Exploring Low-Carbon Energy Security Path for India: Role of Asia-Pacific Energy Cooperation

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Abstract

In World Energy Outlook 2018, India's total primary energy demand (TPED) is expected to grow from 898 million tonne of oil equivalent (Mtoe) in 2017 to 1465 Mtoe in 2030. India's growth in TPED during 2017 to 2030 is expected to be the single largest source of global growth in TPED. India's share in world's TPED will go up from 6.4 percent in 2017 to 9.1 percent in 2030. With rising demand for energy, India's contribution in world's energy-related total CO_2 emission is expected to go up from 6.7 percent in 2017 to 10.6 percent in 2030. Though India's per capita CO_2 emission is one-third of world's average, the rising contribution in CO_2 emission is mostly attributable to high emission intensity of India's GDP. It is expected that India will be the single largest driver of global growth in total energy-related CO_2 emission during 2017-2030. Achieving energy security is important for India to sustain high economic growth and socio-economic wellbeing of Indian populace. However, it would be important for India to reduce emission intensity of GDP and explore low carbon energy security path through inter-regional energy cooperation.

Coal is the single largest source of India's total primary energy demand and it is expected to be so in 2030. Coal is predominantly used in India's power sector and it contributes 71 percent in India's total energy-related CO_2 emission. Reducing dependence on coal in power sector could be the foremost priority in achieving low carbon energy security for India. Power sector contributes 53 percent of India's total energy-related CO_2 emission in 2017 and it is expected to fall to 46 percent in 2030. India needs to explore options for electricity trade rather than high value primary energy sources for power generation to reduce dependence on energy imports as well as greening up the power sector. Being net importer, 58 percent of India's trade imbalance is attributed to import of energy sources. Given the vast potential exists in non-hydro renewable power generation in India, it would be important for India to explore electricity trade in the Asia-Pacific region by mobilizing finance to invest in inter-regional electricity generation and transmission infrastructure.

India's objectives to achieve energy security and environment sustainability need to be integrated. This paper explores challenges in achieving India's low-carbon energy security and possible scope for Asia-Pacific energy cooperation thereof.

Key Words: Energy security, CO_2 emission, inter-regional energy cooperation, India.

1. Introduction

International Energy Agency (IEA) defines energy security as the "uninterrupted availability of energy sources at an affordable price". There are many aspects of energy securities; long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs. On the other hand, short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance.[1] *Sustainable Development Goal (SDG)-7: Affordable and Clean Energy* stresses on universal access to affordable, reliable and modern energy services by 2030.[2] Availability and affordability are the two major factors which drive any country's energy security. Providing access to reliable and clean energy at affordable price is a challenge that many developing countries like India are facing today.

Achieving India's energy security is important to sustain economic growth and socio-economic well-being of the populace. According to *Energy Balance of India for 2016-17* (CSO 2018), India's total consumption of energy is 871.83 million tonne of oil equivalent (Mtoe), of which 484.06 Mtoe (55.5%) is domestic production and 325.92 Mtoe (37.4%) is net import. India's high dependence on import to achieve energy security is a cause of concern for running current account deficit. In 2016-17, India's trade deficit in 'mineral fuels, mineral oils and products or their distillation; bituminous substances; mineral waxes' is Rs. 474.44 thousand crore, which is 65 percent of total trade deficit (i.e., Rs. 728.24 thousand crore) of the year. India's net import of coal is 122.36 Mtoe, crude oil is 218.62 Mtoe, and natural gas is 17.14 Mtoe. India's power sector consumes 292.44 Mtoe of primary energy, which is 33.5 percent of total consumption, and produces 192.73 thousand GWh of power. Indian power sector is the predominant end user of coal, consumes 63 percent of total available coal, and the rest by Indian industry. Total available petroleum products for final consumption is 209.64 Mtoe of which 62.37 Mote (30%) is consumed by Indian industry, 37.4 Mote (18%) by transport sector and the rest is for other uses like residential, agriculture, etc. High dependence of Indian industry on coal and petroleum products is partly attributable to irregular electricity supply which compels industries to install captive power generation plants. Installed capacity of such non-utilities has gone up from 24,986 Megawatt (MW) in 2007-08 to 50,289 MW in 2016-17, showing CAAGR of 8.42 percent (CSO 2018). In utility sector, installed capacity has gone up from 143,061 MW in 2007-08 to 326,833 MW in 2016-17 with CAAGR of 8.61 percent. In total installed capacity of non-utilities, 59.4 percent is steam, 25.6 percent is diesel and 12 percent is gas based (CSO 2018).

With rising demand for energy, India's contribution in world's energy-related total CO_2 emission is expected to go up from 6.7 percent in 2017 to 10.6 percent in 2030. Though India's per capita CO_2 emission is one-third of world's average, the rising contribution in CO_2 emission is mostly attributable to high emission intensity of India's GDP. It is expected that India will be the single largest driver of global growth in total energy-related CO_2 emission during 2017-2030. Achieving energy security along with reducing emission intensity of GDP would be important for India to sustain high economic growth and achieve socio-economic-environmental wellbeing of Indian populace. The objective of this paper is to explore possible pathways to achieve low carbon energy security in India through regional energy cooperation in the Asia-Pacific region.

[1] https://www.iea.org/topics/energysecurity/ (last accessed on 22 March 2019).

[2] https://sustainabledevelopment.un.org/sdg7 (last accessed on 22 March 2019).

In the next section we discuss India's demand for primary energy in general and coal and petroleum products in particular. In section 3, we compare India's energy consumption and emission intensity of GDP (Gross Domestic Product) with other countries/ regions in the world. This is followed by our discussion on drivers for low carbon energy security for India in section 4. In section 5, we discuss present status of India's cross border electricity trade (CBET) and possible scope for expansion of CBET in the Asia-Pacific region through inter-regional energy cooperation. We draw our conclusions in section 6.

2. Structure of India's Demand for Primary Energy

In World Energy Outlook 2018, International Energy Agency (IEA 2018a) has expected that India's total primary energy demand (TPED) will reach 1465 Mtoe in 2030 and 1880 Mtoe in 2040 from 862 Mtoe in 2016 (Table 1). It is also expected that growth rate of India's TPED will be the single largest driver of global growth in TPED. India's share in world's TPED will go up from 6.3 percent in 2016 to 9.1 percent in 2030 and 10.6 percent in 2040. India was experiencing a compound average annual growth rate (CAAGR) of 4.3 percent in TPED during 2000 to 2016, and it is expected to grow at 3.9 percent during 2016 to 2030 and thereafter it will fall to 2.5 percent during 2030 to 2040. Demand for coal constitutes nearly two-fifth of total demand for primary energy in India during 2000-2016. It is expected that CAAGR in demand for coal will fall from 6.2 percent during 2000-2016 to 4.1 percent during 2016-2030 and further to 2.7 percent during 2030-2040. However, the share of coal in TPED is expected to be increasing and will reach nearly half of TPED by 2040. Demand for oil constitutes the second largest source of India's TPED, it contributes nearly one-fourth, and it is expected that CAAGR in oil demand will fall in future. The structural composition of India's TPED is expected to move away from bioenergy and oil to coal, non-hydro renewables, gas and nuclear energy.

Coal and oil are the two major primary energy sources of India and contributes 44 and 25 percent of TPED in 2016 respectively. It is important to discuss coal and oil balances of India to understand the issues associated with achieving India's energy security. High dependence on imports to meet these primary energy sources make Indian economy vulnerable to shocks associated with volatility of global energy prices. To achieve macroeconomic stabilization, India may consider gradual reduction of imports of such primary energy sources where these are predominantly used for power generation. Given large potential exists in renewable power generation in India, mainly from solar (649.3 GW in 2017) and wind (302.3 GW) (CSO 2018), mobilizing finance to investment in such renewable power generation and transmission infrastructure may help in reducing India's dependence on imported primary energy sources for electricity generation. Since electricity demands in neighboring countries are growing, any surplus electricity in India will find immediate markets in the neighborhood. India also needs to invest in improving domestic interconnections to facilitate development of domestic markets for electricity. Access to grid connectivity could play an important role in increasing efficiency of production and distribution of electricity across sources. In the long run, India may also explore available options to generate hydrogen from solar and wind power generation plants to reduce dependence on imports of combustible fuels (like oil and natural gas) used in transport sector. India also needs to reorganize energy baskets by giving more importance to those primary energy sources where international market prices are comparatively less volatile as compared to traditional energy sources like coal and oil.

