Energy Management and Commercialization for Renewable Energy Sources in India

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Abstract— Despite the abundance of Renewable Energy sources available in India, the challenge lies in the Energy management of the same. Technologies growing day by day have to withstand the problems associated with Energy Management especially related to renewable energy. Given to the fact that India having thrice as much population as compared to the United States, the Renewable Energy generated is Five times less than that generated by the US. Thus, the paper focuses on management of renewable sources viz. Solar, Hydro and Wind Energy and studies the related Commercial projects in India including the ones pumped by the Government of India. The outcome will give a comparative on the feasibility and sustainability.

Key words: Energy Saving Technologies, Renewable Energy, Energy Management, Hydro Energy, Solar Energy, Wind Energy

I. Introduction

Energy management includes planning and operation of energy production and energy consumption units. Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need. It is connected closely to environmental management, production management, logistics and other established business functions. It can also be defined as "Energy management is the proactive, organized and systematic coordination of procurement, conversion, distribution and use of energy to meet the requirements, taking into account environmental and economic objectives". Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy often provides energy in four important areas: electricity generation, air and water heating/cooling, transportation, and rural (off-grid) energy services.

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The next sections of the paper contains the detailed information and comparison of the various non-conventional sources of the energy like Solar, wind and Hydro etc. The information from the Various Government and other reputed organizations are compared with view of having the update information for the energy scenario of the country in context of the developing countries.

II. Renewable Energy Sources and Detailed Information

A. Solar:

Electromagnetic energy (solar radiation) transmitted by the sun (approximately one billionth of which reaches the earth) that is the basis of all terrestrial life. Solar energy is harnessed by capturing the sun's heat (through solar heaters) or light (through photovoltaic cells). Growth of solar energy is maximum found in southern region of India (table-1) have 3877.45 MW as of December 2016 [4]. Yearly generation of solar energy in India from 2013-2016 is given, as for the duration of 2015-16 maximum amount of solar energy has been generated which id measured in billion Kwh is tabulated in table-2 [6]. Moreover, the table-3 included the list of the top solar companies that survived the recent harsh market conditions in descending order of their turnover, indicating the need of the hour to stand in the market looking at the future prospective and opportunities of the market to provide the best.

Region	Generation (MW)
Northern Region	2,257.01
Western Region	2,569.15
Southern Region	3,887.45
Eastern Region	214.14
North Eastern Region	17.27
Others	61.07
Islands and others	67.22
Total	9,012.66

Table 1: Region wise solar generation

Year	Generation(Billion Kwh)
2013-14	3.35

2014-15	4.60
2015-16	7.45

Table 2: Solar generation in year span measured in Billion KWH

Rank	Company	Revenue(In Rs Million)
1.	Tata Power Solar Systems Ltd.	5104.67
2.	Vikram Solar Pvt. Ltd.	3815.74
3.	Emmvee Group	3619.11
4.	Waaree Energies Ltd.	2975.94
5.	Moser Baer Solar Group	2421.67

Table 3: Companies in India having their revenue in Rs million

As the solar energy is used widely it is also used as solar steam project in the Mega Kitchen for the purpose of generating steam to cook food. Sri Sai Sansthan Prasadalaya is A Free Kitchen in Shirdi, Maharashtra. It Is Spread Across 4 Roof Tops with 73 Solar Dishes, Making It the Largest Solar-Powered Kitchen In India [8].

To save the daily fuel expenses world's largest Solar System Project is implemented. Its specifications are as follows –Number of solar dishes – 73
Dish size – 16 sq. meter
Total steam generation capacity – 4200 kg/day
Steam generation capacity of each dish – 57.53 kg
Fuel expense saving due to the solar steam will be Rs. 15,439.50 kg/day

The following initiatives have been taken by government for specially promoting Solar Power in the country:

Exemption from excise duties and concession on import duties on components and equipment required to set up a solar plant. A 10-year tax holiday for Solar Power Projects. Wheeling, banking and third party sales, buy back facilities by states. Guaranted market through solar power purchase obligation to states. GBI schemes for small projects connected to grid below 33 kV. Reduced wheeling charges as compared to those for conventional energy. Special incentives for exports from India in renewable Energy technology under renewable energy sector- specific SEZ.A payment security mechanism to cover the risk of default by state utilities/dis com. A subsidy of 30% of the project cost for off-grid solar thermal projects, subject to availability of funds.

