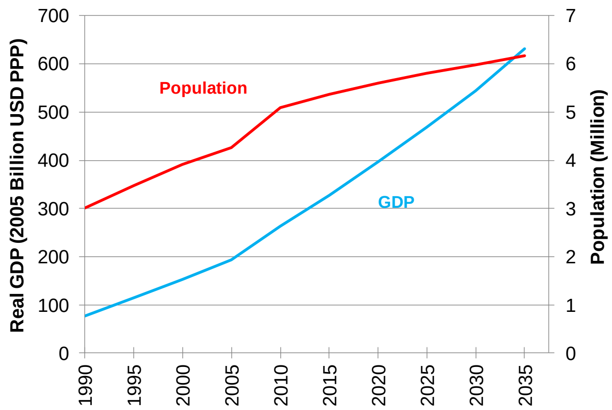
SINGAPORE

- *Singapore's primary energy supply is projected to grow at an average annual rate of 1.1% over the outlook period, dominated by an increasing demand for oil in the transport sector.*
- *As a major logistics hub for the South-East Asia region, Singapore's international transport sector is expected to continue to dominate final energy demand. The domestic transport sector's final energy demand will continue to decline at 0.4% annually.*
- *Final energy intensity is projected to decrease by 38% from 2010 to 2035; however, the absolute amount of CO_2 emitted will continue to grow at 1.8% annually over the same period.*

ECONOMY

The Republic of Singapore is an island city-state located off the southern tip of the Malay Peninsula. It is situated south of the Straits of Malacca on a major shipping route, well-located for the energy industry with regard to international oil refining and trading. It is also an emerging leader in the biotechnology industry. Its total land area is 710 square kilometres (km^2) and it had a population of 4.8 million in 2009, of which 1.2 million were non-residents. The economy's population density is about 7126 persons per km^2. Despite its small land area and population, Singapore is one of the most highly industrialized and urbanized economies in South-East Asia. The climate is hot and humid, with an average temperature ranging from 20 to 35 degrees Celsius and a relative humidity ranging from 80% to 90% throughout the year.

Figure SIN1: GDP and Population



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

Singapore is a mature economy. Its population is expected to grow slightly at 0.8% per year over the projection period. In 2035, the total population is expected to be about 6.2 million.

Singapore is a highly developed and vibrant free-market economy. It is the pricing centre and leading oil trading hub in Asia. In 2011, the service industry contributed 69% of GDP, while manufacturing accounted for 27% (MTI, 2012). Most of the manufacturing output is for export. The top two exports in 2011 were electronic components and parts (31%) and refined petroleum products (26%) (MTI, 2012). Between 2010 and 2035, GDP is projected to grow moderately, at about 3.6% per year or 140% in total growth. By 2035, Singapore's GDP will grow to about USD 632 billion (in 2005 USD PPP) or about USD 102 588 per capita.

Singapore has grown into one of Asia's and the world's leading and most cost effective locations for petrochemical industries. The key for this success is Jurong Island, a collection of seven small islands that is home to three major oil refineries. Singapore is the third-largest oil and oil products trading hub in the world (EDB, 2011). It has a complex refining and petrochemical integration with a refining capacity of about 1.385 million barrels of oil per day (BP, 2012).

Domestic transport energy demand in Singapore mainly comes from road transport. The total length of roads in Singapore is 3411 km and the per capita car ownership rate is about 110 cars per 1000 people (LTA, 2012b). Singapore has been motivated to reduce car ownership and to encourage people to use public transport. Private car ownership has been moderated through the use of various measures, such as mandatory car ownership quotas by limiting the number of vehicle ownership certificates; electronic road pricing on congested roads; a green vehicle rebate to encourage more fuel-efficient vehicles; and trials of green technologies such as diesel hybrid buses and electric vehicles.

