Chapter 2

Hydrogen Policies in EAS Countries

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CHAPTER 2

Hydrogen Policies in EAS countries

This chapter summarises the policies relevant to hydrogen energy, together with the potential of solar and wind energy that could possibly be used to generate zero-emissions hydrogen.

The study team has selected 13 countries from the East Asia Summit (EAS) region based on their potential for developing hydrogen energy. Each country's approach to hydrogen is different, with the governments of Australia, India, China, Japan, and Republic of Korea (henceforth Korea) having already formulated a hydrogen policy, and New Zealand set to draw a hydrogen roadmap in 2019. Though other countries lack any specific hydrogen policy as of January 2019, even in some of these, several pilot projects are being promoted.

When it comes to CO_2, power and transport account for a majority of emissions, and these are expected to increase. Hydrogen itself has various industrial uses, and can be an environmentally friendly energy source. Though hydrogen's production cost was previously thought to be prohibitive, technology is now paving the way for affordable, CO_2-free hydrogen.

This juncture in history features both an urgent need to rein in CO_2 emissions and a high priority placed on global energy security. Fortunately, the EAS region has both abundant renewable energy and untapped hydrogen energy resources. In addition to each individual country's efforts, the EAS countries should draft a communal energy point of view and collaborate on a hydrogen supply chain for the next generation.

1. Selected ASEAN member countries

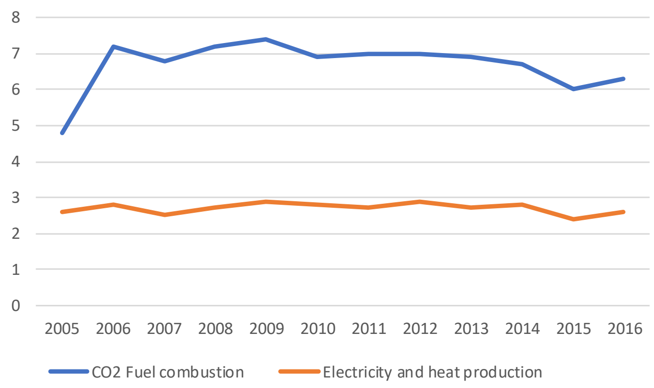
1.1. Brunei Darussalam

1.1.1. Climate policy, INDC

Brunei Darussalam's intended national determined contribution (INDC) is geared to reducing the country's total energy consumption by 63% by 2035, with 10% of total power generation sourced from renewables.

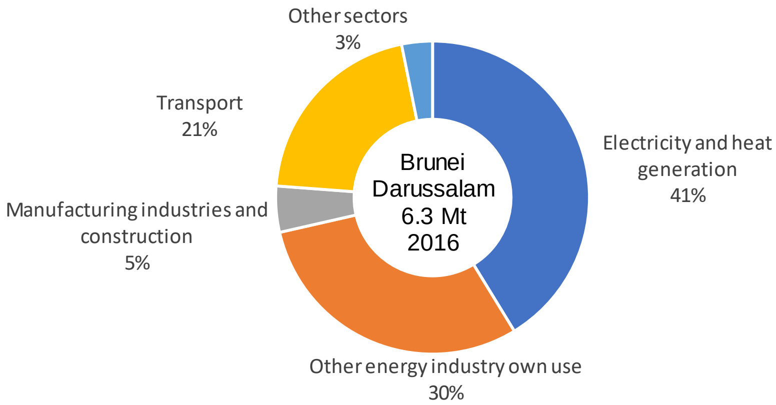
As shown in Figure 2.1, Brunei Darussalam's CO_2 emissions have generally been declining since 2009. Figure 2.2 shows how electricity and heat production in 2016 accounted for 41% of total CO_2 emissions, followed by other energy industry's own use for another 30% (UNFCCC, 2015).

Figure 2.1 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.2 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018

1.1.2 Renewable energy and hydrogen policy

1) Renewable energy policy

The Brunei Darussalam Prime Minister's office issued an energy white paper in 2014 (Energy Department, Brunei Darussalam, 2014), which detailed its four renewables initiatives:

(a) Introduce renewable energy policy and regulatory frameworks;

(b) Scale-up market deployment of solar photovoltaics and promote waste-to-energy technologies;

(c) Raise awareness and promote human capacity development; and

(d) Support research, development and demonstration and technology transfer.

The Prime Minister's office also set a key performance indicator for renewable energy, as shown in Table 2.1:

Table 2.1 Key Performance Indicator for Renewable Energy

Key Performance Indicator	Unit	2010 baseline	2017	2035
Power generation from renewable sources of energy	MWh	808	124,000	954,000

Source: Brunei Darussalam Energy White Paper.

2) Potential of solar and wind energy

The United Nations Food and Agriculture Organization's 2011 renewables survey for Brunei Darussalam indicated 18.9 MJ/m^2/day of solar radiation and 372 MW of potential offshore wind power (Malik, 2011).

3) Hydrogen policy

The Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD) has started a project to deliver hydrogen fuel to Japan. AHEAD is composed of four Japanese companies that have an interest in hydrogen and fuel cell technology sourced from Brunei Darussalam. This supply is meant to help Japan establish a functioning hydrogen society (Chiyoda Corporation, 2018). The project has completed a process for intergovernmental cooperation and involves building a new hydrogen production facility in Brunei Darussalam. The facility is expected to begin operation in January of 2020 and will be active for a year while its capabilities are assessed, with the hydrogen produced delivered to another plant in Japan and supplied to customers and businesses. Once fully operational, the facility is expected to provide Japan with enough hydrogen to power some 40,000 fuel cell vehicles.

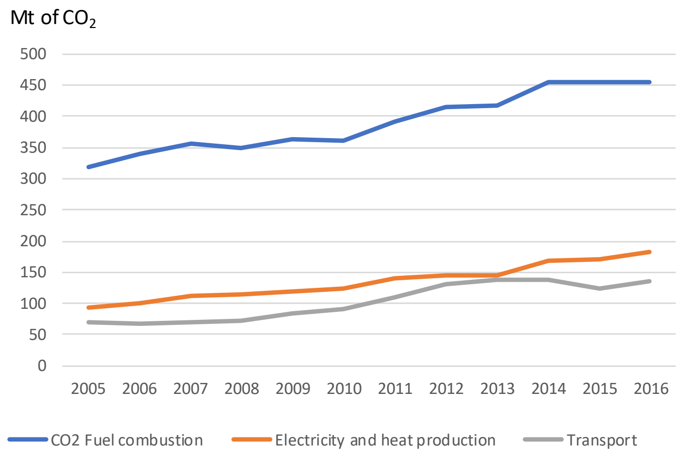
1.2 Indonesia

1.2.1 Climate policy, INDC

Indonesia is committed to reducing its greenhouse gases by 29% from its current baseline by 2030. Reduction will be increased to 41% if international cooperation is provided.

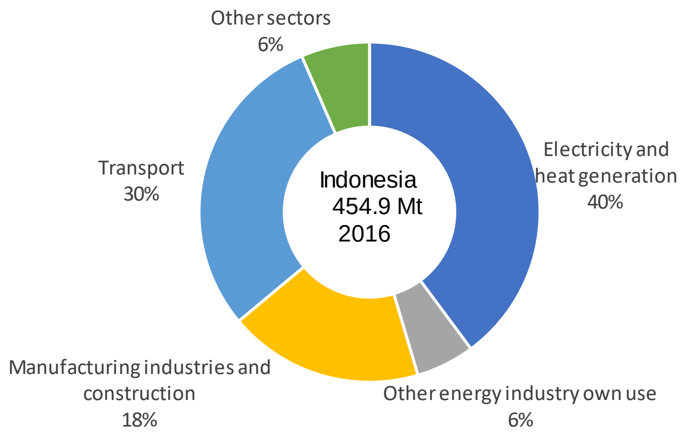
As shown in Figure 2.3, CO_2 emissions have been steadily on the rise, having increased by 43% from 2005 to 2016. Figure 2.4 shows how electricity and heat production accounts for 40% of 2016 CO_2 emissions in Indonesia, followed by transport with 30% (UNFCCC, 2015).

Figure 2.3 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.4 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

1.2.2 Renewable and hydrogen energy policy

1) Renewable energy policy

Indonesia enacted its National Energy Policy in 2014 (Government Regulation No. 79/2014) (IEA, 2018). The policy aims to transform the energy mix to 23% renewables by 2025 and 31% by 2050 (see Table 2.2 for further details).

Regarding solar power, on 16 November 2018, Energy and Mineral Resources Minister Ignasius Jonan issued Ministerial Regulation 29/2018 on the use of electricity produced through rooftop solar photovoltaic panels for customers of the state-owned electricity company PLN (Jakarta Post, 2018). Furthermore, the Ministry's director general for renewable energy, Rida Mulyana, said on 28 November 2018 that the government expected rooftop solar photovoltaic panels to produce 1 GW of electricity nationwide within 3 years.

Table 2.2 Target of Renewable Energy Development (in GW)

Type	Capacity power plants		
	Committed (in 2016)	**2025 Target**	**2050 Target**
Geothermal	7.242	7.242	17.5
Hydro	15.559	20.987	45.0
Bioenergy	2.006	5.500	26.1
Solar	0.540	6.500	45.0
Wind	0.913	1.800	28.6
Other energy	0.372	3.125	6.4
Total	26.631	45.153	168.6

Source: Otoritas Jasa Keuangan OJK (2017).

Every year, the Ministry of Energy and Mineral Resources announces the Electricity Supply Business Plan for the next 10 years. The latest plan for 2018–2027 estimates additional power capacity, as shown in Table 2.3 (ESDM, 2018).

Table 2.3 Additional Power Capacity 2018–2027

Type of Power Plant	Allocated Capacity (GW)	Percentage
Coal-fired Power Plant	26.8	47.8
Gas-fired Power Plant	14.2	25.4
Hydro Power Plant	4.8	8.6
Geothermal Power Plant	4.6	8.2
Others	5.5	9.8
Total	56	100

Note: Others include biomass, biogas, solar (3.4 GW), etc.
Source: ESDM, 2018.

2) Potential of solar and wind energy

Indonesia has significant solar radiation resources, with 4.8 $kWh/m^2/day$. The country's lengthy coastlines and consistent ocean breezes are thought to have huge potential for offshore wind. The Ministry of Energy and Mineral Resources has estimated 208 GW of potential solar power and 60.6 GW of potential wind power (*ESDM*, 2017).

3) Hydrogen policy

Indonesia has not drafted a specific hydrogen policy as of December 2018. To reduce its oil imports and maintain its liquid natural gas export position, Indonesia promotes renewables in addition to gas and coal exploration. Facing fast-growing automotive fuel consumption, the country is promoting biofuels and electric vehicles and will start hydrogen vehicle development.

Regarding hydrogen utilisation for power generation in Indonesia, Toshiba Energy Systems & Solutions Corporation (Toshiba ESS) announced on August 2018 that it has concluded a memorandum of understanding (MOU) with Badan Pengkajian dan Penerapan Teknologi (BPPT), an Indonesian government organisation, on the implementation of the renewables-based H2One™ autonomous off-grid hydrogen energy system. Under the MOU, Toshiba ESS and BPPT will study the installation site, the optimum system specifications, and the operation system, including maintenance, and aim to install the first system by 2022 (Toshiba 2018a).