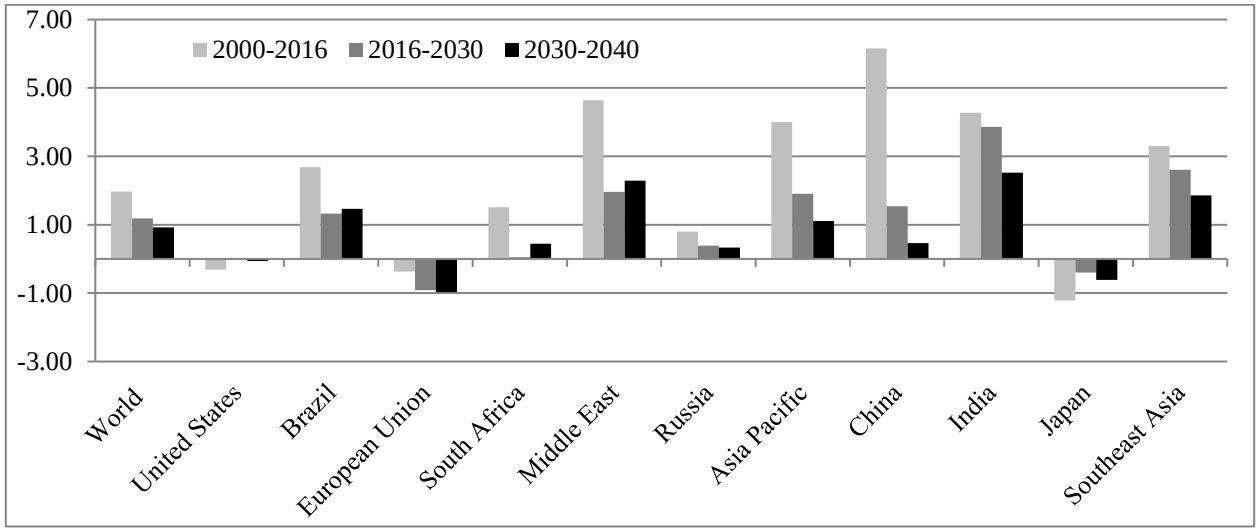
Table 1: Source-wise Projection of India's Total Primary Energy Demand (TPED) (IEA's New Policies Scenario)

Energy Source	Energy Demand (Mtoe)							CAAGR (%)		
	2000	2016	2017e	2025	2030	2035	2040	2000-2016	2016-2030	2030-2040
TPED	**441**	**862**	**898**	**1238**	**1465**	**1683**	**1880**	4.3	3.9	2.5
Coal	146	380	400	561	668	773	868	6.2	4.1	2.7
Oil	112	217	223	300	350	392	421	4.2	3.5	1.9
Gas	23	47	49	81	104	126	147	4.6	5.8	3.5
Nuclear	4	10	11	28	43	58	71	5.9	11.0	5.1
Hydro	6	12	12	17	22	26	30	4.4	4.4	3.2
Bioenergy	149	192	195	220	222	224	224	1.6	1.0	0.1
Other renewables	0	6	7	32	55	85	119	n.a.	17.1	8.0
Energy Source	As Percentage Share in TPED							Average Share	Change in Share	
								2000-2016	2000-16 to 2030	2000-16 to 2040
Coal	33.1	44.1	44.5	45.3	45.6	45.9	46.2	38.6	7.0	7.6
Oil	25.4	25.2	24.8	24.2	23.9	23.3	22.4	25.3	-1.4	-2.9
Gas	5.2	5.5	5.5	6.5	7.1	7.5	7.8	5.3	1.8	2.5
Nuclear	0.9	1.2	1.2	2.3	2.9	3.4	3.8	1.0	1.9	2.7
Hydro	1.4	1.4	1.3	1.4	1.5	1.5	1.6	1.4	0.1	0.2
Bioenergy	33.8	22.3	21.7	17.8	15.2	13.3	11.9	28.0	-12.9	-16.1
Other renewables	0.0	0.7	0.8	2.6	3.8	5.1	6.3	0.3	3.4	6.0

Note: *-CAAGR: Compound average annual growth rate, 2017e implies estimated.
Source: IEA (2018a)

Figure 1 shows that expected India's growth in TPED during 2016-2030 and 2030-2040 will be the single largest driver of global growth in TPED. Like many regions / countries, India's growth rate in TPED is also expected to fall in future. To sustain economic growth in India, energy will play an important role. However, it will be important for India to decouple economic growth from energy consumption.

Figure 1: Compound Average Annual Growth Rate of TPED (%) (IEA's New Policies Scenario)



Data Source: World Energy Outlook 2018 (IEA 2018a)

2.1 India's Demand for Coal

According to Energy Balance of India 2016-17, total coal available in 2016-17 is 576.6 Mtoe, of which 63 percent is used in Indian power sector and the rest is in Indian industry as final consumption (Table 2). India is the second largest producer of coal in the world and produces 730 million tonne (Mt) in 2017 and contributes 9.7 percent in world's total coal production (IEA 2018b). China holds the top position in production of coal with 3376 Mt, which is 44.7 percent of world's total coal production. China also holds the first position in importing coal (263 Mt in 2017) and India is in the second positon (207 Mt). In Asia-Pacific region, Indonesia (first position with 387 Mt) and Mongolia (7th position with 33 Mt) are two prominent net exporters of coal. Australia (379 Mt) and Russian federation (161 Mt) also hold significant shares in world's total exports of coal (1263 Mt). CAAGR of net import of coal in India is 16.4 percent during 2007-08 to 2016-17. To reduce India's dependence on imported coal, Indian power sector needs to give larger importance to invest in renewable sources of energy. Since wholesale electricity prices have been steadily declining in most mature power markets (IEA 2018), initially India may also consider importing electricity through cross border electricity trade (CBET) not only from neighboring countries in Asia but also from Asia-Pacific region to reduce dependence on imports of coal and oil for power generation.

Table 2: Coal Balance of India for 2016-17 (P)

Supply Side (Ktoe)		Demand Side (Ktoe)		
Production	394,724.94	Main activity producer electricity plants	363,982.83	(63.1)
Imports	123,552.77	Energy industry own use	167.62	(0.03)
Exports	-1,195.34	Final consumption	212,491.29	(36.8)
Stcock changes	7,388.67	of which Industry	212,491.29	(36.8)
Total Primary Energy Supply	524,471.04	*Iron & steel*	*40,310.83*	*(7.0)*
Statistical differences	52,170.70	*Chemical and petrochemical*	*2,286.49*	*(0.4)*
		Paper, pulp and print	*917.41*	*(0.2)*
		Construction	*4,552.37*	*(0.8)*
		Textile and leather	*497.24*	*(0.1)*
		Non-specified (industry)	*163,926.96*	*(28.4)*
Total	576,641.74	Total	576,641.74	

Note: Figures in the parenthesis show the percentage share in total demand.
Source: CSO (2018)

2.2 India's Demand for Petroleum Products

More than 80 percent of India's demand for crude oil is met through import. High dependence of India on imported crude oil is one of the major causes of India's high trade deficit. Volatility in international crude oil prices and foreign exchange rate are the causes of volatility in domestic prices of refined petroleum products. India is net exporter of refined petroleum products with installed refinery capacity of 233.97 million metric tonne per annum (MMTPA). During 2016-17, 245.36 million tonne of crude oil is refined in India. 30 percent of refined petroleum products are used in Indian industry, 18 percent in transport and 48 percent in other uses (including agriculture and other non-specified uses) (Table 3). Improving quality of electricity supply could reduce industrial uses of refined petroleum where it is mostly used to generate power in captive power generation plants. Among the distillates, light distillates constitute 27.3 percent (LPG 10%, Petrol

11%), middle distillates 41.4 percent (SKO 2.5%, HSDO 35.4%) and heavy ends 19 percent. 12.6 percent of refined petroleum products is used as cooking fuel (LPG and SKO) where government provides considerable subsidies.3 Many studies have shown that anaerobic digestion of bio-wastes (including cattle manure and faecal sludge) in India has potential to meet the demand for cooking fuel and therefore could save substantial government resources (Breitenmoser et al. 2019, Mukherjee and Chakraborty 2016).