Rail transport plays a significant role in the economy. The total length of the mass rapid transit (MRT) and the light rail transit (LRT) systems as of 2011 is 138 km and they handle an average daily ridership of about 2.4 million passengers (LTA, 2012b). The Land Transport Authority of Singapore has targets to expand the rail network to 278 km by 2020, and to increase the rapid transit system (RTS) density from 31 km per million population to 51 km per million population (LTA, 2012a).

Singapore is the busiest sea port in the world in terms of shipping tonnage, with some 120 000 vessel calls annually, and the economy is connected to more than 600 ports in over 120 countries worldwide (MPA, 2009). Singapore's Changi Airport is ranked the seventh busiest international airport. Each week, more than 6200 flights land or depart from Changi Airport, with more than 46.5 million passengers passing through the airport in 2011 (CAG, 2012).

ENERGY RESOURCES AND INFRASTRUCTURE

Singapore has negligible indigenous energy resources, either in fossil fuels or in alternative energy sources. Singapore imports nearly all the fuel it requires for its energy needs, except for a small portion of energy produced from incinerating municipal waste. In 2009, 146.1 Mtoe (million tonnes of oil equivalent) of energy products were imported, mainly consisting of petroleum products, crude oil and natural gas liquids (NGLs), and natural gas that accounted for 61.8%, 33.2% and 5% of energy imports, respectively (EMA, 2011, p. 10). Singapore exported 84 Mtoe of energy products in the same year, consisting mostly of refined petroleum products (EMA, 2011, p. 10).

Oil is mainly imported from the Middle East, and it is mainly used by the transport and industry sectors. Natural gas is imported from Malaysia and Indonesia. Imported natural gas is transported via four offshore pipelines—two pipelines from Indonesia (9.2 million standard cubic metres per day from West Natuna and 9.9 million standard cubic metres per day from South Sumatra) and two pipelines from Malaysia (supplying 4.2 and 2.8 million standard cubic metres per day).

About 80% of Singapore's electricity demand is produced from natural gas as fuel (EMA, 2011, p. 14). As Singapore's demand for gas is expected to exceed supply via pipeline in the near future, Singapore is planning to import LNG (liquefied natural gas). The construction of Singapore's first LNG receiving terminal began in March 2010 on Jurong Island (EMA, 2010). The LNG receiving terminal is expected to begin operations in the second quarter of 2013. It will have an initial capacity of 3.5 million tonnes per year, which will be increased to 6 million tonnes per year by the end of 2013 (EMA, 2010).

Singapore has limited land area and lacks the natural endowments necessary to make use of non-fossil energy alternatives to meet its needs. As such, Singapore is recognized as 'alternative energy-disadvantaged' under the United Nations Framework Convention on Climate Change (UNFCCC) (NEA, 2010, p. 11). The economy does not have any hydro or geothermal resources, and average wind speeds are too low to generate power efficiently or economically. Wave and tidal technologies have limited application as much of Singapore's sea space is used for ports, anchorage and shipping lanes.

Despite these disadvantages, Singapore is keen to adopt renewable energy solutions to improve its energy security. To this end, the Singapore Government has begun to harness energy from solar photovoltaic (PV), waste incineration and bio-gas for power generation. By 2010, 3% of Singapore's electricity generation came from these renewable resources (EMA, 2011, p. 14).

Singapore does not have a nuclear energy industry. However, nuclear energy is considered by the government as a long-term energy supply option for Singapore 20–30 years down the road.

ENERGY POLICIES

The Singapore Government published the National Energy Policy Report in 2007. The report contains a robust national energy framework aimed at meeting the economy's objectives for economic competitiveness, energy security and environmental sustainability (MTI, 2007). Under the policy, the economy has defined the following key energy strategies:

1. Promote competitive energy markets
2. Diversify energy supplies
3. Improve energy efficiency
4. Build an energy industry and invest in energy research and development
5. Promote greater regional and international cooperation
6. Develop a whole-of-government approach.