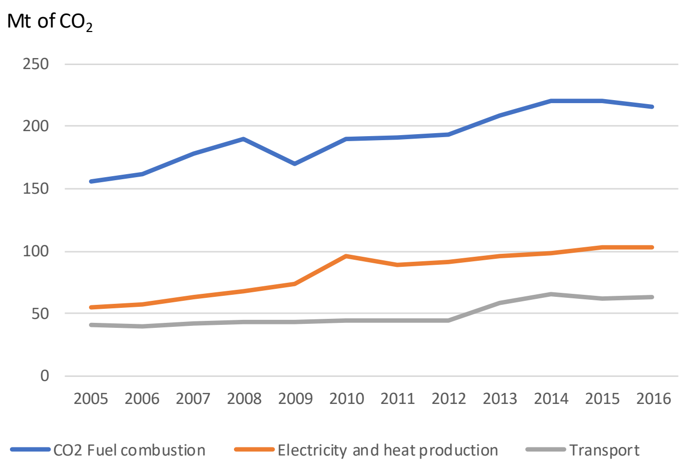
1.3 Malaysia

1.3.1 Climate policy, INDC

Malaysia intends to reduce its greenhouse gases by 45% by 2030 relative to the emissions intensity of GDP in 2005. This consists of a 35% unconditional reduction and a further 10% reduction conditional upon receipt of climate finance, technology transfer, and capacity building from developed countries.

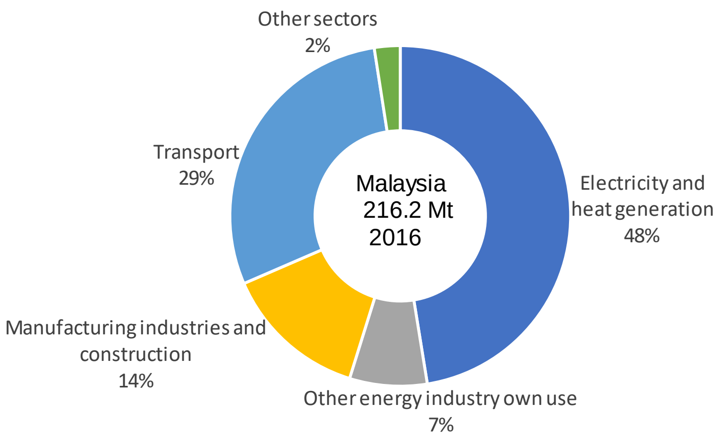
As shown in Figure 2.5, CO_2 emissions have been steadily on the rise in Malaysia, having increased 61% from 2005 to 2016. As shown in Figure 2.6, electricity and heat production accounts for 48% of total CO_2 emissions, followed by transport with another 29%. Especially, electricity and heat production have increased over the last decade (UNFCCC, 2015).

Figure 2.5 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.6 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

1.3.2 Renewable energy and hydrogen policy

1) Renewable energy policy

In 2017, Malaysia's Ministry of Energy, Green Technology and Water formulated its Green Technology Master Plan Malaysia 2017-2030 (Malek, 2017), which detailed the following three power sector goals:

(a) Renewable energy generation capacity will be expanded to 25% in 2025 and 30% in 2030 (see Figure 2.7);

(b) In order to increase power generation efficiency, Malaysia will introduce highly efficient coal-fired power and promote cogeneration; and

(c) Residential and commercial energy consumption will be reduced by 10% in 2025 and 15% by 2030.

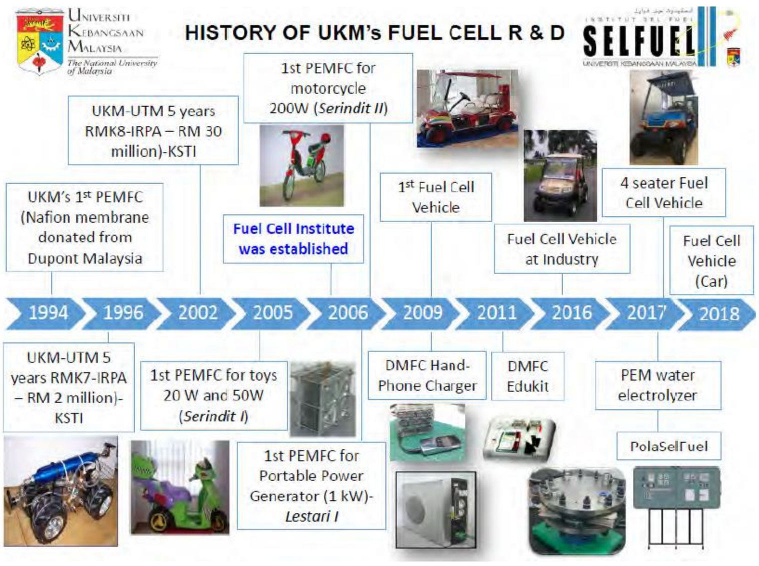
2) Potential for solar and wind energy

Malaysia is ideally suited for solar energy, with an average solar radiation of 400–600 MJ/m^2 per month (CleanMalaysia, 2016). On the other hand, the potential for wind energy has traditionally been recognised as low. However, studies have shown that offshore sites exhibit exploitable conditions for power generation, with average annual wind speeds of 4.1 m/s being recorded in the eastern Peninsula region (Reegle, 2015).

3) Hydrogen policy

In 2005, Fuel Cell Institute of Universiti Kebangsaan Malaysia formulated a hydrogen energy R&D roadmap.[1] However, due to the government changing, the roadmap was not utilised. On the other hand, since then, blueprints related to hydrogen have been published by academia in 2013 and 2017, as shown in Figure 2.7.

Figure 2.7 History of Fuel Cell R&D at the National University of Malaysia



UKM = National University of Malaysia.
Source: The 4th meeting of hydrogen potential, 10 January 2019.[2]

At present, the Sustainable Energy Development Authority (SEDA) is responsible for developing renewables, including hydrogen. However, SEDA has not incorporated hydrogen into its current energy development plan.

[1] http://aspheramedia.com/wp-content/uploads/2015/12/5e_9_01.pdf (accessed November 2018).

[2] Document of The National University of Malaysia obtained by Chiyoda Corporation.

In terms of a provincial initiative, Sarawak Energy, a utility company owned by Sarawak State, is building a pilot hydrogen production plant and refuelling station to evaluate their viability and fuel cells to power the local transportation sector in the future. Scheduled for completion in June 2019, this will be a dedicated refuelling station for transportation in Southeast Asia (Ten, 2018). Hydrogen fuel buses are expected to make their debut on the roads of Kuching city in March 2019. Sarawak's light rail transit system will use hydrogen fuel cell trains starting in 2024. The state is also looking into exporting hydrogen and scientific research is enabling transporting hydrogen almost in the same manner as liquid natural gas cylinders (FuelCellsWork, 2018).

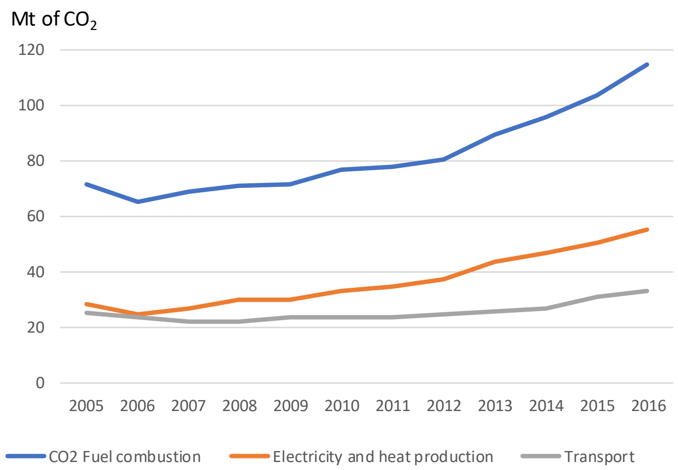
1.4 Philippines

1.4.1 Climate policy, INDC

The Philippines aims to reduce greenhouse gas emissions by about 70% by 2030 relative to its baseline scenario of 2000–2030.

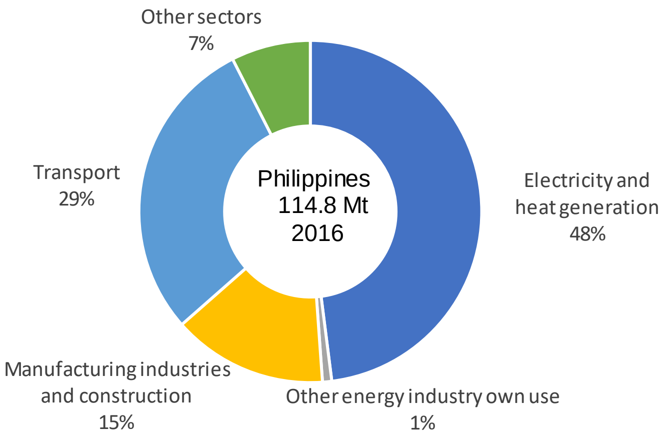
As shown in Figure 2.8, CO_2 emissions have been steadily on the rise in the Philippines, having increased 39% from 2005 to 2016. As shown in Figure 2.9, electricity and heat production accounts for 48%, followed by transport with another 29% (UNFCCC, 2015).

Figure 2.8 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.9 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

1.4.2 Renewable energy and hydrogen policy

1) Renewable energy policy

As shown in Table 2.4, the Philippines looks to increase its renewables-based power generation capacity to an estimated 15,304 MW by 2030, almost triple its 2010 level (DoE, 2019). The plan also intends to increase installed renewables capacity to at least 20,000 MW by 2040. To achieve these goals, the Department of Energy drafted its 'Renewable Energy Roadmap 2017-2040' (DoE, 2018).

Table 2.4 Capacity Addition of Renewable Power Generation by 2030(in MW)

Sector	Installed capacity as of 2010	Target capacity addition by				Total capacity addition 2011-2030	Total installed capacity by 2030
		2015	2020	2025	2030		
Geothermal	1,966.0	220.0	1,100.0	95.0	80.0	1,495.0	3,461.0
Hydro	3,400.0	341.3	3,161.0	1,891.8	0.0	5,394.1	8,724.1
Biomass	39.0	276.7	0.0	0.0	0.0	276.7	315.7
Wind	33.0	4,018.0	855.0	442.0	0.0	2,345.0	2,378.0
Solar	1.0	269.0	5.0	5.0	5.0	284.0	285.0
Ocean	0.0	0.0	35.5	35.0	0.0	70.5	70.5
Total	5,438.0	2,155.0	5,156.5	2,468.8	85.0	9,865.3	15,304.3

Source: Department of Energy, Republic of the Philippines, 2017.

2) Potential of solar and wind energy

Situated just above the equator, the Philippines has great solar energy potential. According to the Philippine Energy Security Plan, nationwide solar radiation has a potential annual average of 5.0–5.1 kWh/m^2/day. Solar potential is greatest from May to July, while the least insolation occurs between November and January.

