Südasien-Chronik - South Asia Chronicle 8/2018, S. 187-212 © Südasien-Seminar
der Humboldt-Universität zu Berlin ISBN: 978-3-86004-337-0

The Way to Sustainable Development Goal 7 "Affordable, reliable, sustainable, and modern energy": The Example of India

MICHAEL VON HAUFF & TARA CHANDRA KANDPAL
hauff-stuttgart@gmx.de , tkandpal@yahoo.com

KEYWORDS: ENERGY SUPPLY, ELECTRICITY, SUSTAINABLE DEVELOPMENT, ENVIRONMENT, CLEAN COOKING

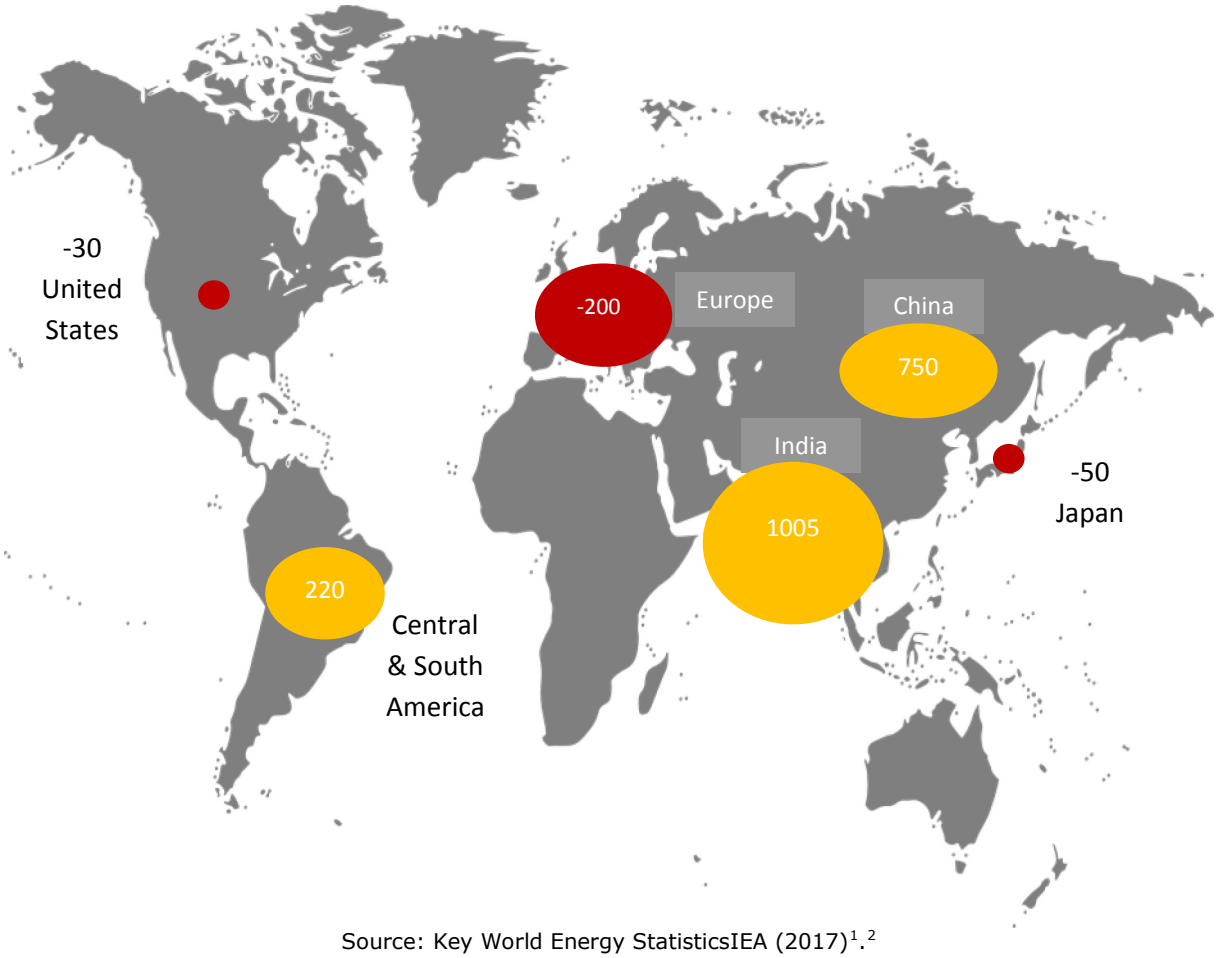
1. Characterisation of the road to Sustainable Development Goal 7

An adequate energy supply is the key to a nation's economic development. This is clearly evident in terms of economic growth. Economic growth can only be stabilised or promoted when sufficient energy is available. The study of past development patterns shows that the development of energy demand is often linked to the gross domestic product: when gross domestic product increases there is also an increasing demand for energy. However, it can also be stated that the secure access to energy can contribute to an increase in the gross domestic product or to an increase in per capita income. Empirical studies show that the income of the population increased between 9 and 30 per cent, for example, after the arrival of electrification to rural areas of Bangladesh (Thomas et al. 2017: 277).

Energy demand has risen sharply in recent decades and will continue to reflect high growth in the future, especially in emerging markets. Considering some recent trends, it can be said that global primary energy consumption increased by 1.8 per cent in 2013. Forecasting global primary energy consumption trends out to 2040 results in an annual increase of 1.4 per cent. The increase in energy demand is determined to a large extent by the development of economic growth

and income, but also by population growth. This implies an increasing demand for energy in the industrialised countries, but even more so in developing and emerging countries such as India, as shown in Fig 1.

Figure 1: Energy demand increase (Primary Energy) 2016-40 (Mtoe)



Source: Key World Energy StatisticsIEA (2017)[1].[2]

The figure provides an interesting perspective of the different distribution of rising energy demand in absolute terms by region. While the demand for primary energy in many industrialised regions, such as the USA, Europe, and Japan is declining significantly, it shows that a rising demand is expected in the developing countries. What stands out is that the highest increase in demand for primary energy is expected in India. Then, close behind, comes China. The regions of the Middle East and Africa follow with approximately the same increase. Only after that do we find the countries of Southeast Asia.

It should be noted that in contrast to industrialised nations, many developing countries seem to have major regional differences in terms of the energy supply and future energy needs. The different energy availability partially explains why there are regional differences in the economic development in developing countries. In rural regions, where the energy supply is often substantially worse

than in the cities, a negative effect is observed on economic development. Furthermore, big differences in the rate of electrification exist in the developing countries. Table 1 presents the relative position of India, where the electrification rate has risen sharply since 2010 and is currently around 85 per cent.

