Output 1 – Literature Survey on the Current Practice of Renewable Energy Applications and Energy Solutions in Green Building in APEC Region (EWG 03/2016A)

APEC Energy Working Group

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Executive Summary

As we all known, energy consumption from building sector accounts for a considerable proportion in the total energy consumption of both APEC region and other areas. This APEC project (e.g. EWG 03/2016A) aims to develop recommendations for application of innovative solar technologies in green buildings to Asia Pacific's various climatic regions, share information on relevant technologies, and promote energy efficiency of APEC region. Green building is one of measures been put forward to mitigate significant impacts of the building stock on the environment, society and economy. The theory of green buildings includes a lower environment load, higher energy efficiency and resource saving throughout a building's whole life cycle. At the same time, green buildings should provide comfortable, safe and healthy environments for people. Renewable energy utilization (REU) is one of the most important aspects of green buildings. This literature survey aims to provide useful information on the current practice of renewable energy applications and energy supply solutions in green buildings in APEC as well as available technologies/solutions in this field. This literature survey will be divided into two main sessions, including session 1, e.g. development status of renewable energy utilization in different APEC Economies, and session 2, e.g. policies on green buildings in APEC region. For session 1, all of the 21 member economies were considered and development status of renewable energy utilization were also summarized. For session 2, policies related to green buildings were introduced to stakeholders in APEC region to help them having a good understanding.

From preliminary workshop and research, our team think that there exists an exciting opportunity for the development of cost-effective renewable energy supply solutions based on innovative solar technologies to promote green buildings in APEC region. Our team hope the final recommendations including this literature survey could make contributions to the sustainability development of all 21 member economies of APEC.

Literature Survey on the Current Practice of Renewable Energy Applications and Energy Solutions in Green Building in APEC Region (EWG 03/2016A)

Project Description and Background

Buildings account for about 40% of global energy consumption; therefore renewable energy-supply solutions for buildings will greatly contribute to energy efficiency and energy security of Asia-Pacific region. Responding to 2015 APEC Energy Ministers' instruction for the EWG to "explore strategies to drive the shift towards green buildings including zero energy buildings", this project seeks to foster APEC members' collaborative efforts in developing cost-effective renewable energy-supply solutions based on innovative solar technologies for green buildings in APEC region.

This project aims to develop recommendations for application of innovative solar technologies in green buildings to Asia Pacific's various climatic regions, share information on relevant technologies, and promote energy efficiency of APEC region. A workshop with experts and attendance from renewable energy and green buildings field will be held in China in April 2017. A final research report on RE solutions for green buildings in APEC Region will be submitted.

Project Objectives

The Project Objectives of EWG 03/2016A are:

- To develop recommendations on technical solutions for promoting advanced solar applications in green buildings to Asia Pacific's various climatic regions.
- To make all partners clear about possible sustainable building energy-supply solutions and to enhance understanding of the innovative solar technologies by sharing results and experiences.
- To build interest of governments, investors, architect, manufacturers of building cladding products and photovoltaic companies in the innovative solar technologies and their applications for green buildings including zero energy buildings.

Aim and Objectives of Literature Survey on the Current Practice of Renewable Energy Applications

and Energy Solutions in Green Building in APEC Region (EWG 03/2016A)

This literature survey aims to provide useful information on the current practice of renewable energy applications and energy supply solutions in green buildings in APEC as well as available technologies/solutions in this field.

Session I: Development status of renewable energy utilization in different APEC Economies

1 Australia

- **Energy utilization status**

Australia has some of the world′s best wind and solar energy resources. Annual solar radiation is 1385240 million tonnes of oil equivalent (Mtoe) covering hundreds of kilometres of land, and wind energy potential is highest along the south-western, southern and south-eastern land areas. Wave and tidal hydro potential is also high, but conventional hydro is limited as Australia is the driest inhabited continent. It is therefore unlikely that existing mature hydro will expand.

The Australian government has promised a 5%-15% decline in greenhouse gas emissions in Australia in 2020 than in 2000. In order to achieve this goal, the Australian government will continue to introduce policies to encourage enterprises and households to reduce carbon emissions, creating the new so-called "green collar" occupation and support the development of the national economy. Among them, the task of building emission reduction is significant. Therefore, the formulation and implementation of relevant policies, regulations and evaluation standards system have been highly valued, and the soft environment construction such as laws and regulations is improving day by day, and its influence is also increasing.

- **Development of renewable energy**

1) Renewable Energy Target

The Renewable Energy Target is an Australian Government scheme designed to reduce emissions of greenhouse gases in the electricity sector and encourage the additional generation of electricity from sustainable and renewable sources.

The Renewable Energy Target works by allowing both large-scale power stations and the owners of small-scale systems to create large-scale generation certificates and small-scale technology certificates for every megawatt hour of power they generate. Certificates are then purchased by electricity retailers (who supply electricity to householders and businesses) and submitted to the Clean Energy Regulator to meet the retailers' legal obligations under the Renewable Energy Target. This creates a market which provides financial incentives to both large-scale renewable energy power stations and the owners of small-scale renewable energy systems.

➢ Large-scale Renewable Energy Target

The Large-scale Renewable Energy Target creates a financial incentive for the establishment and growth of renewable energy power stations, such as wind and solar farms, or hydro-electric power stations. It does this through the creation of large-scale generation certificates.

- Small-scale Renewable Energy Scheme

The Small-scale Renewable Energy Scheme creates a financial incentive for individuals and small businesses to install eligible small-scale renewable energy systems such as solar panel systems, small-scale wind systems, small-scale hydro systems, solar water heaters and air source heat pumps. It does this through the creation of small-scale technology certificates which Renewable Energy Target liable entities have a legal obligation to buy and surrender to the Clean Energy Regulator on a quarterly basis.

The Australian Government has set a Renewable Energy Target of 33000 gigawatt hours of additional renewable energy generation by 2020.

In 2016 the Clean Energy Regulator estimated that for the 2020 target to be reached the total new capacity of renewable energy power projects required to be committed through to the end of 2018 was 6000 MW.

2) Your home-Australia's guide to environmentally sustainable homes

- Renewable energy

Electricity generation systems based on the conversion of solar and wind resources are becoming increasingly accessible to the average homeowner. Renewable energy can also be used for home heating and cooling, hot water and even cooking. On-site production of renewable electricity by photovoltaic systems and wind generators requires design and installation by specialists with the knowledge and accreditation. Renewable energy systems, both grid connected and stand alone, usually operate with low running costs. They can be expensive to install but rebates and other financial incentives may be available to offset the initial cost. Maintenance can also be a cost issue for systems reliant on batteries. To get the most out of your renewable energy system, minimising energy demand in the home first is crucial.

- Photovoltaic systems

Photovoltaic systems are increasingly used to supply price-competitive, zero greenhouse gas emission energy to homes and businesses across the country. The average cost of producing electricity from solar modules over their lifetime is now broadly equivalent to the average cost of purchasing electricity from the grid. Module types fall into two categories, crystalline silicon and thin film, and can be mounted on frames or building integrated. Siting, orientation and tilt of modules are all critical to gain maximum efficiency at the home location, or to match energy production to peak loads. The size of a system is also governed by the household. Design and installation of photovoltaic systems must be undertaken by an accredited specialist.

- Wind systems

The amount of renewable electricity harnessed from the wind is growing rapidly. Australia has an abundant wind resource, which, if used to generate electricity, can save significant greenhouse gas emissions. Only turbines in open sites and on sufficiently tall towers produce energy efficiently. Wind systems installed on roofs typically do not produce much electricity, have short life spans, and are thus never economically sound. Be wary of turbine installers or manufacturers claiming products are suitable for urban or turbulent locations, and always priorities solar photovoltaics if investigating residential renewable electricity options in urban areas.

Site assessment, determining appropriate tower heights, and choosing a system size, design and manufacturer are best done by an experienced contractor.

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2 Brunei Darussalam

- **Energy utilization status**

Brunei Darussalam is a small sovereign state on the northern coast of Borneo, 422 km north of the equator. It has a land area of 5765 km^2 and a 161 km coastline that borders the South China Sea.

Energy is a core pillar of Brunei Darussalam′s economy. It includes oil and gas exploration and production, petrochemical and refineries, fuel, power, energy efficiency and conservation and renewable energy. The energy sector accounts for more than 60 percent of Brunei Darussalam's Gross Domestic Product (GDP).

