

# BEST PRACTICES IN SUSTAINABLE ENERGY – INDIAN CONTEXT

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**Abstract—** In this project, best practices in sustainable energy has been defined. Keeping in view the Indian context, comparison scale has been analyzed with few developing countries. These analyses are based on secondary data research. Comparison of policies also been covered under this subject.

**Index terms-** Sustainable Energy, Solar Policy, Green Energy

## I. INTRODUCTION

Sustainable energy is a form of energy that meet our today's demand of energy without putting them in danger of getting expired or depleted and can be used over and over again. Sustainable energy should be widely encouraged as it do not cause any harm to the environment and is available widely free of cost. All renewable energy sources like solar, wind, geothermal, hydropower and ocean energy are sustainable as they are stable and available in plenty.

Sun will continue to provide sunlight till we all are here on earth, heat caused by sun will continue to produce winds, earth will continue to produce heat from inside and will not cool down anytime soon, movement of earth, sun and moon will not stop and this will keep on producing tides and the process of evaporation will cause water to evaporate that will fall down in the form of rain or ice which will go through rivers or streams and merge in the oceans and can be used to produce energy through hydropower. This clearly states that all these renewable energy sources are sustainable and will continue to provide energy to the coming generations.

There are many forms of sustainable energy sources that can be incorporated by countries to stop the use of fossil fuels. Sustainable energy does not include any sources that are derived from fossil fuels or waste products. This energy is replenishable and helps us to reduce greenhouse gas emissions and causes no damage to the environment. If we are going to use fossil fuels at a steady rate, they will expire soon and cause adverse affect to our planet.

## A. SUSTAINABLE ENERGY IN INDIAN CONTEXT

India is perceived as a developing country, but it is developing at a pace that is not matched by many others. We have experienced significant economic growth. Yet the fact remains that our growth is constrained by energy supply and availability. The increasing appetite for energy that has

developed in the recent past has been further complicated by rapidly diminishing conventional sources, like oil and coal. India has transitioned from being the world's seventh-largest energy consumer in 2000 to fourth-largest one within a decade. The country has the fifth-largest power generation portfolio worldwide. India's energy basket has a mix of all the resources available including renewable (RES).

### India energy facts

25% of Indians lack access to electricity. Electricity access ranges from 90% in some states to 40% in others 31% (78m households) use kerosene for lighting

67% of Indians use biomass for cooking.

Biomass represents 25% of India's primary energy consumption

More than 1m households' use solar to satisfy all their lighting needs

Sources: Indian National Census, Indian National Electrification Corporation, Indian Planning Commission, International Energy Agency

### 1) Best Practices – Indian Context

- Collaborating between Foundation / NGOs/ Corporate and Ministries to produce a series of briefing papers on the practical implementation of rural projects in India.
- Supporting advocacy efforts for the Reserve Bank of India to accord 'priority' status to bank lending for household renewable energy applications: a development that could transform the sector into a booming industry.
- Policy dialogues on regulations for off grid energy, subsidy and incentives, tariffs for off-grid energy – which resulted in recommendations to the government to create an enabling policy environment for off-grid renewable energy.
- Several Collective members are inputting into plans for the second phase of the government's flagship Jawaharlal Nehru National Solar Mission, which aims to mainstream off-grid solar power.

### 2) Best Practices – International Case Studies

Sustainable energy continued to grow in 2014 against the backdrop of increasing global energy consumption, particularly in developing countries, and a dramatic decline in oil prices during the second half of the year. Despite rising energy use, for the first time in four decades, global carbon emissions associated with energy consumption remained stable in 2014 while the global economy grew; this stabilization has been attributed to increased penetration of sustainable energy and to improvements in energy efficiency.

Globally, there is growing awareness that increased deployment of sustainable energy (and energy efficiency) is critical for addressing climate change, creating new economic opportunities, and providing energy access to the billions of people still living without modern energy services.

## II. CASE STUDIES OF MAJOR COUNTRIES ARE MENTIONED BELOW:

1. China: The Renewable Energy Law provided the institutional backing needed to stimulate China's renewable energy industry, resolving important open questions on total quantity targets, feed-in tariffs, compulsory power purchase, cost allocation, and special funds. China has several advantages in the race to produce sustainable energy. Around 250 million people have moved from the country to the city since 1990, and an equal number are expected to become urbanized in the next few decades, providing a huge market for new housing, electricity, and technology. China also benefits from low labor and raw material costs. Already, Chinese companies produce the lowest priced solar panels in the world. Polysilicon, the main ingredient in solar photovoltaic, cost about \$400 per kg in 2008. China can now produce it for \$45 per kg, and expects to drive prices down even further in coming years. Furthermore, China has a near monopoly on several rare earth elements, such as dysprosium and terbium, essential in green technology. Solar power stations and wind farms are built with relative ease in China, meeting little of the public resistance that hampers Western developers and government officials in China can simply order utilities to switch to renewable power. The rapid emergence of China as a world leader in green technology is big news for both our global environment and world economy.

