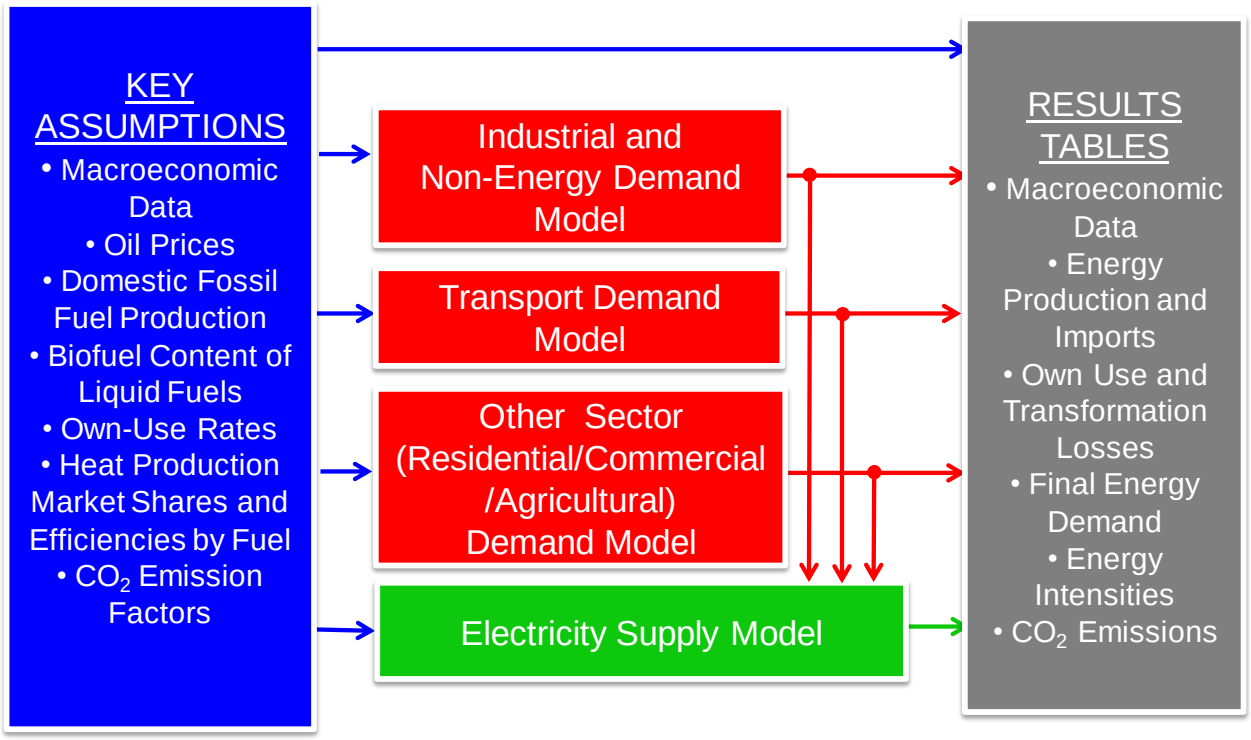
3 OVERVIEW OF APERC'S ENERGY DEMAND AND SUPPLY MODEL

Figure 3.1: Structure of APERC's Model



This chapter presents an overview of the model APERC has used to project energy demand and supply by economy and for APEC as a whole. It also discusses the key assumptions that were made in developing these projections.

MODEL OVERVIEW

Figure 3.1 shows the overall structure of the model for each economy; the model is always the same for each of the 21 APEC economies. APERC's regional and APEC-wide results are simply sums of results for the relevant economies.

The modelling process begins by assembling a database of key assumptions for each economy. These key assumptions are either required by more than one of the sub-models or are used in the summary sheets to estimate results not modelled in one of the sub-models. These key assumptions include:

- historical and projected macroeconomic data (including population, GDP, employment, and agricultural value-added projections)
- historical and projected crude oil prices
- historical and projected domestic fossil fuel production (including coal, oil, and gas)
- historical and projected percentage content of biofuel in road gasoline, road diesel, and rail diesel
- historical and projected average energy sector own-use rates (for coal, oil, and gas)
- historical and projected fuel shares and efficiency rates for heat production (coal, oil, gas, new renewable energy (NRE), and nuclear)
- CO_2 emissions factors for coal, oil, and gas.