Table 1: The electrification rate—a comparison of Asian and Middle Eastern countries

	Electrification Rate						Population without access (million)
	National				Urban	Rural	
	2000	2005	2010	2016	2016	2016	2016
Developing Asia	**67%**	**74%**	**83%**	**89%**	**97%**	**81%**	**439**
China	**99%**	**99%**	**99%**	**100%**	**100%**	**100%**	**-**
India	**43%**	**58%**	**66%**	**82%**	**97%**	**74%**	**239**
Indonesia	**53%**	**56%**	**67%**	**91%**	**99%**	**82%**	**23**
Other Southeast Asia	**67%**	**76%**	**83%**	**89%**	**97%**	**82%**	**42**
Brunei	99%	99%	100%	100%	100%	100%	<1
Cambodia	16%	12%	23%	60%	97%	50%	6
Lao PDR	20%	11%	63%	91%	99%	85%	1
Malaysia	97%	98%	99%	99%	100%	97%	<1
Myanmar	5%	12%	49%	59%	79%	43%	22
Philippines	87%	82%	83%	90%	98%	83%	11
Singapore	100%	100%	100%	100%	100%	100%	-
Thailand	82%	99%	99%	100%	100%	100%	-
Viet Nam	76%	95%	97%	98%	100%	98%	2
Other Developing Asia	**32%**	**39%**	**53%**	**73%**	**87%**	**65%**	**135**
Bangladesh	20%	34%	47%	75%	90%	67%	41
DPR Korea	20%	23%	26%	27%	36%	11%	18
Mongolia	90%	65%	86%	91%	98%	73%	<1
Nepal	15%	35%	76%	77%	97%	72%	7
Pakistan	53%	56%	67%	74%	90%	63%	51
Sri Lanka	62%	68%	77%	100%	100%	100%	-
Other Asia	10%	14%	30%	63%	87%	51%	17
Middle East	**91%**	**80%**	**91%**	**93%**	**98%**	**79%**	**17**
Bahrain	99%	99%	99%	100%	100%	100%	<1
Iran	98%	98%	98%	99%	100%	96%	1
Iraq	95%	29%	98%	99%	100%	95%	1
Jordan	95%	100%	99%	100%	100%	100%	-
Kuwait	100%	100%	100%	100%	100%	100%	-
Lebanon	95%	100%	100%	100%	100%	99%	<1
Oman	94%	96%	98%	100%	100%	93%	<1
Saudi Arabia	98%	97%	99%	99%	100%	98%	<1
Syria	86%	91%	93%	N.A.	N.A.	n.a.	n.a.
Qatar	95%	99%	99%	99%	100%	99%	<1
United Arab Emirates	96%	94%	100%	100%	100%	100%	-
Yemen	50%	37%	40%	48%	72%	32%	14

Source: Energy potential of the mountains, p. 57, E. A. Lampenscherf.

Still, relatively pronounced regional differences exist. While the urban rate is now 97 per cent, in rural areas it is only 74 per cent. It is even much lower in the mountainous regions of India. Comparing India with other countries in Asia, it is noticeable that India is still lagging behind, especially in rural areas. So far there are about 240 million people in India without electrification and the vast majority of them are living in the rural regions.

In addition to population growth, the expanding industrial and service sectors in emerging markets is particularly responsible for the growing energy demand. Economic development is also leading to an increase in income levels, particularly in emerging economies, which leads to a rising per capita household energy consumption. The further growth of energy demand depends, to some extent, on how much success individual countries as well as the global community, will have in saving energy through greater energy efficiency. At present, the developing and emerging countries are giving too little attention to this subject.

Fossil fuels continue today to leave their imprint on energy systems. Granted, they have enabled people in industrialised countries, but also increasingly in the emerging economies as well, to achieve strong economic upturns and raise the material standard of living. At the same time, however, it has to be said that the exploitation and reliance on fossil fuels increases the pollutants released into the environment that cause a number of additional problems. This is especially true in India, where the high population growth rates have led to sharply rising CO_2 emissions (v. Hauff & Veling 2018: 84).

In principle, the risks or negative consequences of the presently dominant fossil fuel-based energy systems are well known. Specifically, this refers to climate change, the acidification of soils, and the degradation of entire ecosystems. The negative consequences regarding human health are empirically proven as well. The current focus is on the many negative effects of climate change such as extreme weather events, floods, droughts, the spread of infectious diseases, the destruction of whole ecosystems, and declining agricultural yields, all of which lead to increased follow-on costs, especially, for future generations.

As a result, in the context of sustainable development, the generation and provision of energy through renewable energy sources is gaining in importance, especially, in developing countries where short-term profit-seeking is still the focus of energy generation and use, that is, the economic dimension. In contrast, sustainable energy systems reconcile long-term economic success with other requirements. If we think of energy as a public good in a sustainable energy system, the consumption of this public good should also be reconciled with the needs of future generations. Fuels with a limited supply such as oil and gas should also be available for use by future generations in accordance with intergenerational equity. Furthermore, harmful emissions must be reduced so

that follow-on costs for future generations are as low as shown in the well-known Stern Report (Stern 2006).

Beyond the economic and social goals, a sustainable energy system must also appropriately address environmental goals. This can be justified in terms of ecological damage as follows: in the context of fossil fuels, it can be stated that environmental damage has negative external effects, for example, the release of harmful pollutants can result in what can be termed a market failure. Such negative external effects must be internalised, which can help to reduce or eliminate macroeconomic misallocation.

Although negative externalities, in principle, can be monetised, the full internalisation of externalities is not possible because of the problems of economic valuation of environmental damage and the determination of polluters, who in principle should be paying for it. These externalities include, for example, the costs for environmental and health hazards, the need to clean buildings due to air pollution and reduced harvest yields, and forest damage caused by acid rain. The generation and use of renewable sources is one way to avoid environmental damage and the resulting negative external effects.

The deficits of the energy systems still based on fossil fuels, which are dominant and explicitly oriented on economics were analyzed in terms of their relevance in a sustainable energy system and the results clearly justify the necessity of a transformation. The following section outlines the requirements for the transformation to a sustainable energy system.

2. Energy in the context of sustainable development

In the context of sustainable development, the energy supply is not limited to individual economic development, but also has a social dimension. A broad international consensus today believes that access to energy promotes income, education, social participation, good health and liberates, for example, women and girls from activities such as collecting firewood in the developing countries. This is especially true in rural areas like in India where commercial energy is not yet available everywhere. These few indicators suggest that the use of renewable energies may contribute to the satisfaction of life's basic needs. That is illustrated by the following two examples: most foods can only be consumed after cooking or heating. Similarly, a qualitatively and quantitatively secure supply of drinking water can only be provided by purification and, especially, in most of the rural areas, by pumping. Furthermore, it is also clear that advanced communication and information technologies such as computers and mobile phones depend on a safe and cost-effective energy supply.

As energy is so important for the social dimension of sustainable development, it is also highly relevant to the environment. Along with the transportation sector, the energy sector accounts for a large proportion of greenhouse gas emissions. In many industrialised and emerging economies, such as India, there is a causal link between energy production and use and climate change. The carbon dioxide emissions further cause significant damage to human health and irreparable destruction of valuable ecosystems. In addition, the mining and transport of fossil energy resources like oil, coal, and natural gas endangers or destroys ecosystems.

However, as already mentioned, the transformation process from a conventional to a sustainable energy system cannot be achieved without exploiting the potential of energy efficiency (Thomas et al. 2017: 276). Energy efficiency can be increased in many sectors, such as household, transport, industry, as well as the commercial and public services sector. For example, only 30 per cent of the potential energy efficiency in the global industrial sector is currently achieved, while 70per cent remains untapped. Even more energy efficiency potential—up to 80 per cent untapped—could be found in private households (GEA 2012: 653). There are already a variety of measures and technologies available today that are cost effective and energy efficient, which also leads to a growing market for these technologies.