For Brunei Darussalam's 2013 total domestic energy consumption, oil was the most consumed fuel type accounting for 65.6 percent, followed by electricity at 32.2 percent and town gas at 2.2 percent respectively. Thermal power stations generated 99.95 percent of total power generation, while 0.05 percent was generated by the solar power plant Tenaga Suria Brunei.

- **Development of renewable energy**

To drive Brunei Darussalam′s economy into a sustainable future, Brunei Darussalam supports the implementation of strategies related to energy security, diversification of supply, energy efficiency and conservation. The Government is working to achieve the country′s target while exploring plans to diversify the energy mix through a concerted effort and promotion of alternative and renewable energy sources for power generation. The potential of non-conventional energy resources and power transmission interconnection for energy exchange or power transactions will need to be exploited fully to create the additional power generation capacity. It is expected that the economy′s venture into renewable energy along with its work to upgrade and expand existing electricity-generating facilities will help to ensure the economy′s energy security.

Brunei Darussalam has set the target of reducing its energy usage by 25% compared with its 2005 level by the year 2030. In order to achieve this, in its Energy White Paper that was updated in 2014 it indicated that it would cover 10% of its total power with power generated from renewable energies by the year 2035.

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3 Canada

- **Energy utilization status**

Canada has the second-largest land area in the Asia-Pacific Economic Cooperation (APEC) region. Canada is an energy-intensive economy, with heavy industry and manufacturing contributing 13% to GDP. Major industries are forestry, mining, agriculture, chemicals, metal products, machinery and energy (Statistics Canada, 2015). Canada is endowed with a rich energy resource pool of both non-renewable and renewable1 resources, including oil and natural gas, coal, uranium, hydro, solar and biomass. Natural resource development has supported growth of the Canadian economy.

- **Development of renewable energy**

Solar power (i.e. solar photovoltaic) accounts for about 0.3% of total electricity production in Canada. To enhance this contribution to energy supply from solar power, financial incentives and technological breakthroughs alone may not guarantee change.

In Canada, a country best known for its fossil fuel resources, investments in solar technology are growing steadily, particularly in the Province of Ontario where feed-in tariffs encourage adoption at commercial and household scales. Solar capacity in Ontario accounts for about 4.5% of total installed electricity capacity. Yet, at the national level, solar capacity is hardly significant at approximately 1.0% of total capacity in 2014. In reporting these numbers, the Canadian National Energy Board states that solar adoption across Canada is likely to depend on ″local solar potential, costs and incentives, ease of integration with the existing grid, and further technological breakthroughs″.

Although the contribution of solar technology to generation capacity remains low, this trend may change as federal and provincial governments push for renewable energy transition with 2016 commitments to phase out coal-fired power and to establish a national benchmark for carbon pricing.

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4 Chile

- **Energy utilization status**

Chile, bordered by Peru to the north, Bolivia to the north-east and Argentina to the west, has a land area of 756 102 km^2. Its Pacific coastline is 6435 km long and it has an average width of 175 km. The north is Atacama Desert, which is one of the richest areas of light resources in the world. In central and southern Chile, hydro and biomass resources are abundant and are the main energy sources. Thanks to the long coastline of Chile, it has enough wind energy resources. On the other hand, it also benefits from policy support.

As a result of its Geography, Chile has four separate National Electricity Networks: The North Network, which serves mainly to mining companies and Industry; The Central Network, representing approximately 75% of electricity use two networks; and the South, which only has a small number of people. Given the hydrological conditions of Chile, the utilization of renewable energy in large hydropower plays an important role in the energy supply of the country, representing approximately 35% of the installed capacity.

Chile has a high potential for the generation of renewable energy, especially hydropower, wind and solar. Despite the efforts and remarkable achievements in renewable energy in Chile over the past ten years, renewable energy is still a fraction of the country's energy supply.

- **Development of renewable energy**

By December 2013, in Chile, the installed capacity reached 170 thousand kilowatts, of which 60% were fossil fuel sources, approximately 34% of large size Hydraulic and 6% ERNC. Among them, biomass energy provides 332MW, wind energy provides 335MW, small hydropower provides 444MW, and solar energy provides 6.7MW.

In 2016, the Chilean government approved the new energy strategy. The goal is that 50% of the electricity will come from new energy by 2035. In 2050, 70% of the power generation will come from new energy. It is estimated that the target of 50% will be achieved by 2035.

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5 People's Republic of China

- **Energy utilization status**

China is rich in energy resources, including fossil fuels and renewables. The reserves per capita, however, are relatively low, with coal at 84 tonnes (68% of world average), oil at 13 barrels (bbl.) (5.6%) and gas at 2569 cubic meters (m^3 ; 9.9%). An additional challenge is that China is energy resource-rich in the western regions, while population and energy demand are concentrated in the central and eastern regions. The share of renewables in Chinaʹs energy mix was 13% in 2010, including an estimated 6% traditional use of biomass, and 7% modern renewables. Hydroelectricity (3.4%) and solar thermal (1.5%) accounted for most of Chinaʹs modern renewable energy use.

China has become a global leader in renewable energy; in 2013, it installed more renewable capacity than all of Europe and the rest of the Asia-Pacific region combined (IRENA, 2014). China has identified 46 renewable energy building application demonstration cities, 100 demonstration counties and 8 solar energy comprehensive utilization provincial-level demonstration, and implemented 398 solar photovoltaic building application demonstration projects, with installed capacity of 683 MW. By the end of 2015, the area of solar thermal energy application in China's cities and towns was over 3 billion square meters, and the application area of shallow solar energy was more than 500 million square meters. The proportion of renewable energy instead of civilian buildings for conventional energy consumption was over 4%.

By the end of 2017, China's renewable energy generation installed capacity reached 650 million kilowatts, an increase of 14%, of which 341 million kilowatts, 164 million kilowatts of wind power installed, 130 million kilowatts of photovoltaic power installed, 14 million 880 thousand kilowatts for biomass power installed, 2.7%, 10.5%, 68.7% and 22.6% respectively. The installed capacity of renewable energy power generation accounts for 36.6% of the total installed capacity of electricity, up 2.1 percentage points compared to the same period last year, and the replacement effect of clean energy of renewable energy is increasingly prominent.

In 2017, China’s renewable energy generated 1 trillion and 700 billion kwh, an increase of 150 billion kwh; renewable energy generation accounted for 26.4% of the total power generation, up 0.7 percentage points over the same period. Among them, water and electricity 11945 billion kwh, up 1.7% compared to the same period, 305 billion 700 million kilowatt hours of wind power, a year-on-year increase of 26.3%; photovoltaic power generation 118 billion 200 million kwh, a year-on-year increase of 78.6%; biomass generation 79 billion 400 million kwh, an increase of 22.7% over the same period. When the water quantity is 51 billion 500 million kwh in the year, the water energy utilization rate is about 96% when the water is better than last year. The abandoned wind power is 41 billion 900 million kwh, the rate of abandoning the wind is 12%, which is 5.2 percentage points down from the same year, and the rate of light electricity is 7 billion 300 million kwh, the rate of abandoning the light is 6%, and the year-on-year decrease of 4.3 percentage points.

- **Development of renewable energy**

The nineteen major reports of China pointed out that we should promote the energy production and consumption revolution, and build clean, low carbon, safe and efficient energy system. In 2017, China's central economic work conference proposed that we should increase clean electricity supply and promote the development of green industry, such as energy saving, environmental protection, clean production and clean energy. At present, the lack of flexibility in the regulation of power system and the rigid operation mode of power grid have caused the system difficult to fully adapt to the requirements of the new situation. It is difficult for large units to give full play to the advantages of energy saving and high efficiency. In some areas, some serious problems of abandonment, abandonment and abandonment of water have appeared in some areas, and the contradiction of regional electricity consumption is prominent. In order to achieve the target of 15% and 20% of non-fossil energy consumption in 2020 and 2030, to guarantee the safety supply of electricity and the heat demand for the people's livelihood, we should improve the adjustment and operation efficiency of the power system, and raise the flexibility and adaptability of the system from the load side, the power supply side and the power grid side, to solve the new energy dissipation problem and promote the green development.

China will speed up the construction and planning of pumped storage power stations, and speed up the construction of leading reservoir power plants. By 2020, the installed capacity of pumped storage power stations will reach 40 million kilowatts, effectively improving the power system regulation capacity.

China actively supports solar thermal power generation, and promotes industrial development and large-scale application. During the "13th Five-Year", solar thermal power plants are striving to reach 5 million kilowatts and 4 million kilowatts to improve the power system adjustment capacity.