In terms of wind energy, the National Renewable Energy Laboratory findings indicate over 10,000 km^2 of land area, equivalent to about 76,600 MW, with good to excellent wind potential (APCTT, 2018).

3) Hydrogen policy

The Philippines has not drafted a specific hydrogen policy as of December 2018. As outlined in its 'Energy Policy 2017-2040', the Department of Energy will embark on activities in line with the identified strategies throughout the planning period. The Alternative Fuels and Energy Technologies Roadmap 2017-2040 consists of three stages, Short-term (2017–2018), Medium-term (2019–2022) and Long-term (2023–2040) (DoE 2017). Preparation of the regulatory and infrastructure requirements of identified alternative fuels and technologies will be laid out by 2023–2040, and alternative fuel vehicles are expected to be mainstreamed in the country's transportation sector.

Furthermore, the government plans to install a CO_2-free hydrogen energy system for remote islands. On October 2018, the National Electrification Administration, a government organisation, concluded an MOU with Toshiba Energy Systems & Solutions Corporation on the implementation of the renewables-based H2One™ autonomous off-grid hydrogen energy system. Under the MOU, Toshiba and the National Electrification Administration will study the installation site, and determine the optimum local system specifications and the operation system, including maintenance (Toshiba, 2018b).

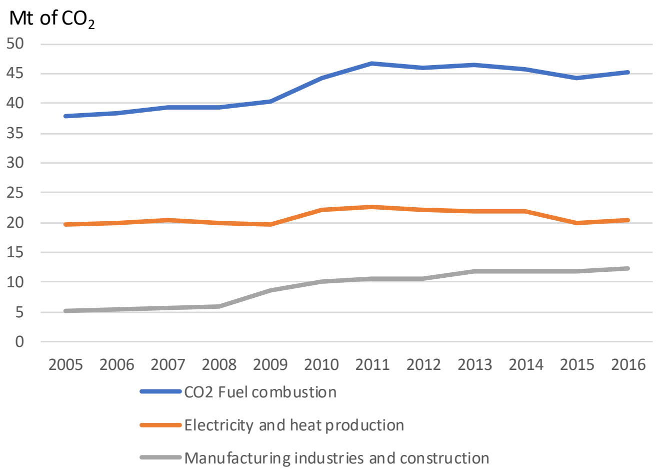
1.5 Singapore

1.5.1 Climate policy, INDC

Singapore plans to reduce its greenhouse gas emissions by 36% from its 2005 baseline by 2030 and stabilise its emissions with the aim of peaking around 2030.

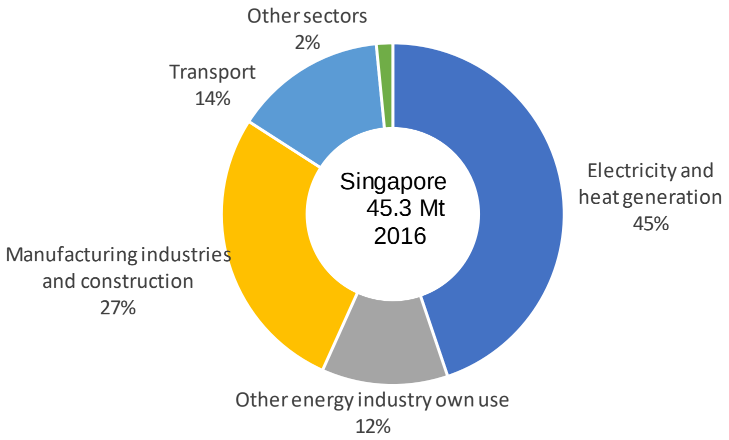
As shown in Figures 2.10 and 2.11, CO_2 emissions have generally been levelling off since 2011, with electricity and heat production accounting for 45% of the 2016 total, followed by manufacturing, industries and construction for another 27% (UNFCCC, 2015).

Figure 2.10 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.11 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

1.5.2 Renewable energy and hydrogen policy

1) Renewable energy policy

In 2014, Singapore released its 'Sustainable Singapore Blueprint 2015,' which outlined plans to generate 350 MW of solar power by 2020. In June 2017, the Deputy Prime Minister of Singapore, Mr. Teo Chee Hean, said that the government plans to raise solar power capacity to 1 GW beyond 2020, representing about 15% of peak electrical power demand during the day (Bhunia, 2017).

2) Potential for solar and wind energy

Singapore's solar power potential is estimated around 2 GW (Hicks, 2017). In a further development, the Singapore Housing Board is set to collaborate with a landscaping firm for the development of a floating solar system for coastal marine conditions (Tan, 2018). On the other hand, wind power potential is thought to be limited.

3) Hydrogen policy

Singapore has not drafted a specific hydrogen policy as of December 2018; however, Engie SA and other firms have experimented with storing renewables, and they plan to build a renewables storage system with hydrogen molecules on Semakau Island (Murtaugh, 2017).

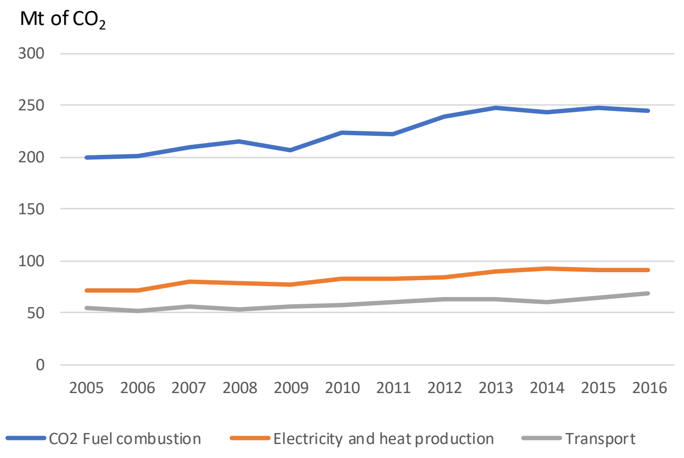
1.6 Thailand

1.6.1 Climate policy, INDC

Thailand intends to reduce its greenhouse gas emissions by 20% from the current baseline by 2030. This level of reduction could increase to 25%, subject to enhanced access to technology development and transfer, financial resources, and capacity building support through a balanced and ambitious global agreement under the United Nations Framework Convention on Climate Change.

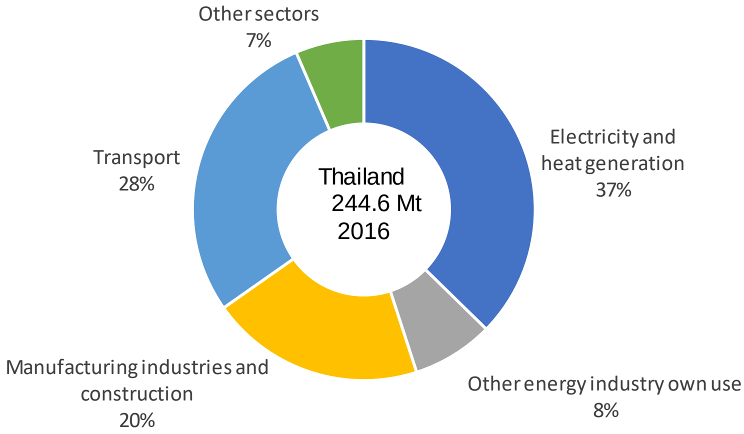
As shown in Figure 2.12, Thailand's CO_2 emissions have been steadily on the rise, having increased 22% from 2005 to 2016. As shown in Figure 2.13, electricity and heat production accounts for 37%, followed by transport for another 28% (UNFCCC, 2015).

Figure 2.12 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.13 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

1.6.2 Renewable energy and hydrogen policy

1) Renewable energy policy

As shown in Table 2.5, Thailand has formulated an 'Alternative Energy Development Plan 2015-2036' that targets 30% renewables in total energy consumption by 2036 (Achawangkul, 2017b).

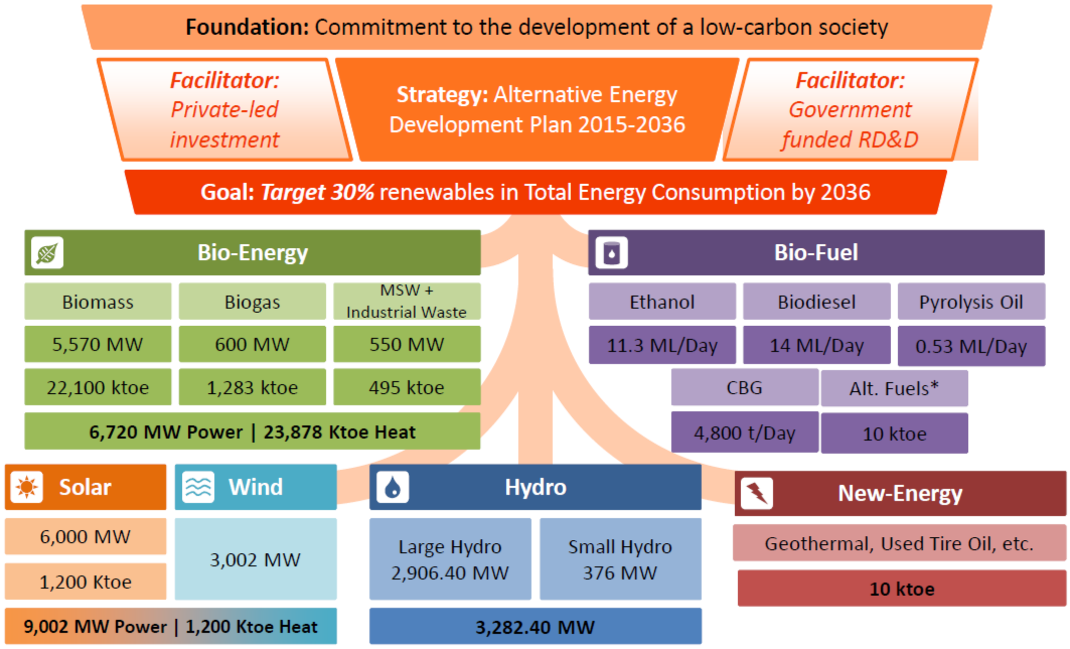
Table 2.5 Renewables Targets by 2036

Target	ktoe
RE consumption	39,388.67
Final energy consumption	131,000
RE share (%)	30%

ktoe = thousand tonnes of oil equivalent, RE = renewables.
Source: Alternative Energy Development Plan 2015–2036.

The plan outlines Thailand's renewable targets toward 2036, as shown in Figure 2.14:

Figure 2.14 Structure of Alternative Energy Development Plan 2015–2036



*Alternative fuels = Bio-oil, Hydrogen.
CBG = compressed biogas, ktoe = thousand tonnes of oil equivalent, MSW = municipal solid waste.
Source: Alternative Energy Development Plan 2015–2036.

- National Power Development Plan

In January 2019, Thailand's National Energy Policy Council approved the new version of its power development plan (PDP) 2018–2037. The PDP can be revised every 5 years as changes and technological trends occur in the power sector. The new PDP provides for additional power capacity of 56,431 MW till 2037, up from 46,090 MW in 2017. Of the increased capacity, 20,766 MW is set to be generated by renewable energy (Pugnatorius, 2019). A new version of the 'Alternative Energy Development Plan' has not been released as of January 2019.