B. Hydroenergy:

Hydropower or water power is power derived from the energy of falling water or fast running water, which may be harnessed for useful purposes. Since ancient times, hydropower from many kinds of watermills has been used as a renewable energy source for irrigation and the operation of various mechanical devices, such as gristmills, sawmills, textile mills, trip hammers, dock cranes, domestic lifts, and ore mills. A trompe, which produces compressed air from falling water, is sometimes used to power other machinery at a distance. In the late 19th century, hydropower became a source for generating electricity. Cragside in Northumberland was the first house powered by hydroelectricity in 1878 and the first commercial hydroelectric power plant was built at Niagara Falls in 1879. In 1881, street lamps in the city of Niagara Falls were powered by hydropower.

Since the early 20th century, the term has been used almost exclusively in conjunction with the modern development of hydroelectric power. International institutions such as the World Bank view hydropower as a means for economic development without adding substantial amounts of carbon to the atmosphere, but dams can have significant negative social and environmental impacts.

Hydropower is used primarily to generate electricity. Broad categories include: Conventional hydroelectric, referring to hydroelectric dams. Run-of-the-river hydroelectricity, which captures the kinetic energy in rivers or streams, without a large reservoir and sometimes without the use of dams. Small hydro projects are 10 megawatts or less and often have no artificial reservoirs. Micro hydro projects provide a few kilowatts to a few hundred kilowatts to isolated homes, villages, or small industries. Conduit hydroelectricity projects utilize water which has already been diverted for use elsewhere; in a municipal water system, for example. Pumped-storage hydroelectricity stores water pumped uphill into reservoirs during periods of low demand to be released for generation when demand is high or system generation is low. Pressure buffering hydropower use natural sources (waves for example) for water pumping to turbines while exceeding water is pumped uphill into reservoirs and releases when incoming water flow isn't enough. A conventional dammed-hydro facility (hydroelectric dam) is the most common type of hydroelectric power generation [7] is shown in figure 1 and the hydro power plant and their generating capacity existing in India is mentioned below in table-4.

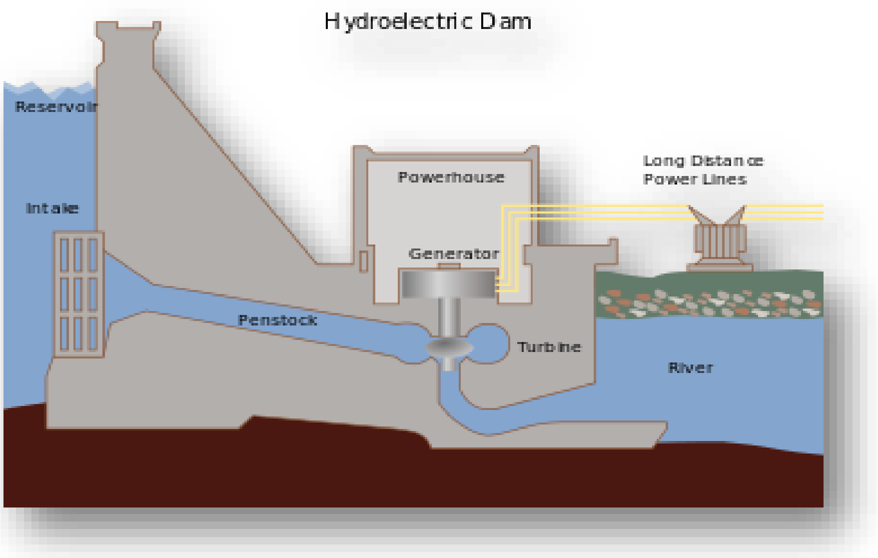

Fig. 1: Basic Hydroelectricity Dam

SR. NO.	Dams in India	Total Generating capacity (MW)
1.	The Tehri Dam	2400
2.	The Koyna Hydroelectric Dam	1960
3.	The Srisailam Dam	1670
4.	The Nathpa Jhakri Dam	1500
5.	The Sardar Sarovar Dam	1450

Table 4: Dams in India and their generating capacity measured in MW

India has gone from an electricity deficit state to an electricity surplus state by making use of pumped storage schemes which store surplus power to meet peak load demands. The pumped storage schemes also capture secondary, seasonal power at no additional cost when rivers are flooded with excess water. India has already established nearly 6,800 MW pumped storage capacity with the installation of hydropower plants. Pumped storage units can also be used as pumping stations to supply river water for upland irrigation, industrial needs, and drinking water. In a tropical country like India, abundant water for agriculture is needed due to a very high annual evaporation rate. The amount of water necessary to meet this demand can be harnessed from India's rivers via pumped storage units. Food security in India is improved with water security, which in turn is possible from the energy security needed to supply the power for the pumped storage schemes.