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6 Hong Kong, China

- **Energy utilization status**

Hong Kong is a metropolitan city with a population of almost seven million and a land area of about 1100 km^2. There are no indigenous energy resources such as oil, gas or coal and the city has been relying mainly on imported fossil fuels to meet its energy needs. Energy consumption has been increasing over the past decades, driven by the growth in the economy. Owing to its highly developed and service-dominated economy, energy intensity is the lowest in APEC.

In 2013, final energy intensity per unit of GDP was 82% below the APEC average, and it is projected to be 80% below the APEC average by 2040. The government has put in considerable efforts to promote energy efficiency and renewable energy in order to restrain the rise in energy demand, for sustainable development of the territory. Along with energy structure optimization, more gas and renewables are energy is substituted for coal, while more electricity is imported from mainland China. The economy's total energy-related carbon dioxide (CO_2) emissions are projected to decrease to 35 million tonnes by 2040 from 46 million tonnes in 2013.

(1) Renewable Energy Target for Hong Kong

In the document "A First Sustainable Development Strategy for Hong Kong" published in May 2005, the following targets in the area of renewable energy have been put forward:

- To organize more public education programs on RE and sustainable energy consumption that links these issues to local and global sustainable development.
- To aim to have between 1 and 2% of Hong Kong's total electricity supply met by power generated from renewable sources by the year 2012, with this target being subject to regular review in the light of advances in technological solutions and emerging sustainability considerations.
- To develop plans to promote energy efficiency and conservation as part of a sustainable energy policy.

It is also expressed in the same document that "The challenge for Hong Kong is to see whether we can find a way to obtain regular and cost-effective electricity from renewable sources for supply to consumers - especially given that current RE technologies, for example, wind turbine installations, tend to be land-intensive, and that we have few sites suitable for locating large scale facilities locally. As there are limits to how much we can do within the boundaries of Hong Kong itself, we have to set ourselves realistic objectives and targets for deriving some of our electricity from RE sources, and consider other practices that will lead to a more sustainable and efficient use of energy."

(2) Development of renewable energy

Starting from the 1980s, the government of Hong Kong has built several large-scale solar water heating installations on government buildings. Small-scale photovoltaic installations have also been used for some decades to provide power to equipment in the form of standalone (i.e. non-grid-connected) power supply systems. The first grid-connected photovoltaic installation is the 55 kW building-integrated photovoltaic installation at Wanchai Tower, built in 2002 by EMSD as a pilot project. Since then, a number of grid-connected PV installations have been built. In 2005, a 350 kW PV installation went into operation on the roof of the EMSD Headquarters building in Kowloon Bay.

Landfill gas from landfills has been utilized for process heating and electricity generation purpose (for on-site use) since the late 1990s. Biogas generated during the sewage treatment process has also been used for electricity generation and other process uses since the 1980s.

In end-2005, the Environment, Transport and Works Bureau of the Government of Hong Kong SAR promulgated a technical circular ETWB TC (Works) No. 16/2005 on "Adoption of Energy Efficient Features and Renewable Energy in Government Projects and Installations". This technical circular encourages greater adoption of energy efficient features and RE technologies in public works projects, and requires works departments to regularly report their progress. The technical circular also provides guidance on the criteria for the application of solar water heating, photovoltaic, wind, and biogas technologies in government projects and installations.

There are many non-government renewable energy projects throughout the community. Other than the demonstration wind turbines and offshore wind farm feasibility studies of the power companies as described in the previous section, the Hong Kong and China Gas Company Ltd has used landfill gas for process heating in town gas production. In addition, there are quite a number of solar water heating installations, photovoltaic installations, and small wind turbines built by various sectors of the community.

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7 Indonesia

- **Energy utilization status**

Indonesia is a large archipelago located southeast of mainland South-East Asia, between the Pacific Ocean and the Indian Ocean. Its territory of 7.8 million km^2. Renewables are abundant in Indonesia. Based on 2014 data from the Ministry of Energy and Mineral Resources, diverse sources show strong potential including geothermal (29 GW), hydro (75 GW), wind (62 GW of commercial potential) and biomass for electricity (33 GW). Theoretical potential also exists for ocean wave (142 GW) and ocean thermal (4.2 GW), while solar potential irradiation is between 2.6 kilowatt-hours per square metre (kWh/m^2) and 5.8 kWh/m^2.

Indonesia is among the world′s fastest growing countries in terms of energy consumption. This is fuelled by robust economic development, increasing urbanisation and steady population growth. The country is the largest energy user in the Association of Southeast Asian Nations (ASEAN), accounting for nearly 40% of total energy use among ASEAN members. Between 2000 and 2014, energy consumption in Indonesia increased by nearly 65%. In a business-as-usual outlook (a ″Reference Case″ in IRENA), it is set to grow another 80% by 2030. Indonesia is therefore crucial to a renewable energy transition for the region as a whole.

- **Development of renewable energy**

Indonesia already has ambitious targets to increase its use of renewable energy. The country has set an overall target to have modern renewables (excluding traditional uses of bioenergy) provide 23% of total primary energy supply by 2025, and 31% by 2050. The Reference Case, which assumes that these targets are met, implies a share for renewable energy of 17% in total final energy consumption by 2030, up from about 6% today.

In terms of science and technology planning, the national science and technology agenda 2015 - 2019, issued by the Indonesian National Research Council, will clearly give priority to the development of three areas, including food, energy and ocean. In the field of energy, the focus is on the establishment of a small scale test nuclear power plant and a small scale test geothermal power station to strengthen the supervision of the application of nuclear technology. According to the national budget allocation plan of key science and technology fields formulated by the Indonesian government from 2017 to 2019, the R & D budget of Indonesia in the field of clean energy will be 10 trillion rupiah (5 billion yuan) in the next three years. Indonesia on technology and the Ministry of higher education led the development of the national science and technology "2015-2045" overall planning, determine the subject areas of 10 key technology and research for the next 30 years , new energy and renewable energy are the second key areas of science and technology to agriculture.

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8 Japan

- **Energy utilization status**

Japan has limited indigenous fossil fuel resources, resulting in its low energy self-sufficiency rate (6.1%).Japan has a variety of potential renewable energy sources, including solar, onshore/offshore wind, geothermal and hydro. However, it faces technical, environmental and economic challenges to developing renewables. Of onshore wind installation potential, 75% is in Hokkaido and Tohoku, far from the major electricity consumption areas. More than 70% of geothermal potential is within Japan′s National Park Areas, where environmental regulations limit constructing facilities.

- **Development of renewable energy**

Energy and resources are very scarce in Japan, and energy security has always been the top priority of the government. In particular, the warming of the earth is becoming more and more severe in recent years, and the global environmental problems are becoming more and more prominent. Therefore, the Japanese government has long been unremitting through laws, regulations, institutional policies and so on to guide the national building energy conservation work and green building promotion. The relevant laws and regulations and policy systems in Japan are quite various, and they continue to bring forth new ones, which have formed a more perfect soft environment.

The government′s outlook aims for a well-balanced power mix where nuclear accounts for 20% to 22% of total generated electricity, renewables for 22% to 24%, liquefied natural gas for 27%, coal for 26% and oil for 3%. The share of nuclear is smaller than before the earthquake (when it was around 30%), thus lowering nuclear dependence. Within renewables, the two largest sources are hydro, accounting for 8.8% to 9.2%, and solar (7%).

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9 Republic of Korea

● Energy utilization status

Korea has very limited domestic energy resources: oil resources consist of a small amount of condensate, and it has only 320 million tonnes (Mt) of recoverable coal reserves and 6 billion cubic metres (bcm) of natural gas. To sustain high economic growth, Korea imports large quantities of energy products‾about 89% of TPES in 2013. It was the world′s fifth-largest importer of oil and liquefied natural gas (LNG) and third-largest importer of coal.

Energy policy in the past focused on ensuring a stable energy supply to sustain economic growth. The government is now seeking a new direction that supports sustainable development and fully considers the '3Es' (energy security, efficiency and the environment).

The past priority of keeping energy prices low in consideration of socioeconomic circumstances has caused inefficient use of energy, especially electricity as it was the most affordable. Lack of active demand control led to electricity replacing oil and gas in heating and cooling, creating over-dependence on electricity. This higher dependence causes additional transformation losses during generation, which does not occur when oil or gas is used as a heating fuel. The electricity boom also created supply instability, as it takes considerable time for an economy to expand its capacity.