2) Potential for solar and wind generation

The Ministry of Energy's Department of Alternative Energy Development and Efficiency has estimated the potential of solar power to be around 42 GW. Regarding wind potential, areas in which the average wind speed is greater than 6 m/s have potential for power generation of around 14 GW (Achawangkul, 2017a).

3) Hydrogen policy

Thailand has yet to draft a hydrogen policy as of December 2018. In the 'Alternative Energy Development Plan 2015-2036', hydrogen is just referred to as one of several alternative fuels (Bangkok Post, 2018).

Meanwhile, as a move toward utilising hydrogen, Phi Suea House in Chiang Mai hosted the Hydrogen Energy Summit in January 2018 to lay the foundation stone of the Green Hydrogen Refuelling Station in Southeast Asia. Developed by CNX Construction and owned by Sebastian-Justus Schmidt, the Phi Suea House is powered entirely by a solar-hydrogen system, a world's first for energy storage of its size. The solar-powered hydrogen storage system provides 24-hour, year-round access to clean energy, even during periods of bad weather (Phi Suea House, 2019).

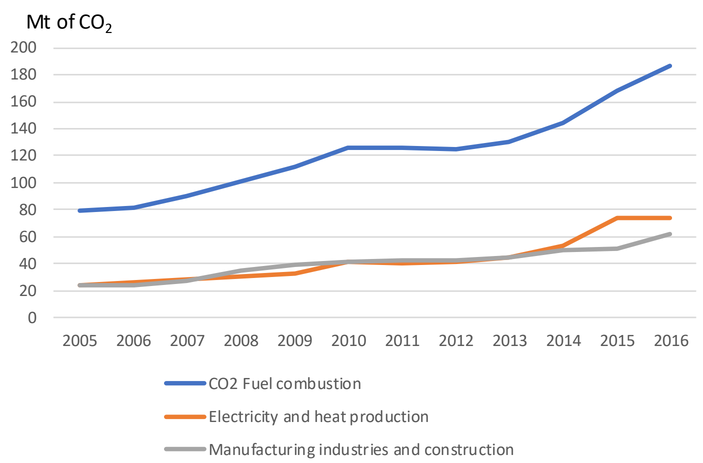
1.7 Viet Nam

1.7.1 Climate policy, INDC

Viet Nam intends to reduce its greenhouse gas emissions by 8% compared to its baseline level by 2030. The reduction could increase up to 25% if international support is received through bilateral and multinational mechanisms under the Global Climate Agreement.

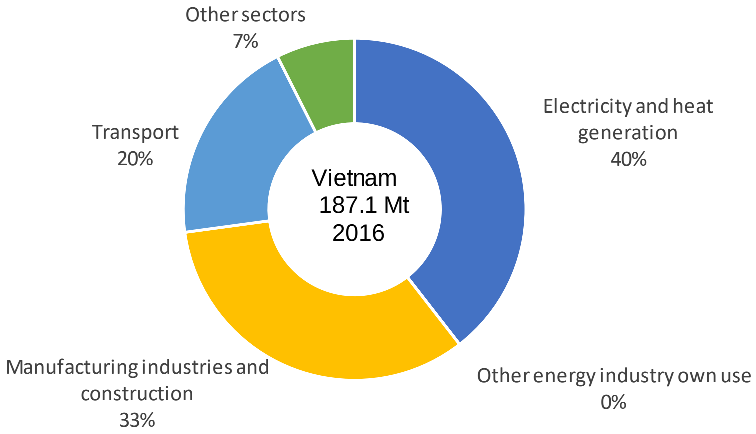
As shown in Figure 2.15, CO_2 emissions have been steadily on the rise, having increased 37% from 2005 to 2016. As shown in Figure 2.16, electricity and heat production accounts for 40%, followed by manufacturing, industries and construction for another 33% (UNFCCC, 2015).

Figure 2.15 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.16 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

1.7.2 Renewable energy and hydrogen policy

1) Renewable energy policy

Viet Nam's 'Revision of National Power Development Plan' details its plans to increase wind power from the current 140 MW to about 800 MW in 2020, about 2,000 MW in 2025, and about 6,000 MW in 2030 (Vietnam Electricity, 2016). Viet Nam also plans to increase solar power capacity from the current negligible rate up to about 850 MW in 2020, about 4,000 MW in 2025, and about 12,000 MW by 2030. The percentage of production from solar energy will be about 0.5% in 2020, about 1.6% in 2025, and about 3.3% in 2030.

Furthermore, Prime Minister Phuc said on June 2018 that Viet Nam will increase the electricity output produced from renewable sources from approximately 58 billion kWh in 2015 to 101 billion kWh by 2020, and 186 billion kWh by 2030 (Pearson and Vu, 2018).

2) Potential for solar and wind energy

A support programme for the Ministry of Industry and Trade sponsored by the German Corporation for International Cooperation indicates that the country has a solar power potential of 130 GW and a wind power potential of 27 GW (MOIT, 2016).

3) Hydrogen policy

Viet Nam has yet to draft a hydrogen policy as of December 2018. Any movement related to utilising hydrogen has not been observed at present.

2. Other EAS countries

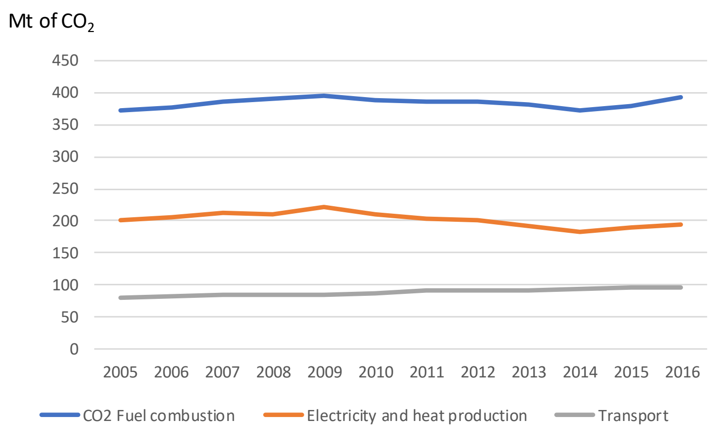
2.1 Australia

2.1.1 Climate policy, INDC

Under the Paris climate agreement, Australia has committed to reducing greenhouse gas emissions by 26% to 28% from 2005 levels by 2030.

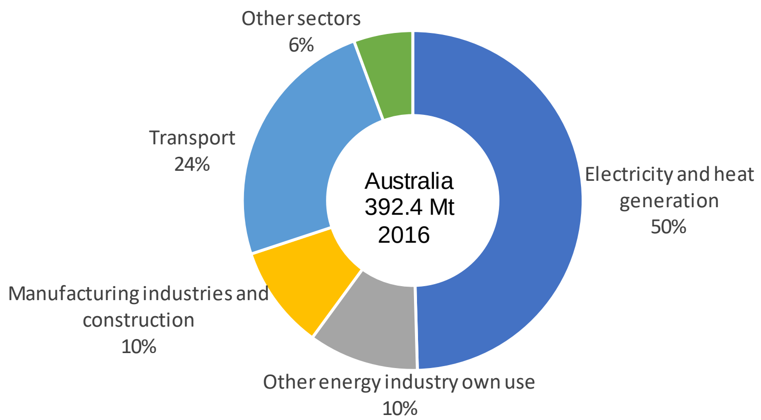
As shown in Figure 2.17, CO_2 emissions have increased 6% from 2005 to 2016. As shown in Figure 2.18, electricity and heat production accounts for 50%, followed by transport for another 24%.

Figure 2.17 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.18 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

2.1.2 Renewable energy and hydrogen policy

1) Renewable energy policy

Australia's Renewable Energy Target includes a scheme that mandates the production of 33 TWh of renewable energy (or 23.5% of the electricity mix) by 2020. The former government's energy policy, National Energy Guarantee (Department of Energy and the Environment, Government of Australia, 2018), was abolished in October 2018, with the country's new energy policy being discussed at the Council of Australian Governments (Hannam, 2018).

The report 'Australian Energy Projections to 2049-50', released in 2014, projects electricity generation by sector as shown in Table 2.6 (Department of Industry, Innovation and Science, Government of Australia, 2014).

Table 2.6 Projection of Electricity Generation (in TWh)

Energy type	2014-15	2034-35	2049-50	% share 2014-15	% share 2049-50	% average annual growth 2014-15 to 2049-50
Non-renewables	**216**	**252**	**265**	**85**	**80**	**0.6**
Coal	163	200	214	64	65	0.8
black coal	117	153	163	46	49	1.0
brown coal	47	47	51	18	15	0.3
Gas	50	49	48	19	14	-0.1
Oil	3	3	3	1	1	0.0
Renewables	**39**	**63**	**67**	**15**	**20**	**1.5**
Hydro	19	19	18	7	6	-0.1
Wind	16	32	33	6	10	2.0
Bioenergy	2	5	6	1	2	3.7
Solar	2	3	6	1	2	3.0
Geothermal	0	4	4	0	1	
Total a	**255**	**315**	**332**	**100**	**100**	**0.8**

Source: Australian Energy Projections to 2049–2050.

2) Potential of solar and wind energy

Australia's Renewable Energy Agency says that its annual solar radiation is approximately 58 million petajoules, approximately 10,000 times Australia's annual energy consumption Australian Energy Resource Assessment (2010). Roughly, 58 million petajoules are the equivalent of 16.11×10^9 GWh.

Regarding wind energy resources, the website 'Ramblings of a Bush Philosopher' has estimated that if the best wind resources of Australia were developed, at least 90 GW of wind power would be possible (Ramblingsdc, 2018).

3) Hydrogen policy

Australia is committed to a technological-neutral policy and regulatory framework that supports new energy sources and enables market innovation and uptake of transformative technology, including hydrogen, which has been noted as a significant opportunity as a transport fuel and for export (Dewar, 2018).

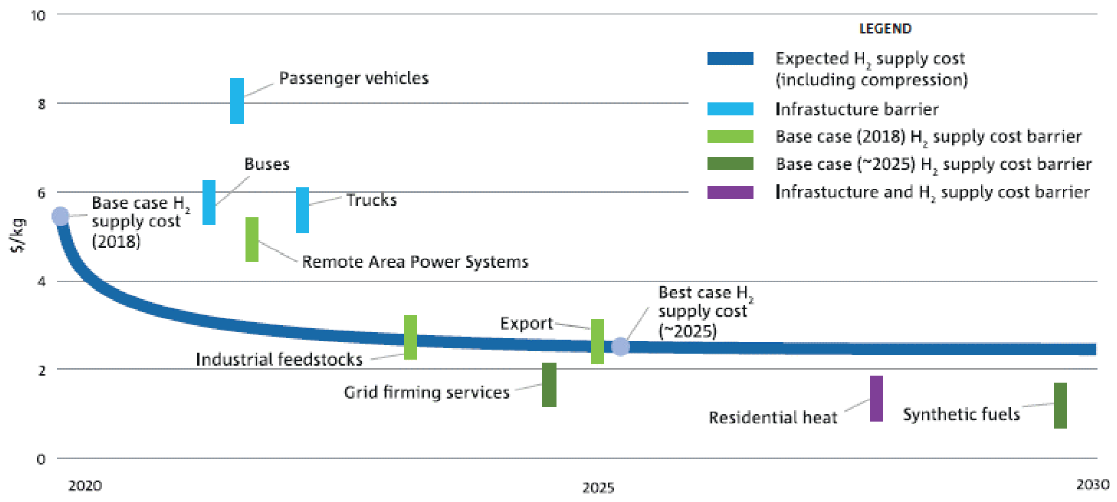
The Australian Energy Council released a plan on 19 December 2018 for a dedicated Working Group that will have six work streams: hydrogen exports; hydrogen for transport; hydrogen in the gas network; hydrogen for industrial users; hydrogen to support electricity systems; and cross-cutting issues. Key priorities for the Working Group include developing a national hydrogen strategy for 2020–2030, and a coordinated approach to projects and programmes that support industry development (Council of Australian Governments, 2018).