In 2009, Singapore voluntarily committed to a 16% reduction in emissions below 2020 business-as-usual (BAU) levels, contingent on a legally binding global agreement on climate change in which all countries implement their commitments in good faith (NEA, 2010, p. 37). The Sustainable Singapore Blueprint (SSB) was developed based on this commitment. It details several other energy goals to be achieved by 2030, including reducing energy intensity (per SGD GDP) by 35% from 2005 levels; setting a cap for sulphur dioxide (SO_2) levels at 15 micrograms per cubic metre ($\mu g/m^3$); and improving the recycling rate to 70% (NEA, 2010, p. 5).

The Energy Market Authority (EMA), under the Ministry for Trade and Industry, is mandated to regulate the electricity and piped gas industries and the district cooling services in designated areas. Both the electricity and gas industries have been liberalised—the electricity industry since 1995 and the gas industry since 2008. The gas pipeline network is owned and operated by PowerGas Ltd.

The electricity industry is divided into contestable and non-contestable sectors. The non-contestable consumers constitute 25% of the total electricity sales in Singapore and purchase their electricity from SP Services Ltd at a regulated tariff. Generation companies compete to sell electricity to the National Electricity Market of Singapore (NEMS), established in January 2003. Electricity is then transmitted through the grid network operated by the EMA.

The EMA has launched several initiatives to spur the development of more diverse and sustainable energy solutions. These initiatives include setting up the Electric Vehicles Test Bed for electric vehicles (EVs) that provides an open platform for industry players to test EV prototypes and vehicle charging technologies; setting up the Pulau Ibin Micro-grid Test Bed to assess the feasibility and scalability of electricity supply from a micro-grid infrastructure using an intermittent renewable energy supply; and the Intelligent Energy System (IES) pilot to test and evaluate new smart grid applications and technologies. These initiatives will transform Singapore's energy landscape into something more dynamic, and will enable the economy to spearhead the adoption of new, smart technologies in the region.

Energy efficiency is an integral part of Singapore's energy policy and the Energy Efficiency Programme Office (E^2PO) was established to promote and facilitate the adoption of energy efficiency in Singapore. E^2PO focuses on a sectoral approach to energy efficiency, targeting five sectors namely power generation, industry, transport, building and household. The following outlines some of the ongoing and planned programmes:

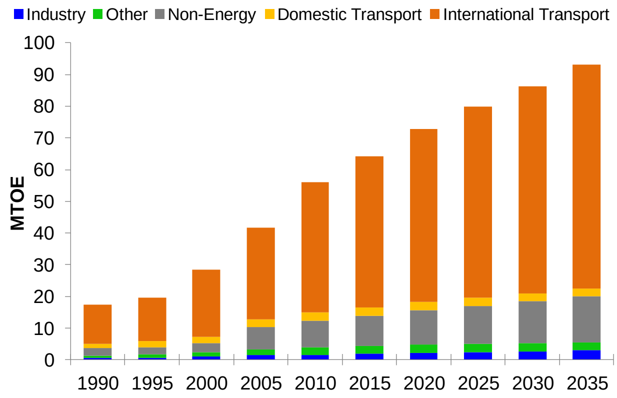
- *Power generation sector.* Market competition in Singapore's electricity industry acts as a natural incentive for power generation companies to be energy efficient. The government aims to further maximize efficiency in this sector by encouraging more co-generation and tri-generation facilities—these facilities produce two to three utilities (like electricity, steam, chilled water) from a single integrated system.
- *Industry sector.* A SGD 10 million (USD 8.1 million) Energy Efficiency Improvement Assistance Scheme (EASe) was launched in 2005 to provide financial assistance to Singapore's companies to conduct energy appraisals for buildings and industrial facilities. To equip facility owners and technical staff with the necessary knowledge and skills to manage energy services within their facilities, a Singapore Certified Energy Manager Training Grant was introduced. Investment in energy efficient equipment is encouraged through the Investment Allowance Scheme (IAS).
- *Transport sector.* The Fuel Economy Labelling Scheme (FELS) was launched to provide buyers of passenger cars and light goods vehicles with fuel economy information at point of sale. The Green Vehicle Rebate (GVR) encourages the purchase of green vehicles by providing green passenger cars and electric motorcycle rebates of 40% and 10% of the open market prices. The Vehicle Quota System (VQS) and Electronic Road Pricing (ERP), on the other hand, limit car ownership and usage, and promote the use of public transport.
- *Building sector.* The Energy Smart Labels are awarded to existing buildings with good energy performances. The Green Mark Buildings rating system evaluates new buildings on their environmental impact and performance, and awards Certified, Gold, GoldPlus or Platinum ratings depending on the points scored on a set of criteria. The EASe scheme for the industry sector also applies to buildings.
- *Household sector.* To encourage energy efficient purchases, the Mandatory Energy Labelling Scheme (MELS) and the Minimum Energy Performance Standards (MEPS) were introduced for energy intensive appliances like air conditioners and refrigerators. In 2008, the government launched the 10% Energy Challenge, a national public awareness campaign challenging households to reduce their electricity consumption by at least 10% by adopting simple energy saving habits.