● Development of renewable energy

On 14 January 2014, Korea launched the 2nd Energy Basic Plan covering 2014-2035; it is the energy sector′s main framework document. The plan introduced policies on demand management, distributed power generation, energy sustainability, energy security and public acceptance. The share of nuclear in the economy′s generation capacity is expected to be kept at around 29%, a decrease from the 41% set out in the 1st Energy Basic Plan in 2008. The 2011 Fukushima accident raised public environmental and nuclear safety concerns, heightening the importance of transparency and investment in safety measures. To ensure the safety of nuclear reactors, the government recently decided to retire the oldest reactor, Gori-1, in 2017 at the end of a 10-year life extension.

Increased renewables has also been proposed. The government indicated 11% of TPES will be renewables by 2035 in the 4th New and Renewable Energies (NRE) Basic Plan of 2014, where 13.4% of total electricity will be renewables by 2035 with development of solar and wind as major energy sources.

The Korean Institute of Energy has well developed plans for future technology development of solar energy. Like many APEC economies it is implementing the strategic development of technology that can reduce the manufacturing costs of crystalline silicon and next-generation thin film solar cell that which will also reduce the manufacturing costs of the solar cell.

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10 Malaysia

- **Energy utilization status**

Malaysia, located in South-East Asia, has a total territory of about 330 803 km^2. The economy is separated by the South China Sea into two main geographical areas comprising Peninsular Malaysia in the west, and Sabah and Sarawak on the island of Borneo. The capital city of Malaysia is Kuala Lumpur while Putrajaya hosts the seat of the federal government.

Malaysiaʹs energy resources can be considered moderate in absolute terms. A 2013 survey shows that East Malaysian states hold nearly two-thirds of the economy's energy reserves; Peninsular Malaysia holds the rest. The Malaysian Energy Commission estimates oil reserves (including condensate) at 5.9 billion barrels. Abundant natural gas reserves are estimated at 2.8 tcm or 98 trillion standard cubic feet, with nearly half found in the Sarawak basin. The coal reserves deposit, assessed at 1.9 billion tonnes. In 2013, coal consumption reached more than 14 Mtoe of oil equivalent, or 21 million tonnes of coal), at which time Malaysia ranked as the ninth-largest coal importer in the world. This reflects rapid expansion of coal generation capacity, especially between 2000 and 2013 when coal consumption in the power sector swelled from 1.5 Mtoe per year (Mtoe/yr) to 13.6 Mtoe/yr. Coal generation capacity was expanded to meet increasing electricity demand and reduce dependence on natural gas, which previously dominated generation.

- **Development of renewable energy**

Malaysia taking into consideration the nationʹs natural resources and the impacts of their use on the environment. The 11th Malaysia Plan covers almost the entire spectrum of energy, of which this Outlook highlights a few notable strategies, initiatives and targets. To improve the existing green market, the 11th Malaysia Plan includes adoption of green buildings criteria and strengthens green certification. It also sets a target to increase the share of renewable energy5 sources to 7.8% of total installed generation capacity in Peninsular Malaysia and Sabah by 2020, by exploring the potential for wind, geothermal and other renewables. Besides exploring other renewables potential, the economy plans to introduce a new market mechanism, which is net energy metering. Under this new mechanism, consumers that generate excess electricity through solar photovoltaics (PV) will be able to send electricity to the grid, and utility companies will compensate for transferred energy on a net consumption basis. By 2020, renewable energy capacity is expected to reach 2.1 gigawatts (GW), contributing 7.8% of total installed capacity in Peninsular Malaysia and Sabah.

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11 Mexico

- **Energy utilization status**

Mexico has a large and diverse renewable energy resource base. Mexico is located on the largest solar radiation belt on earth. Meanwhile, under the interaction of the Mexico Bay and the Pacific Ocean currents, the Isthmus of Tehuantepec across the Strait forms the most important wind energy resource. The huge tectonic movement and volcanic activity of Mexico provide it with abundant geothermal energy resources. In the same way, many of the country's fast flowing rivers and lakes indicate that it contains huge water resources.

With nearly 2 million km^2 of territory rich in natural resources, Mexico has abundant fossil and renewable energy resources. Proven reserves of fossil resources at the end of 2014 amounted to 1211 million tonnes (Mt) of coal, 11 billion bbl of oil, 0.35 bcm of natural gas and nearly 3 kt of uranium, and inferred resources are of a large magnitude. In renewable energy, proven annual potential is 1932 GWh of geothermal, 4457 GWh of hydro, 15307 GWh of wind, 8171 GWh of solar and 728 GWh of biomass. This combined potential is 60% above Mexico’s current electricity generation from renewables.

- **Development of renewable energy**

In 2013, Mexico's renewable energy generation installed capacity of 14891 megawatts and installed capacity of 5487 megawatts. According to the national energy strategy "Mexico 2013-2027", to 2027, the national renewable energy in the total installed capacity of 35000 MW, 2013-2027 years, the installed capacity of renewable energy will be increased to 21089 MW, including wind and hydro power generation installed capacity accounted for 52% and 25% respectively. The prospects for the development of renewable energy in Mexico are broad.

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12 New Zealand

- **Energy utilization status**

New Zealand is an island economy in the South Pacific, comprising the North Island, the South Island and numerous outer islands. New Zealand is rich in energy resources, primarily coal and renewable energy. It also has oil and gas, but only modest quantities have been discovered to date. It is able to meet all domestic gas needs and one-third of oil demand.

New Zealand is self-sufficient in all energy sources except oil. It has vast renewable energy potential: in 2013 renewables accounted for 74% of electricity generation, largely from hydro, geothermal and wind. For fossil energy resources, the remaining reserves are more modest: 128 Mbbl of oil and condensate, 59 bcm of natural gas and liquefied petroleum gas (LPG), and 571 million tonnes (Mt) of coal at the end of 2012.

The ratio of non-renewable and renewable energy sources was fairly consistent from 1975 to 2008, with about 70 per cent of primary energy supply coming from hydrocarbon fuels. This ratio decreased to about 60 per cent in 2014. The proportion of non-renewable energy varies annually, depending on water flows into hydro-electricity lakes and demand for energy. In 2014, approximately 60% of primary energy was from non-renewable hydrocarbon fuels and 40% was from renewable sources. In 2007 energy consumption per capita was 120 gigajoules. Per capita energy consumption had increased 8 per cent since 1998. New Zealand uses more energy per capita than 17 of 30 OECD countries.

Renewable energy potential is significant. Renewable energy comes from sources that are naturally replenished in a relatively short timeframe. Sunlight, wind, water and geothermal heat are all renewable energy sources. In addition to 74% of electricity being renewable in 2013 (hydropower accounting for half of all generation), wind energy is being deployed without any government support, and geothermal energy is widely used in electricity generation and industry. In 2015 New Zealand sourced 40% of its total energy from renewable resources. Most of this was used to produce electricity - the rest was mainly wood fuel used to produce heat for industrial processes and home heating.

- **Development of renewable energy**

➢ Hydroelectricity Energy

In New Zealand, more than half of the electricity are generated from hydro generation. Hydroelectricity generation will continue to provide the backbone of New Zealand’s electricity system. There is still significant scope to develop new hydroelectricity generation in New Zealand, but as the major opportunities have already been taken, and there is keen public interest in preserving our waterways, large projects are unlikely.

➢ Wind Energy

Currently New Zealand has 19 wind farms operating or under construction which provide 690 MW of electricity generation capacity. Small wind turbines can be useful as part of a stand-alone power system but vibration problems, getting consent for masts in built-up areas, wind shielding from neighboring properties and the difference in value of imported and exported electricity mean they're unlikely to be widely used in urban settings.

➢ Geothermal Energy

Centuries before New Zealand began turning geothermal energy into electricity. These days geothermal energy provides 22% of NZ's total primary energy supply, including over 17% of our electricity. Total geothermal electricity capacity in New Zealand stands at over 900 MW. It has been estimated that there is approximately another 1,000 MW of geothermal resource that could be used for generating electricity. We could also use more geothermal energy directly, for example as industrial process heat, or by finding uses for waste heat from geothermal power stations.

➢ Solar Energy

The sun is an abundant energy source that's freely available and renewable in New Zealand. Solar generation is currently a small proportion of New Zealand's energy supply, making up only 0.1% of our total renewable energy. Price reductions in solar PV equipment have made it more popular with homeowners and businesses, despite the fact that for most it remains more costly than grid-supplied electricity.