Table 3: Crude Oil and Petroleum Products Balances of India for 2016-17 (P)

Crude Oil			
Supply Side (Ktoe)		**Demand Side (Ktoe)**	
Production	36,801.12	Oil refineries	250,759.40
Imports	218,618.60	Losses	20,511.49
Exports			
Stock changes			
Total Primary Energy Supply	255,419.71		
Statistical differences	15,851.18		
Total	271,270.89		271,270.89
Petroleum Products			
Supply Side (Ktoe)		**Demand Side (Ktoe)**	
Production	248,741.88	Main activity producer electricity plants	823.79
Imports	36,327.16	Final Consumption	209,638.14
Exports	-68,429.32	Of which	
Stock changes		*Industry*	*62,368.47*
Total Primary Energy Supply	216,639.72	*Transport*	*37,396.77*
Statistical differences	-6,177.78	*Other*	*101,068.12*
		Non-energy use industry/ transformation/ energy	8,804.77
Total	**210,461.94**	**Total**	**210,461.92**

Source: CSO (2018)

India's total consumption of natural gas is 49.1 Mtoe in 2016-17, of which 17.1 Mtoe (35%) is imported and the rest is domestic production. Natural gas is mostly used in generation of electricity, oil refineries, energy industries and fertilizer industry. India needs to explore options to reduce import of natural gas for electricity generation and other uses where other energy substitutes are available at lower price. India needs to reduce dependence on imports of high value primary energy sources, especially oil and natural gas initially and coal in the long run, for generation of electricity – both in utility and non-utility sector (captive power generation plants) – to achieve macro-economic stability and contain current account deficit.

3. Energy Consumption and Emission Intensity of Indian GDP

India's per capita total primary energy supply (TPES) is only 0.65 tonne of oil equivalent (toe) in 2016 and it is nearly one-third of the global average (i.e., 1.85 toe) (IEA

[3] Total subsidy/ under-recovery on petroleum products is Rs. 28,684 crore for 2017-18 (PPAC undated).

2018b). India's per capita TPES is lower than many neighbors in Asia. Per capita electricity consumption in India is only 918 KWh in 2016 and it is 3.4 times lower than global average (i.e., 3110 kWh). There is an increasing relationship between per capita electricity consumption and per capita income, and therefore it is expected that providing access to quality electricity could play an important role in human capital formation (education and health achievements), generation of employment and value addition. However access to quality electricity supply is still lacking in many rural habitations in India. According to Census of India 2011, nearly 400 million population are outside the grid connection (RG&CC 2011). India's CO2 emission intensity of TPES is higher than world's average whereas emission intensity of GDP is marginally lower than world's average in 2016. Though India's per capita CO2 emission is one-third of world's average, India needs continuous efforts in greening up GDP growth.

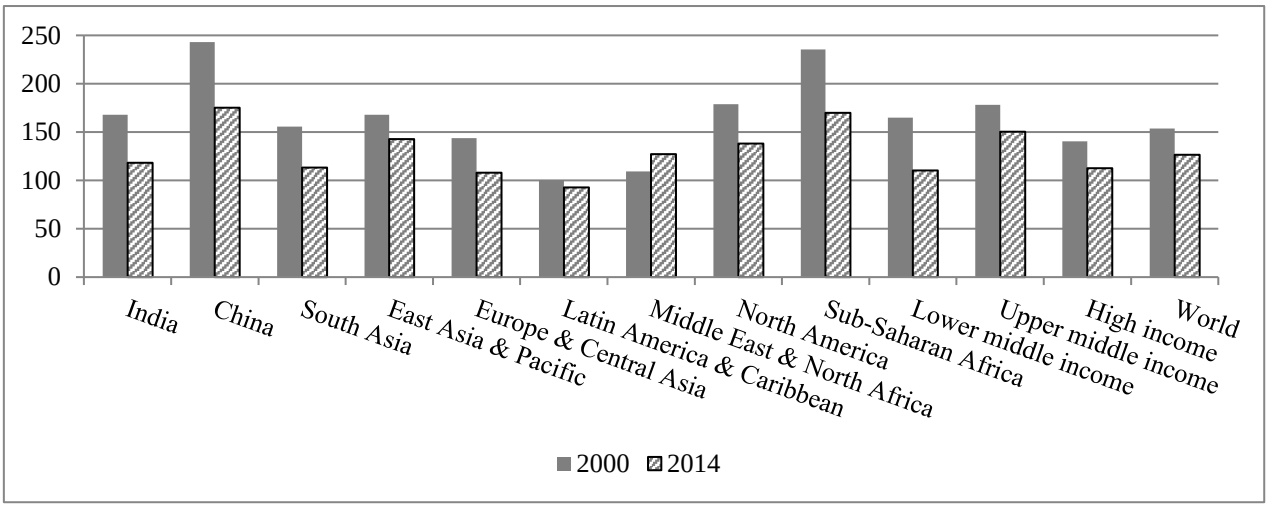
Table 4: Selected indicators for 2016

Country	TPES/ pop (toe/capita)	Elec. Cons./pop (kWh/ capita)	CO_2/ pop. (tCO_2/ capita)	TPES/ GDP(PPP) (toe/000 2010 USD)	CO2/ TPES (tCO_2/ toe)	CO2/ GDP (PPP) ($kgCO_2$/ 2010 USD)
Australia	5.29	9918	16.02	0.12	3.02	0.35
Bangladesh	0.24	353	0.45	0.07	1.85	0.14
Brazil	1.37	2504	2.01	0.10	1.46	0.15
China	2.15	4279	6.57	0.15	3.06	0.47
India	**0.65**	**918**	**1.57**	**0.11**	**2.41**	**0.26**
Indonesia	0.88	865	1.74	0.08	1.98	0.17
Japan	3.35	7971	9.03	0.09	2.7	0.24
Malaysia	2.85	4654	6.93	0.11	2.43	0.28
Myanmar	0.37	293	0.40	0.07	1.09	0.08
Nepal	0.44	172	0.29	0.20	0.66	0.13
Philippines	0.53	799	1.11	0.07	2.09	0.16
Russian Federation	5.07	6717	9.97	0.23	1.96	0.45
Sri Lanka	0.55	627	0.99	0.05	1.79	0.09
South Korea	5.51	10627	11.51	0.16	2.09	0.33
South Africa	2.51	4032	7.41	0.21	2.95	0.62
Thailand	2.01	2866	3.55	0.13	1.77	0.23
United Kingdom	2.73	5037	5.66	0.07	2.07	0.15
United States	6.7	12825	14.94	0.13	2.23	0.29
Viet Nam	0.87	1616	2.02	0.15	2.31	0.35
OECD	4.11	8051	9.03	0.11	2.2	0.24
World	**1.85**	**3110**	**4.35**	**0.13**	**2.35**	**0.30**

Source: Key World Energy Statistics 2018 (IEA 2018b)

Except China, average of North America, upper middle income countries, in general India's energy intensity of GDP is higher than other regions (Figure 2). As compared to 2000, Indian energy intensity has gone down in 2014 and it is lower than average of East Asia and Pacific and Middle East and North Africa. This shows that India needs continuous effort to improve energy efficiency.