In this context, Kaygusuz questions the impact of energy efficiency on social and economic development. He prepared a correlation model to study these relationships. The model is divided into three dimensions that all relate in some way to each other. Kaygusuz asks about the effects of energy in general and, unfortunately, does not differentiate between energy generated based on fossil fuels and renewable energies. Nonetheless, the model offers a number of insights into the effects of energy, which also relate to sustainable development. These can be expanded by supplementing the model. The model differentiates between three dimensions:

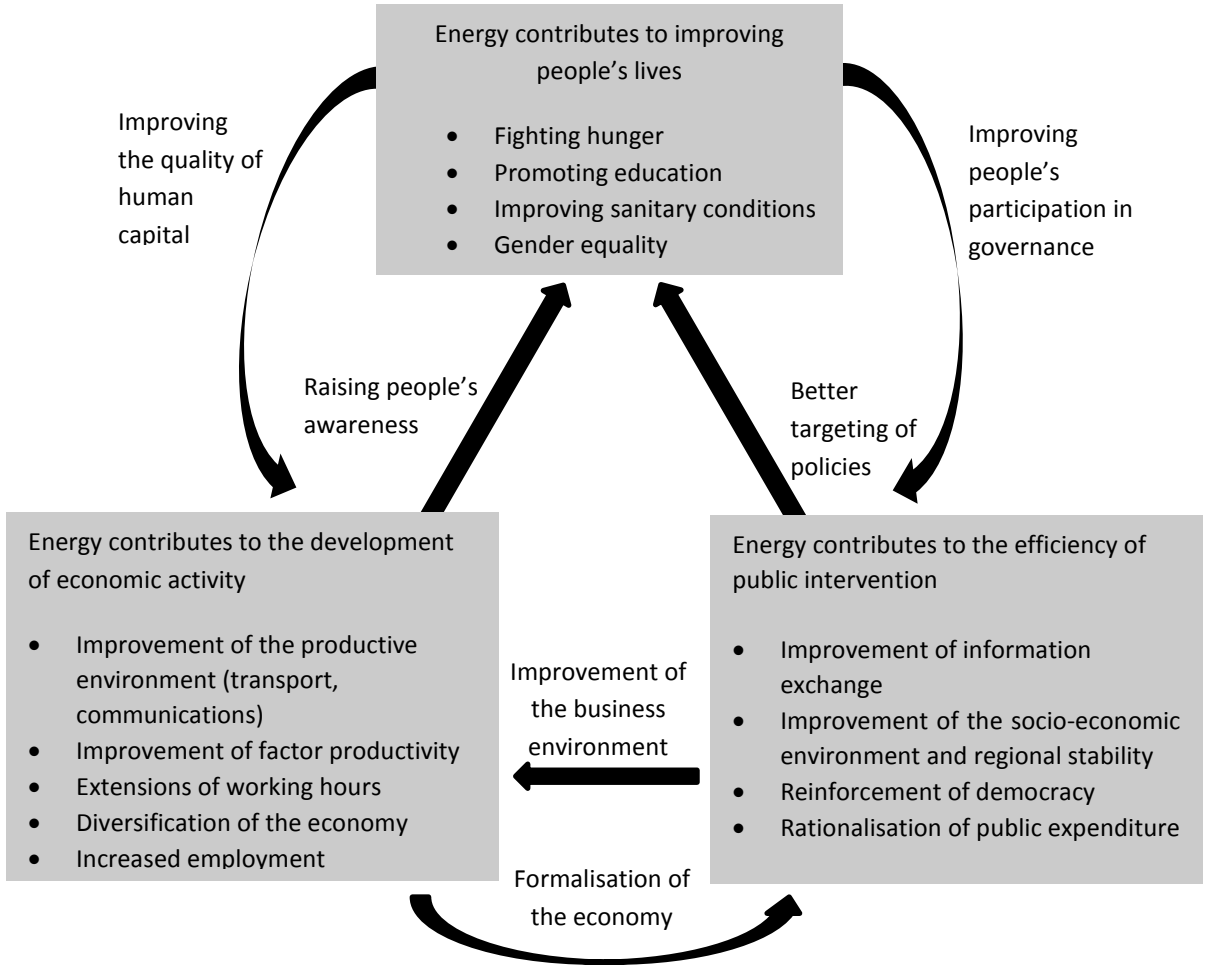
- Energy contributes to improving people’s lives
- Energy contributes to the development of economic activity
- Energy contributes to the efficiency of public intervention

Considering the content related specifications in each dimension, a basic energy supply essentially leads to an improvement of the circumstances or quality of life, to improvements in economic activity and development, and to greater civic participation. It can be stated in regard to the first dimension that providing access to energy, things like hunger and famine can be combated, education improved, and gender equality promoted. In the economic dimension the model leads to improvements in the production environment (transport, communications), increased factory productivity, extensions of working hours, diversification

of the economy, and increased employment. The use of power equipment speeds up work and makes it more efficient, transports goods and workers, and enables better vocational training and advanced training and education programmes.

Finally, the social dimension leads to an improved exchange of information leading to more regional stability and the strengthening of democracy. This is the foundation for efficient social and political integration and is the basis for positive development in many areas of public and private life. These include the education system, medical care, and gender equality.

Figure 2: Correlations between energy and human, social, and economic development



Source: Kaygusuz 2012: 1119.

3. The relevance of Sustainable Development Goal 7

Kaygusuz's theoretical model, however, fails to address the question of whether people have a right to a modern energy supply. An ongoing discussion among scientists is about whether there should be an international legal basis for a

claim to energy. For example, Guruswamy advocates that energy should be declared a human right. This would lead to regional human rights courts being able to deal with cases of insufficient access to energy (Guruswamy 2015: 122). He also names other UN conventions, such as the Women's Rights Convention CEDAW, which could serve as an international legal basis for a right of access to energy.

Another shortcoming in the Kaygusuz model is the lack of consideration of the environmental dimension. A great importance is given to environmental protection of the international level regarding the demands for universal electrification as is adequately discussed and substantiated in the paradigm of sustainable development. This is explained for the most part by the direct relationship between energy demand and climate change: it is undisputed that increasing energy needs have led to an increase in harmful CO_2 in the atmosphere.

The portrayals of sustainable energy systems have primarily concentrated on specifying the requirements for sustainable energy. They did not focus first and foremost on the formulation of concrete goals. In the year 2015, however, the 17 Sustainable Development Goals were presented in Agenda 2030 with the title "Transforming Our World: the Agenda for Sustainable Development," to which the international community is committed. This agenda applies to the industrial as well as the developing countries.

The 17 sustainability goals that were agreed substantiate the requirements of sustainable development. By agreeing to achievable goals, various sustainability areas can be specified and implemented. In the context of sustainable energy, Sustainable Development Goal 7 stipulates that universal access to affordable, reliable, and modern energy will be secured by 2030; the global share of renewable energies will be significantly increased, and the rate of increase in energy efficiency worldwide will be doubled. Clearly, determining what sub-goals must be targeted and implemented by 2030 is of key importance.

4. Specification of energy requirements under Sustainable Development Goal 7

The UN guidelines basically express global ambitions and compromises. All countries have made a commitment to develop and implement a national sustainability strategy based on Agenda 2030 and the 17 Sustainable Development Goals. This leads to further specification of sustainable development goals at the national level. Still, it is up to each individual government to determine how the global goals are to be incorporated and implemented in national planning processes, policies, and strategies (v. Hauff et al. 2018: 33). The goals should be specified based on national circumstances. It is possible to check the progress of the individual goals under the framework sustainable of a

monitoring system and, in cases of under achievement, to initiate corrections and strive for target achievement. Internationally, the goal that addresses the provision of energy has received special attention.

Sustainable Development Goals 7 directs that "affordable, reliable, sustainable, and modern energy" be provided. The following sub-goals are listed, to facilitate the specification and quantification of individual sub-goals within the framework of the national sustainability strategy:

> **7.1** By 2030, ensure universal access to affordable, reliable and modern energy services.
>
> **7.2** By 2030, increase substantially the share of renewable energy in the global energy mix.
>
> **7.3** By 2030, double the global rate of improvement in energy efficiency.
>
> **7.a** By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency, and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.
>
> **7.b** By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective support programs. (UN 2015)

Summarising the individual sub-goals, we reach the following conclusions: the sub-goals call for access to affordable and reliable energy while increasing the share of renewable energy in the global energy mix. In this context, Sachs calls for the "end of energy poverty." (Sachs 2015: 487) This implies improved energy efficiency and better international cooperation. The outcome should make open access to clean energy technology and more investment in clean energy infrastructure easier. Special planning emphasis should go to supporting the infrastructure of the least developed countries, small islands and landlocked developing countries.