BUSINESS-AS-USUAL OUTLOOK

FINAL ENERGY DEMAND

Business-as-usual (BAU) final energy demand is expected to grow at 1.6% per year over the outlook period, from about 56 Mtoe in 2010 to over 22.5 Mtoe by 2035 (This figure includes demand from international transport sector). If we discount demand from international transport sector, by 2035 over 75% of the final energy demand will be for oil, followed by electricity and natural gas. Demand for new renewable energy (NRE) will grow the fastest at 5.3% annually; however the share for NRE in 2035 will still be comparatively low at 0.3%.

Figure SIN2: BAU Final Energy Demand

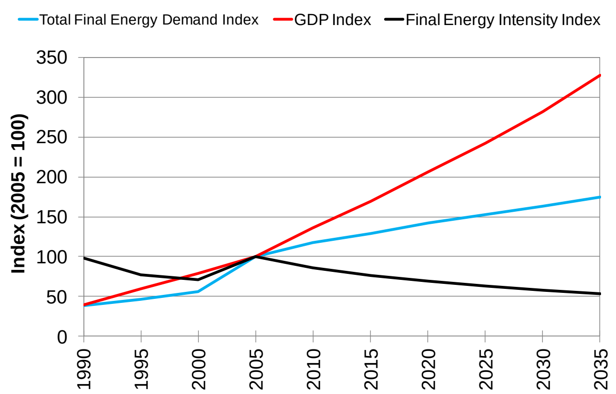


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

As a major trading and oil refining hub, international transport and the non-energy sector dominate Singapore's final energy demand, taking up 76% and 16% respectively of the total final energy demand by 2035. With the exception of the domestic transport sector, all sectors will show growth from 2010 to 2035. Domestic transport sector demand is expected to decline at the rate of 0.4% annually from 2010 to 2035; this can be attributed to the comprehensive energy efficiency measures expected in the transport sector.

For Singapore, final energy intensity is likely to decline by 47% between 2005 and 2035. Please note that for the purpose of calculating final energy intensity, international transport is excluded so only domestic energy demand is considered.

Figure SIN3: BAU Final Energy Intensity



Source: APERC Analysis (2012)

Industry

Energy demand in the industry sector is projected to grow at an average annual rate of 2.5% until 2035, reflecting the growth of Singapore's industries. Industrial electricity demand will consistently account for the largest share from 2010 to 2035 at about 65%, while industrial gas demand will see the highest growth, by 87% to 0.8 Mtoe by 2035.

Transport

Domestic transport demand is projected to decrease from 2010 to 2035 by 0.4% annually, to 2.5 Mtoe by 2035. The oil share in total domestic transport demand will decline from 96% in 2010 to 88% by 2035. The rest will be taken up by natural gas (5%), electricity (4%) and bio-fuel (3%). With less oil combustion, energy intensity for this sector will decrease by over 60% from 2010 to 2035.

This positive trend could probably be attributed to the many initiatives the government has put in place to reduce and diversify energy use in the transport sector, particularly its initiatives to promote the use of alternative vehicles and public transport.