The development of these key assumptions estimates is discussed in subsequent sections of this chapter.

There are three sub-models that estimate energy demand in key sectors. These are:

- *The Transport Demand Model.* This sub-model projects demand in the transport sector, for both domestic and international transport. It is discussed in more detail in Chapter 5 on Transport Sector Energy Demand.
- *The Industrial Demand Model.* This sub-model projects demand in the industrial sector, for both energy consumed in industry and 'non-energy'. Non-energy refers to coal, oil, and gas used as feedstocks in the production of petrochemicals and other non-fuel products. This sub-model is discussed in more detail in Chapter 6 on Industrial Sector Energy Demand.
- *The Other Sector Demand Model.* This sub-model projects demand in the residential, commercial, and agricultural sectors. It is discussed in more detail in Chapter 8 on Residential, Commercial, and Agricultural Sector Energy Demand.

These three sub-models also require a number of additional assumptions. These are examined in the chapters that discuss each sub-model.

The fourth sub-model is:

- *The Electricity Supply Model.* This takes as inputs the demand for electricity projected by the three sub-models (above) and simulates the production of this electricity from primary fuels. It also simulates the capacity expansion for each type of electricity generating capacity.

Finally, the Results Tables pull together the results of all four sub-models and present them in an organized fashion. They include a complete energy supply and demand balance sheet for each economy, known as the Summary Table.

The Results Tables are, however, not just passive reports; they contain 'models' for some outputs not modelled in the four sub-models, although the models are fairly simple. These outputs include:

- *Energy sector own-use.* This is the energy consumed in the energy sector itself, including in energy production and in refineries. These projections are based on the loss rates in the Key Assumptions database (see above). However, energy losses in the production, transmission, and distribution of electricity are modelled in the Electricity Supply Model. The demand for fuel used to operate gas and oil pipelines is modelled in the Transport Demand Model.
- *CO_2 emissions from energy combustion.* These are modelled by multiplying the assumed emissions factors for each fuel by the quantities of each fuel demanded. This modelling is discussed in more detail in Chapter 16 on Carbon Dioxide Emissions.
- *Liquid biofuel demand.* The Transport Demand Model estimates the final demand for gasoline and diesel fuel in the road sector and diesel fuel in the rail sector. The Results Tables break each of these demands into the demand for oil product and the demand for biofuel, based on the percentage content of biofuel shown in the Key Assumptions database (see above).
- *Heat production.* The Other Sector Demand Model and the Industrial Demand Model estimate the demand for heat (usually in the form of steam) in these sectors. The Results Tables use the fuel shares and efficiency rates shown in the Key Assumptions database (see above) to estimate the demand for the primary fuels needed to produce heat. Note, 'heat production' refers only to heat produced for sale; it does not include self-produced heat.

The Results Tables also calculate projected energy intensities for each economy (see Chapter 2) and produce a set of graphs for each economy, some of which are reproduced in Volume 2.

Because of their size, the Results Tables for each economy are not reproduced in this report. Rather, they are available on-line on the APERC website http://aperc.ieej.or.jp. There is an on-line document that explains how to read the Results Tables and defines the terms used.

The APERC website includes business-as-usual (BAU) Results Tables for each APEC economy, along with a Results Table for the APEC region as a whole. It also includes a similar set of Results Tables for the High Gas Scenario discussed in Chapter 12 on Natural Gas Supply.

HISTORICAL DATA SOURCES AND KEY ASSUMPTIONS

This section discusses the historical data sources and key assumption projections for key assumptions other than macroeconomic data, oil prices, and domestic fossil fuel production. Macroeconomic data and oil prices are discussed in later sections of this chapter. Domestic fossil fuel production is discussed in Chapter 10 on Primary Energy Demand and Supply.