In some cases, however, it is recognised that the grants to the individual goals in the national sustainability strategies are inadequate for the full achievement of a comprehensive sustainability. As a result, potential synergistic effects as well as potential conflicts between the individual goals and their sub-goals go unnoticed. In response, the UN Department of Economic and Social Affairs convened the Sustainable Development Goals7 Multi-Stakeholder Technical Advisory Group to perform a review of Sustainable Development Goals7 for the High Level Political Forum (HLPF) for sustainable development in June. The Advisory Group consists of representatives from 50 organisations (21 from the

UN), as well as from governments and other international organisations and interest groups.

The global agenda, which has been presented as a road map for universal energy access, aims to break down measurable actions to be accomplished within a set period of time into four interrelated areas:

- **Advancing Sustainable Development Goals 7 implementation through:** Prioritizing clean-cooking solutions; Closing the electricity access gap; Accelerating the pace of transition towards renewable energy; Scaling up investments in energy efficiency across all sectors of the economy; Doubling global financing for Sustainable Development Goals7; Scaling up capacity-building and education; Enhancing innovation, and Investing in data collection systems and data analysis.
- **Strengthening the links between Sustainable Development Goals7 and other Sustainable Development Goals by:** Taking a unified approach to Sustainable Development Goals7 and the Paris Agreement on climate change; Integrating gender equality and women's empowerment into all energy actions, and Promoting sustainable, low-carbon footprint cities.
- **Addressing regional priorities** through strengthening cooperation at the regional level and prioritizing ending energy poverty in the most vulnerable countries.
- **Accelerating the transformation towards a sustainable and inclusive future** by: Promoting transformative investments; Transforming human behavior from energy-intensive lifestyles to more sustainable patterns; Strengthening decision-making through improvements in energy data collection, indicators and monitoring, and harnessing the power of all stakeholders to drive change. (UN-High Level Political Forum 2018)

The road map enables further differentiation and specification of Sustainable Development Goals 7, which leads to a much better determination of the necessary implementation measures and also the further refinement of the keyword-like differentiation in the four areas. For example, as Sheila Oparaocha, executive director of ENERGIA, points out in the context of Sustainable Development Goals 7, the creation of gender-driven global and national policies are needed for the energy sector. Citing clean cooking as an example, she creates a link to Sustainable Development Goals 3. Consequently, it is clear that the inter-connectedness of the goals and sub-goals must be acknowledged for a full understanding of sustainability.

It should be noted, however, that the above-mentioned measures are associated with high costs. Marcel Alers from the UNDP has presented a summary of the funding requirement for Sustainable Development Goals 7. Furthermore, he shows that there is a large funding gap for universal access to clean energy. The cost of the annual investment is USD 240 million. The

forecasted funding requirement out to the year 2030 is USD 4.4 billion. Alers acknowledges a danger in the fact that many developing countries cannot raise these funds, which in turn leads to an imbalance in investment activities. He further emphasises that the current annual global funding for Sustainable Development Goals7 of USD 500 billion would have to double to USD 1 to 1.2 trillion USD per year by 2030 (Lebada 2018). According to Alers, private financing must assume a central role in the fulfilment of Sustainable Development Goals 7. Against this background, the following sections analyse the energy supply in India and the perspectives for India's energy supply based on Agenda 2030.

5. Current energy scene in India and future projections

India currently has over one-sixth of the world's population but uses only 6 per cent of global energy with its per capita energy consumption being one third of the global average (IEA 2015). About 20 per cent of its population is presently living below the national poverty line. India has one of the highest electricity access deficit and also clean cooking access deficit (World Bank 2018). Already high inequality in the country is likely to further increase as the unemployment is projected to increase in the short-term future. The country has rather low global rankings in terms of Human Development Index (HDI) and Gender Inequality Index. On the other hand, India is likely to be the largest consumer of energy being the third largest economy with a still expanding population. India being in its early stages of economic development has a variety of economic and environmental challenges as well as trade-offs in energy policy making.

Thus, it is critically important that the country develops and implements efficient and effective strategies to address its multitude of developmental challenges in an environmentally sustainable manner. The Government of India is looking for ways to power economic growth needed to raise the living standards of about one fifth of Indians. The Government of India is also envisaging to expand electricity access to over 200 million people without grid electricity. Moreover, there is an acute demand for more reliable power supply besides about 500 million people still dependent on solid biomass for cooking. Due to demographic trends, rising income, urbanisation and industrialisation the energy consumption in the country has been rising rapidly and contributing to worsening of air, water and land pollution in the country. As an example, eleven of the world's 20 most polluted cities are in India with life expectancy in the country estimated to be reduced by 23 months due to air pollution (IEA 2016).

India has achieved marginal reduction in its primary energy intensity in the last decade. Some of the important demographic and other characteristics of India that are likely to directly affect the energy sector of the country include (a)

population growth continuing (at more than 1 per cent), (b) rapidly increasing energy demand, (c) high GDP growth rates envisaged that would lead to further increase in demand, (d) need for improvement in the quality of life of a large fraction of its population—need for incremental energy requirement per person, (e) need for improving access to electricity and clean cooking options at the household level, (f) high rate of urbanisation, (g) increase envisaged in share of manufacturing in the country's GDP, (h) the production of both oil and gas in India is very likely to fall behind the growth in their demand thus further increasing the reliance of the country on oil and natural gas imports (estimated to be above 90 per cent by the year 2040).

India is likely to account for about 25 per cent of the increase in the energy demand at global level. The energy and electricity demands in the country are likely to grow at a compounded annual growth rates in the range of 3.7 per cent-4.5 per cent and of 5.4 per cent—5.7 per cent respectively until the year 2047. As per an energy modelling exercise undertaken by National Institute for Transforming India (NITI)Aayog (2017a), between the year 2010 and the year 2040, the energy demand of India is likely to go up by 2.7-3.2 times with the electricity demand to increase by 4.5 times. Similarly, as per the 2017 edition of BP's Energy outlook (BP 2018), the energy consumption is projected to increase by 129 per cent between 2015 and 2035 with 86 per cent of the energy demand to be met with fossil fuels.

As on 31 August 2018 the total installed electricity generation capacity in India was 344,689 MW (Table 2) with 45.6 per cent being in the private sector, almost 30 per cent in the central sector and the balance being in the state sector. Out of the total installed capacity 64.3 per cent is thermal electricity, 13.2 per cent is hydro, about 2 per cent nuclear and balance about 20.5 per cent is based on renewable sources of energy (excluding large hydro). In 2016 India produced 1478 Tera Watthour (TWh) of electricity (1105 TWh of this from coal, 138 TWh from Hydro, 71 TWh from natural gas, 59 TWh from solar and wind, 38 TWh from nuclear, 44 TWh from biofuels and 23 TWh from oil). For the year 2018-19, the electricity generation target of conventional sources has been fixed as 1265 billion units (kWh) with a growth of approximately 4.87 per cent over actual conventional generation of 1206.92 billion kWh for the previous year (2017-18) which itself was 3.95 per cent higher than the 2016-17 value of 1160,141 billion kWh. The average Plant Load Factor (PLF) of coal thermal power plants in the country has been around 60 per cent during 2015-17. During the period 2016-18 the country had an energy deficit of almost 1.5 per cent and peak deficit of about 2 per cent. Despite approximately 30 million people being provided access to electricity each year between 2010 and 2016, India has by far the World's largest number of households without access to electricity (owing mainly to its large and increasing population)—around 200 million people with less than half

of all households in the poorest income group having access to electricity (World Bank 2018).