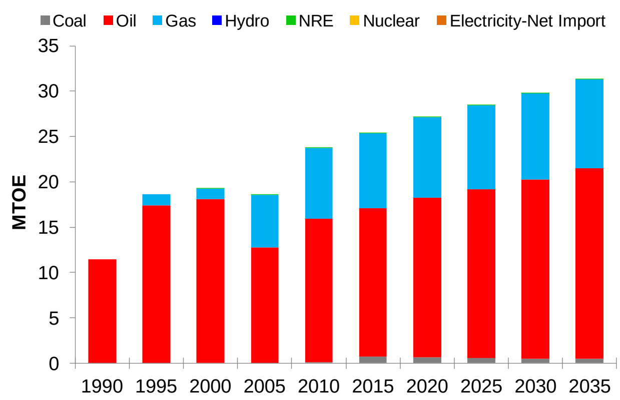
Other

Energy demand in the 'other' sector, which includes residential, commercial, agricultural, and construction demand, is expected to grow at 0.5% per year over the outlook period. Electricity is expected to continue to dominate the fuel mix in this sector, accounting for about 90% of 'other' energy consumption from 2010 to 2035.

PRIMARY ENERGY SUPPLY

Singapore's primary energy supply is projected to grow at an annual rate of 1.1% per year over the projection period, from 24 Mtoe in 2010 to 31 Mtoe by 2035.

Figure SIN4: BAU Primary Energy Supply

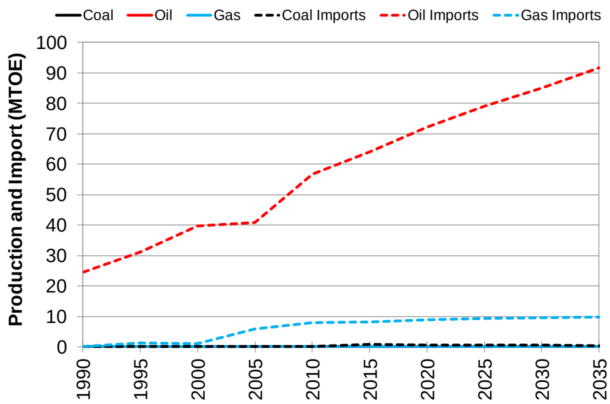


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

Oil will dominate the primary energy mix accounting for 64–68% of primary energy supply from 2010 to 2035, most likely to meet the demand of the international transport sector. Natural gas, coal, and NRE will constitute the remaining share of supply at 31%, 1.4% and 0.4% respectively by 2035.

Singapore's first 160 MW biomass clean coal (BMCC) co-generation plant, developed as part of the Tembusu multi-utilities complex on Jurong Island, is expected to begin operations by the end of 2012. This will contribute to the introduction of coal fuel and biomass into the primary energy supply mix from 2012 onwards.

Figure SIN5: BAU Energy Production and Net Imports



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

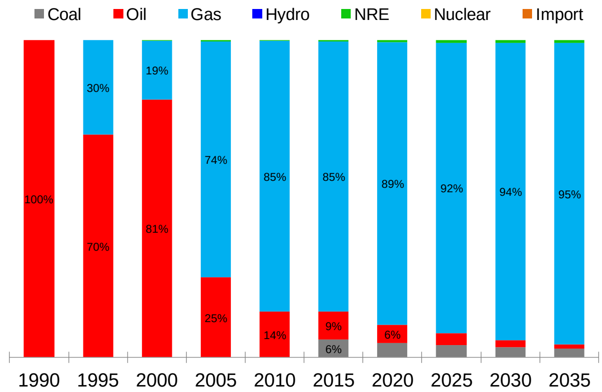
Singapore has negligible indigenous energy resources, either in fossil fuels or in alternative energy sources. The economy imports nearly all the fuels it requires for its energy needs, particularly oil. The supply of imported gas via pipelines is likely to remain constant. The future demand for natural gas (for electricity generation) will probably be supplied by imported LNG once the LNG import terminal on Jurong Island begins operations in 2013.