Solar PV is regarded as a 'disruptive technology' as it challenges the traditional model of electricity provision. Along with other disruptive technologies (such as advanced metering, smart devices, and advanced batteries) it's likely to contribute to changes in energy market design, energy policy and pricing structures in the future.

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13 Papua New Guinea

- **Energy utilization status**

Papua New Guinea has small reserves of oil and gas as well as coal reserves of unknown size. It has produced over 400 million barrels of light crude oil since 1992, reducing its oil reserves to 0.2 billion barrels in 2015. Existing oil reserves are depleting rapidly and are expected to dry up in the 2020s.

Papua New Guinea's significant gas reserves are mainly undeveloped. Thanks to the completion of its LNG liquefaction terminal in 2014, it began exporting LNG in May of that year, the only form of gas export for the island economy. Targeting spot markets, its main consumers are China, Japan and Chinese Taipei. Renewables, primarily hydro but also geothermal, account for slightly over 38% of the power mix, adding to diesel fuel and gas.

Papua New Guinea's energy consumption is projected to grow more than fourfold over the Outlook period. Total final energy demand (TFED) increases from 1.6 Mtoe in 2013 to 5.7 Mtoe in 2040, with the expansion of the mining sector, particularly gas, as the main contributing factor. Total primary energy supply (TPES) also grows over fourfold from 2.6 Mtoe in 2013 to 12 Mtoe in 2040. Oil loses its large share of TPES (almost 78% in 2013) by 2040 as its share falls to almost 47% while that of gas rises to 37% from nearly 5% in 2013.

- **Development of renewable energy**

In pursuit of APEC's region-wide goal of reducing energy intensity by 45% by 2035, Papua New Guinea has initiated policies to decrease energy consumption, improve energy efficiency and reduce energy-related CO2 emissions. Under the Business-as-Usual (BAU) Scenario, Papua New Guinea reduces its energy intensity by 40% between 2005 and 2035. It reflecting a major improvement in energy intensity from 87 toe per USD million to 52 toe per USD million. More efficient performance in all sectors, excluding buildings, is the reason for this drop in energy intensity. Papua New Guinea's energy intensity reduction by the target date could improve further under the Improved Efficiency Scenario to reach 45% by 2035.

Papua New Guinea's renewable power generation in 2013 was 1.3 TWh. Hydro is the main contributor to renewables, followed by geothermal. Under the BAU, renewable generation is projected to increase threefold to 4.2 TWh by 2030 to surpass the APEC target. Hydro generation rises from 1 TWh to 2.7 TWh and geothermal generation almost quadruples, from 0.42 TWh to 1.6 TWh. By 2040, hydro grows to 3.1 TWh and geothermal to 1.9 TWh.

Papua New Guinea's energy demand increases over the Outlook period, with the share of gas increasing as oil's share decreases. The economy's total energy-related CO2 emissions increase despite renewables maintaining a significant share of energy demand as a result of a substantial increase in consumption of domestically produced gas. This is a major challenge for the economy, which aims to decrease its GHG emissions by at least 50% before 2030 and become carbon neutral before 2050. Increasing renewables' share of energy demand and improving energy efficiency are two ways the economy could achieve its emissions reduction targets. Other measures that would be effective include developing the economy's public transport to reduce the current heavy reliance on private transport, which is a major source of CO2 emissions. Electricity-driven means of mass transport would be especially appropriate. Papua New Guinea's vast, but still mainly underdeveloped, hydro potential could be fully developed to supply environmentally clean power for transport. Run-of-river hydro should be considered as an inexpensive, non-polluting option for purposes such as addressing the economy's low rate of access to electricity in rural areas.

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14 Peru

- **Energy utilization status**

Peru's proven gas reserves were 0.43 tcm in 2014, which is expected to increase to 0.8 tcm by 2025, based on information from the Ministry of Energy and Mines. The Camisea gas project is the largest energy project in Peru, with a development cost of USD 2.7 billion since commencing operation in 2004. The project is located 500 km from Lima, in the region of Cusco, and had proven reserves of 0.4 tcm in 2015. The pipeline has a length of 560 km and passes through the Andes from Las Malvinas plant (Cusco) to the liquefaction port in Pisco (130 000 barrels per day). A second pipeline connects Las Malvinas plant to Ica and Lima (715 km) and is used to distribute gas to residential and industrial consumers (655 million cubic feet per day). A third pipeline, with a transport capacity of 1 500 million cubic feet per day, is under construction from Camisea to the regions of Arequipa and Moquegua in the south of Peru.

Oil reserves in Peru are 1.6 billion barrels, which is insufficient to keep pace with future demand. Additionally, this oil is largely unsuitable for refining in Peru, making the economy a net importer of oil. If 2014 production levels were sustained, proven oil reserves would be exhausted in 31 years.

Peru needs to further develop energy resources to support its future economic growth. It also needs to build energy-related infrastructure to help access and develop resources. In 2014, the Peruvian government released the National Energy Plan 2014-2025, which details the economy's energy policy and objectives. The plan sets out the aim of a reliable, continuous and sufficient energy system in Peru that can support sustainable development, in part by promoting investments in infrastructure and exploration.

Seeking to become an energy hub in the South American region, Peru is encouraging energy integration projects with Ecuador, Colombia and Chile (electricity), Brazil (hydro), and Bolivia (gas). Peru has electricity interconnection projects with Ecuador through two transmission lines. Agreements with Bolivia will support transportation of its gas to the liquefied natural gas (LNG) terminal in Peru, expected to begin operations by 2018. In the electricity sector, Peru and Bolivia are carrying out studies to assess the potential to interconnect their own power systems in order to jointly supply electricity to Chile. Finally, Peru and Brazil have a cooperation agreement to develop up to 6 000 megawatts (MW) of hydropower generation in Peruvian territory, which would be transmitted to Brazilian territory.

- **Development of renewable energy**

Peru has made significant steps in promoting renewable energy in the electricity market with the aim of diversifying its electricity mix and reducing its dependence on fossil fuels. Renewable electricity can help meet rapidly growing electricity demand, which is forecast to increase at an average annual rate of almost 9%. Furthermore, the Law for the Promotion of Investment in Renewable Energy Generation, sets a target of up to 5% of the national energy demand to be covered by renewable energy generation between 2008-2013.

Following the reform of the electricity sector in 2006, auctions were adopted in Peru as the preferred mechanism for introducing cost-effective electricity rates to users. The country is therefore already familiar with auction processes. It has perfected it for large hydropower and combined cycle natural gas power plants, and has now also introduced this mechanism for renewable energy.

Peru aims to promote biomass, wind, solar and small hydro using technology-specific auctions. The first two renewable energy auctions awarded nearly 1 400 GWh/year of renewable energy power to solar, wind and biomass and 281 MW to small hydro. This attracted a total investment of almost USD 1.5 billion. In 2013, Peru announced the third renewable energy auction. This covers 320 GWh per year of biomass and 1 300 GWh per year of small hydro.

Peru is fine-tuning the auction design and process for renewable energy technologies by incorporating lessons learnt into the next round. There are ongoing discussions on the size of auction rounds, hybrid generation systems, and local content requirements

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15 Philippine

- **Energy utilization status**

The Philippines has modest energy resources, with proven reserves of around 76 million barrels (bbl) of oil (including condensate), 24 bcm of natural gas, and 440 million tonnes (Mt) of coal. According to the Philippines Department of Energy, renewable energy sources (geothermal and hydro) made up 26% of total generation in 2013 and 32% of generation capacity in 2013. The government has a longstanding policy of harnessing domestic energy resources to improve and maintain the economy's energy self-sufficiency and reduce dependence on imported energy. In 2013, the economy produced 6 million bbl of oil (including condensate) and 3.5 bcm of gas. Coal production in 2013 reached 7.8 Mt mostly sub-bituminous, a low-rank coal.

Since 1990, the Philippines has obtained almost half of its total energy supply from renewable energy sources, mostly geothermal, hydro and biomass. Development and optimal use of renewable energy resources is one of the government's key policies to address climate change and increase energy security, sustainability and access to energy. A recent assessment found that vast amounts of renewables are yet to be developed, including 11 gigawatts (GW) of new capacity that are already covered with renewable energy service or operating contracts.