Moreover, a large fraction of households with access to electricity lacks reliable power supply. Infrastructure for providing electricity to rural and remote areas of the country is often underfinanced and is unreliable as the revenue stream from rural households is insufficient to secure a financially sustainable distribution system due to inevitable conflict between social and financial viability objectives of energy pricing. Potential remedial initiatives could include (a) providing higher quality service with customers at its focus, (b) charging consumers a fair price, (c) customising systems and technical standards to meet low levels of rural demand, and (d) involving rural communities in the process of electrification. Table 2 also presents energy source wise projected values of installed capacities and annual electricity likely to be produced in 2022 and 2027.

India imports more than 80 per cent of its oil needs. For example, 220,43 million tonnes of crude oil was imported in the financial year 2016-17 at a cost of USD 70,196 billion. With increasing incomes and trade and business opportunities the demand for motorised transportation to move goods, services and people is growing in the country. For example, the sales of domestically manufactured vehicles have increased at an annual rate of at least 15 per cent since the year 2008. The liquid fuel requirement of the transportation sector is likely to increase rapidly since, as indicated above, with increasing income the ownership of personal cars is increasing at a rapid rate (monthly registration of approximately 250,000 cars in the country). The country imported 169,27 million tonnes of thermal coal and 47 million tonnes of coking coal during the financial year 2016-17. As per the draft energy policy by NITI Aayog (2017a), despite best possible efforts towards enhancing domestic energy supply and energy demand side management measures, the overall primary energy import of the country could increase in the range 36-55 per cent by 2040 as against a value of 31 per cent in 2012. Huge import burden of fossil fuels directly affects the trade deficit of the country and the same is further adversely affected by a change in exchange rate of USD to Indian Rupee. Thus, India’s dependence on imported energy resources (primarily oil and coal) is expected to be a major challenge to satisfying rising demand for the same.

Table 2: Existing Installed Capacities of Electricity Generation and Projected Capacities as well as Output of Electricity based on Different Energy Sources

S. No.	Energy Source(s)	Installed Capacity (MW)	Projected Installed Capacity (MW)		Projected Electricity Output (GWh)	
		June 2018	March 2022	March 2027	March 2022	March 2027
1	Coal + Lignite	196098	217302	238150	1071801	1238906
2	Natural Gas + Diesel	25705	25736	25735	82626	86182
3	Hydro	45457	51301	63301	155742	268859
4	Nuclear	6780	10080	16880	62643	110696
5	Renewable Sources of Energy	70649	175000	275000	327000	518000
Total		344689	479419	619066	1609812	2222643

Source: Compiled from different sources.

Another main concern in India is pertaining to the adverse impact(s) of energy sector on the ambient air quality. The ambient air quality is being monitored across the country under the National Air Monitoring Programme of the Centre Pollution Control Board of India. There are around 600 air quality monitoring stations in service covering 245 cities in 28 states and five union territories. High concentration of the Particulate Matter (PM) is one of the main concerns in India, as in many monitoring stations, the PM10 concentration is more than 60mg/m3, the value stipulated in the standard. In a growing number of locations, the concentration of Nitrogen Oxides (NOx) is also approaching the limit of 40µg/m3. Air pollution is contributed by a number of energy related sources that include vehicle tail-pipes, thermal power plants, captive power generation units, brick kilns, industrial activities and biomass combustion. Moreover, non-energy related air pollution from road dust, waste and agricultural residue (stubble) burning and construction activity also plays an important role. Residential sector, especially through the traditional use of biomass feed-stocks as fuels is the main contributor to PM2.5 emissions; accounting for almost 65 per cent of the total for the country. 25 per cent of urban households and almost 85 per cent of rural households in the country use solid fuels for domestic cooking—high indoor pollution.

Government is promoting Liquefied Petroleum Gas (LPG) as cleaner alternative under its PAHAL and UJJWALA schemes through direct subsidy payments and other modalities. However, initiatives towards promoting improved biomass

cook-stoves and biogas as cooking fuel are yet to provide benefits at the expected levels commensurate to their estimated potentials in the country. Around 80 million households still use kerosene lamps for lighting that release high level of PM including black carbon. There are approximately 140,000 brick kilns in the country with many small plants with heavy reliance on traditional production methods. Brick kilns in the country consume almost 15% of the total industrial demand and are a source of about 11 per cent of industrial SO2 and about 17 per cent of industrial PM2.5 emissions. Brick kilns also release black carbon which is even more damaging category of PM2.5. Though emission standards were set for brick kilns in 1996, achieving compliance is a major challenge.

There has been near tripling of passenger vehicle ownership in India over the last decade. Moreover, almost three quarters of total passenger vehicle kilometres are driven in urban areas leading to large increase in tailpipe and non-exhaust emissions. NOx emissions primarily arise in the transport sector (contributing 40 per cent to the total) followed by power sector (about 20 per cent). Most of the NOx emissions of the transport sector can be attributed to road transport involving heavy duty vehicles such as trucks and buses. Government of India is aiming at adoption of Bharat VI (analogous to Euro 6) for Light and Heavy Duty Vehicles even before 2020.

Coal intensive power sector in India contributes substantially to the air pollution. Power sector is the source of more than half of SO2 emissions from the energy sector. With consumption of high ash content coal there is risk of further increase in dust emissions if not adequately controlled. In December 2015, Environment Protection Amendment Rules (EPAR) strengthened the emission standards for new and existing plants (for example, limit for PM from new power plants reduced to 30 mg/m3 from the existing value of 50 mg/m3, similarly new limits for SO2 and NOx emissions). However, there is considerable risk of delays and non-compliance in the enforcement of EPAR and there is need for introducing strict monitoring of plant emissions in coal thermal power plants.

6. The perspectives for energy supply in India based on the Agenda 2030

One of the important features of the Sustainable Development Goals is the existence of strong inter-linkages between different goals (and targets). Each of the goals is often dependent on several of the other goals and achievement of one goal may affect the process and possibility of achieving other goal(s). For example, the Sustainable Development Goal 7 is essentially an enabler towards ensuring provision of basic services for all aspects of human welfare and growth and has direct inter-linkages with other Sustainable Development Goals (and associated targets) such as poverty eradication, food security, clean water and

sanitation, health, education, job creation etc. Sustainable Development Goal 7 is also the key to achieve international targets pertaining to climate change mitigation. Thus, achieving Sustainable Development Goal 7 would play a central role in achieving success in 2030 agenda.

An increasing number of countries across the world (including India) are aligning themselves with the 2030 agenda for sustainable development with the aim of ensuring that the country is not left behind in its efforts to eradicate poverty and hunger, achieve sustainable development and build an inclusive and sustainable future for all its citizens. These countries are aiming at promoting strong sustainable and balanced growth while protecting the planet from degradation. India, as a member of the G20 group is aiming to ensure implementation of the 2030 Agenda in all three dimensions (economic, environmental and social) of sustainable development in a balanced and integrated manner. In India, NITIAayog has been assigned the role to oversee implementation of 2030 Agenda. A mapping of the various ministries of the Central Government has been undertaken against each of the goals and targets of the 2030 Agenda by the NITI Aayog with the aim of ensuring inclusive participation and faster implementation of all sustainable development goals.