Historical Data on Energy Demand and Supply

Many of the graphs and tables in this outlook report, as well as the Results Tables, show historical data for 2009 and prior years for comparison with APERC's future outlook. For all economies except Papua New Guinea, this data is from International Energy Agency (IEA) statistics (IEA, 2011c). It is reproduced here with the kind permission of the IEA and is ©2011 IEA/OECD. For Papua New Guinea, the historical data is from the APEC Energy Database (APEC, 2011).

Biofuel Content of Gasoline and Diesel

Historical data on the percentage content of biofuel in road gasoline, road diesel, and rail diesel was obtained from the IEA (IEA, 2011c). Future projections for the BAU scenario were estimated by APERC researchers based on the requirements of the existing laws and regulations in each economy. For economies with no legal biofuel requirements, researchers estimated the amount of biofuel that might be economic in a competitive market, which was generally a very small or zero amount.

Energy Sector Own-Use Rates

Historical data on the percentage energy sector own-use of each fuel was obtained from the International Energy Agency (IEA, 2011c). In most cases, the 2009 percentage rates were assumed to continue into the future. However, in some cases APERC researchers made adjustments based on projected changes to the economy's energy infrastructure or production methods.

Fuel Shares and Efficiency Rates for Heat Production

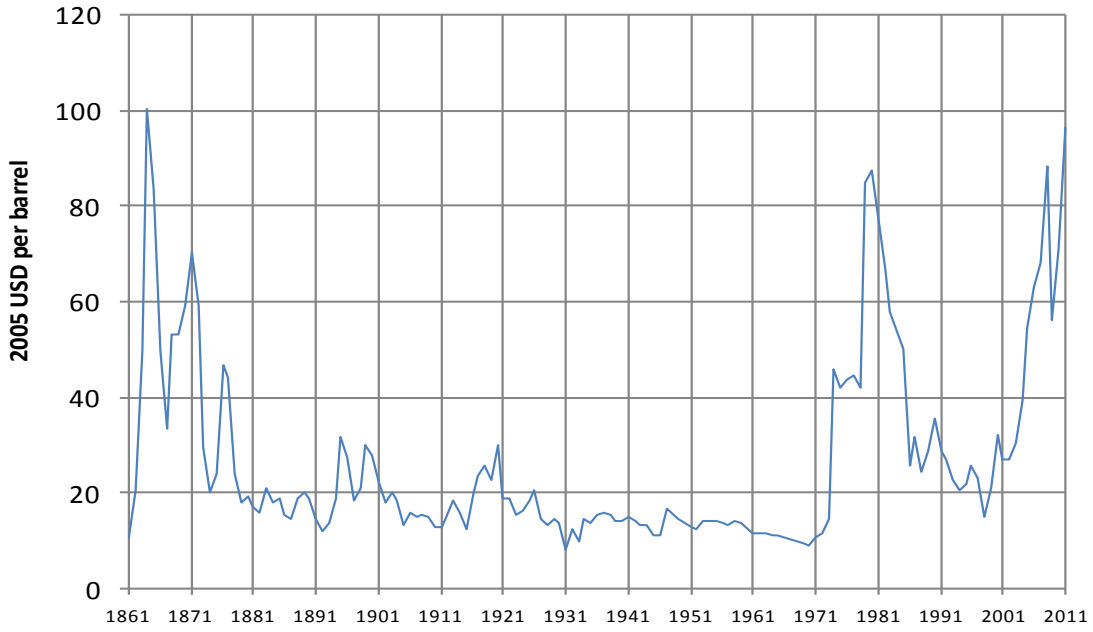
Historical data on fuel shares and efficiency rates for heat production for each fuel was obtained from the IEA (IEA, 2011c). In most cases, the 2009 fuel shares and efficiency rates were assumed to continue into the future. However, in some cases APERC researchers made adjustments based on projected changes to the economy's energy infrastructure or primary energy production. Note, only a few APEC economies have significant commercial heat production.