- **Development of renewable energy**

The Philippines was among the 195 signatories to the Paris Agreement on Climate Change, pledging to reduce its carbon emissions down by 70 percent by 2030. To fulfill this, goals should be geared towards a cleaner form of energy. The low-carbon scenario envisioned by the Department of Energy entails a 30-30-40 power generation mix. Coal and liquefied natural gas or LNG would comprise 30 percent each and the remaining 40 percent from renewable sources of energy. To accelerate renewable energy resource exploration and development, the Department of Energy (DOE) issued a circular in July 2015 prescribing policy for maintaining renewable energy's share of total power capacity at a minimum of 30% and other pertinent provisions under the Renewable Energy Act. In August 2014, the DOE endorsed an increase in the installation target for solar from 50 megawatts (MW) to 500 MW with application of a lower rate for the additional capacity. The following year (April 2015) the wind installation target was raised from 200 MW to 400 MW.

The Philippines Department of Energy has moved to promote RE development and use. Solar Philippines, one of the largest developers of rooftop solar power plants in Southeast Asia, has completed its 63.3-megawatt (MW) solar farm in Batangas, providing additional power supply in the western part of the province.

There is some limited research work being undertaken at the Solar Energy cell of the De La Salle University Manilla. The vision is to produce new knowledge through discovery and research on solar energy applications that are relevant and practical in making the society more environmentally sustainable and responsive to the call against environmental degradation. As new knowledge on solar energy applications is produced, it is envisioned that the economy's state of "energy poverty" will be significantly alleviated, most especially in the rural areas. The priority research areas may initially be on materials, devices, processes and systems for photovoltaic electricity generation. Research may also focus on measurements and system characterization as well as studies on performance and reliability improvement of PV components and systems.

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16 Russia

- **Energy utilization status**

Russia has the largest land area of any country or economy in the world and a population of 143 million in 2014, which is projected to grow 5.2% to reach 151 million in 2040. Russia's major industries include oil and gas production, petroleum refining, mining, iron and steel, chemicals, machinery and motor vehicles. The energy sector is important not only to Russia's economic development but also to the survival of its population during its harsh winters.

In terms of proven reserves, in 2014 Russia held 17% of the world's gas reserves, 6.1% of its oil reserves and 18% of its coal reserves. Even more resources are likely to be discovered, but obstacles of climate, terrain and distance hinder their exploitation. Almost 80% of Russia's oil production comes from large fields with remaining resources of five to ten years at current production rates. Russia has enormous resource potential for renewables, including 1 500 Gtoe of solar; 620 Gtoe of wind, mainly along its Arctic and Pacific shores; 306 Gtoe of small hydro; technical potential of 100 Mtoe of bioenergy; and 22 Mtoe of geothermal in Kamchatka and the North Caucasus region. Total technical potential is 3 150 Mtoe per year. However, the use of this potential is constrained by the vast distances over which the energy would have to be transmitted to consumers.

- **Development of renewable energy**

Electricity is projected to grow by 30% from 2013 to 2040. This requires the construction of 2.3 GW of average annual capacity additions to increase installed generation capacity from 232 GW in 2013 to 294 GW by 2040. Natural gas-fired generation accounts for 53% of the total power mix in 2040, followed by nuclear (21%), hydro (14%) and coal (12%). The share of electricity generated from other renewables increases from 0.32% to 0.46% over the projection period. Petroleum products conversely decline from 0.82% to 0.14% of electricity generation, but both fuel types remain the major fuel for generation in isolated areas, in particular for northern regions in the Far East. The nuclear energy share in generation increases from 16% in 2013 to 21% in 2040 as construction of projected nuclear plants is completed. Coal capacity remains flat, but electricity generation from coal rises slightly as outdated technology is replaced with more efficient units. Russia's target of a 2.5% share of renewable energy in 2020 outlined by the government is not met. Meeting these goals requires stronger measures to achieve renewable energy development targets and avoid implementation delays.

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17 Singapore

- **Energy utilization status**

In highly urbanized and energy intensive countries like Singapore all possible avenues for power generation need attention. In this context, rooftop installations of both solar and wind energy are of particular interest for Singapore, especially because of Singapore's condition of land limitation. Decentralized and distributed energy sources such as rooftop wind and solar installations have numerous advantages.

Singapore's installed electricity generation capacity is 12.5 GW, which is almost entirely derived from fossil fuels. Household electricity consumption is 15% of the total electricity consumption and consumption by commercial and services sector is 37%. Singapore is committed to reducing its emissions by 7%-11% below 2020 business-as-usual levels. Hence, decentralized and distributed energy sources such as rooftop wind and solar installations require due attention in terms of resource estimation and techno-economic evaluation. Based on the space availability in Singapore, maximum cumulative capacity of rooftop photovoltaic installations is estimated to be 5 GW p by 2030, with 80% of the installed capacity on rooftops and facades. However, the potential for wind energy is not fully understood in built-up areas and hence not fully estimated. In order for Singapore to achieve this goal and to diversify the energy mix, several government agencies are working with Institutes of Higher Learning and local SMEs. Singapore is 100% dependent on imports of oil and gas for domestic consumption, including power generation and supplying oil refineries.

- **Development of renewable energy**

Singapore is exploring further ways of diversifying the energy mix by scaling up deployment of solar PV panels, regarded as the ‘most economically and technically viable renewable energy option’. It has launched the Solar Nova Programme to aggregate demand for solar energy ‘across government buildings and spaces, to yield savings from economies of scale’ while seeking to ‘demonstrate solar energy’s viability in Singapore to catalyze further adoption by the private sector’. Singapore is also intensifying efforts to promote more efficient energy use and decrease carbon dioxide (CO_2) emissions. One key strategy is to improve energy efficiency to reduce the carbon footprint and help ‘businesses and households save costs’. Singapore continues to invest in research, development and demonstration (RD&D) of innovative energy technologies to help achieve its energy objectives. The Energy National Innovation Challenge (ENIC) seeks to ‘find and deploy cost-competitive energy solutions that improve energy efficiency, reduce carbon emissions and broaden energy options’. It is complemented by the Energy Strategic Research Programme (ESRP), aimed at developing ‘the clean energy industry by building a vibrant clean energy ecosystem with a critical mass of companies, skilled manpower and R&D capabilities’ .

Apart from a limited expansion of grid-connected rooftop solar photovoltaic (PV) installations (636 solar PV installations with a combined capacity of 26 megawatts alternating current in 2014), waste-to-energy is the main renewable energy source in use, accounting for 3.7% of Singapore's power mix in 2014. Singapore has currently excluded nuclear energy as a way of decreasing its heavy reliance on fossil energy because of concerns over the safety of existing nuclear energy technologies.

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18 Chinese Taipei

- **Energy utilization status**

Chinese Taipei, located off the southeastern coast of China, consists of the island groups of Formosa, Penghu, Kinmen and Matsu. The total area of Chinese Taipei is 36 193 square kilometres (km^2), being 394 km long and 144 km at its widest point. Chinese Taipei has very limited domestic energy resources; it imports nearly 99.7% of its fossil fuel supply. In 2013, domestic natural gas accounted for only 0.25% of TPES, while hydro provided 0.43% and geothermal, biomass, solar and wind power combined provided just 1.8%. Improving energy self-sufficiency is vital to energy security. Policies are being implemented to increase domestic renewable energy production, as well as to enhance natural gas production.

Chinese Taipei's 2008 sustainable energy policy outlines a solution beneficial not only for energy production but for the environment and the economy as well: A high-efficiency, high-value-added, low emission and low-dependence energy consumption and supply system. The government aims to reduce energy demand by improving energy efficiency, to secure energy supply by diversifying energy sources and increasing upstream acquisitions, and to balance supply and demand.

- **Development of renewable energy**

Chinese Taipei's Bureau of Energy formulates and implements energy policy and is responsible for creating a better energy business environment. It recently introduced a suite of energy-related policies that define market rules for renewable energy, petroleum products, natural gas and electricity. The overarching aim is to improve energy security by developing domestic energy resources, especially renewables, supported by secure oil, natural gas and coal imports. Several renewable projects have already been initiated, including the Penghu Low Carbon Island Development Project, the Million Rooftop PVs Promotion Project and the Thousand Wind Turbines Promotion Project. To secure energy supply and meet future demand, in October 2012 Chinese Taipei released its Guideline on Energy Development, which readdresses energy security, energy efficiency and clean energy policy. In addition to diversifying sources and methods of acquiring energy imports, and enhancing the rate of domestic production, the guideline promotes energy development and proliferation via new technologies. High costs and instability of supply are identified hurdles to developing accessible and affordable clean energy domestically, which new energy technologies may be able to resolve.