ELECTRICITY

Singapore's final electricity demand is projected to increase slightly by 38% from 37 TWh in 2010 to 51 TWh by 2035. Singapore is a mature economy that employs various incentives and regulations to promote energy efficiency measures; hence the small growth compared to its developing neighbours Malaysia (103%) and Indonesia (293%).

On the supply side, Singapore will begin to diversify its electricity generation mix from 2012 with the introduction of coal and NRE (in the form of solar and biomass) into the supply mix. However, natural gas will continue to be the dominant fuel throughout the outlook period.

Figure SIN6: BAU Electricity Generation Mix

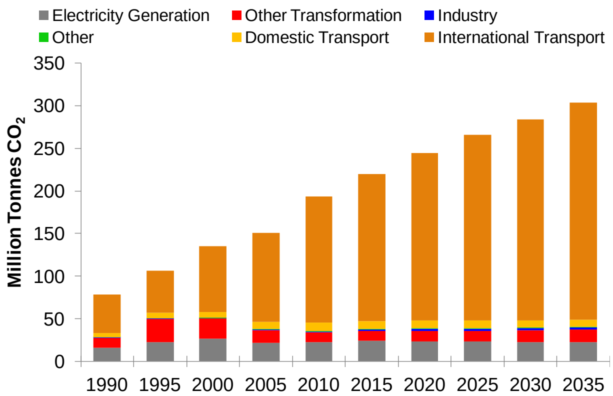


Source: APERC Analysis (2012)
Historical Data: *World Energy Statistics 2011* © OECD/IEA 2011

CO_2 EMISSIONS

Over the outlook period Singapore's total CO_2 emissions from fuel combustion are projected to increase 1.8% annually to reach 304 million tonnes of CO_2 by 2035, compared to 194 million tonnes of CO_2 in 2010. While the international transport sector will continue to be the largest contributor to CO_2 emissions in Singapore, emissions from the domestic transport sector will show a 14% emissions reduction from 2010 to 2035. The industry sector will show the highest growth rate at 2.5% annually from 2010 to 2035.

Figure SIN7: BAU CO_2 Emissions by Sector



Source: APERC Analysis (2012)

The decomposition analysis shown in Table SIN1 below suggests that, from 2010 to 2035, the total change in carbon emissions is affected by Singapore's GDP growth, offset by the reduction in energy intensity (energy efficiency) and CO_2 intensity of energy (fuel switching).

Table SIN1: Analysis of Reasons for Change in BAU CO_2 Emissions from Fuel Combustion

(Average Annual Percent Change)

	1990-2005	2005-2010	2005-2030	2005-2035	2010-2035
Change in CO_2 Intensity of Energy	-0.2%	-1.2%	-0.2%	-0.2%	0.0%
Change in Energy Intensity of GDP	-1.6%	0.1%	-1.3%	-1.4%	-1.7%
Change in GDP	6.4%	6.4%	4.2%	4.0%	3.6%
Total Change	4.4%	5.2%	2.6%	2.4%	1.8%

Source: APERC Analysis (2012)

CHALLENGES AND IMPLICATIONS OF BAU

As a small economy without any significant energy resources, Singapore is totally dependent on imported energy to meet its energy needs. Energy security is a main challenge, along with economic competitiveness and environmental sustainability.

Singapore continues to take various measures to meet these challenges, intensifying its efforts in energy diversification to enhance the security of supply, and energy efficiency to reduce demand and mitigate carbon emissions. Research and development is another important part of Singapore's energy strategy. The economy is likely to capitalize on its strength in this area to develop innovative and sustainable solutions to address Singapore's energy needs.

ALTERNATIVE SCENARIOS

To address the energy security, economic development, and environmental sustainability challenges posed by the business-as-usual (BAU) outcomes, three sets of alternative scenarios were developed for most APEC economies.