2. United States of America (U.S.A): In U.S.A, the local government has two ways of pro-actively promoting sustainable procurement of energy. First, they adopt public sustainable procurement (SP) practices in their own operations, i.e. introduce sustainability criteria in local government/municipal purchasing decisions of goods and services. Second, the local governments implement strategies that facilitate and enable private actors to have a SP choice. For instance, the Green Choice Program in Austin in the United States (US), active since 2001, played an important role in the city's climate and energy agenda by stimulating the initial demand for renewable energy (RE) based electricity, facilitating municipal and community procurement of RE. Without any significant upfront investment by the local government, they were able to increase demand for RE above a critical threshold by providing new energy options to customers as well as buying into this option themselves through public SP. This sent a strong signal to energy

suppliers; led to lower and more stable costs in the long run and contributed to wind energy becoming a cost-competitive option in the region as the price of fossil fuels increased.

3. Germany: Renewable energy at Germany now provide close to 30% of Germany's power on an average basis. And on some peak days in 2014, solar and wind supplied close to 80% of peak power demand at specific times of the day. In the future, Germany is targeting a 35% average share by 2020 and a 50% average share by 2030. The reason behind the success in renewable energy for Germany comes from following reasons: The two most important reasons are: (1) the existing strength of its power grids; and (2) flexible operation of coal and nuclear plants (and to a lesser extent gas and pumped hydro). In addition, Germany has managed quite well because of: (3) better design of the balancing (ancillary) power markets, to make them more effective, faster, and open; (4) better system control software and day-ahead weather forecasting; (5) modest technical improvements to local-level distribution systems; (6) exports of power to neighboring countries; and (7) solving the "50.2 hertz" inverter problem.

4. Brazil: Brazil is often cited as an example of good practice and of divergence from the 'norm' among upper-middle- income countries. Between 1990 and 2010, Brazil more than doubled its overall energy supply while reducing its energy imports from 25% to less than 10% of total production. Brazil has replaced around 40% of its petrol / gasoline needs with home grown ethanol fuel. Brazil's continental-sized territory and broad natural resource endowment offer a range of energy options: hydropower, bio-fuels, wind and solar energy, as well as thermal power including fossil fuels. This presents policy-makers with a number of different possibilities for energy development. Brazil has certainly achieved impressive progress in increasing energy production to supply its fast growing economy and population, with noticeably lower emissions of greenhouse gases (GHGs) than in comparable countries.

5. Australia: Adelaide in Australia has established an intergovernmental framework to develop and implement the city's sustainable policies. In April 2010, the Adelaide City Council and the Minister for Sustainability and Climate Change for South Australia entered into the Adelaide Green City Sector Agreement, forming a joint commitment to "respond to climate change by pursuing development of the City of Adelaide as an environmentally sustainable city" (ACC and Government of South Australia, 2010: 1). South Australia set a target to reduce greenhouse gas (GHG) emissions by at least 60 percent of 1990 levels by 2050; this agreement is a means of collaboration between the two governments to achieve that goal. The Environmental Sustainability Strategy 2009-2012, the Adelaide City Council's guiding document for achieving sustainability, envisions Adelaide as an "energy efficient City that maximizes the use of renewable energy and local renewable energy generation. The country believes that, in developing policy or financial incentive programs are an important tool, not only for promoting strategies for reducing emissions, but also for fostering a strong foundation for future initiatives through public-private collaboration.