The federal government has also issued three reports related to hydrogen:

- ‘Hydrogen for Australia’s Future’ by the Hydrogen Strategy Group
- ‘National Hydrogen Roadmap’ by Commonwealth Scientific and Industrial Research Organisation (CSIRO, 2018)
- ‘Australia’s Opportunities from Hydrogen Exports’ by Australian Renewable Energy Agency

Especially, the National Hydrogen Roadmap projects the production cost of hydrogen further down the road, as shown in Figure 2.19. The cost of hydrogen from both types of electrolysis, i.e., thermochemical and electrochemical, can be significantly reduced via the scaling of plant capacities (e.g., from 1 MW to 100 MW), greater utilisation, and favourable contracts for low emissions electricity. With several demonstration projects needed to de-risk these assets at scale over the next 3–4 years, it is expected that costs could reach approximately A$2.29–2.79/kg by 2025.

Figure 2.19 Hydrogen Competitiveness in Targeted Applications



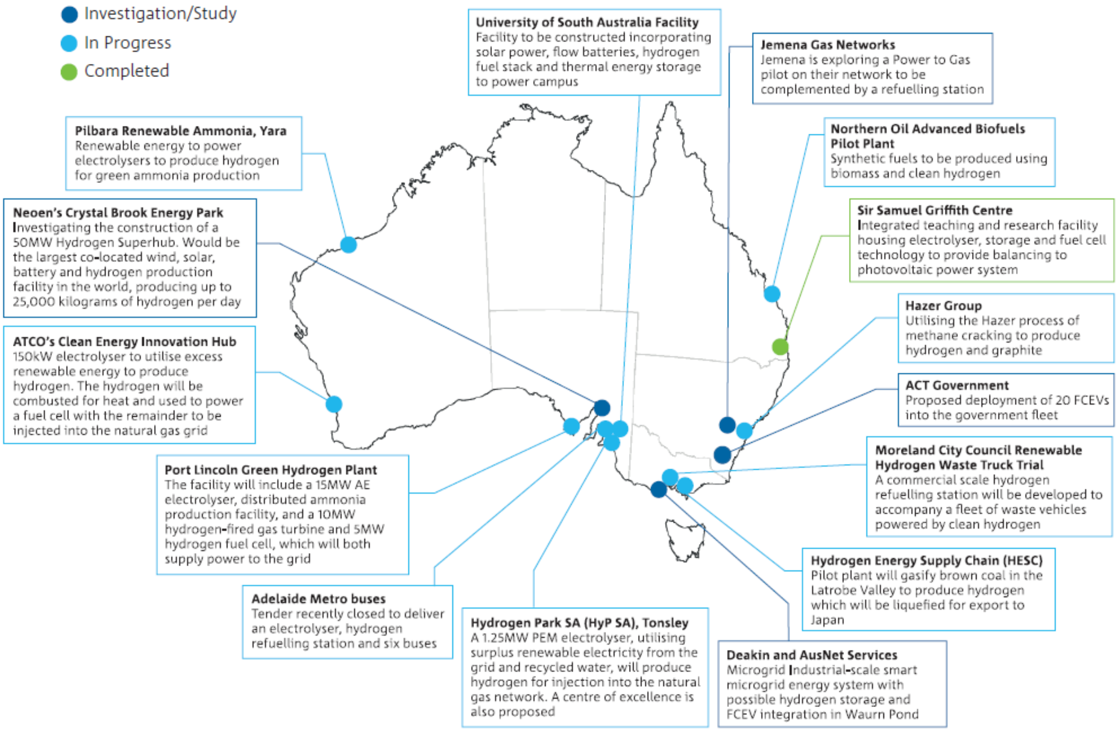
Source: Commonwealth Scientific and Industrial Research Organisation; National Hydrogen Roadmap.

Besides the national strategy, the state of South Australia also drafted 'A Hydrogen Roadmap for South Australia' in September 2017 (Government of South Australia, 2017).

Regarding international efforts, Japan's Kawasaki Heavy Industries has teamed up with the Australian government to lead a A$500 million project to turn coal into liquid hydrogen, in what it has described as one of the world's first attempts to commercialise the technology. The pilot project aims to generate green energy for use in cars, electricity generation, and industry in Japan from brown coal, one of the dirtiest fuels. This involves converting coal to hydrogen at a power plant in the Latrobe Valley, a region in Australia with some of the world's most abundant supplies of lignite (Smyth, 2018).

Other hydrogen demonstration projects are also underway, including business-driven projects, as shown in Figure 2.20. For instance, a natural gas powerhouse, ATCO, is about to launch the production, storage, and use of renewable hydrogen to energise a commercial-scale microgrid, testing the use of hydrogen in different settings and applications, including in household appliances, at Jandakot, Western Australia (ARENA, 2018). Renewable energy developer Neoen will start the world's largest solar- and wind-powered hydrogen hub in South Australia. With a 125 MW windfarm, a 150 MW solar farm, and a 130 MW lithium ion battery, its facility will produce 50 MW hydrogen.

Figure 2.20 Hydrogen Demonstration Projects and Activities in Australia



Source: Commonwealth Scientific and Industrial Research Organisation; National Hydrogen Roadmap.

2.2 China

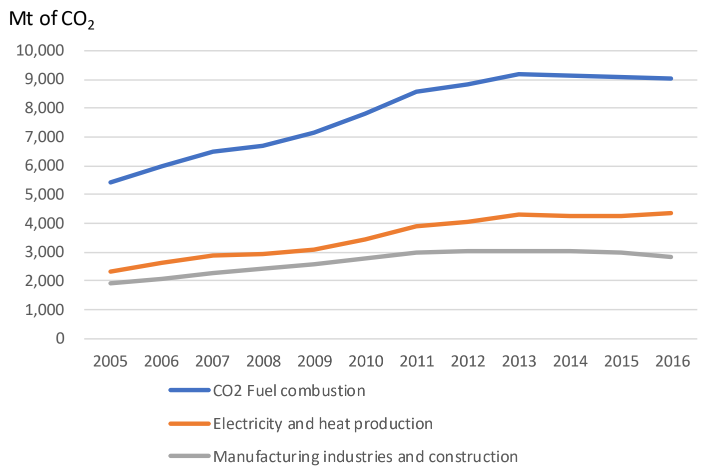
2.2.1 Climate policy, INDC

China has determined its national climate policy goals as follows:

- To achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early;
- To lower carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level; and
- To increase the share of non-fossil fuels in primary energy consumption to around 20%.

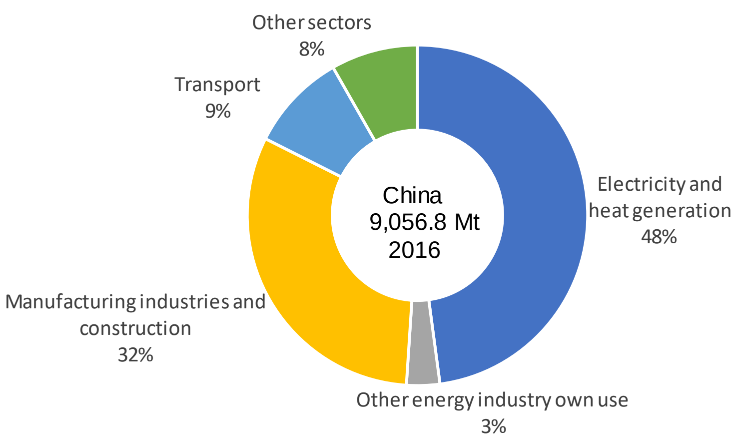
As shown in Figure 2.21, China's CO_2 emissions have plateaued for the last several years. As shown in Figure 2.22, electricity and heat production accounts for 48%, followed by manufacturing, industries and construction for another 32% (UNFCCC, 2015).

Figure 2.21 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.22 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

2.2.2 Renewable energy and hydrogen policy

1) Renewable energy policy

According to China's 13th Five-Year Plan for renewable energy, the National Energy Administration and the state-run Energy Research Society have announced the country's energy prospects. Table 2.7 shows its installed prospects of renewables toward 2030.

Table 2.7 Development Plan for Renewables (in GW)

	2015	**2020**	**2030**
Hydro	320	380	450
Wind power	131	290	450
Solar power/heat	43	160	350
biomass	10	12	50
Total	**504**	**842**	**1,300**

Source: The 13th Five-Year Plan for renewables.

2) Potential of renewable energy

The National Energy Administration released a mid- and-long term development plan for renewables in August 2007. According to the plan, the country gets a solar radiation of 5,000 MJ/m^2/year, and two-thirds of its land could be developed. Regarding wind potential, the plan estimates 300 GW for on-shore and 700 GW for off-shore (NEA, 2007).

3) Hydrogen policy

China has released its Energy Technology Revolution & Innovation Initiative (2016–2030), which sets main 15 targets, including hydrogen (XTECH, 2017; NDRC, 2016). The outline concerning hydrogen is as follows:

(a) Priority fields

(1) The country develops core technologies related to mass production of hydrogen and storage materials, transportation, and hydrogen stations. Specifically, it promotes hydrogen production technology via renewable energy and nuclear power, coal evaporation, reforming methane, and oxidising. It also studies the standardisation and application of storage and filling technologies at hydrogen stations.

(2) The country develops a proton exchange membrane fuel cell (PEMFC) technology, a methane fuel cell (MFC), a solid oxide fuel cell (SOFC), a metal air battery (MeAFC), and other technologies. It promotes the model operation of electric vehicles equipped with PEMFCs and MFCs, and the integrated design of PEMFCs and SOFCs.

(b) Numerical targets, as shown in Table 2.8.

(1) In 2020, the constant output of the PEMFC power system is 50–100 kW, the output weight ratio of the system is 300 Wh/kg or more, the output capacity ratio reaches 3,000 W/L or

more and the lifespan reaches 5,000 hours or more. The fixed amount output of the MFC power supply system is 5–10 kW, the output weight ratio of the system is 345 Wh/kg or more and the lifespan reaches 3,000 hours or more. Hydrogen storage technology with capacity higher than 5% and long-distance, large-volume transportation is realised.