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19 Thailand

- **Energy utilization status**

The Kingdom of Thailand, located in Southeast Asia, is home to 68 million people in an area of 513,000 square kilometers divided into 76 provinces. Thailand has explicitly set energy security as the top policy objective, followed by economic affordability and environmental sustainability, in the Thailand Integrated Energy Blueprint (TIEB) underpinned by five individual but interrelated energy plans covering natural gas, oil, energy efficiency, the power sector and alternative energy sources, respectively. Such prioritization was in response to the continuous growth in energy demand while depleting domestic reserves of energy resources in Thailand.

Thailand has long been promoting and supporting energy development, especially in the field of alternative energy21 and energy conservation, driven primarily by the pursuit of enhanced energy security, stabilized economic prosperity and improved well-being.

- **Development of renewable energy**

With the steadily increased use of alternative energy sources and improved energy efficiency, imports of fossil fuels would be expected to decline, and so would the long-term risks of energy expenditure on energy importation. In addition, indigenous clean energy development could bring multiple co-benefits such as environmental, social and economic advantages, including job creation, in comparison to imported fossil fuels. Toward this end, indigenous renewable energy resources, including solar, wind, various biomass-based energy sources and hydropower, have been given priority with clear and ambitious targets and supportive policy schemes in place. By 2015 Thailand had developed a decent share of renewables in primary energy production. In 2015 alone, modern renewable energy increased by 11.7% on a year-on-year basis – as much as four times the annual growth rate of the total primary energy supply. Of the total amount of renewable energy consumption in 2015 (10 306 ktoe), about 64% was used for heating, 16% for electricity generation, and nearly 20% for biofuel production.

As far as the power sector is concerned, installed renewable energy generating capacity has doubled over the past decade and seen a steeper ramp-up since 2012, as illustrated in Figure 9. Among the power mix, hydropower and bioenergy account for the lion's share, while the share of solar PV and wind power has quickly caught up, attributed largely to the generous adder rates and favorable Feed-in Tariffs (FITs) for these two technologies. Bioenergy has scaled up by a factor five over the same period.

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20 The United States

- **Energy utilization status**

The United States is endowed with abundant natural resources; it is the second-largest coal and the largest oil and gas producer in the world. Oil, natural gas, coal and uranium are the primary non-renewable resources. Renewable resources include on- and off-shore wind, solar, hydro, diverse biomass and tidal power.

Wind, both on- and off-shore, and solar resources, including a substantial amount suitable for concentrated solar power generation, are abundant. Solid biomass resources in the West and East North Central regions are significant, as is methane potential. Geological studies show significant enhanced geothermal resources are available, but commercially successful technology is still being developed. Large-scale development of traditional and pumped-storage hydroelectricity is slow due to environmental concerns and water restrictions, and is expected to be limited to medium-scale installations.

Of the variety of renewable and non-renewable energy resources available, the most important are solar, wind, coal and natural gas. Availability of relatively inexpensive energy resources has supported recent growth of the economy.

- **Development of renewable energy**

A clean energy revolution is taking place across America, underscored by the steady expansion of the U.S. renewable energy sector. The clean energy industry generates hundreds of billions in economic activity, and is expected to continue to grow rapidly in the coming years. There is tremendous economic opportunity for the countries that invent, manufacture and export clean energy technologies.

Responsible development of all of America’s rich energy resources -- including solar, wind, water, geothermal, bioenergy & nuclear -- will help ensure America’s continued leadership in clean energy. Moving forward, the Energy Department will continue to drive strategic investments in the transition to a cleaner, domestic and more secure energy future.

The US has been actively involved in PV research for many decades, its market was relatively slow to develop overall, but is now a world leader in solar application with increasing tighter government Federal directives creating positive investment in all renewable energy. Significantly advanced markets exist in particular States, such as California, which have had long term deployment programs. The goal of the U.S. Department of Energy Sun Shot Initiative is to make large-scale solar energy systems at low grid penetrations cost-competitive with other energy sources by 2020.

The tremendous growth in the U.S. solar industry is helping to pave the way to a cleaner, more sustainable energy future. Over the past few years, the cost of a solar energy system has dropped significantly helping to give more American families and business access to affordable, clean energy. Through a portfolio of R&D efforts, the Energy Department remains committed to leveraging America’s abundant solar energy resources driving research, manufacturing and market solutions to support widespread expansion of the nation’s solar market.

Reference

[1] https://www.energy.gov/science-innovation/clean-energy

[2] APEC Energy Demand and Supply Outlook 6th Edition (2016) , Asia Pacific Energy Research Centre (APERC),Institute of Energy Economics, Japan Tokyo, Japan.

21 Viet Nam

- **Energy utilization status**

Viet Nam, in the centre of South-East Asia, has a geographically diverse land area of 330 967 km^2. Being in a tropical monsoon zone and profoundly impacted by the East Sea, Viet Nam has warm weather, abundant solar radiation, high humidity and generous seasonal rainfall.

As of end 2014, Viet Nam's proven fossil energy reserves were 4.4 billion barrels of oil, 620 bcm of gas and 150 Mt of coal. Coal basins are mainly in northern regions, while oil and gas have been found offshore and in the south. Renewables suitable for electricity are hydro, solar, biomass, wind and geothermal. The economic and technical potential of hydro is estimated at 25 gigawatts (GW), excluding about 4 GW to 7 GW of small hydropower (less than 30 megawatts [MW]). Potential capacity within the next 20 years for wind is 8 GW, biomass 2 GW and municipal solid waste (MSW) 300 MW to 400 MW.

- **Development of renewable energy**

From 15 GW in 2013, renewables expand to over 34 GW in 2040. The High Renewables Scenario adds a further 2.8 GW of small hydro and 18.6 GW of other renewable power sources. As a result, the share of renewables in the power mix increases considerably from 2013 levels: 45% in 2030 and 41% in 2040 for capacity, and 35% in 2030 and 30% in 2040 for generation. A higher penetration of renewables increases the total power installed capacity requirement to 136 GW in 2040. However, renewable growth under the High Renewables Scenario happens gradually, in step with policy reforms and with international technical and financial support. The High Renewables Scenario demonstrates power sector CO2 emissions benefits, with reductions of 6% to 14% per year during 2025-40. This scenario also leads to significantly reduced thermal coal imports.

Reference

[1] APEC Energy Demand and Supply Outlook 6th Edition (2016) , Asia Pacific Energy Research Centre (APERC),Institute of Energy Economics, Japan Tokyo, Japan.

Session 2: Policies on green buildings in APEC region

At present, the green building evaluation system of APEC mainly includes the "Assessment standard for green building " (GB50378-2014) of China, the "Leadership in Energy & Environmental Design Building Rating System" (LEED) of American, the "Comprehensive Assessment System for Building Environmental Efficiency" (CASBEE) of Japan, the "National Australian Built Environment Rating System" (NABERS) of Australian, and the "GB tools" of Canadian GB Tools evaluation system.

1 Assessment standard for green building

In order to carry out China's technical and economic policies, save resources, protect the environment, standardize the evaluation of green buildings and promote sustainable development, China has formulated the assessment standard for green building.

The assessment of green building should follow the principle of local conditions, combined with the climate, environment, resources, economy and culture of the region where the building is located, and comprehensively evaluate the performance of energy saving, land saving, water saving, timber saving and protecting environment during the whole life period of the building.

Green building, refers to the building's full life cycle to maximize resource conservation (energy, land, water, and materials) to protect the environment and reduce pollution, provide people with healthy, appropriate and efficient use of space, and harmonious society construction.

The evaluation of green building should be based on single building or building group. When evaluating a single building, any index that involves systematicness and integrity should be evaluated based on the overall evaluation of the project.

The evaluation of green building is divided into design evaluation and operation evaluation. The design evaluation should be carried out after the examination and approval of the construction drawing design document, and the operation evaluation should be carried out after completion of the building acceptance and put into operation for a year.

The applicant should carry out the technical and economic analysis of the whole life period of the building, rationally determine the scale of the building, select the appropriate construction technology, equipment and materials, control the whole process of the planning, design, construction and operation, and submit the corresponding analysis, test report and document.

The evaluation index system of green building consists of 7 indexes, that is, land saving and outdoor environment, energy saving and energy utilization, water saving and water resources utilization, timber saving and material resources utilization, indoor environment quality, construction management and operation management. Each category includes a control item and a scoring item. When designing evaluation, 2 kinds of indicators such as construction management and operation management are not evaluated, but relevant provisions can be pre evaluated. 7 kinds of indicators should be included in the operation evaluation. The evaluation results of control items are satisfied or not satisfied, and the scores of scoring items and bonus points are classified. The evaluation of green building should be determined according to the total score.