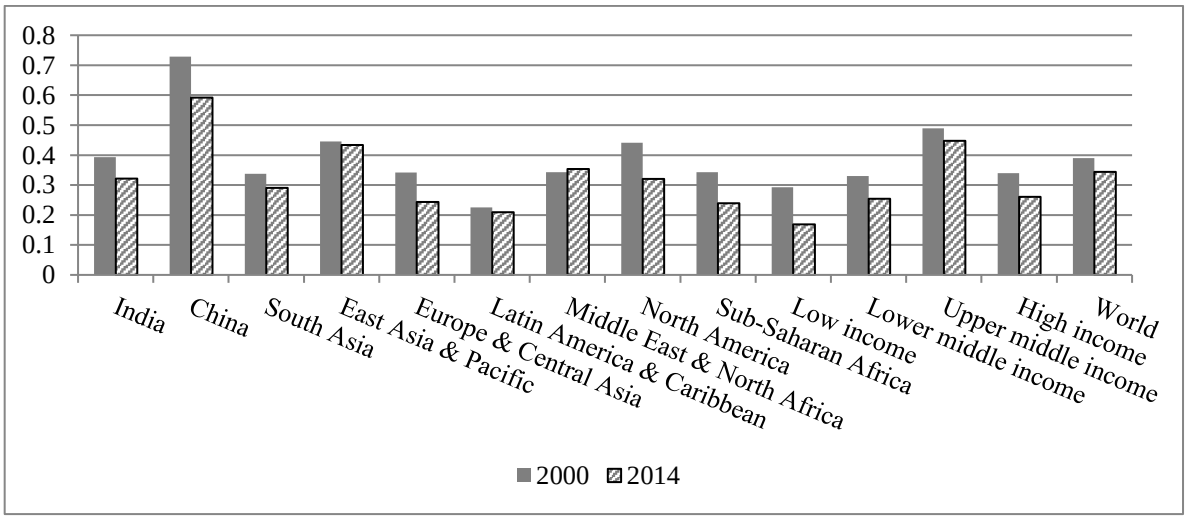
Figure 2: Energy Intensity of GDP (kg of oil equivalent per $1,000 GDP at constant 2011 PPP)



Source: World Bank's World Development Indicator Database

Except China, average of East Asia and Pacific, average of upper middle income countries, in general India's CO2 emission intensity of GDP is higher than other regions (Figure 3). As compared to 2000, Indian emission intensity has gone down in 2014 and it is lower than world's average. This shows that India needs to put continuous effort to decouple economic growth from CO2 emission.

Figure 3: CO2 Emission Intensity of GDP (kg per 2011 PPP $ of GDP)



Data Source: World Bank's World Development Indicator Database

4. Drivers for Low Carbon Energy Security for India

With rising demand for primary energy, it is also expected in the World Energy Outlook 2018 that growth rate of India's energy-related CO2 emission will be the single largest driver of global growth in energy-related CO2 emission. India's CO2 emission was growing at CAAGR of 5.5 percent during 2000-2016, whereas it was 6.9 percent in China. It is expected that India's CO2 emission will grow at CAAGR of 4.2 percent during 2016-

30, as compared to 0.4 percent in China. The fall in growth rate in CO2 emission is expected in India during 2030 to 2040, at CAAGR of 2.6 percent (Table 5). Since many countries are reducing their energy-related CO2 emission, there will be considerable expectation from India to cut CO2 emission (Figure 4). Therefore, it will be important for India to follow 'low-carbon energy security' path to sustain economic growth as well as socio-economic-environmental well-being of the Indian populace.

Table 5: India's Energy Related CO2 Emission (IEA's New Policies Scenario)

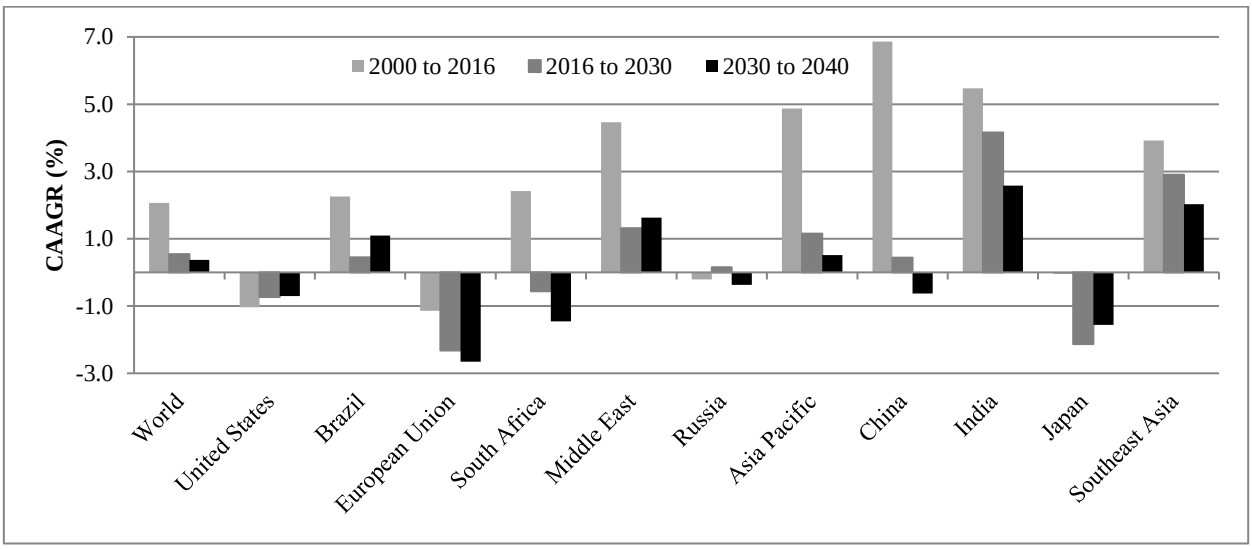
	CO2 Emission (Mt)							CAAGR (%)		
	2000	2016	2017e	2025	2030	2035	2040	2000-2016	2016-2030	2030-2040
Total CO2	885	2075	2195	3076	3673	4242	4738	5.5	4.2	2.6
Coal	572	1468	1568	2182	2593	2993	3360	6.1	4.1	2.6
	(64.6)	(70.7)	(71.4)	(70.9)	(70.6)	(70.6)	(70.9)			
Oil	277	534	527	726	860	982	1066	4.2	3.5	2.2
	(31.3)	(25.7)	(24)	(23.6)	(23.4)	(23.1)	(22.5)			
Gas	36	73	100	169	221	267	312	4.5	8.2	3.5
	(4.1)	(3.5)	(4.6)	(5.5)	(6)	(6.3)	(6.6)			
Power Sector	459	1071	1160	1471	1685	1887	2062	5.4	3.3	2.0
	(51.9)	(51.6)	(52.8)	(47.8)	(45.9)	(44.5)	(43.5)			
Total Final Consumption	393	965	995	1560	1937	2299	2614	5.8	5.1	3.0
	(44.4)	(46.5)	(45.3)	(50.7)	(52.7)	(54.2)	(55.2)			

Note: Figures in the parenthesis shows the percentage share in India's total energy-related CO2 emission.
Source: World Energy Outlook 2018

Coal is the single largest source of India's energy-related CO2 emission, contributes 71 percent in 2016 (Table 5). It is expected that contribution of coal in India's energy-related CO2 emission will remain at 71 percent till 2040. CAAGR of CO2 emission from coal was 6.1 percent during 2000-2016, and it is expected to fall to 4.1 percent during 2016-2030 and further to 2.6 percent during 2030-2040. Indian power sector is the single largest user of coal and therefore reducing dependence on coal in power sector would be the foremost priority to achieve low carbon energy security in India. The share of oil is the second largest in India's CO2 emission, contributes 26 percent in 2016. However, it is expected that contribution of oil will go down to 23.4 percent in 2030 and 22.5 percent in 2040. Oil used in the transport sector contributes the largest share in total CO2 emission from oil.