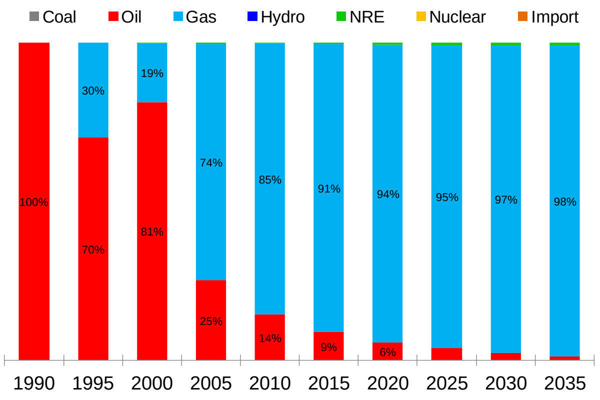
HIGH GAS SCENARIO

To understand the impacts higher gas production might have on the energy sector, an alternative 'High Gas Scenario' was developed. The assumptions behind this scenario are discussed in more detail in Volume 1, Chapter 12. The scenario was built around estimates of gas production that might be available at BAU prices or below, if constraints on gas production and trade could be reduced. Singapore does not produce natural gas, so Figure SIN8 is not included for this economy.

Additional gas consumption in each economy in the High Gas Scenario will depend not only on the economy's own additional gas production, but also on the gas market situation in the APEC region. Singapore currently imports natural gas from Malaysia and Indonesia via pipelines, and will soon import LNG through the new LNG import terminal on Jurong Island. In a situation where there is more gas available, Singapore will likely choose to import additional gas via LNG.

Additional gas in the High Gas Scenario was assumed to replace coal in electricity generation. Figure SIN9 shows the High Gas Scenario electricity generation mix. This graph may be compared with the BAU scenario graph shown in Figure SIN6. It can be seen that the gas share has increased by 3% by 2035, while the coal share has declined by an equal amount.

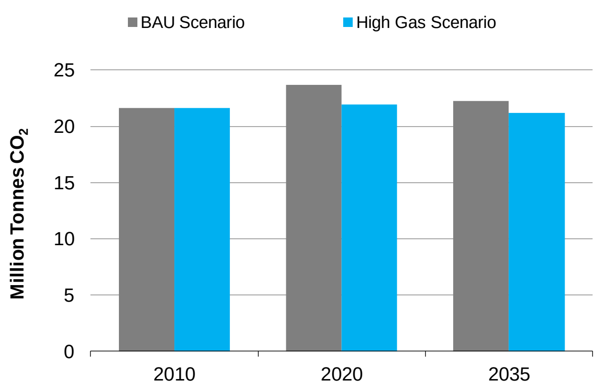
Figure SIN9: High Gas Scenario – Electricity Generation Mix



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

Since gas has roughly half the CO_2 emissions of coal per unit of electricity generated, this had the impact of reducing CO_2 emissions in electricity generation by 5% by 2035. Figure SIN10 shows this CO_2 emissions reduction.

Figure SIN10: High Gas Scenario –CO_2 Emissions from Electricity Generation



Source: APERC Analysis (2012)

ALTERNATIVE URBAN DEVELOPMENT SCENARIOS

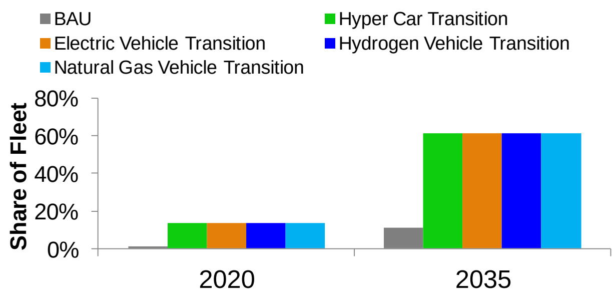
The Alternative Urban Development Scenarios are not performed for Singapore since it is already a compact city with high urban density and low energy consumption. Therefore, Figures SIN11–SIN13 are not included here.