More and more solar power generation is becoming available due to lowering cost and its advantage in terms of environmental impact. Solar power may have the capacity to meet daytime energy demands while pumped storage units could meet night-time demands. Many of the existing hydropower stations on the west-flowing rivers located in the Western Ghats of Kerala and Karnataka are already expanding to include pumped storage units in an effort to solve the water deficit of east-flowing rivers like the kaveri , the Krishna, etc. With India having the highest total capacity of 2400MW from Tehri Dam which is almost 10 times lower than the total capacity of the biggest hydro power station Three Gorges Dam which is located in china having total capacity of 22,500 MW.

C. WIND ENERGY:

Wind power generation capacity in India has significantly increased in the last few years and as of 31 Aug 2016 the installed capacity of wind power was 27,676.55 MW, mainly spread across the South, West and North regions. By year end 2015 India had the fourth largest installed wind power capacity in the world. The cost of wind power reached a record low of ₹ 3.46 per kWh during auctions for wind projects in February 2017. The development of wind power in India began in 1986 with the first wind farms being set up in coastal areas of Maharashtra (Ratnagiri), Gujarat (Okha) and Tamil Nadu (Tirunelveli) with 55 kW Vestas wind turbines. Wind power accounts nearly 8.6% of India's total installed power generation capacity and generated 28,604 million kWh in the fiscal year 2015-16 which is nearly 2.5% of total electricity generation. The capacity utilization factor is nearly 14% in the fiscal year 2015-16 (15% in 2014-15). 70% of wind generation is during the five months duration from May to September coinciding with Southwest monsoon duration. The fiscal year ending capacity in the year 2005 for India was 6,270 MW which is almost 4 times lower than the fiscal year ending capacity in 2015 having capacity of 26,769 MW.

The state wise installed wind capacity by October, 2016 depicts that Tamil Nadu has the highest capacity of total 7684.31 MW including this with every other state in India total capacity is considered as 28,082.95 MW. Table-5 shows the country wise Installed wind power capacity MW. Despite having the highest installed capacity in comparison with China in 2006, India in the year 2016 is almost 6 times less compared to China in wind power capacity.

SR. NO.	Nation	Year 2006	Year 2016
1.	China	2599	1,68,690
2.	European Union	48,122	1,53,730
3.	United States	11,603	-
4.	Germany	20,622	50,019
5.	India	6270	28,665
6.	Spain	11,630	23,075

Table 5: Installed wind power capacity MW

Once the location of wind farm is selected based on the available wind data, next step is to optimize the wind power output from the farm area using the available wind turbines from the manufactures. The spacing between the adjacent wind turbines is between 5 and 9 times of the rotor diameter in the prominent wind direction and 3 to 5 times perpendicular to wind direction. If needed CFD analysis can be performed to finalize the optimum layout. Higher rotor diameter increases the swept area of wind by increasing the wind turbine power. Higher hub height from the ground enables the rotor to use high velocity air available at higher elevation. Selecting a bigger rotor diameter and more hub height with latest transmission (mechanical to electrical energy) technology would maximize a wind farm power generation capacity, reduce the wind electricity generating cost and optimize the installation cost per MW capacity.

Offshore wind power plants are also being installed all round the world including in India where India is planning to enter in to offshore wind power, with a 100 MW demonstration plant located off the Gujarat coast. In 2013, a consortium (instead of group of organizations), led by Global Wind Energy Council (GWEC) started project FOWIND (Facilitating Offshore Wind in India) to identify potential zones for development of off-shore wind power in India and to stimulate R & D activities in this area. The other consortium partners include the Centre for Study of Science, Technology and Policy (CSTEP), DNV GL, the Gujarat Power Corporation Limited (GPCL) and the World Institute of Sustainable Energy (WISE). The consortium was awarded the grant of €4.0 million by the delegation of the European Union to India in 2013 besides co-funding support from GPCL. The project action will be implemented from December 2013 to March 2018.

The project focuses on the States of Gujarat and Tamil Nadu for identification of potential zones for development through techno-commercial analysis and preliminary resource assessment. It will also establish a platform for structural collaboration and knowledge sharing between stakeholders from European Union and India, on offshore wind technology, policy, regulation, industry and human resource development. FOWIND activities will also help facilitate a platform to stimulate offshore wind related R&D activities in the country. The consortium published initial pre-feasibility assessment reports for offshore wind farm development in Gujarat and Tamil Nadu on 16 June 2015. In September 2015, the India's cabinet has approved the National Offshore Wind Energy Policy. With this, the Ministry of New & Renewable Energy (MNRE) has been authorized as the Nodal Ministry for use of offshore areas within the Exclusive Economic Zone (EEZ).