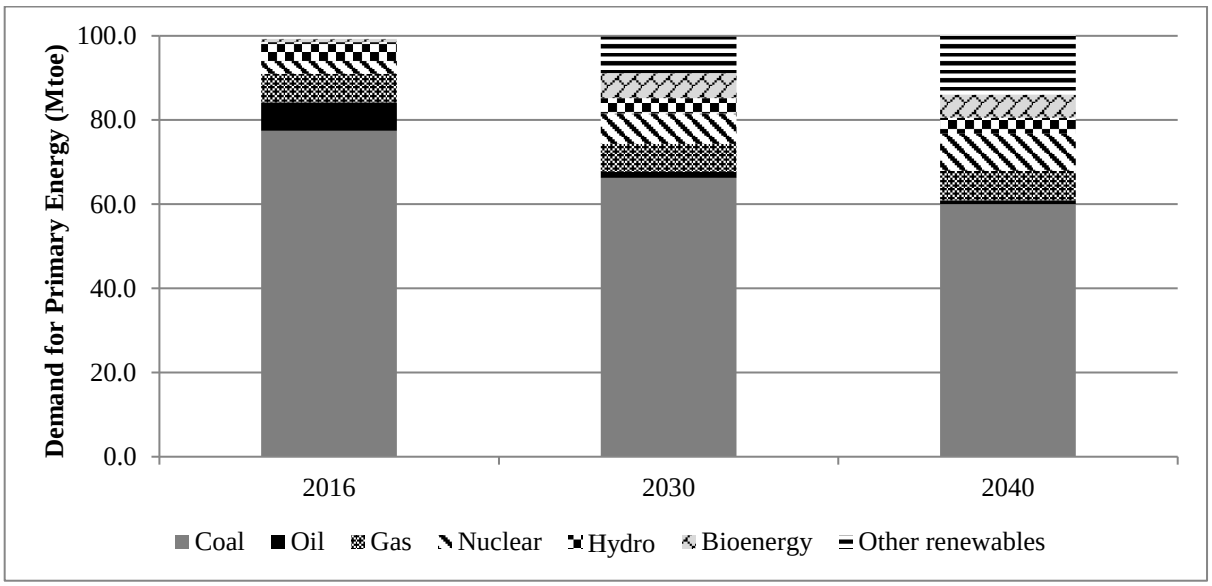
Power sector is the single largest source of energy-related CO2 emission in India and contributes 52 percent in 2016. However, the share is expected to go down to 46 percent in 2030 and 44 percent in 2040. It is expected that with larger share of renewables in Indian power sector, CO2 emission will reduce (Figure 5). India needs to accelerate investment in renewable source power generation to reduce dependence on energy imports as well as greening the power sector. However, sustaining investment in India's renewable energy sector needs mobilizing finance as well as technology transfers.

Figure 4: Compound Average Annual Growth Rate of Energy-Related CO2 Emission (IEA's New Policies Scenario)



Source: World Energy Outlook 2018

Figure 5: Present and Future Energy Demand by Fuel in Indian Power Sector

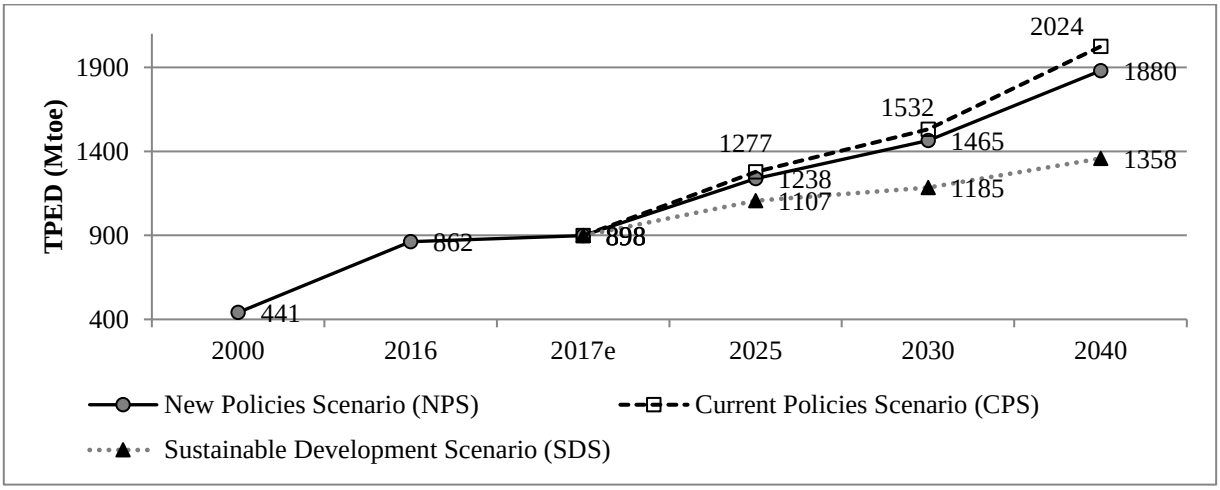


Source: World Energy Outlook 2018

4.1 India's Energy Demand and CO2 Emission Scenarios

In World Energy Outlook 2018, IEA has presented India's demand for TPED and corresponding energy-related CO2 emissions in three alternative scenarios - New Policies Scenario (NPS), Current Policies Scenario (CPS) and Sustainable Development Scenario (SDS) - where CPS serves as baseline scenario. The details of these scenarios are presented in Table A1 in Appendix. Figure 6 shows that in NPS, India's TPED will be moderately lower than CPS. However, India's TPED will fall if India follows SDS scenario. It is desirable for India to follow policies associated with SDS to save energy as well reduce dependence on energy imports.

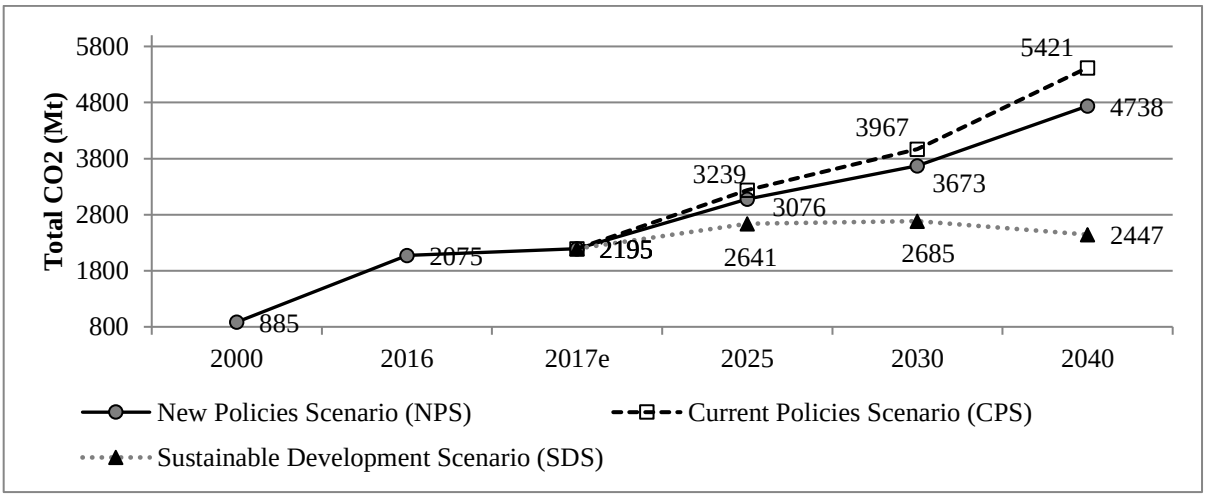
Figure 6: India's Demand for TPED in Alternative Scenarios



Source: World Energy Outlook 2018

Corresponding to three alternative scenarios, India's energy-related CO2 emissions are presented in Figure 7. It shows that by following SDS, India will not only save in energy but also global environmental space for CO2 emission. India's objectives to achieve energy security and environmental sustainability needs to be integrated and following 'low carbon energy security' path could help India to achieve this objective.