1) Total Power Capacity Ranking of Top 5 Countries as of End 2014-15 Globally<sup>1</sup>

Power	1	2	3	4	5
Renewable Power (incl. hydro)	China	U.S.	Brazil	Germany	Canada
Renewable Power (incl. not hydro)	China	U.S.	Germany	Spain/Italy	Japan
Bio-power Generation	U.S.	Germany	China	Brazil	Japan
Geothermal Power Capacity	U.S.	Philippines	Indonesia	Mexico	New Zealand
Hydropower Capacity	China	Brazil	U.S.	Canada	Russia
Hydropower Generation	China	Brazil	Canada	U.S.	Russia
Concentration Solar Thermal Power	Spain	U.S.	India	U.A.E.	Algeria
Solar PV Capacity	Germany	China	Japan	Italy	U.S.
Solar PV Capacity Per Capita	Germany	Italy	Belgium	Greece	Czech Republic
Wind Power	China	U.S.	Germany	Spain	India
Wind Power Capacity Per Capita	Denmark	Sweden	Germany	Spain	Ireland

<sup>1</sup>[http://www.ren21.net/wp-content/uploads/2015/07/REN12-GSR2015\\_Onlinebook\\_low1.pdf](http://www.ren21.net/wp-content/uploads/2015/07/REN12-GSR2015_Onlinebook_low1.pdf)

2) Total Annual Production Ranking of Top 5 Countries as of End 2014-15 Globally<sup>2</sup>

Energy Sector	1	2	3	4	5
Geothermal Power Capacity	Kenya	Turkey	Indonesia	Philippines	Italy
Hydropower Capacity	China	Brazil	Canada	Turkey	India
Solar PV Capacity	China	Japan	U.S.	U.K.	Germany
CSP Capacity	U.S.	India	-	-	-
Wind Power	China	Germany	U.S.	Brazil	India
Solar Water Heating Capacity	China	Turkey	Brazil	India	Germany
Biodiesel Production	U.S.	Brazil	Germany	Indonesia	Argentina
Fuel Ethanol Production	U.S.	Brazil	China	Canada	Thailand

<sup>2</sup>[http://www.ren21.net/wp-content/uploads/2015/07/REN12-GSR2015\\_Onlinebook\\_low1.pdf](http://www.ren21.net/wp-content/uploads/2015/07/REN12-GSR2015_Onlinebook_low1.pdf)

### III. OVERVIEW OF GUJARAT RENEWABLE ENERGY SCENARIO

To promote the green energy environment and better ecological balance, the state is having wide rich capacity of solar power. Gujarat came up with its new solar power policy on 13th August 2015, which would be operative up to March 31, 2020. This new policy intends to facilitate and promote large scale promotion of the solar power generation capacities in the state and the interests of all the investors, developers, consumers and various other stakeholders. The main features of the Policy are as follows:

- The minimum size of a MW scale project shall be 1 MW and 1 Kw for KW scale projects.
- Any company or group of individuals shall be eligible for setting up a solar generating plant, irrespective of whether they or not fall under REC mechanism in accordance with Electricity Act 2003.

The state is blessed with several natural resources of energy that augments its renewable energy growth. Through its proactive planning on capacity addition front it has successfully managed to eliminate the demand supply deficit. In sync with the solar power policy the Government has also launched the Industrial Policy 2015, through which Government would encourage private participation in all energy generation to meet the growing demands in the state.

#### 1) Comprehensive Analysis of State Wise Renewable Energy Policies in India

1. West Bengal: West Bengal has come up with a first ever policy on Co-Generation and Generation of Electricity from Renewable Sources of Energy. This is a major step to harness renewable energy and develop renewable energy projects in the state. This policy envisages substantial increase in electricity generation from renewable energy sources including Co-generation so as to reach 1040 MW by 2017 and 2706 MW by 2022, compared to present installed capacity of 193 MW. This effort is primarily aimed at addressing the issues relating to climate change as also to encourage tapping of renewable energy sources, as the conventional sources of energy are becoming costly day by day.

2. Karnataka: Karnataka has about 30,000 MW of officially estimated Renewable Energy (RE) potential, making it one of the country's top five RE-rich states. Karnataka Renewable Energy Policy seeks to enhance the contribution of renewables to the overall energy mix in the state, create a favorable investment environment for RE projects, implement energy efficiency measures and achieve commercial viability for RE projects. The main policy features include capacity addition targets from various RE sources, creation of a green energy

fund and establishment of a single window clearance procedure.

3. Kerala: The conventional sources of energy in Kerala are fuel wood, petroleum products and electricity. Till recently Kerala has been depending solely on hydro-power for electricity, availability of which is limited due to lack of technically favorable sites and unfavorable ecological impacts. To cater to ever-increasing demand of power, Government of Kerala has decided to give encouragement to power generation from Non-conventional Energy Sources. It is proposed to generate energy from municipal waste, agro waste, industrial waste, sewage and other biomass, small hydel units, solar photo voltaic, wind, tide, wave, geothermal etc. These technologies are environment friendly. The use of Municipal Solid Waste for power generation, besides generating power, will eliminate the problem of pollution and disposal of urban waste. Private investment will be attracted in all these sectors.