The concerned ministries have also taken initiatives towards achieving goals and/or targets assigned. NITI Aayog, has also undertaken an exercise of monitoring action plans and roadmaps of implementation being prepared by various ministries of the central Government. In addition, NITI Aayog has also carried out discussions on policy aspects as well as the outcome budget for implementing 2030 Agenda thus ensuring internalisation of the Agenda as the guiding principle form the initial stage itself. NITI Aayog has also been assigned the responsibility to approve and monitor outcome budgets of various ministries so as to implement respective programmes conforming to the goals/targets of Agenda 2030. In order to ensure coherence in policy across sectors and states regular interactions are being held with all stakeholders (concerned ministries, local governments and other grass root level organisations/entities) on implementation and other related issues. It is also worth mentioning that most of the flagship schemes of the Central Government (such as Pradhan Mantri Jan DhanYojana for financial inclusion, Make in India, Smart Cities Mission, Start-up India, Digital India, the Beti Bachao Beti Padhao which literally means “save daughters, educate daughters” essentially a programme for gender equity) as well as the programmes such as "Power for All", "Housing for All", "Clean India Mission" as well as large scale road connectivity initiatives etc. are all expected to contribute to meeting commitments under the 2030 Agenda for Sustainable Development Goals.

India accounted for 6.43 per cent of the global greenhouse gas emissions in the year 2014 with its energy sector being the main contributor. For example, in India, the share of greenhouse gas emissions from the energy sector reportedly increased from 61 per cent in 1994 to 71 per cent in the year 2010. The Government of India is following an all-inclusive approach to energy supply based on fossil fuels as well as renewable sources of energy particularly solar, wind and biomass. The country ratified Paris Climate Change Agreement on October 02, 2016 with a commitment (a) to reduce emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level, (b) to install 40 per cent power from non-fossil fuels by 2030 with flow of international technology and finance—360 GW of renewable energy based electricity generation capacity expected. Government of India has set a target of 175 GW of installed capacity based on renewable sources of energy by March 2022, and (c) to create additional carbon sink of 2.5 to 3 billion tonnes of carbon dioxide equivalent by 2030. Thus, the Indian roadmap of energy transition would be affected by the commitments made by the country under the Paris Agreement while simultaneously addressing the issues of energy poverty, access and affordability. On renewable energy utilisation front, India recently demonstrated the lowest costs for electricity produced from photovoltaic and on-shore wind power projects within the Asia Pacific region (United Nations 2017).

However, any roadmap for the country must ensure a balance between the goals of minimising environmental emissions from the energy sector and meeting increasing energy demand of the country. India envisages pursuing climate sensitive policies in diverse field of economic activities to shape its future energy supply mix by creating capacities, promoting research and development and mobilising resources domestically and globally besides shifting towards more efficient super-critical technologies for coal thermal power plants and providing financial/fiscal incentives and regulating energy price. For example, until recently the Clean Environment Cess on the use of coal discouraged the production and consumption of coal by increasing its cost to the consumer (and thus making alternative options financially more attractive). Moreover, a part of the revenue from the Cess was being reallocated to support the development and deployment of renewable energy technologies. Also, as a member of the G20, India has committed to phase out fossil fuel subsidies that encourage wasteful consumption with provision for appropriate targeted support for low income consumers. Phasing out fossil fuel subsidies is also expected to save fiscal resources for better use in developmental activities including facilitation of energy transition (Government of India 2017).

The prevailing trends that are likely to affect the road map for energy transition in India include (a) energy demand per capita in India is much lower than the world average, (b) India is set to contribute more than any other

country in the world to the projected rise in global energy demand, (c) urbanisation in India is a key driver of energy trends as an additional 315 million people are expected to live in India's cities by 2040, (d) India's need for new infrastructure underlies strong demand for energy intensive goods, (e) rising levels of vehicle ownership keeps transportation sector demand on an even steeper upward curve, (f) India's power system needs to almost quadruple in size by 2040 to catch up and to keep pace with electricity demand boosted by rising incomes and new connections to the grid—expected to increase at an annual rate of 5 per cent, (g) over 50 per cent of the new generation capacity in 2040 to be based on renewable sources and nuclear energy.

India's reliance on coal is expected to persist even beyond 2040 with a share of coal in the range of 42-50 per cent in the energy mix. The draft National Energy Policy (NITI Aayog, 2017a) projects doubling of coal-fired capacity in 2040 as against that in 2017—from 195 GW in June 2017 to 330-441 GW by 2040 (even in the ambitious scenario, there is huge dependence on import with a substantial share of fossil fuels). The new coal fired power plants in India would represent almost half of the net coal-based capacity addition in the world and, as a consequence, (h) India to become second largest coal producer in the world. Estimates from a modelling exercise undertaken by NITI Aayog (2017a) show that India will achieve peak production of coal in 2037 after which the production will decline and the country will depend on imports to meet its incremental requirements. In fact, due to rising demand, as early as by the year 2020 the country is likely to become world's largest coal importer in the world. Thus, besides variety of other green energy initiatives, for India, it is also extremely important to explore all appropriate clean coal technology options to minimise adverse impacts of coal utilisation on the environment.

Similar to the case in most of the countries of the world, in India also, the progress in transport as well as heating and cooling sectors is rather poor as compared to the growth in renewable energy-based power sector. In other words, renewable energy based de-carbonisation of the transport sector is apparently not yet prioritised at the same level as the power sector initiatives. There is a strong case for promoting use of biofuels for shipping and aviation sectors (in view of the difficulty in electrifying them). Initiatives towards electrification of the road transport sector have not been successful so far due to high cost of electric vehicles, limits on distance and also on battery life, lack of charging infrastructure, need for robust electricity supply and the need to ensure availability of low carbon electricity. Synergy must be established with efforts towards energy efficiency improvements and consequent reduction in energy intensity. Moreover, there is a critical need for grid improvements and power sector reforms. Also, there is a need to address the market distortion caused by

continuation of direct and/or indirect subsidy for perpetuating dependence on fossil fuel-based energy supply.

There is huge investment requirement for following the low carbon energy supply strategy envisaged by the Government of India to ensure compliance with Paris Agreement commitments made by the country. As per an estimate, India requires a cumulative USD 2.8 trillion in investment in energy supply (with 75 per cent of it for the power sector) and USD 0.8 trillion for energy efficiency improvements. Another estimate predicts that India will need investment of USD 1.6 trillion in power generation, transmission and distribution until the year 2035. In this regard the country is expecting to mobilise significant amounts of funds with the help of International Solar Alliance. There have been proposals of diverting National Clean Energy Cess to subsidise Goods and Services Tax (GST) induced losses and levy import duty to protect domestic manufacturers of solar energy technologies. Another important issue is the apparent mismatch between the locations with solar and wind energy resource potentials (most of the renewable energy concentrated in southern and western states of the country) and the areas with high energy demand (large share of population of the country lives in central and eastern states of UP, Bihar, West Bengal).

India aims to reduce its oil dependence by 10 per cent by 2022 with natural gas being the bridge fuel—the country is aiming to move towards gas-based energy system as part of its strategy to clean fuel regime. The share of natural gas is expected to increase from 6.5 per cent to 15 per cent with increase in LNG import from 15 million tonnes to 30 million tonnes in 2030. Centrality of coal in India's energy mix is noteworthy with the same accounting for 44 per cent of it and thus likely to impede the pace of transition to green energy supply. In view of inevitability of large share of coal in Indian energy supply mix, the country is actively promoting clean coal technology to improve its quality including the ash content and also focusing on upgradation of thermal power plants with supercritical and ultra-supercritical technology. Government of India has taken initiatives to encourage use of clean fuels in the industry by (a) avoiding use of highly polluting fuels such as petroleum coke, furnace oil and used lubricants, (b) better taxation and pricing strategy for cleaner fuels, (c) regulate and notify the acceptable cleaner fuels for specific regions/cities and (d) facilitating city gas distribution projects in medium size towns (NITI Aayog 2017b). The country is also envisaging employing electric vehicles at mass scale (NITI Aayog 2018).