Offshore wind power refers to the construction of wind farms in bodies of water to generate electricity from wind. Unlike the typical usage of the term "offshore" in the marine industry, offshore wind power includes inshore water areas such as lakes, fjords and sheltered coastal areas, utilizing traditional fixed-bottom wind turbine technologies, as well as deep-water areas utilizing floating wind turbines. The U.S. National Renewable Energy Laboratory has further defined offshore wind power based on its siting in terms water depth to include shallow water, transitional water, and deep water offshore wind power. Fig.2. Progression of expected wind turbine evolution to deeper water.

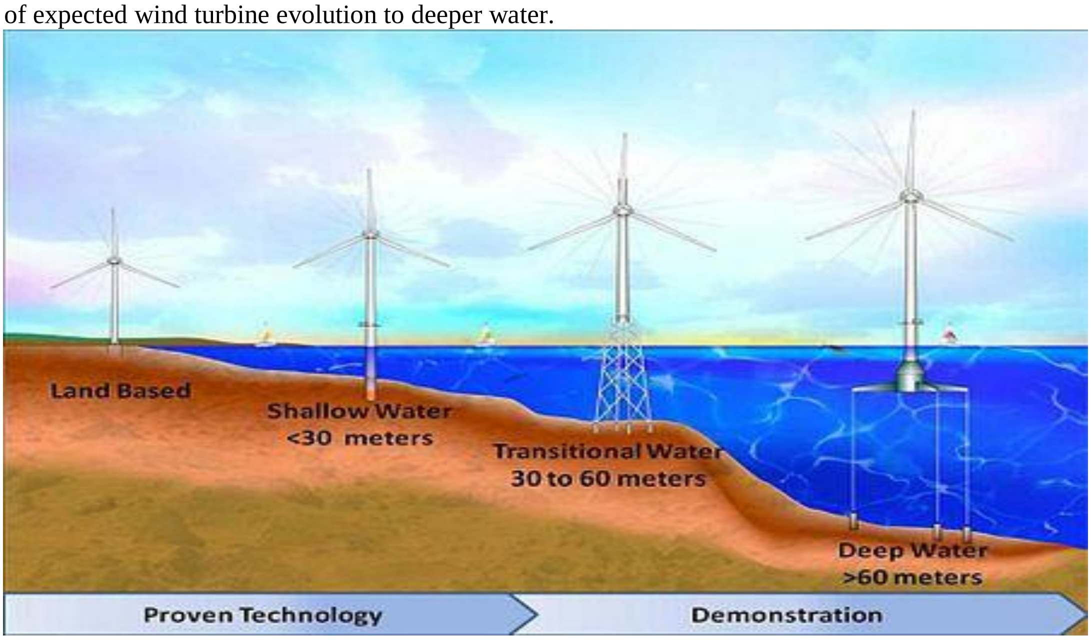

Fig. 2: Progression of expected wind turbine evolution to deeper water

Government Initiatives For Renewable Energy Sources

The Government of India has identified power sector as a key sector of focus so as to promote sustained industrial growth. Some initiatives by the Government of India to boost the Indian power sector: [2]