#### IV. FACTS AND FIGURES OF STATE WISE RENEWABLE ENERGY IN INDIA<sup>3</sup>

##### 1. Hydro:

Sl. No.	State	Potential (MW)		Projects Installed		Projects Under	
		Nos.	Capacity	Nos.	Capacity	Nos.	Capacity
1.	Andhra Pradesh	387	978.4	67	219.03	14	34.04
2.	Arunachal Pradesh	677	1341.38	149	103.905	44	22.23
3.	Assam	119	238.69	5	31.11	4	15
4.	Bihar	93	223.05	29	70.7	5	17.7
5.	Chhattisgarh	200	1107.15	9	52	4	115.25
6.	Goa	6	6.5	1	0.05	0	0
7.	Gujarat	292	201.97	5	15.6	0	0
8.	Haryana	33	110.05	7	70.1	2	3.35
9.	Himachal Pradesh	531	2397.91	149	587.905	40	122.2
10.	J & K	245	1430.67	35	130.53	9	34.65
<b>Total</b>		<b>2583</b>	<b>8035.77</b>	<b>456</b>	<b>1280.93</b>	<b>122</b>	<b>364.42</b>

The above mentioned table briefs that, in terms of hydro power renewable energy several states have been mapped on the criteria of potential of state, projects installed in the state and projects under implementation. It has been found out that out of mapped 10 states, Goa is having least potential MW capacity for power generation whereas Gujarat stands for highest number of potential MW capacity in the country.

##### 2. Solar:

The above mentioned table briefs that, in terms of solar power renewable energy several states have been mapped on the criteria of solar potential capacity of state as well as total cumulative capacity till date. It has been found out that out of mapped 10 states, Jammu and Kashmir is having lowest cumulative solar potential capacity whereas Gujarat till date is having highest number of solar potential capacity in the country.

<sup>3</sup><https://data.gov.in/catalog/state-wise-numbers-and-aggregate-capacity-shp-projects-upto-25-mw>

##### 3. Wind Energy:

Sl. No.	State	Installable Potential (MW) @ 50 M Level	Installable Potential (MW) @ 80 M Level	Total MW	Total MW Installed (31.12.2014)
1.	Andhra Pradesh	5394	14497	19891	912.5
2.	Arunachal Pradesh	201	236	437	-
3.	Assam	53	112	165	-
4.	Bihar	-	144	144	-
5.	Chhattisgarh	23	314	337	-
6.	Diu Daman	-	4	4	-
7.	Gujarat	10609	35071	45680	3581.3
8.	Haryana	-	93	93	-
9.	Himachal Pradesh	20	64	84	-
10.	J & K	5311	5685	10996	-
<b>Total</b>		<b>21611</b>	<b>56220</b>	<b>77831</b>	<b>4493.8</b>

The above mentioned table briefs that, in terms of wind renewable energy several states have been mapped on the criteria of installable potential capacity of state as well as total capacity installed till the time. It has been found out that out of mapped 10 states, Andhra Pradesh has total installed capacity of 912.5 MW of wind energy in the state, whereas Gujarat accounts for 3581.3 MW of total installed capacity of wind energy in the state.

##### 4. Biomass:

Sl. No.	State	Bio-Energy Biomass Power (MW)	Bio-Energy - Bagasse Cogeneration (MW)	Total Bio-Energy (MW)	Installed Capacity (MW)
1.	Andhra Pradesh	578	300	878	380.75
2.	Arunachal Pradesh	8	0	8	0
3.	Assam	212	0	212	0
4.	Bihar	619	300	919	43.42
5.	Chhattisgarh	236	0	236	279.9
6.	Goa	26	0	26	0
7.	Gujarat	1221	350	1571	56.3
8.	Haryana	1333	350	1683	45.3
9.	Himachal Pradesh	142	0	142	0
10.	J & K	43	0	43	0
<b>Total</b>		<b>7749</b>	<b>1000</b>	<b>8749</b>	<b>505.97</b>

The above mentioned table briefs that, in terms of biomass energy several states have been mapped on the criteria of total bio-energy capacity of the state as well as total installed bio-energy capacity of the state. It has been found out that out of mapped 10 states, Andhra Pradesh has total bio energy installed capacity of 380.75 MW in the state, whereas Bihar accounts for lowest 43.42 MW of total installed capacity of Bio-energy energy in the state.