(2) In 2030, the lifespan of the PEMFC's discrete power system is over 10,000 hours, that of the MFC discrete power system is over 40,000 hours and that of the MeAFC discrete power system is over 10,000 hours.

(3) By 2050, the country will deliver the goals of diffusion and application of hydrogen energy and fuel cells.

Table 2.8 Roadmap for Hydrogen Development[3]

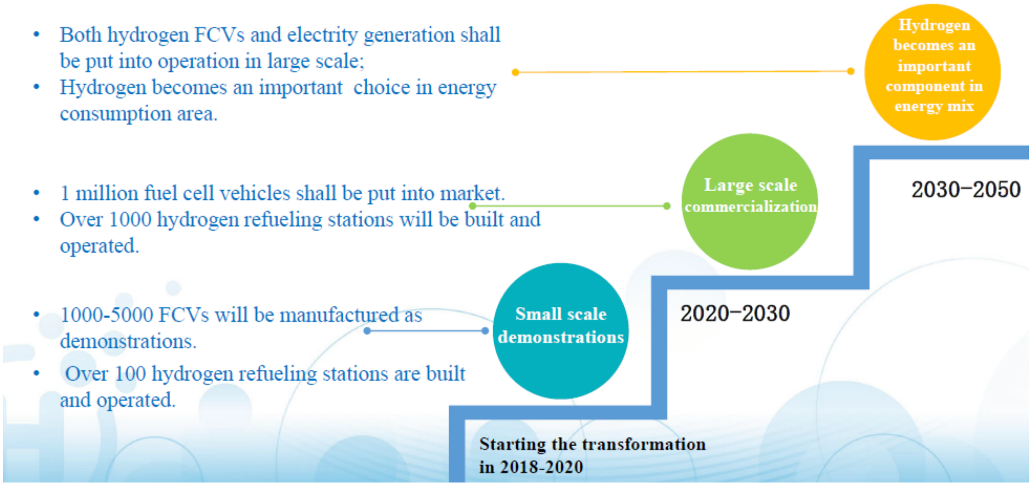
	2016	2020	2030	2050
Hydrogen production capacity (billion cubic meter/year)	70	72	100	-
Hydrogen filling station (unit)	4	100	1,000 or more	-
Fuel cell power plant capacity (MW)	-	200	100,000	-
Fuel cell vehicle (thousand unit)	-	10	2,000	10,000

Source: China National Institute of Standardization.

In February 2018, an interdisciplinary, cross-industry, interagency national alliance, the National Alliance of Hydrogen and Fuel Cell, was founded in Beijing to promote hydrogen (Zhang and Xue, 2018). The alliance is fully committed to developing China's hydrogen industry. At the world's first Hydrogen Energy Ministerial Meeting in Tokyo on October 2018, the Chairman of the China Hydrogen Alliance outlined the targets for China's hydrogen infrastructure, as shown in Figure 2.23.

[3] http://www.china-hydrogen.org/hydrogen/mix/2016-11-08/5718.html (accessed November 2018).

Figure 2.23 Development Target of China's Hydrogen Infrastructure



FCVs = fuel cell vehicles.

Source: Status and Outlook on China's Hydrogen Energy, October 2018 (Wen, 2018).

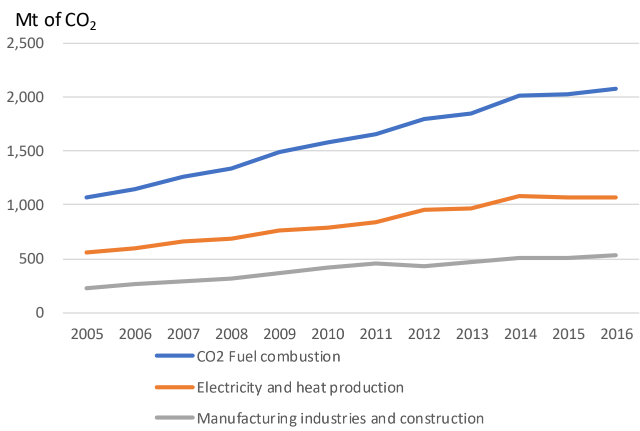
2.3 India

2.3.1 Climate policy, INDC

India intends to reduce the emissions intensity of its GDP by 33%–35% by 2030 from 2005 levels. It also aims to achieve 40% cumulative electric power installed capacity from non-fossil fuel-based energy sources by 2030, with the help of transfer of technology and low-cost international finance, including the Green Climate Fund.

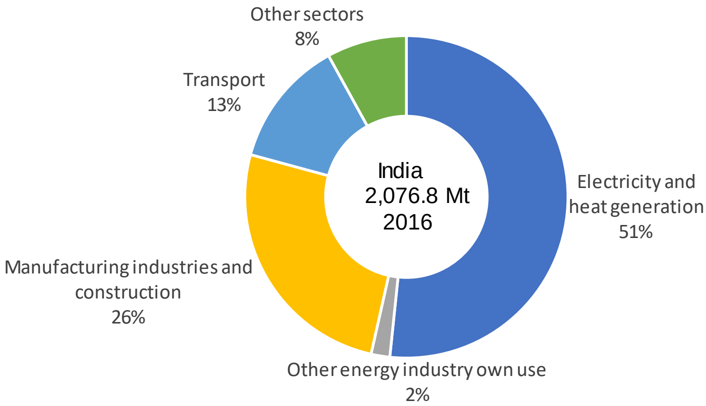
As shown in Figures 2.24 and 2.25, CO_2 emissions have nearly doubled from 2005 to 2016, with electricity and heat production accounting for 51%, followed by manufacturing, industries and construction for another 26% (UNFCCC, 2015).

Figure 2.24 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.25 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

2.3.2 Renewable energy and hydrogen policy

1) Renewable energy policy

Power and Renewables Minister Raj Kumar Singh said in June 2018 that India will add 227 GW of renewable energy capacity by March 2022, which overrides the previous target of 175 GW by 52 GW (Saluja, 2018). Beyond 2022, India is going to leave its future growth market-driven, which is meant to ensure smooth integration (capacity growth will be market-driven without any targeting) (NITI Aayog, Government of India, 2017a).

To hasten streamlining renewables, New and Renewable Energy Secretary Anand Kumar said 30 June 2018 that the country would auction 40 GW of renewable energy projects comprising 30 GW solar and 10 GW wind every year for the next 10 years till 2028 (Economic Times 2018).

The National Institution for Transforming India (NITI Aayog), Government of India, formulated its 'Draft National Energy Policy' in June 2017 (NITI Aayog, Government of India, 2017b). NITI Aayog is going to present the policy to Prime Minister in 2019 (Abdi, 2018).

Table 2.9 Electricity Capacity Forecast in Draft National Energy Policy

GW	2012	2022		2040	
		BAU	Ambitious	BAU	Ambitious
Gas Power Stations	24	34	39	46	70
Coal power stations	125	266	251	441	330
Carbon Capture Storage (CCS)	0	1	1	26	26
Nuclear power	5	12	12	23	34
Hydro Power Generation	41	61	61	71	92
Solar PV	1	59	59	237	275
Solar CSP	0	4	5	28	48
Onshore Wind	17	62	62	168	181
Offshore Wind	0	2	2	19	29
Distributed Solar PV	0	36	36	102	120
Other Renewable Sources	8	18	20	43	56
Total	221	555	548	1204	1261

CSP = concentrated solar power, PV = photovoltaics.
Source: NITI Aayog, Draft National Energy Policy.

2) Potential of solar and wind energy

According to the Ministry of Energy, Trade, and Industry's Energy Environmental Strategy Research Report in 2016, India has 753 GW of solar potential throughout the country (METI, 2017b). In terms of wind energy resources, the Ministry of New and Renewable Energy (MNRE) estimates that wind power potential at 100 m above ground level is 302 GW (Jethani, 2016).

3) Hydrogen policy

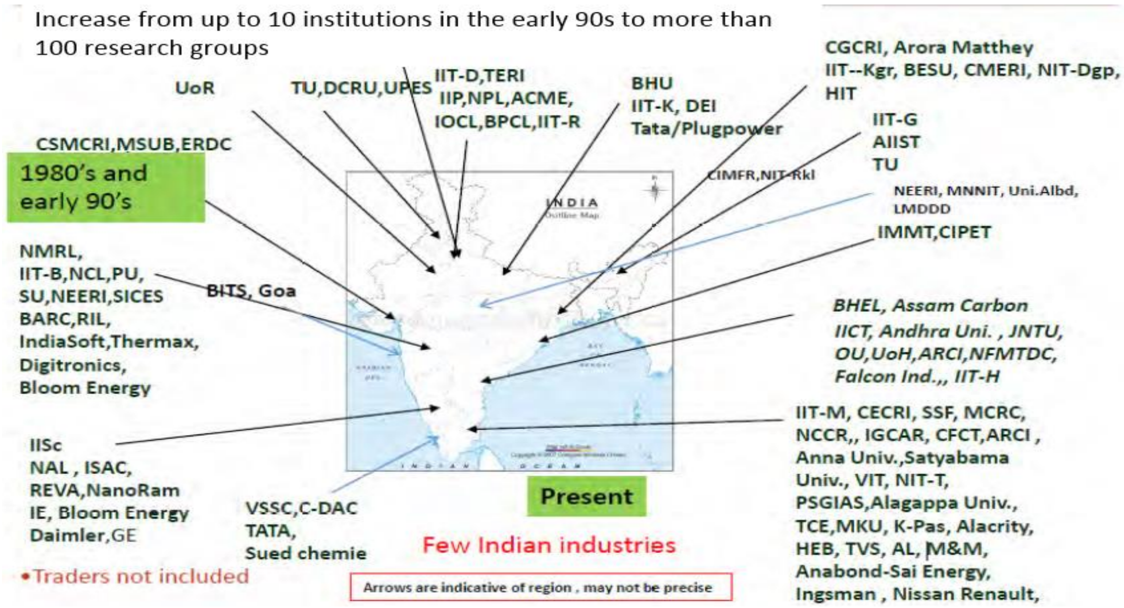
MNRE supports Research, Development and Demonstration, with up to 100% funding to academic and research institutions and up to 50% to industry. Favourable import duties have been introduced for fuel cell systems to be deployed with renewable-generated fuels. Focus areas of the ministry's Research, Development and Demonstration are as follows:

- Hydrogen production from renewable routes;
- Development of materials and techniques for safe storage of hydrogen;
- Research on different types of fuel cells, including materials, components, sub-systems;
- Demonstrations for stationary power generation and transportation; and
- Support development of hydrogen energy infrastructure in the country (Maithani, 2018).

In June 2016, technical reports related to hydrogen and fuel cells have been submitted to a steering committee as the result of studies by experts under the auspices of the Indian government.

As of December 2018, over 100 organisations are working on hydrogen-related research, development, and demonstration across the country, as shown in Figure 2.26. Detailed ongoing projects are shown on the MNRE website (MNRE, 2018).

Figure 2.26 Major Hydrogen and Fuel Cell Activities in India



Source: ARCI International Advanced Research Center.[4]

In terms of international cooperation, at the 9th meeting of the Japan-India Energy Dialogue on May 2018, both governments committed to cooperating on hydrogen utilisation (Seko and Singh, 2018).