OIL PRICE AND AVAILABILITY ASSUMPTIONS

Crude Oil Prices and Resources Availability

As depicted in Figure 3.2, crude oil prices have been historically volatile. Particularly since the 1970s, oil prices have been susceptible to geopolitical events that have affected global supply. The major price upswings were caused by the Arab Oil Embargo and the Iranian Revolution in the 1970s, and more recently by the Iraq War and the social movements known as the 'Arab Spring' in North Africa and the Middle East. This volatility has made crude oil prices rather complex to analyse and project.

Figure 3.2: International Crude Oil Prices, 1861–2011



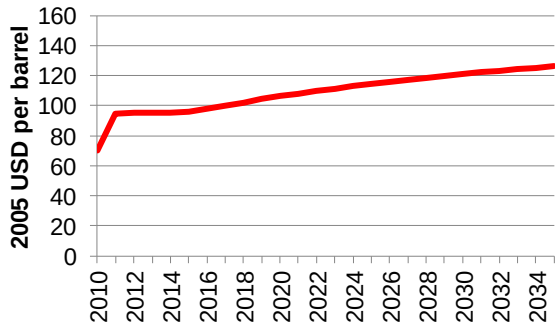
Source: BP (2012)

APERC bases its crude oil price assumptions on the modelling work of the IEA for their *World Energy Outlook 2011* (IEA, 2011b). In particular, APERC follows the crude oil price assumptions of the IEA's Current Policies scenario which, like APERC's BAU scenario, assumes the continuance of existing policies. The IEA bases its crude oil price projections on a sophisticated field-by-field model of the worldwide crude oil supply (IEA, 2011a).

There are many different crude oil prices in the world. The crude oil price projected by IEA is an average price for crude oil imports into IEA member economies. However, over the long term, this price tends to closely mirror the price of key marker crudes, such as Brent and West Texas Intermediate (WTI).

Figure 3.3 shows APERC's assumed crude oil prices for this edition of the *APEC Energy Demand and Supply Outlook*. The oil price assumed by 2035 amounts to USD 126 per barrel, and represents a 79.2% jump from the IEA's 2010 average crude oil import price. Despite the smooth trend suggested by the projection, unpredictable events are nearly certain to cause prices to continue to fluctuate dramatically, as they have in the past.

Figure 3.3: APERC's Crude Oil Price Assumptions, 2010–2035



Note: Actual data from 2010 and 2011
Source: IEA (2011b)

Aside from the uncertainties due to unpredictable short-term events, there are also uncertainties about the long-term evolution of oil supply. In particular, the perspectives of analysts differ on the long-term sufficiency of oil resources. However, there appears to be a reasonable alignment between the views of the Organization of the Petroleum Exporting Countries (OPEC), which represents the major oil exporting economies, and those of the IEA, which represents the major oil importing economies.

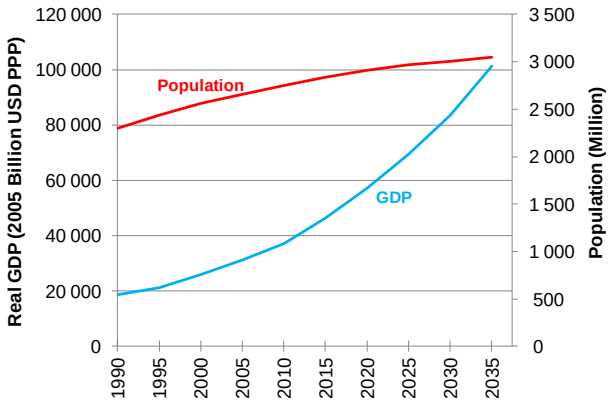
OPEC's opinion is "the world has enough oil resources to meet demand and satisfy consumer needs for decades to come" (OPEC, 2011, p. 2). The IEA's position accepts the "end of cheap oil" and stresses the risks of underinvestment by Middle Eastern and African oil producing countries, but does not appear to question the basic adequacy of oil resources for the foreseeable future (IEA, 2011b, p. 41).

There is a general consensus that unconventional resources will be increasingly important to the world's oil supply, and that these resources will be difficult and costly to develop. Consequently, it is likely higher prices will prevail in the years to come.