## V. GROWTH FACTORS FOR INITIATING GREEN RENEWABLE PROJECTS IN INDIA

India has a large potential for energy generation by utilization of renewable energy source. As per the report of E&Y report regarding renewable energy index, which takes into accounts various factor governing renewable energy growth in a country, India is ranked 3rd overall. India has high potential for development across various renewable sources.

### A. Indian Solar Energy Market Overview: Massive Potential of India:

- Huge potential for Solar Energy development in India.
- High sunshine days, abundance of sites makes solar energy an enticing prospect
- Market in Growth Stage:
- Installed manufacturing capacity has grown from a meager 10 MW in 2000 to a total of approximately 750 MW in 2016.
- Generation capacities expected to pick up with generation linked subsidy announced by government.

### B. Indian Hydro Energy Market Overview: Potential of India:

- India ranks 8th in terms of hydro-electricity generation.
- Potential to provide energy in remote and hilly areas
- where extension of an electrical transmission grid system is uneconomical
- Till now, approximately 14 states have announced policies for setting up commercial SHP projects

### C. Initiatives by Govt. of India:

As per the Govt. of India initiative, through Make in India plan, setting up of renewable energy projects in India is seen to be as major growth drivers in transforming the economic generation capacity of the country as well as in reduction of fossil fuels and carbon emission which harming the global environment rapidly in the era of globalization. Economic growth, increasing prosperity, a growing rate of urbanization and rising per capita energy consumption has widened access to energy in the country.

As per the facts and figures provided by Govt. of India, current renewable energy contribution stands at 77 GW of the total installed capacity of 271.722 GW in the country as on 31.03.2015. Wind energy is the largest renewable energy source in India. The Jawaharlal Nehru National Solar Mission aims to generate 1,00,000 MW of solar power by 2022, creating a positive environment among investors keen to tap into India's potential.

India's Annual Solar installations to grow over four times by 2017. 10.86 GW of utility-scale solar and grid connected rooftop solar capacity will be added by 2016-17. Wind energy accounts for nearly 70% (23.44 GW) of installed capacity, thereby making India the world's fifth largest wind energy producer.

On the basis of various need-assessment and feasibility studies carried to select prospective locations, it can be

conclude that at present the large area development i.e., townships, neighborhoods, educational and institutional campuses, medical colleges, hospitals, group housing, commercial complexes etc. is taking place in a fast track mode in the country through private and public sectors and even by the Government.

With a view to achieve the target set by Govt. of India, prospective locations for initiating green renewable projects can be the towns and rural areas of Karnataka, town and rural areas of North East areas with rich in hydro energy as well as western locations of India like Rajasthan and Gujarat having abundant energy generation capacity through wind energy.

According to industry experts, with 1.2 billion people, India desperately needs energy to fuel its growth and the total demand for electricity will be above 950,000 MW by 2030. India has taken all the steps needed to provide energy from renewable sources such as wind and solar power. In March 2011, the capacity of wind power in India stood at around 12,000 MW. It is also expected that, India aims for 350 GW of energy production from renewable energy sources by 2030.

## VI. MAPPING INDIA'S RENEWABLE ENERGY GROWTH POTENTIAL

Power generation from renewable sources is on the rise in India, with the share of renewable energy in the country's total energy mix rising from 7.8% in FY08 to 12.3% in FY13. India had about 28.1 GW of installed renewable energy capacity as of 31 March 2013.

With a Compound Annual Growth Rate (CAGR) of 18.4 % between FY07 to FY13, investment in clean energy in India decreased 45% to US\$6.9 billion in 2012. The wind energy sector attracted US\$ 3.4 billion, while the share of the solar sector was down 45% to US\$ 2.32 billion. The Govt. of India has set a renewable energy capacity addition target of 29.8 GW for the twelfth FYP, taking the total renewable capacity to almost 55 GW by the end of Financial Year 17. This includes 15 GW from wind, 10 GW from solar, 2.7 GW from biomass and 2.1 GW from small hydro. Investment in renewable energy is expected to almost quadruple to INR 3,186 billion in the 12 FYP from INR 892 billion in the 11th FYP, implying average annual investments of nearly INR640 billion.

The government is playing an active role in promoting the adoption of renewable energy resources by encouraging the private sector investment and mandating the use of renewable resources. It is offering various incentives such as GBIs and tax holidays to encourage the development and use of renewable energy sources.

### CONCLUSION

The best practices in sustainable energy will come across a fruitful stage when government along with all private stakeholders will put up the initiative to promote green and renewable energy for better sustainability, economic generation and provide better livelihood to the community.

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