2.4 Japan

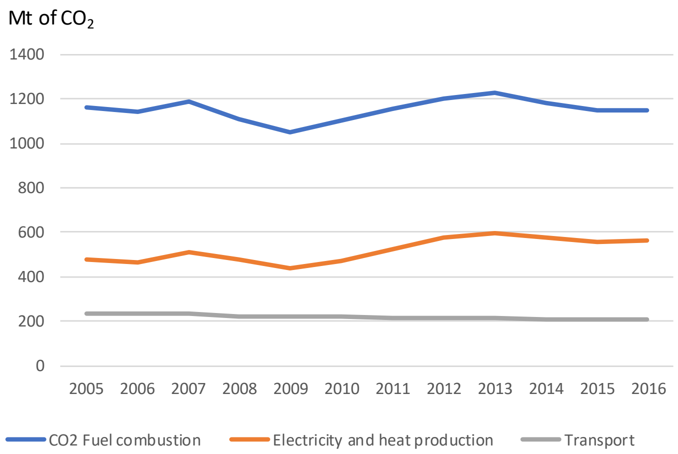
2.4.1 Climate policy, INDC

Japan's goals for reducing greenhouse gas emissions are at the level of 26% by fiscal year 2030, compared to fiscal year 2013.

As shown in Figure 2.27, Japan's CO_2 emissions have been on the decline since 2013. As shown in Figure 2.28, electricity and heat production accounts for 49%, followed by transport for another 18% in 2016.

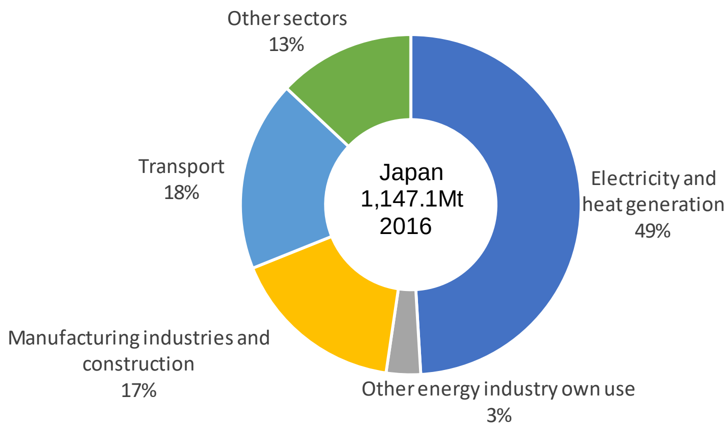
[4] The 4th meeting of hydrogen potential, 10 January 2019.

Figure 2.27 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.28 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

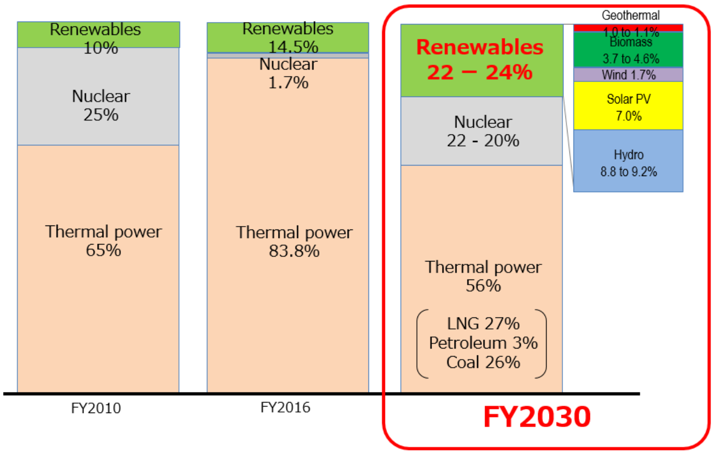
2.5.2 Renewable energy and hydrogen policy

1) Renewable energy policy

Japan's government formulated the 'New Strategic Energy Plan' under the Basic Act on Energy Policy. The plan is based on fundamental principles, namely, 'safety', 'energy security', 'improvement of economic efficiency' and 'environmental suitability'. The latest revision was approved by the cabinet on July 2018 (METI, 2018).

As shown in Figure 2.29, the plan indicates the generation mix target in 2030, when renewables will account for 22%–24% of the total generation. The breakdown of the renewables is shown in Figure 2.30.

Figure 2.29 Generation Mix Target in 2030



FY = fiscal year, LNG = liquefied natural gas, PV = photovoltaic.
Source: Ministry of Energy, Trade, and Industry; the New Strategic Energy Plan.

Figure 2.30 Renewables Introduction toward 2030 Target

	Before FIT (June 2012)	After FIT [A] (as of Sep 2017)	Target [B] (FY2030)	Progress [A]/[B]
Geothermal	0.5GW	0.5GW	1.4 - 1.6GW	33%
Biomass	2.3GW	3.5GW	6.0 - 7.3GW	53%
Wind	2.6GW	3.4GW	10GW	34%
Solar PV	5.6GW	42.4GW	64GW	66%
Hydro	48.1GW	48.4GW	48.5 - 49.3GW	99%

FIT = feed-in tariff, FY = fiscal year, PV = photovoltaic.
Source: Ministry of Energy, Trade, and Industry; the New Strategic Energy Plan.

2) Potential of solar and wind energy

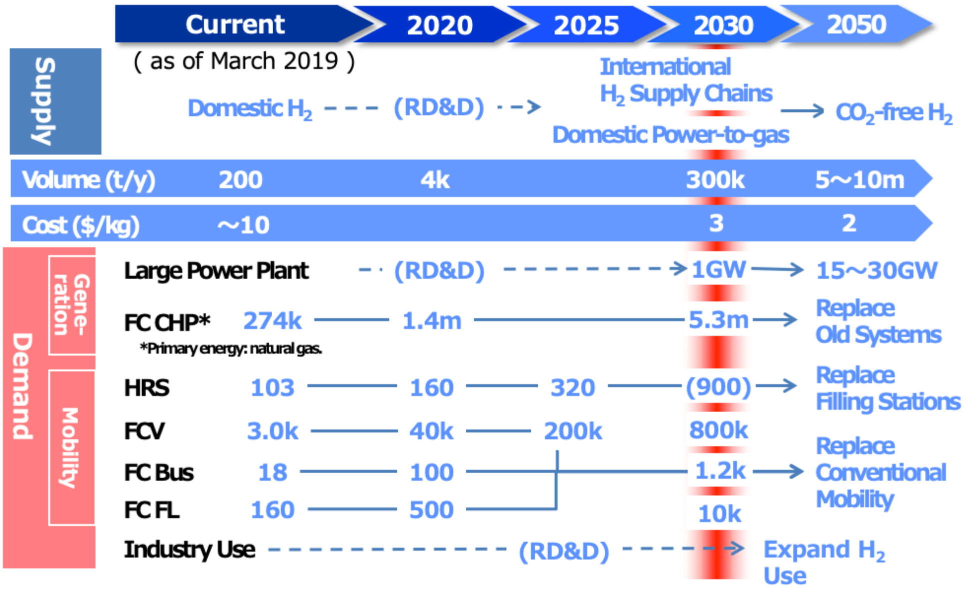
The Ministry of the Environment in Japan calculated that solar potential is 360 GW, and the wind potential, including both on-shore and off-shore, is 1,679 GW (ENV, 2018).

3) Hydrogen policy

On December 2017, Japan released its 'Basic Hydrogen Strategy' (METI, 2017a), which shows future visions that Japan should achieve with an eye on 2050, and also serves as an action plan to accomplish them by 2030. The strategy sets a goal that Japan should reduce hydrogen costs to the same level of conventional energy and provides integrated policies across ministries ranging from hydrogen production to utilisation under the common goals.

Through achieving a carbon-free society under the strategy, Japan will present hydrogen to the rest of the world as a new energy choice and will lead global efforts for establishing a carbon-free society taking advantage of Japan's strong points. The country's hydrogen strategy is shown in Figure 2.31.

Figure 2.31 Japan's Long-Term Scenario for Hydrogen



CHP = combined heat and power, FC = fuel cell, HRS = hydrogen refuelling station, FCV = fuel cell vehicle, FL = forklift.
Source: Ministry of Energy, Trade, and Industry (updated in April 2019).

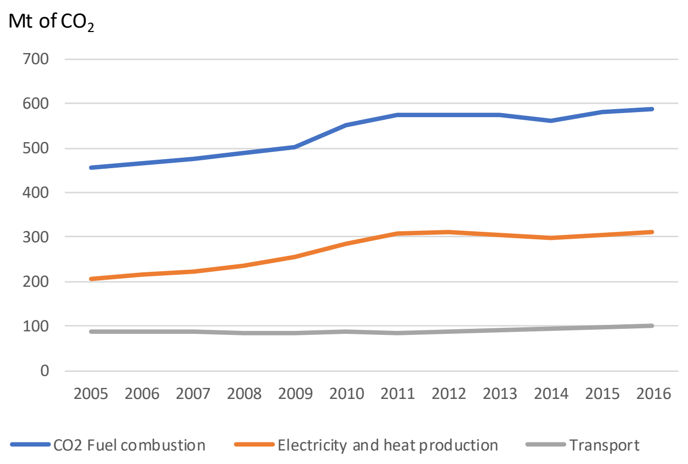
2.5 Korea

2.5.1 Climate Policy, INDC

Korea intends to reduce its greenhouse gas emissions by 37% from its baseline level by 2030.

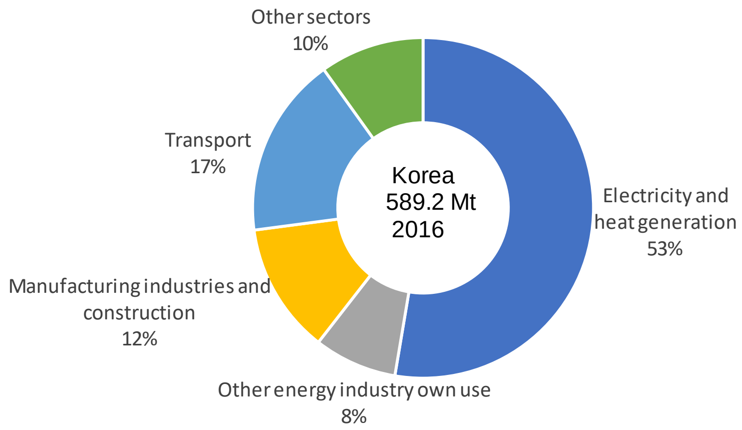
As shown in Figure 2.32, CO_2 emissions have been on the rise, having increased nearly 30% from 2005 to 2016. As shown in Figure 2.33, electricity and heat production accounts for 53%, followed by transport for another 17% in 2016 (UNFCCC, 2015).