Figure 7: India's Energy-related CO2 Emissions in Alternative Scenarios



Source: World Energy Outlook 2018

5. India's Cross Border Electricity Trade and Role of Asia-Pacific Energy Cooperation

To achieve energy security, India may explore possible regional energy cooperation with energy surplus countries in Eastern South Asia and South East Asia. Table 6 shows that Indonesia Malaysia, Myanmar and Vietnam are net energy exporters whereas Bangladesh and India are net energy importers. Any regional energy cooperation among coun-

tries presented in Table 6 (excluding Australia and Thailand) may result in additional energy available for trade. However, the available energy may not be sufficient to sustain for long, given the rising demands from origin countries. Moreover, it is to be noted that China is the largest Asian county with mammoth trade deficit in energy and therefore India will face competition from China to access any energy available in the Asian region. Except for a few countries in Asia and that also due to historical and geo-political reasons, China's investment in the Asia-Pacific region is much higher than India. Therefore, it would be beneficial for India to expand the scope and coverage of energy cooperation beyond Asian region and look for opportunities of energy trade (including electricity) in the Asia-Pacific region. To reduce energy-related CO2 emission and vulnerability of Indian economy due to volatility of international prices of primary energy sources, India needs to consider expanding the horizon of energy trade beyond primary energy sources to electricity through cross border electricity trade (CBET). However, expanding the scope of energy cooperation in the Asia-Pacific region also required inclusion of all countries to reduce cost of transmission of electricity and improve connectivity of grids. Any energy cooperation among selected countries in Table 6 may assure energy availability for relatively longer time horizon. Given the vast potential exist in India for renewable source power generation, in such energy cooperation India may not necessarily be an importer of electricity. Modernization and connectivity of grids in the Asia-Pacific region would be the foremost priority to operationalize CBET in the region.

Table 6: Net Energy Imports of Selected Countries in Asia Pacific Region (Mtoe)*

Country	2010	2011	2012	2013	Remarks**
Australia	-196.05	-184.49	-194.22	-218.09	ESC
Bangladesh	4.43	5.36	5.91	5.08	EDC
India	196.52	212.33	238.87	251.99	EDC
Indonesia	-167.66	-218.03	-227.27	-244.23	ESC
Malaysia	-15.93	-11.28	-9.24	-5.06	ESC
Myanmar	-8.54	-8.34	-7.25	-6.61	ESC
Thailand	47.26	49.03	50.75	57.64	EDC
Vietnam	-7.48	-9.40	-9.43	-9.05	ESC
Total	**-147.44**	**-164.81**	**-151.88**	**-168.34**	**Energy Surplus**
Total Excluding Australia	***48.61***	***19.67***	***42.34***	***49.75***	***Energy Deficit***
Total Excluding Australia & Thailand	***1.35***	***-29.35***	***-8.41***	***-7.89***	***Energy Surplus***
China	**299.31**	**332.62**	**418.01**	**443.42**	**EDC**

Note: *-Energy imports, net (Mtoe) = [Energy imports, net (% of energy use)* Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP)*(GDP, PPP (constant 2011 international $)/1000)]/$10^9$

**-ESC – Energy surplus country, EDC – Energy deficit country

Source: Computed based on World Bank's WDI Database

India's demand for electricity is ever increasing with rising per capita income, urbanization and coverage of rural habitations under the electricity network. According to Energy Balance of India 2016-17, India exports 577.06 Ktoe (6710 GWh) of electricity and imports 483.06 Ktoe (5617 GWh). India is net exporter of electricity and India's CBET is limited to neighboring countries like Bangladesh, Bhutan, Nepal and Myanmar (only 3 MW from Manipur) (Table 7). India imports 5,427 GWh electricity from Bhutan and exports 3,764 GWh to Bangladesh, 100 GWh to Bhutan and 1,778 GWh to Nepal. India's CBET is mostly driven by availability of hydro-electricity in the countries located in the

Himalayan region. However, Himalayan region is identified as one of the most vulnerable regions for geological and hydro-climatic hazards and therefore construction of hydro-electric power projects may result in environmental hazards as well as financial risks associated with natural calamities (Huber 2019).

Table7: Export and Import of Electricity, 2016

From/To (GWh)	Bangladesh	Bhutan	India	Myanmar	Nepal	Sri Lanka	Thailand	Others	Total Export
Bangladesh		-	-	-	-	-	-	-	-
Bhutan	-		**5,427**	-	-	-	-	-	**5,427**
India	**3,764**	**110**		**N.A.**	**1,778**	**-**	**-**	**-**	**5,652**
Myanmar	-	-	-		-	-	-	-	-
Nepal	-	-	-	-		-	-	-	-
Sri Lanka	-	-	-	-	-		-	-	-
Thailand	-	-	-	-	-	-		1,385	**1,385**
Others	-	-	-	-	-	-	19,825		**19,825**
Total Import	**3,764**	**110**	**5,427**	**-**	**1,778**	**-**	**19,825**	**1,385**	**32,289**

Source: BIMSTEC Energy Outlook 2030, Page 31 (SARI/EI 2017)

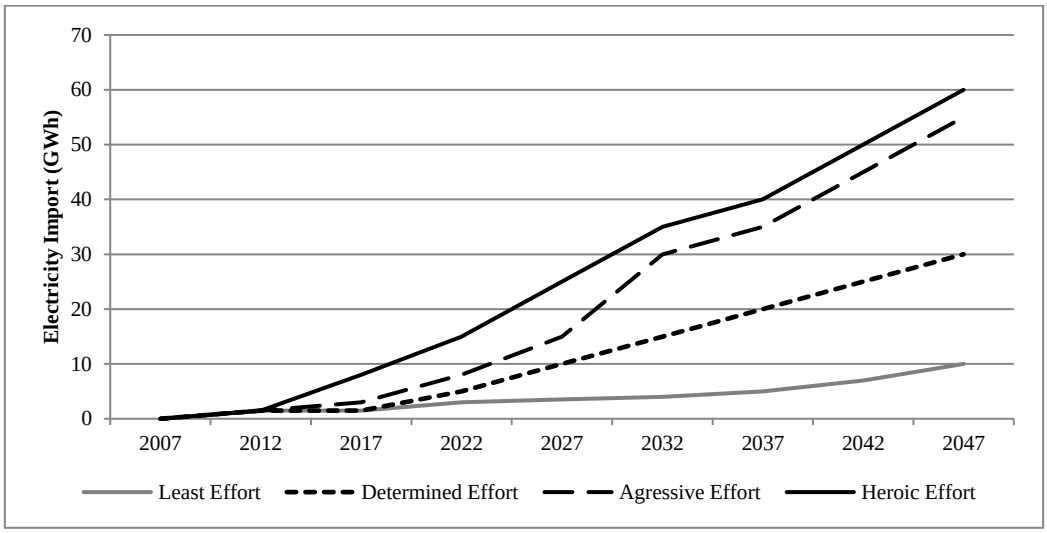
Given India's energy-related CO2 emission projections, any plan to decarbonize Indian energy basket in general and power sector in particular may induce India to explore the horizon of CBET beyond Asia. India envisages increasing import of electricity between 4 to 35 GWh by 2032 and between 10 to 60 GWh by 2047. India also plans to export electricity between 1.5 to 3.5 GWh by 2032 and 2 to 10 GWh by 2047 (Figure 8 & 9) (NITI Aayog undated).

To achieve the desired label of CBET, India needs to explore energy cooperation beyond Asia. It is reported in World Energy Outlook 2018 that Asia-Pacific region is adding considerable capacity in generation of both traditional as well as non-hydro renewable source power generation. Asia-Pacific region is leading in investment to generate electricity from non-hydro renewable sources – nearly 150 GW in solar PV and 80 GW of wind – which will be operational by 2020 (World Energy Outlook 2018, Page 294). In future, the energy cooperation in the Asia-Pacific region will not be restricted to trade in primary energy sources and electricity only but also hydrogen produced using renewable power (IRENA 2018b).

Recent studies show that Australia has abundant non-hydro renewable energy electricity generation potential, especially in Western Australia.4 Asian Renewable Energy Hub (AREH) is one of the examples where Australia – Indonesia cooperation has proposed to set up 11 GW capacity renewable electricity plant in the Western Australia. The proposed project will provide electricity to Indonesia and Singapore (Box 1).