In India, grid-based electricity supply to all households is expected to be the primary endeavour with the target of achieving universal electrification in terms of providing 24x7 power to all by 2022 (NITI Aayog 2017a). However, electricity being a concurrent subject in India, both the central as well as state level governments can legislate on the matter and the Central Government cannot

direct the states to take specific actions. For example, matters relating to inter-state transactions are in the domain of the Centre while states are responsible for the intra-state sale, purchase, distribution and supply of electricity. The Centre can facilitate and incentivise the States to achieve renewable energy targets, the responsibility for compliance and penalise for non-compliance is with the States. In India, so far, the electricity distribution companies on the state level are the largest purchasers of electricity, including that based on renewable sources of energy. Initiatives towards low carbon electricity supply are critically dependent on the ability of distribution companies to purchase such power. A large number of State Electricity Boards are in a severe financial distress due to (a) Commercially unviable tariffs (b) Losses arising due to theft, and (c) Transmission and billing inefficiencies.

As a consequence, the state owned distribution companies are often under massive debt and their decisions are usually affected by local political factors as against operational and technical factors. States have often used the above-mentioned constitutional authority (electricity being a concurrent subject) to push back on reforms that do not apparently suit their political agenda. For example, the Central Electricity Regulatory Commission (CERC) issued a regulation in the year 2010 to boost the Renewable Purchase Obligation (RPO) compliance with Renewable Energy Certificates (RECs). However, the onus of framing RPO regulation, setting RPO targets and its implementation is on the respective State Electricity Regulatory Commissions (SERCs) with CERC as a facilitator. As a consequence, non-compliance of RPO by the States is a major challenge and there has been huge backlog piling up due to non-purchase of RECs by states to bridge the gap for RPO compliance. For example, the total REC inventory until 31 January 2017 was 17.82 million (12.91 million non-solar and 4.91 million solar RECs).

Existing and potential initiatives to reduce the adverse impacts of energy sector on air quality in India may include: (a) launching a National Clean Air Mission for Multi-scale and Cross-sectoral Coordination, (b) switch to low sulphur fuel (10 ppm) and implement Bharat VI (analogous to Euro VI) standards for engine emissions which require tail-pipe controls like diesel particulate filters for PM and selective catalytic reduction for NOx, (c) shift freight transport from road to lower-emission modes such as rail, inland, waterways, and coastal shipping, (d) give priority to small scale, distributed renewable energy that is available close to the end use location as compared to large scale centralised mode of energy supply wherever feasible (e) provide cleaner fuels (LPG, Electricity) and highly efficient biomass stoves employing a forced draft fan to those who cannot afford LPG, (f) develop business models for collection, transport, and storage of agriculture sides and farm manure, (g) convert agriculture residues and farm manure to electricity for rural power and biomass pellets for households who

depend on biomass stoves, (h) adopt cleaner and efficient production technologies such as supercritical technologies in power sector, vertical shaft kilns, Hoffman kilns, and tunnel kilns for brick manufacturing etc., (i) Deploy National Emission Trading Schemes (ETS) with cap and trade for power generation and other large polluting industries, (j) implement stringent emission standards to control gaseous pollutants (NOx, SO_2) and fine particulate (black carbon and fly ash) emissions from both power plants and big industries, (k) implement wall-to-wall paving of streets and vacuum cleaning of roads; enforce ban on open burning of solid waste; manage waste and recovery of methane from landfills.

7. Conclusion

The energy sector across the globe is undergoing unprecedented change as the geographical landscape of energy is quickly shifting owing to global, regional and local environmental constraints. However, the share of modern renewable and traditional use of biomass in the total final energy consumption declined from 2 per cent in 1990 to 18.3 per cent in 2014; essentially due to increase in energy demand (United Nations, 2018). For the long run, as the economics of competing energy supply options is changing it has become necessary to plan and implement initiatives towards sustainable energy transition.

In the present context, the expectations from the energy sector of a country include (a) availability of and access to energy for satisfaction of demand of all consumers at affordable price (with synergy between fossil fuels and renewable sources of energy), (b) long term sustainability of energy supply, (c) energy efficiency and conservation—low energy intensity of goods produced and services provided in an economy, (d) minimum environmental emissions—low carbon footprint/emission intensity of goods produced and services provided, (e) minimum import burden, (f) enhanced energy security and self-dependence in energy sector, (g) transition to low carbon economy—increase the share of non-fossil energy in the supply mix, create additional carbon sinks and also (h) ensuring equity (particularly in a country with high unemployment and under-employment rates).

As any other emerging economy, India also has its unique vulnerabilities as well as developmental requirements and hence priorities. With over 15 per cent of the global population and a variety of developmental challenges, India as one of the largest as well as fastest growing economies is essentially at the centre stage of the global energy transition initiatives. In order to meet India’s growing energy needs, huge amounts of capital investments supported with adoption of innovative technologies as well as appropriate policy and regulatory measures is needed. The developmental process in the country is constrained by the issues of energy security, energy equity and environmental sustainability. The country is

expected to enhance its developmental efforts with the formulation and implementation of suitable policies and schemes as well as greater involvement of all stakeholders including governments at different levels and private sector. About two-thirds of the total greenhouse gas emissions in India are contributed by the energy sector and thus it is important to decarbonise energy supply as a strategic choice. India is one of the largest consumers of fossil fuels and also one of the largest emitters of greenhouse gases.

Thus, its compliance to Paris Agreement is critically important for meeting the envisaged targets as per the time line for the same. In fact, energy developments in India have the potential to transform the international energy systems and, as a consequence, India will be increasingly exposed to developments and changes in the international energy markets. The country has always reiterated its commitment towards clean energy and reducing carbon emissions—as is evident from the ambitious target of installed capacity of 175 GW based on renewable sources of energy by the year 2022 (100 GW solar, 60 GW wind, 10 GW biomass, and 5 GW small hydro). The envisaged enhanced penetration of renewable energy-based electricity generation capacity essentially seeks to address key energy objectives of the country pertaining to enhancement in energy security, reduction in energy poverty and improvement in energy sustainability.

The country has policy environment conducive to the renewable energy sector with the provision of preferential tariffs, subsidy programmes for renewable energy, concessions in transmission and distribution charges in some states, Renewable Purchase Obligation, Tax Holidays, Accelerated Depreciation, Exemption in excise and customs duties etc. Owing to a substantial reduction in the unit cost of electricity delivered by solar photovoltaic power plants in the country in recent years, the same is becoming cost-competitive with fossil fuel-based electricity. However, with increased share of electricity generation capacity based on variable sources of renewable energy, the cost of integrating the same into the main grid also needs to be taken into account. It is necessary that policies and regulations are governed by a long-term vision of the country's energy sector while specifying elaborate and regularly revised mid- term targets and continuous concrete adjustment steps on a short-term basis.

Though there could be a variety of unprecedented risks associated with interventions aiming at transition to a low carbon economy, the same are also likely to provide opportunities for economic growth in a sustainable manner. India is likely to be a major market for solar and other renewable energy technologies due to its ambitious plans to harness renewable sources of energy.

Digital transformation of energy systems—smart meters, energy management systems, automated demand response, micro-grid could help people access

reliable and affordable source(s) of energy. Moreover, two-way communication between energy producers and consumers, as well as increased number of prosumers (those who both produce and consume energy) can facilitate dispatch of distributed energy sources to areas that need it the most—areas encountering supply shortages and grid stability issues or those where resources provide only an intermittent energy supply. Any strategy towards sustainable energy transition should internalise these new developments.