Figure 2.32 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.33 CO_2 Emissions by Sector (2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

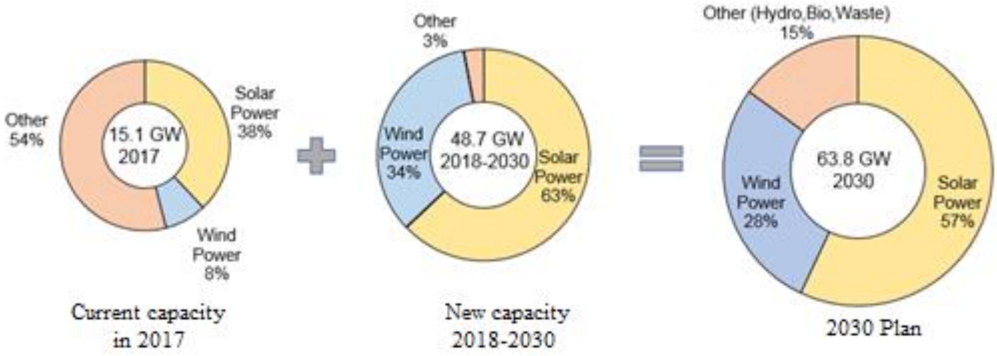
2.5.2 Renewable energy and hydrogen policy

1) Renewable energy policy

Korea has launched energy transition 'RE 2030', aiming to produce 20% of its power from renewable sources by 2030. As shown in Figure 2.34, Korea will increase renewable energy's share of the energy mix from its current level of 7% in 2017 to 20% by 2030 by providing 48.7 GW in new generation capacity.

To achieve this, Korea intends to expand solar panels for personal use in rural areas and by small business operators by 19.9 GW, which would represent 40% of new capacity. The remaining 28.8 GW will be supplied by large-scale projects at the six public generating companies.

Figure 2.34 Renewable Energy 3020 Goals for Provision of Facilities



Source: Republic of Korea's Ministry of Trade, Industry and Energy.

2) Potential of solar and wind energy

According to the New and Renewable Energy White Paper 2016, the highest technological potential of Korea's solar power is 7,451 GW, and the wind potential is estimated at 63.5 GW for onshore, and 33.2 GW for offshore.

3) Hydrogen policy

Korea released 'Industrial Innovation 2020 Platform' in June 2018. In the platform, the government and the private sector decided to invest W2.6 trillion by 2020 to build a car industry ecosystem and stay ahead of the global market. Korea plans to expand hydrogen production plants and establish package-type hydrogen filling stations to supply 16,000 hydrogen vehicles by 2022, as shown in Table 2.10.

Table 2.10 Investment Plan for Hydrogen Vehicles

	2018	2019	2020–2022
Amount of investment	190 billion won	420 billion won	2 trillion won
Major projects	- Establishment of private-driven special purpose company for hydrogen vehicle	- Production of prototype hydrogen bus - Commercialised hydrogen storage facilities for buses - Mass production of local CNG	- Expansion of factories that produce hydrogen vehicles - Expansion of factories that produce fuel cell stacks - Mass production of package-type fuel charging stations

CNG = compressed natural gas.
Source: Ministry of Trade, Industry, and Energy, Industrial Innovation 2020.

Furthermore, in January 2019, the government announced a hydrogen economy roadmap (see Table 2.11 for an outline). The plan is focused on increasing production of hydrogen-powered fuel cell vehicles, expanding the supply of fuel cells, and building systems for producing and supplying hydrogen. By 2040, the plan seeks to increase the cumulative total of fuel cell vehicles to 6.2 million, raise the number of hydrogen refuelling stations to 1,200, and boost the supply of power-generating fuel cells. Through these measures, the government hopes to create 420,000 jobs and W43 trillion in value added each year by 2040 (Hankyoreh, 2019; FuelCellsWorks, 2019).

Table 2.11 Outline of Hydrogen Roadmap

Field	Content
Hydrogen Buses	- Thirty-five buses are to be rolled out in 2019. - This number will be ramped up to 2,000 by 2022 and to 41,000 by 2040.
Hydrogen Trucks	- From 2021, the public sector will convert garbage collection trucks and sweepers into hydrogen trucks and gradually spread this to the private sector such as logistics trucks and vans.
Energy	- Supply 15 GW of fuel cell for power generation by 2040. ▶ Development of fuel cells: 307.6 MW (2018 years) → 1.5 GW (domestic 1 GW, 2022) → 15 GW (2040) ▶ Supply of 2.1 GW (940,000 households) from fuel cells for homes and buildings by 2040
Hydrogen Production	- By 2040, the annual supply of hydrogen will reach 5,260,000 tonnes, and the price per kg will reach 3,000 won. ▶ Use about 50,000 tonnes (250,000 hydrogen vehicles). ▶ Overseas production: Establish overseas production base to stabilise hydrogen production, imports, supply and demand
Legal basis for hydrogen economy support	- In 2019, the Hydrogen Economy Act (tentative name) will be enacted to establish a basic plan for the implementation of the hydrogen economy, and a legal basis for the hydrogen economy will be established.

Source: Ministry of Trade, Industry, and Energy, Hydrogen roadmap (Park, 2016).

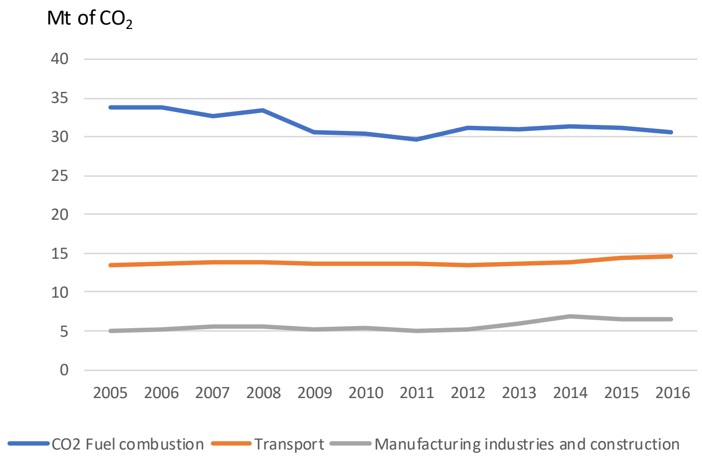
2.6 New Zealand

2.6.1 Climate policy, INDC

New Zealand has committed to reducing greenhouse gas emissions to 30% below 2005 levels by 2030.

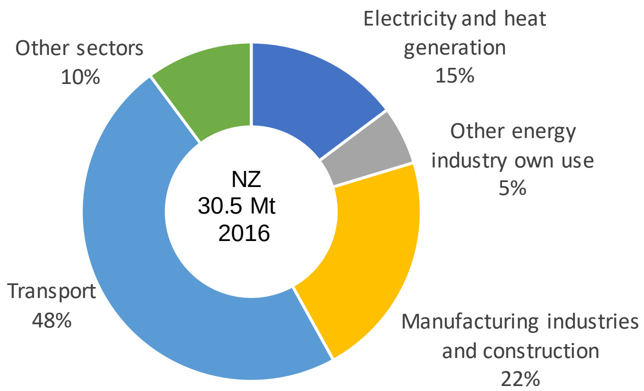
As shown in Figure 2.35, CO_2 emissions have been decreasing since 2005, and have remained unchanged for the last several years. As shown in Figure 2.36, transport accounted for 48%, followed by manufacturing, industries, and construction for another 22% (UNFCCC, 2015).

Figure 2.35 CO_2 Emissions from Fuel Combustion (2005–2016)



Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

Figure 2.36 CO_2 Emissions by Sector (2016)



NZ = New Zealand.
Source: International Energy Agency, CO_2 Emissions from Fuel Combustion 2018.

2.6.2 Renewable energy and hydrogen policy

1) Renewable energy policy

Building on New Zealand's 2011 'Energy Strategy 2011-2021', the country's prime minister, Jacinda Ardern, launched a new plan on November 2017 that aims for 100% renewable electricity generation by 2035, and carbon neutrality by 2050 (Jones, 2017).

2) Potential of solar and wind generation

Solar power generation is currently a small proportion of New Zealand's energy supply. Price reductions for solar photovoltaic equipment have made it more popular with homeowners and businesses, despite its remaining costlier than grid-supplied electricity (EECA, 2016). According to the Energy Efficiency and Conservation Authority, New Zealand's solar energy resource is about 4 kWh/m^2 (Eltayeb, 2013).

Regarding wind potential, New Zealand is exposed to winds travelling across the ocean uninterrupted by other land forms. A steady succession of troughs and depressions passes to the east of the country, creating the predominantly westerly wind flow (Windenergy, 2018). According to a report, 'Renewable Energy Potential in New Zealand' by Massey University, an upper limit of the available onshore wind resource is approximately 127,370 GWh/year (Eltayeb, 2013).

3) Hydrogen policy

The government is developing transition plan toward decarbonisation that will launch in 2019. To promote hydrogen, New Zealand signed a Memorandum of Cooperation with Japan in October 2018 (Seko and Woods, 2018). In the agreement, both countries are set to cooperate on a strategic road map for New Zealand to develop and expand the demand of hydrogen in the country.

New offshore oil and gas development will be prohibited in 2019, and the country needs to shift toward new industries, such as hydrogen. For automotive fuel, New Zealand promotes biofuel and electrical vehicles and considered introducing fuel cell vehicles for reduction of gasoline and diesel consumption.

Regarding reports related to hydrogen, Hiringa Energy, New Plymouth District Council, and its partners published 'Energy Future Action Plan for Taranaki' on March 2018, including establishment of a hydrogen-based energy ecosystem 'H2 Taranaki' (Hiringa, 2019).

A new venture to investigate hydrogen production using geothermal energy is also underway. For instance, Taupo-based Tuaropali Trust and Japan's construction company, Obayashi Corporation, have signed an MOU for a project to pilot the commercial production of hydrogen on 14 February 2018 (Obayashi, 2019), starting with the construction of a plant in December 2018.

With regard to business-oriented efforts, Ports of Auckland unveiled in December 2018 that it will build a hydrogen production and refuelling facility at its Waitematā port. The company, and project partners Auckland Council, Auckland Transport, and KiwiRail, will invest in hydrogen fuel cell vehicles, including port equipment, buses, and cars as part of the project. They have set an ambitious target to be a zero-emissions port by 2040. Demonstration vehicles will be able to fill up with hydrogen at the facility, which will be just like filling up a car with CNG or LPG (Ports of Auckland, 2018).

Table 2.12 Organisations in Charge of Hydrogen Policy

Area	Country	Ministry, Department, or Organization
ASEAN	Brunei Darussalam	Energy Department, Prime Minister's office
	Indonesia	Ministry of Energy and Mineral Resources (MEMR)
	Malaysia	Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) Sustainable Energy Development Authority (SEDA)
	Philippines	Department of Energy (DOE)
	Singapore	Ministry of Trade and Industry (MTI)
	Thailand	Ministry of Energy (MOE) Department of Alternative Energy Development and Efficiency (DEDE)
	Viet Nam	Ministry of Industry and Trade (MOIT)
EAS	Australia	Department of Industry, Innovation and Science Australian Renewable Energy Agency (ARENA)
	China	National Energy Administration (NEA) National Alliance of Hydrogen and Fuel Cell
	India	Ministry of New and Renewable Energy (MNRE)
	Japan	Ministry of Economy, Trade and Industry (METI)
	Republic of Korea	Ministry of Trade, Industry and Energy (MOTIE)
	New Zealand	Ministry of Business, Innovation and Employment (MBIE)

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