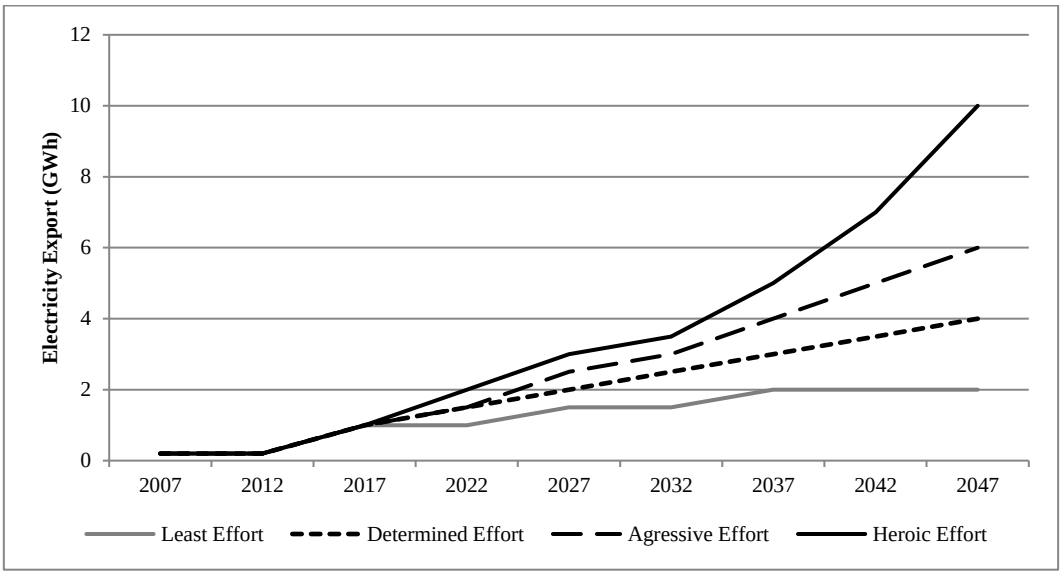
[4] ANU Energy Change Institute, Australian National University, "Zero-Carbon Energy for the Asia-Pacific", Available at: http://energy.anu.edu.au/files/ECI%20Grand%20Challenge%20Public%20Pitch.pdf (last accessed on 16 March 2019).

Figure 8: Prospects for Electricity Import (GWh) for India



Source: NITI Aayog (undated)

Figure 9: Prospects for Electricity Export (GW) from India



Source: NITI Aayog (undated)

Major factors which will drive the CBET are mobilizing finance to invest in power generation and transmission infrastructure, volatility of electricity prices in international markets and geo-political stability (or environment) for sustaining energy cooperation.

With reference to average wholesale electricity prices in selected competitive markets, IEA in World Energy Outlook 2018 has observed that "Since 2010, some electricity markets have experienced a decline in wholesale energy prices brought about by stagnant demand, low natural gas prices and higher output of generation with low marginal costs" (Page No. 315). International Renewable Energy Agency (IRENA 2018a) has also observed that cost of electricity from renewable has declined for majority of renewable sources during 2010 to 2017 (Table 8). The highest fall in prices is observed for solar photovoltaic (72%) followed by concentrating solar power (32%), onshore wind (25%) and offshore wind (18%). Since both costs of production and market prices are falling, it

may be beneficial for importing countries to import electricity rather than primary energy sources for power generation. Table 8 also shows that cost of installation of solar PV has gone down by 68 percent during 2010 to 2017. Similarly, installation cost of CSP has gone down by 27 percent, onshore wind by 20 percent and offshore wind by 2 percent. Falling costs of installation and generation of electricity may be good signs for countries having renewable source power generation potential to invest in such plants, but any decision of investment needs to be based on detailed benefit-cost analysis backed by future market price of electricity. Countries having considerable domestic demand for electricity may find beneficial to invest in generation of power from renewable sources at this time, given present and future prices of electricity.

Box 1: Asian Renewable Energy Hub (AREH)

The Asian Renewable Energy Hub (AREH) is one of the most exciting energy projects in the world, with the potential to solve several key energy and sustainable development challenges facing Indonesia. The project will harness Western Australia's abundant wind and solar resources, to export renewable energy to Indonesia via subsea power cables. The proposed project includes, 7.5+ GW of wind generation and 3.5+ GW of solar generation, 8GW+ of generation for green hydrogen production, transmission power lines to major electrical loads, two subsea power cables from Australia to Jakarta and Singapore, over 40 TWh of total annual generation, of which 20 TWh would be exported overseas for new export revenues and regional economic interconnectedness and a design life of 50+ years.

Source: https://asianrehub.com/

Table 8: Cost of Electricity from Renewable Sources

Renewable Energy Source	Global levelised cost of electricity from utility-scale power generation technologies, 2010-17 (2016 USD/kWh)		Global weighted average total installed costs, 2010-2017 (2016 USD/kW)	
	2010	2017	2010	2017
Solar Photovoltaic (PV)	0.36	0.10	4394	1388
Concentrating Solar Power (CSP)	0.33	0.22	7583	5564
Offshore Wind	0.17	0.14	4331	4239
Onshore Wind	0.08	0.06	1843	1477

Source: IRENA (2018a)

In addition to cost of installation, for CBET there will be additional cost of infrastructure installation for transmission of electricity, operation and maintenance costs of those infrastructure and any un-anticipated costs associated with risks of natural calamities etc. The estimated costs of transmission electricity through high-voltage DC link lines in the ASEAN region is presented in Table 9. Setting up HVDC line submarine would be 1.6 times costlier than HVDC line on the ground, therefore active participation and cooperation of countries located in the Asia-Pacific region could help in minimizing the cost of transmission.

Table 9: Cost assumptions for high-voltage DC (HVDC) cables in AUD

	Capex	Opex fix annual ($/kW$_{NTC}$/km/a)	Opex Var ($/kWh$_{NTC}$)	Lifetime Years (a)
HVDC line on the ground	$0.955 /kW$_{NTC}$/km	0.0117	0	50
HVDC line submarine	$1.548 /kW$_{NTC}$/km	0.00156	0	50
HVDC converter pair	$281 /kW$_{NTC}$	2.808	0	50

Source: Wang et al (2018)

Existing regional energy cooperations in Asia could play important role in operationalizing Asia-Pacific electricity transmission corridor. One of the key initiatives under ASEAN (Association of Southeast Asian Nations) Plan of Action for Energy Cooperation (APAEC) is multilateral electricity trading to accelerate the realization of the ASEAN Power Grid (APG) (Zamora 2015). It could be beneficial for India to join ASEAN Power Grid initiative to connect and transmit non-hydro renewable power available in Australia and other countries in the Asia-Pacific region.

In 2014, member states of SAARC (South Asian Association for Regional Cooperation) signed "SAARC Framework Agreement for Energy Cooperation (Electricity)" with the following objectives:5

a) The Agreement would facilitate integrated operation of regional grid across SAARC region and cross border trade.

b) This Agreement shall enable cross-border trade of electricity amongst the Member States on voluntary basis subject to the laws, rules and regulation of the respective Member States. Cross border electricity trade would facilitate surplus power of one number state to other state(s) in short to long term time frame.

It is evident that Cross Border Electricity Trade (CBET) is one of the thrust areas of regional energy cooperation in Asia. However, it would be beneficial to extend the scope and coverage of the energy cooperation in the Asia-Pacific region. Mobilizing finance to invest in the Asia-Pacific electricity transmission corridor could be an issue where multilateral development banks (e.g., Asian Development Bank, World Bank) and dedicated infrastructure banks (e.g., Asian Infrastructure Investment Bank) could play important roles (Sengupta et al. 2015).