VIRTUAL CLEAN CAR RACE

To understand the impacts of vehicle technology on the energy sector, four alternative vehicle scenarios were developed: 'Hyper Car Transition' (ultra-light conventionally-powered vehicles), 'Electric Vehicle Transition', 'Hydrogen Vehicle Transition', and 'Natural Gas Vehicle Transition'. The assumptions behind these scenarios are discussed in Volume 1, Chapter 5.

Figure SIN14 shows the evolution of the vehicle fleet under BAU and the four 'Virtual Clean Car Race' scenarios. By 2035 the share of the alternative vehicles in the fleet reaches around 62% compared to about 11% in BAU. The share of conventional vehicles in the fleet is thus only about 38%, compared to about 89% in the BAU scenario.

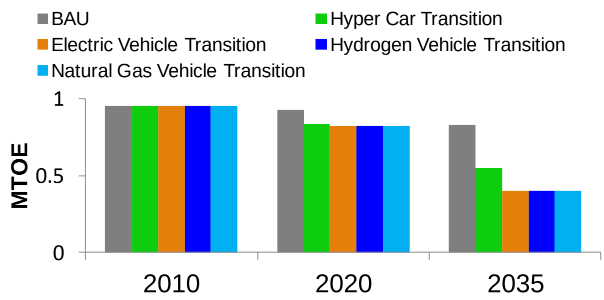
Figure SIN14: Virtual Clean Car Race – Share of Alternative Vehicles in the Light Vehicle Fleet



Source: APERC Analysis (2012)

Figure SIN15 shows the change in light vehicle oil consumption under BAU and the four alternative vehicle scenarios. Oil consumption drops by 52% in the Electric Vehicle Transition, Hydrogen Vehicle Transition, and Natural Gas Vehicle Transition scenarios compared to BAU by 2035. The drop is large as these alternative vehicles use no oil. Oil demand in the Hyper Car Transition scenario is also significantly reduced compared to BAU—down 35% by 2035—even though these highly-efficient vehicles still use oil.

Figure SIN15: Virtual Clean Car Race – Light Vehicle Oil Consumption



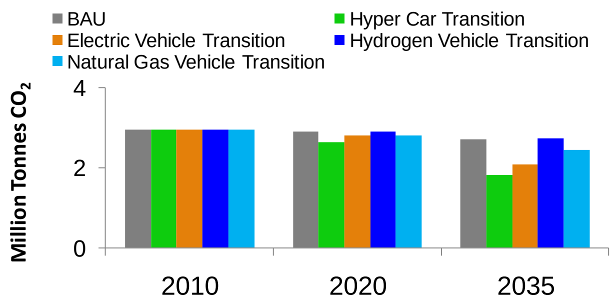
Source: APERC Analysis (2012)

Figure SIN16 shows the change in light vehicle CO_2 emissions under BAU and the four alternative vehicle scenarios. To allow for consistent comparisons, in the Electric Vehicle Transition and Hydrogen Vehicle Transition scenarios the change in CO_2 emissions is defined as the change emissions from electricity and hydrogen generation. The impact of each scenario on emission levels may differ significantly from its impact on oil consumption, since each alternative vehicle type uses a different fuel with a different level of emissions per unit of energy.

In Singapore, the Hyper Car Transition scenario is the clear winner in terms of CO_2 emissions reductions, with an emissions reduction of 33% compared to BAU in 2035. Hyper cars rely on their ultra-light carbon fibre bodies and other energy-saving features to reduce oil consumption. In the other alternative vehicles oil combustion is replaced by other fuels; namely electricity for electric vehicles, hydrogen for hydrogen vehicles and natural gas for natural gas vehicles. In Singapore, electricity generation mostly comes from thermal combustion; thus additional demand for electricity and hydrogen generation would produce more CO_2 emissions, offsetting some of the benefits gained from oil replacement.

The Electric Vehicle Transition, Natural Gas Vehicle Transition and Hydrogen Vehicle Transition scenarios offer less emissions reductions (23%, 10% and 0% respectively).

Figure SIN16: Virtual Clean Car Race – Light Vehicle CO_2 Emissions



Source: APERC Analysis (2012)

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