A parameter defined as the "Energy Transition Index (ETI)" is recently being used to measure the ability of a country to balance Energy Security and Access with Environmental Sustainability and Affordability. The ETI provides benchmarks across a country's energy system performance based on energy security and access, environmental sustainability and economic development and growth—sometimes referred to as the "Energy Triangle". The countries are sometimes also assessed on their transition readiness—the future preparedness of the energy system of a country towards the desired transition. India has taken bold measures to (a) improve energy access, (b) improve energy utilisation efficiency in several sectors of the economy, and (c) development and deployment of renewable energy technologies. However, India presently ranks 78th on the Energy Transition Index since the energy needs in India are primarily met by fossil fuels with implications for environmental sustainability and increasing energy import costs. Also, as mentioned earlier, a considerable share of India's population still lacks access to electricity and clean cooking fuel. While some tangible progress has been made in increasing access to electricity, progress in expanding access to clean cooking options at household level has been rather slow. It is also important to mention that two critically important factors required for energy transition are (a) huge investments and, (b) an enabling environment and robust regulatory frameworks to support the transition.

India is proactively looking for global cooperation to meet its carbon emissions related commitments. Several countries provide excellent examples of energy transition. India can certainly learn from their experience in making its energy supply secure, affordable and sustainable (besides opening up new business opportunities, foster innovation, create jobs, boost growth and reduce dependence on imported fossil fuels). For example, there is a need to encourage exchange of know—how on grid integration of increasing share of renewable energy based electrical power, electric mobility, energy storage etc. One of important pre-conditions for a successful energy transition in India that would eventually culminate in the much-needed transformation of the energy sector is the need to make it a dream of every common person in India as against that of the government functionaries alone. Efforts should thus be made to involve common people in contributing to climate change mitigation initiatives. While treating renewable energy as a resource of national and strategic importance,

the same can be mandated as a significant component of the power and transportation sector. Moreover, it is extremely important to adopt an integrated approach to power sector planning including generation, transmission and distribution. Wherever feasible, there is a need to prioritise small-scale, distributed renewable energy systems that are available close to the end use location as compared to large-scale centralised mode of energy supply.

Moreover, the strategy should not be just to have numbers as targets for renewable energy technology development and deployment. For example, it is critically important to carefully analyse long-term implications of import-based deployment of solar photovoltaic power plants in the country. Solar (PV) industry in India lacks in terms of complete value chain and almost entire demand is met through imports. Near term obstacles to low carbon transition in the country include (a) continued growth in energy demand, (b) use of fossil fuels inevitable for satisfaction of short and mid-term needs of the country, (c) conflict between the priorities of the central and state governments, (d) lack of robust transmission and distribution capacity for renewable energy generation. There is a need to strengthen existing policy and regulatory mechanisms and develop new measures to help achieve the envisaged levels of penetration while internalising state-specific realities in the same. Also, it is important to address existing institutional inefficiencies including the need for coordination amongst Central and State level institutions.

Moreover, the country must prioritise creation of indigenous manufacturing capability and also address issues relating to Quality Control, Financing and Capacity Building in the field of renewable energy technologies as well as energy efficiency and conservation measures. With conscious attempt to reduce fossil fuel consumption, the country needs to strive towards developing dispatch able energy supply based on renewable sources and mobilise flexibility options to manage higher shares of variable renewable (often these are site specific with modalities required being dependent on specific local circumstances). There is a need to provide increased support for distributed renewable energy technologies and also develop policies that strengthen local capacity for facilitating renewable energy penetration in heating and cooling as well as transport sectors. Often, large integrated players are in a better position with higher returns compared to smaller contractors. The government should also create an enabling environment for businesses to seize opportunities in improving energy access for underserved population. For example, suitable policies to address issues pertaining to (a) lack of finance, (b) existing subsidies for diesel, kerosene and electricity, (c) import and fiscal barriers (import duty, GST), (d) lack of awareness and of relevant information and (e) quality and reliability of products-standards should be designed and carefully implemented.

Endnotes

[1] World Energy Outlook. 2017. *A World in Transformation*, https://www.iea.org/weo2017/ [retrieved 03.01.2019].

[2] https://cdn.pixabay.com/photo/2014/04/02/16/19/map-306920_960_720.png/ [retrieved 03.01.2019].

Bibliography

B. P. 2018. *2018 BP Energy Outlook, British Petroleum plc*. London.

CSO. 2018. *Energy statistics-2018*. New Delhi: Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India.

GEA. 2012. *Global energy assessment – towards a sustainable future*. Cambridge: Cambridge University Press.

Government of India. 2017. *Economic survey 2016-17*, vol. 2. New Delhi: Economic Division, Department of Economic Affairs, Ministry of Finance, Government of India.

Guruswamy, Lakschman. 2015. *International energy and poverty: the emerging contours.* New York: Routledge.

IEA. 2017. *Key world energy statistics.* Vienna: International Energy Agency.

_____. 2016. Energy and air pollution. *World Energy Outlook Special Report*. Vienna: International Energy Agency.

_____. 2015. India energy outlook. *World Energy Outlook Special Report*. Vienna: International Energy Agency.

Kaygusuz, Kamil. 2012. Energy for sustainable development: a case of developing countries. *Renewable and Sustainable Energy Reviews*, 16 (2), pp. 1116-26.

Lebada, Anna Maria. 2018. *Advisory group proposes global agenda to accelerate SDG 7 implementation*. New York: UNDP.

NITI Aayog. 2018. *Zero Emission Vehicles (ZEVs): towards a policy framework, September 2018*. New Delhi: National Institute for Transforming India (NITI) Aayog, Government of India.

_____. 2017a. *Draft national energy policy 2017*. New Delhi: National Institute for Transforming India (NITI) Aayog, Government of India.

_____. 2017b. *Energizing India: a joint progress report of NITI Aayog India and the Institute of Energy Economics, Japan, June 2017*. New Delhi: National Institute for Transforming India (NITI) Aayog, Government of India.

Sachs, Jeffrey. 2015. *The age of sustainable development*. New York: Columbia University Press.

Stern, Nicholas. 2006. The economics of climate change. *The Stern Review*, Cambridge.

Thomas, Stefan, Lukas Hermwille & Kilian Topp. 2017. Sustainable energy. In: M. v. Hauff & C. Kuhnke, eds. *Sustainable development policy*. London: Routledge.

UN High-Level Political Forum. 2016. *Accelerating SDG 7 Achievement policy briefs in support of the first SDG. Instruments to promote renewable energy*.

UNDP (United Nations Development Program). 2018. *Delivering sustainable energy in a changing climate strategy note on sustainable energy 2017-2021*. New York: United nations Development Programme.

United Nations. 2017. Asia-Pacific progress in sustainable energy: a global tracking framework 2017. *Regional Assessment Report 2017.* Bangkok: United Nations Economic and Social Commission for Asia and the Pacific.

United Nations. 2018. Energy transition pathways for the 2030 Agenda in Asia and the Pacific. *Regional Trends Report on Energy for Sustainable Development 2018*. Bangkok: United Nations Economic and Social Commission for Asia and the Pacific.

von Hauff, Michael & Anne Veling. 2018. *India's need for a sustainability strategy: creating a stable and balanced development*. Delhi: Ane Books.

von Hauff, Michael, Robin Schulz & Robin Wagner. 2018. *Deutschlands Nachhaltigkeitsstrategie*. Konstanz: UVK Verlagsgesellschaft.

World Bank. 2018. Tracking SDG7. *The Energy Progress Report 2018*. NW Washington DC: The World Bank, 1818 H Street.