6. Conclusions

In World Energy Outlook 2018, International Energy Agency has expected that India's TPED will grow at CAAGR of 3.9 percent during 2016 to 2030, whereas world' TPED will grow by 1.2 percent. India's growth in TPED would be the single largest driver of world's growth in TPED. With rising growth, India's share in world's TPED will rise from 6.3 percent in 2016 to 9.1 percent in 2030. Source-wise composition of India's TPED reveals that coal holds the largest share (44% in 2016) and it will increase to 46 percent in 2030. CAAGR of demand for coal will remain higher than TPED growth rate. Share of oil in TPED is 25 percent in 2016 and it is expected to fall in future. With rising demand for energy, India's energy-related CO2 emission is also expected to grow at CAAGR 4.1 percent during 2016 to 2030 and India's share in world's total energy-related CO2 emission will increase from 6.5 percent in 2016 to 10.6 percent in 2030. Coal and oil are the major

5 https://powermin.nic.in/en/content/saarc-framework-agreement-energy-cooperation-electricity (last accessed on 22 March 2019).

contributors of India's total CO2 emission and contributes 71 percent and 26 percent respectively in 2016. Though India's per capita CO2 emission is one-third of world's average, both energy and emission intensity of Indian GDP is higher than global average. Therefore, India's energy security needs to be integrated with environmental sustainability to sustain high economic growth and achieve socio-economic-environmental wellbeing of Indian population.

India's energy security is significantly dependent on imports of primary energy sources. A large part of India's imported energy sources are used – either directly and/or after refinement- for generation of electricity. Therefore to achieve energy security as well as reduce current account deficit, it will be important for India to gradually reduce imports of high value primary energy sources like crude petroleum and natural gas which are used for power generation. In the long run India also needs to reduce dependence on imported coal for power generation. Given the vast potential exist in India in renewable source power generation (mainly solar and wind power), accelerating investment in domestic electricity generation and interconnections may help to reduce dependence on imported primary sources for electricity generation. In future it would be important for India to explore Asia-Pacific region in mobilizing finance to invest in inter-regional electricity transmission infrastructure to facilitate cross border electricity trade (CBET). High dependence of Indian industry on coal and petroleum products is partly attributable to irregular electricity supply which compels industries to install captive power generation plants. India's needs to add additional 15 percent in the existing installed capacity under utility sector to ensure uninterrupted power supply to industries/ establishments. There may be some specific advantages of distributed production of electricity, but efficiencies of the captive power generation plants vary across units and there is need for intensive monitoring to control emissions from these plants. Moreover, these plants are mostly located in the vicinity of habitations and cause maximum health hazards to urban population. Therefore, it would be important for India to improve quality of electricity supply to industries and establishments so that dependence on captive power generation will go down gradually over the years. Petroleum products provides mobile sources of energy security for transport sector and to reduce dependence on petroleum products from transport sector, adoption of electrical vehicles (EVs) needs to be encouraged, at least in metros and class I cities, along with improvement in mass rapid transport infrastructure. However, given the dependence on transport fuels (mainly from diesel and petrol) for revenue generation, it would be against the revenue interests of the governments to promote EVs unless government deregulates electricity price as well as put tax on electricity at per with other transport fuels. In future, hydrogen produced using renewable power may reduce India's dependence on imports of oils for production of combustible fuels for transport sector.

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Appendix

Table A1: India's Policy Scenarios with reference TPED and CO_2 Emission

Scenarios	Cross-cutting policy Assumptions	Power sector policies and measures	Transport sector policies and measures
	Assumptions	**Assumptions**	**Assumptions**
Current Policies Scenario (CPS)	• National Mission on Enhanced Energy Efficiency • National Clean Energy Fund (NCEF) to promote clean energy technologies based on a levy of INR 400 ($6) per tonne of coal. • "Make in India" campaign to increase the share of manufacturing in the national economy.	• Renewable Purchase Obligation and other fiscal measures to promote renewables. • Increased use of supercritical coal technology. • Restructured Accelerated Power Development and Reform Programme to finance the modernisation of transmission and distribution networks. • Pollution control rules limiting emissions from coal power plants.	• Increasing blending mandate for ethanol and support for alternative-fuel vehicles. • LDVs: Bharat IV emissions standards and Euro 4 equivalent fuel sulfur standards. • HDVs: Bharat IV emissions standards and Euro IV equivalent fuel sulfur standards.
New Policies Scenario (NPS)	• Nationally Determined Contributions (NDC) Greenhouse Gas (GHS) Target: reduce emissions intensity of GDP 33-35% below 2005 levels by 2030. • NDC energy target: achieve about 40% cumulative installed capacity from non-fossil fuel sources by 2030 with	• Environmental (Protection) Amendment Rules. • Universal electricity access achieved by 2023. • Strengthened measures such as competitive bidding to increase the use of renewables towards the national target of	• Declared intent to move to 30% electric share in vehicle sales by 2030. • Extended support for alternative-fuel two/three-wheelers, cars and public buses. • National Biofuel Policy with indicative blending share targets for bioethanol and biodiesel.

Scenarios	Cross-cutting policy Assumptions	Power sector policies and measures	Transport sector policies and measures
	Assumptions	**Assumptions**	**Assumptions**
	the help of technology transfer and low-cost international finance. • Efforts to expedite environmental clearances and land acquisition for energy projects. • Opening of coal, gas and oil sectors to private and foreign investors.	175 GW of non-hydro renewables capacity by 2022 (100 GW solar, 75 GW non-solar). • Expanded efforts to strengthen the national grid, upgrade the transmission and distribution network, and reduce aggregate technical and commercial losses to 15%. • Increased efforts to establish the financial viability of all power market participants, especially network and distribution companies.	• LDVs: Bharat VI emissions standards by 2020; fuel-economy standards at 130 g CO2/km in 2017 and 113 g CO2/km in 2022. • HDVs: Bharat VI emissions standards by 2020; fuel-economy targets for 2018 and 2021. • Dedicated rail corridors to encourage shift away from road freight.
Sustainable Development Scenario (SDS)	• Provides an integrated strategy to achieve the key energy-related elements of the United Nations Sustainable Development agenda, including energy access, air quality and climate objectives. The emissions trajectory of the SDS is fully in line with achieving the long-term objectives of the Paris Agreement. • To deliver the outcomes of this scenario, the power sector proceeds further and faster with the deployment of low-emissions generation. Renewable energy technologies provide the main pathway to the provision of universal energy access. All economically viable avenues to improve efficiency are pursued, keeping overall demand in 2040 at today's level.		

Scenarios	Industry sector policies and measures	Buildings sector policies and measures
	Assumptions	**Assumptions**

Current Policies Scenario (CPS)	• Energy Conservation Act:
	  ◦ Mandatory energy audits.
	  ◦ Appointment of an energy manager in seven energy-intensive industries.
	• National Mission on Enhanced Energy Efficiency (NMEEE):
	  ◦ Cycle II and III of Perform, Achieve and Trade (PAT) scheme, which benchmarks facilities' performance against best practice and enables trading of energy savings certificates.
	  ◦ Income and corporate tax incentives for energy service companies, including the Energy Efficiency Financing Platform.
	  ◦ Framework for Energy-Efficient Economic Development offering a risk guarantee for performance contracts and a venture capital fund for energy efficiency.
	• Energy efficiency intervention in selected SME clusters including capacity building.
		• Universal electricity access achieved by 2023.
		• Rural electrification under Deen Dayal Upadhyaya Gram Jyoti Yojana scheme.
		• Promotion of clean cooking access with LPG, including free connections to poor rural households through *Pradhan Mantri Ujjwala Yojana.*
		• Measures under the National Solar Mission.
		• Energy Conservation Building Code 2007 with voluntary standards for commercial buildings.
		• "Green Rating for Integrated Habitat Assessment" rating system for green buildings.
		• Promotion and distribution of LEDs through the Efficient Lighting Programme.

New Policies Scenario (NPS)	• Further implementation of the NMEEE's recommendations including: • Tightening of the PAT mechanism under Cycle III. • Further strengthening of fiscal instruments to promote energy efficiency. • Strengthen existing policies to realise the energy efficiency potential in SMEs.	• Standards and Labelling Programme, mandatory for air conditioners, lights, televisions and refrigerators, voluntary for seven other products and LEDs. • Phase out incandescent light bulbs by 2020. • Voluntary Star Ratings for the services sector. • Measures under the National Mission on Enhanced Energy Efficiency. • Energy Conservation in Building Codes made mandatory in eight states that regulate building envelope, lighting and hot water. • Efforts to plan and rationalise urbanisation in line with the "100 smart cities" concept. • Enhanced efforts to increase electricity access for households.

Source: World Energy Outlook 2018 (IEA 2018a)

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