

Figure 13.6: Efficiency of Electricity Generation Technologies



Source: *World Energy Statistics* 2011 © OECD/IEA 2011

The lower efficiency of coal generation is because the energy density of coal is lower than that of oil and gas and, as coal is a solid, its combustion control is complicated. It is more so when low quality coals with high ash contents or high moisture contents are used.

At traditional coal generating plants, efficiencies may be assessed in three areas: coal combustion at the boiler, driving the steam turbines, and running supplementary systems (such as moving and pulverizing coal before burning, exhaust gas treatment to remove particulates, SOx and NOx, and ash disposal). Needless to say, coal preparation is an important process before combustion. Ramping rates and the optimum operation of the power plant are also important factors.

Regarding coal combustion, various technologies were tested in the 1960s and 1970s, and pulverized coal burning has become the standard technology. Recent efficiency improvements are mainly achieved through improvements in driving the steam turbines. In general, higher temperature and higher pressure steam drives turbines more efficiently. Turbine driving technology has evolved from the 'sub-critical' system to the 'super-critical' (SC) system. The latter uses steam above the critical temperature and pressure where distinct liquid and vapour phases cease to exist. The SC technology was adopted in Japan around 1980. It was further upgraded to the 'ultra-super critical' (USC) system in the late 1990s, with steam temperatures around 600 degrees C. The typical design efficiency (based on sent-out electricity and lower heating values of the coal) is:

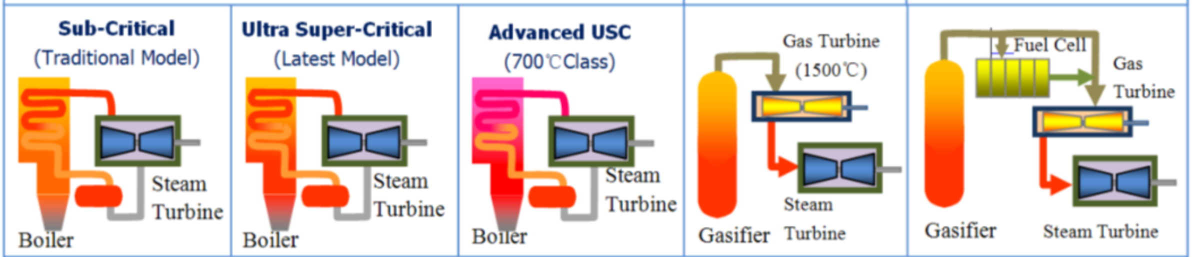
- below 38–40% for sub-critical plants (250 MW class, typically at 16.6 megapascals (MPa), 566(main steam)/538(recovery steam) degrees C)
- 40–42% for super-critical plants (500-1000 MW class, typically at 24.1 MPa, 538/538 degrees C)
- 41–43% for ultra-super critical plants (600–1000 MW class, typically at 25 MPa, 600/610 degrees C).

The best USC plants in Japan have achieved 45% efficiency (25 MPa, 600/620 degrees C). Currently, a 700 degrees C, 35 MPa turbine system is under development as an 'advanced USC' (A-USC) aiming at a generating efficiency of 52% or a sent-out efficiency of 50% (J-Power, 2011).

Water becomes highly corrosive under super-critical conditions. The manufacture of USC systems requires high quality materials to cope with the high temperatures, pressures and corrosiveness. Sub-critical plants are still used in many economies as they are less expensive. Some may not even have exhaust gas treatment systems to remove particulates, SOx and NOx, resulting in heavily polluted air. Such situations need to be improved as soon as possible.

Figure 13.7: Improving Coal Thermal Plant Efficiencies

Steam Thermal using Pulverized Coal Combustion			IGCC	IGFC
Sub-Critical (Traditional Model)	Ultra Super-Critical (Latest Model)	Advanced USC (700℃Class)		



	Sub-Critical	Ultra Super-Critical	Advanced USC	IGCC	IGFC
Approx. ΔCO_2:	Base	-15%	-25%	-25%	-35%
Efficiencies					
Generated:	40%	45%	52%	51–53%	60%+
Sent-out:	37%	43%	50%	48–50%	55%+
	Many	J-Power, TEPCO, etc	Under development		

Sources: J-Power (2011), Energia (2010), METI (2009) and IEEJ (2012)

In addition to research and development on A-USCs, higher efficiency technologies are being developed to burn a synthetic gas produced from coal (coal gasification). This technology would bring the efficiency of natural gas CCGT generation to coal generation. Known as IGCC (integrated coal gasification combined cycle), such a hybrid system would burn the gas in a gas turbine then use recovered heat to produce steam to drive a steam turbine. An IGCC plant with a 1500 degree C gas turbine is expected to achieve 51–53% net energy efficiency. Although this is lower than the efficiency of natural gas CCGT generation (CCGT has already achieved 60% efficiency with 1600 degree C gas turbines at the #4 system of Tokyo Electric's Futtsu Power Station), IGCC will improve coal generation efficiency by almost 20% to 51–53%, from 43–45% for the best existing USCs. A further technological development would be an IGFC (integrated coal gasification fuel cell) system, using fuel cells on top of IGCC. IGFC aims at further efficiency improvements to above 60%. These technologies are now being intensely researched. They are expected to reduce greenhouse gas emissions substantially, especially when used in combination with carbon capture and storage.

In Japan, a verification test of IGCC with 1200 degree C gas turbines is being conducted on a commercial scale plant at the Nakoso Power Station by the Clean Coal Power R&D Co., Ltd. (a joint venture of Japanese power companies). At present, many developing economies are introducing SC and USC technology; the latter will dominate as the main technology for the near future. With the existing best USC systems, global coal thermal efficiency can be improved from 35% to 45%.

Although USC is an effective technology, its benefits would be limited where low-quality coal is the main fuel source, as the high moisture and ash contents prohibit efficient burning. Coal gasification can overcome this limitation by extracting pure gaseous fuel from the coal before burning. According to a recent study by the Institute of Energy Economics, Japan (IEEJ) on a renovation plan for a power plant in an Asian economy burning lignite, generation efficiency by the existing sub-critical system (16.1 MPa, 538/538) is 36.2% and that for a USC system (24.5 MPa, 600/600) will be 38.4%. Compared with this, an IGCC system (10 MPa, 550/550) is expected to achieve a 43.4% net generation efficiency (IEEJ, 2012). Thus, IGCC will bring significantly improving efficiencies to generating plants burning low quality coal, which are common all over the world.

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