The total score of the 7 indicators of the evaluation index system is 100 points. The scoring items of the 7 types of indexes are Q1, Q2, Q3, Q4, Q5, Q6, Q7, according to the actual score values of the rating items of the evaluation architecture divided by the total score value applied to the building and then multiplied by 100 points.

2 Leadership in Energy & Environmental Design Building Rating System

The “Leadership in Energy & Environmental Design Building Rating System”, which is established and implemented by the American green building association, is called LEEDTM in the world. It is considered to be the most perfect and most influential assessment standard in all kinds of architectural environmental assessment, green building evaluation and construction sustainability assessment standards of all countries in the world.

The LEEDTM evaluation system consists of five aspects, which constitute its sustainable sites, water efficiency, energy & atmosphere, materials & resources, indoor environmental quality, innovation & design process. LEED certification evaluation elements:

- **Sustainable Sites (14 points):**

The sustainable site evaluation includes the control of soil and water conservation and surface deposition in the building process; maintaining and restoring public green space; reducing outdoor light pollution; reasonable tenant design and construction guidelines.

- **Water Efficiency (5 points):**

LEED-CS in the part of the construction of water saving, the section of the festival water as the "landscape water consumption, use of advanced science and technology to save water, reduce the average daily water" three items. Rainwater recovery technology and intermediate water reuse technology can be used.

- **Energy & Atmosphere (17 points):**

In the first building process, the minimum energy consumption standard must be reached. In the ASHRAE STANDARD, the minimum energy consumption in the building process is clearly explained. LEED is also a standard to determine whether the energy consumption is up to LEED in the light of the energy consumption standard. The main technical measures are not to use the refrigerant containing Freon; double Low-e glass; optimize the insulation and sun shading system; passive design; install the household metering system; choose energy saving air conditioning; install solar energy, wind energy and other renewable energy systems.

- **Materials & Resources (13 points):**

In view of the actual situation of building material waste, the scoring point of material and resource utilization is groundbreaking in the process of LEED certification. This scoring point is aimed at promoting the rational use of resources in the construction process, making full use of recyclable materials and manifests in the LEED certification process in the form of bonus. In the material and resource assessment, the following articles are mainly referred to: the storage and collection of recyclable articles, the management of the construction waste, the reuse of resources, the components of recycling and the utilization of local materials.

- **Indoor Environmental Quality (15 points):**

Indoor air quality monitoring is mainly to monitor the built environment and indoor environment quality. In the implementation process, the following are taken into consideration: minimum indoor environmental quality requirements, smoking environment control, new wind monitoring, enhanced ventilation, indoor air environment quality management, low volatile material application, use and control of indoor chemical substances, system controllability, thermal comfort and natural lighting and field of vision distribution. The technical measures adopted include installation of fresh air monitoring system and independent exhaust system in dangerous gas or chemical products storage and use area.

- **Innovation & Design Process (5 points):**

Design innovation means that in the process of building design, it adds a reasonable and pioneering design concept that has great benefits to energy conservation and environmental protection, and can get extra innovation score.

It is platinum, gold, silver and certification level to reflect the green level of building. LEED according to the indicators in every aspect: 1, sustainable site planning; 2, protection and conservation of water resources; 3, efficient energy utilization and atmospheric environment; 4, materials and resources issues; 5, indoor environmental quality. The total score is 110 points, and it is divided into four certification grades: Certification level 40-49; Silver grade 50-59; Gold grade 60-79; Platinum is more than 80.

3 Comprehensive Assessment System for Building Environmental Efficiency

CASBEE, a comprehensive environmental performance evaluation system for Japanese buildings, was launched in 2001, supported by the Ministry of land and transportation. It is mainly developed by JSBC, Japan's Sustainable Building Association, and its members are from enterprises, governments and academia. Since 2003 promulgated for evaluation of the new building standards, so far has promulgated for the existing buildings, the renovation of buildings, evaluation of the new independent residential, city planning, schools, and thermal effect, property assessment standards, and will be issued for urban evaluation standards.

CASBEE is to improve the residential building (indoor environment) and reduce the system of performance evaluation of integrated environment of the earth environment integration, a clear delineation of the evaluation object boundary is used between the boundary and the construction of the highest point of the imaginary closed space creatively introduced the "building environmental efficiency BEE", "building and environmental quality the performance of Q" and "the structure of the external environment load L" strictly divided.

At present, CASBEE can be used for “building environmental efficiency evaluation” and “$LCCO_2$ evaluation”. According to the value of “building environmental efficiency BEE”, “building environmental efficiency evaluation” is more concise and clearly divided into five grades of S, A, B+, B- and C from high to low. Green buildings get “red label” and three star B+ above evaluation. "$LCCO_2$ evaluation" is to evaluate the $LCCO_2$ of the total life cycle CO_2 discharge from building construction, application until discarded. The standard calculation method of automatic and simple calculation of $LCCO_2$ is introduced. In order to clearly express the performance of $LCCO_2$, a comprehensive evaluation based on BEE is added to evaluate the construction and reference building (with the equivalent standard of the criteria for building the energy saving building). The $LCCO_2$ is compared, indicating that the ratio is also divided into five grades, which is called "green label".

4 National Australian Built Environment Rating System

NABERS is a national rating system that measures the environmental performance of Australian buildings, tenancies and homes. Put simply, NABERS measures the energy efficiency, water usage, waste management and indoor environment quality of a building or tenancy and its impact on the environment.

NABERS provides four environmental rating tools NABERS Energy, NABERS Water, NABERS Waste and NABERS Indoor Environment to measure the actual operational performance of existing buildings and tenancies.

NABERS can be used to rate commercial offices, shopping centres, hotels and homes.

NABERS ratings for offices can be used to measure the performance of a tenancy, the base building or the whole building. The tenancy rating includes only the energy or resources that the tenant controls. A base building rating covers the performance of the building's central services and common areas, which are usually managed by the building owner.

A whole building rating covers both the tenanted spaces and the base building, and is typically used in an owner-occupied building, or where there is inadequate metering to obtain a base building or tenancy rating.

It does this by using measured and verified performance information, such as utility bills, and converting them into an easy to understand star rating scale from one to six stars. For example, a 6 star rating demonstrates market-leading performance, while a 1 star rating means the building or tenancy has considerable scope for improvement.

The NABERS approach to rating the environmental performance of buildings is world leading and unique. It takes real, measured impacts and communicates these in a clear and simple way.

Through NABERS, the Australian property industry has a credible standard to confidently communicate results, and to judge environmental initiatives by their actual results in star ratings. NABERS ratings are used throughout the property sector to drive deep cuts in environmental impacts, and evaluate the real results of initiatives. NABERS star ratings are now common language.

This deep knowledge of building performance and potential for improvement has transformed the Australian property industry, which is now acknowledged as an international leader in the greening of buildings. It has led to a real, measured and significant reduction in environmental impact.

Each of the NABERS tools has been developed to:

- provide a credible and independent market-based benchmark
- communicate environmental performance through a simple star rating
- drive best practice through setting stretch targets meet the needs of industry, and
- achieve real positive environmental outcomes.

5 GB tools

In 1996, Canada launched a "Green Building Challenge" activity, the initial participation in the activity of more than 14 countries, after the study of 35 projects, the final introduction of a set of building environment evaluation system for many countries ——GB Tools.

The GBC's evaluation system is called “The Green Building Tool”, or the “GB Tools”, which is built on the excel platform. The evaluation system covers all aspects of the evaluation of the building environment because the number of countries involved in the development of the project and the content of the project involved in the practice are involved in all areas of the building. The GB Tools evaluation system is divided into 4 levels, consisting of 6 fields and 120 indicators. The range of GBTool evaluation index is from -2 to 5, which only indicates the "green" degree of the evaluation building, so the evaluation scale of the GBTool system belongs to the relative value, in which the -2 points, representing the performance of the building, are not required, and the 0 points are the benchmark, indicating the performance of the lowest acceptable requirement in the area; 1-4 points, representing different levels of architecture in the middle. The performance is 5 points, indicating the building environmental performance which is higher than the standard.

The evaluation includes: energy consumption, indoor environmental quality, environmental management, economic burden, performance, quality of service.

Evaluation method: four level weight calculation: the values of each bottom line are multiplied by their respective weight percentages and then added. The value of -2 to 5 represents the degree of "green".

Advantages: each index is independent of each other, and the expansion of the system is also conducive to the objectivity of the evaluation.

Disadvantages: complex structure and heavy workload.