MACROECONOMIC DATA ASSUMPTIONS

Figure 3.4 shows the assumed APEC-wide GDP and population up to 2035; Table 3.1 shows the assumed APEC-wide growth rates for GDP and population for the same period. Reflecting the growing GDP share of fast-growing developing economies and the recent demographic trends, the GDP growth rate over the 25-year outlook period is assumed to be slightly higher than that of the previous 20 years, while the population growth rate is a bit lower.

Figure 3.4: Assumed APEC GDP and Population



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

Table 3.1: 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)

GDP, Employment, and Agricultural Value-Added

Historical figures and future projections of GDP, employment, and agricultural value-added for all economies except Brunei Darussalam and Papua New Guinea were obtained from IHS Global Insight (Global Insight, 2012), a well-known macroeconomic forecasting service, as of May 2012. In a few cases, the data was modified by APERC researchers based on data from the United States Department of Agriculture (USDA, 2011) as of December 2011, or from other sources. Projections for 2032–2035 are trend extrapolations by APERC.

For Brunei Darussalam and Papua New Guinea (economies not covered by IHS Global Insight), historical and projected GDP data was obtained from the United States Department of Agriculture (USDA, 2011) as of December 2011. Employment in these economies was assumed to grow in proportion to the population, while agricultural value-added was assumed to grow in proportion to GDP. Projections for 2031–2035 are trend extrapolations by APERC.

For all economies, the original source data on real GDP in local currency was converted to 2005 purchasing power parity (PPP) values using conversion rates from the World Bank (The World Bank, 2008, Summary Table).

Table 3.2 shows the assumed projections of total GDP and GDP per capita, by economy. The economies that have the lowest income per capita in 2010 will tend to have the largest percentage increases in GDP. There will thus be a tendency in the APEC region toward less income disparity between economies by 2035.

Population Assumptions

Historical and projected population figures for each economy are based on data and projections by Global Insight (2012). They are generally based on United Nations projections (United Nations, 2011).

Table 3.2: Assumed Projections of Total GDP and GDP per Capita by Economy

Economy	Total GDP (Billion USD PPP)			GDP Growth Rate (%)	GDP per Capita (USD PPP)		
	2010	2020	2035	2010–2035	2010	2020	2035
Australia	790	1 038	1 533	2.7%	35 460	41 103	52 755
Brunei Darussalam	18	22	28	1.7%	45 763	46 731	50 564
Canada	1 206	1 539	2 170	2.4%	35 383	40 543	49 320
Chile	233	375	724	4.6%	13 644	20 299	36 259
China	9 120	19 564	45 117	6.6%	6 802	14 099	32 415
Hong Kong, China	295	447	729	3.7%	41 818	59 667	86 727
Indonesia	931	1 603	3 341	5.2%	3 880	6 106	11 605
Japan	3 946	4 430	4 672	0.7%	30 807	35 539	40 044
Korea	1 321	1 885	2 727	2.9%	27 415	37 845	54 025
Malaysia	376	576	1 000	4.0%	13 244	17 450	25 325
Mexico	1 410	2 056	3 433	3.6%	12 427	16 326	24 515
New Zealand	110	142	203	2.5%	25 258	29 500	37 570
Papua New Guinea	15	27	45	4.4%	2 217	3 311	4 044
Peru	248	407	788	4.7%	8 417	11 945	20 956
Philippines	332	526	1 006	4.5%	3 561	4 792	7 443
Russian Federation	2 014	2 868	4 505	3.3%	14 348	20 336	33 617
Singapore	264	398	632	3.6%	51 801	71 057	102 588
Chinese Taipei	743	1 078	1 687	3.3%	32 249	47 598	70 611
Thailand	530	783	1 505	4.3%	7 674	10 864	20 392
United States	13 088	16 843	24 362	2.5%	42 157	49 305	62 389
Viet Nam	250	462	1 148	6.3%	2 845	4 803	11 055

Source: APERC Analysis (2012), based on data from Global Insight (2012) and USDA (2012)

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