The Government of India plans to set up a US$ 400 million fund, sourced from The World Bank, which would be used to protect renewable energy producers from payment delays by power distribution firms, while at the same time protecting the distribution firms from the shrinking market for conventional grid-connected power, caused by wider adoption of roof-top solar power generation. The Ministry of Power plans to set up two funds of US$ 1 billion each, which would give investment support for stressed power assets and renewable energy projects in the country. Mr. Piyush Goyal, Minister of State with Independent Charge for Power, Coal, New and Renewable Energy and Mines, launched an online portal for star rating of mines, which will bring all mines to adopt sustainable practices, and thereby ensure compliance of environmental protection and social responsibility by the mining sector. The Ministry of New and Renewable Energy (MNRE), which provides 30 per cent subsidy to most solar powered items such as solar lamps and solar heating systems, has further extended its subsidy scheme to solar-powered refrigeration units with a view to boost the use of solar-powered cold storages. Mr. Piyush Goyal, Minister of State with Independent Charge for Power, Coal, New and Renewable Energy and Mines, inaugurated the Tarang (Transmission App for Real Time Monitoring & Growth) mobile app and web portal for electronic bidding for transmission projects, which is expected to enhance ease, accountability, transparency, and boost investor confidence in power transmission sector. The Ministry of Shipping plans to install 160.64 MW of solar and wind based power systems at all the major ports across the country by 2017, thereby promoting the use of renewable energy sources and giving a fillip to government's Green Port Initiative. The Government of India and the Government of the United Kingdom have signed an agreement to work together in the fields of Solar Energy and Nano Material Research, which is expected to yield high quality and high impact research outputs having industrial relevance, targeted towards addressing societal needs. The Ministry of Petroleum and Natural Gas is seeking to enhance India's crude oil refining capacity through 2040 by setting up a high-level panel, which will work towards aligning India's energy portfolio with changing trends and transition towards cleaner sources of energy generation. The Government of India plans to start as many as 10,000 solar, wind and biomass power projects in next five years, with an average capacity of 50 kilowatt per project, thereby adding 500 megawatt to the total installed capacity. Mr. Piyush Goyal, Minister of State (Independent Charge) for Power, Coal and New & Renewable Energy outlined Government of India's goal to provide electricity to every home in India by 2020, while also focusing on ensuring the cost of power is affordable to everyone. Government of India has asked states to prepare action plans with year-wise targets to introduce renewable energy technologies and install solar rooftop panels so that the states complement government's works to achieve 175 GW of renewable power by 2022. The Government of India announced a massive renewable power production target of 175,000 MW by 2022; this comprises generation of 100,000 MW from solar power, 60,000 MW from wind energy, 10,000 MW from biomass, and 5,000 MW from small hydro power projects. In the Budget 2015, Government has announced a target of adding 175 GW of renewable energy, including addition of 100 GW of solar power, by the year 2022. This was stated by Shri Piyush Goyal, Minister of State (IC) for Power, Coal & New and Renewable Energy in a written reply to a question in the Lok Sabha. It is also being planned to increase the Renewable Purchase Obligations to the levels as envisaged under National Action Plan on Climate Change (NAPCC) [5]. The Minister further stated that for grid connected Solar Rooftop, subsidy of 30% of the benchmark cost for general category States and 70% for special category states is being provided also under off grid Solar PV program, subsidy of 30% of the benchmark cost for general category States and 70% for special category States is being provided for defined category and subjected to availability of funds. Micro-grids are localized grids that can disconnect from the traditional grid to operate autonomously and help mitigate grid disturbances to strengthen grid resilience [1].

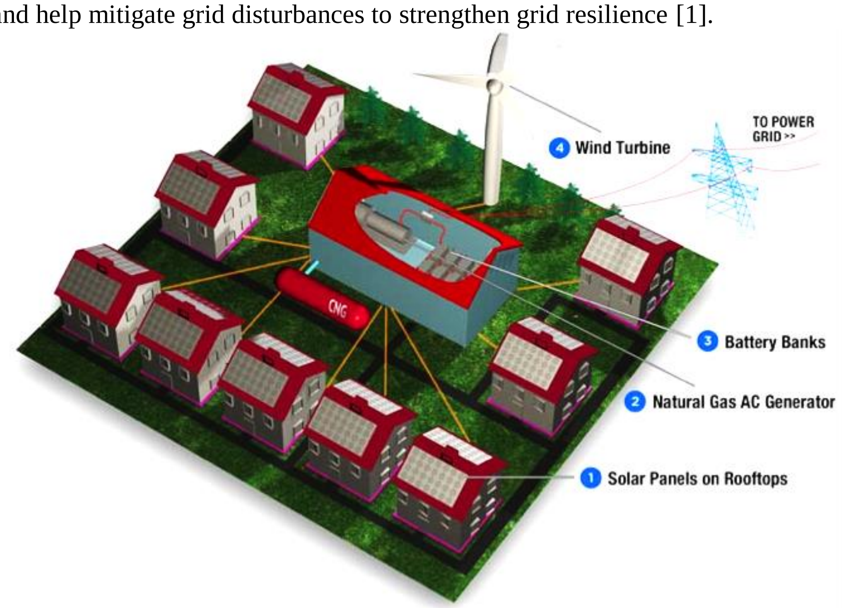

Fig. 3: A typical scheme of micro-grid with renewable energy sources in grid-connected mode

III. CONCLUSION

Taking all the Renewable Resources in India the is no limit for their usage for the proper utilization and proper distribution of the source to the farthest remote places Micro-grids should be installed to overcome every possible challenge regarding the need of electricity. Micro-grid is a localized grouping of electricity sources and loads that normally operates connected to and synchronous with the traditional centralized electrical grid (macro-grid), but can disconnect and function autonomously as physical and/or economic conditions dictate. By this way, it paves a way to effectively integrate various sources of distributed generation (DG), especially Renewable Energy Sources (RES). It also provides a good solution for supplying power in case of an emergency by having the ability to change between islanded mode and grid-connected mode. On the other hand, control and protection are big challenges in this type of network configuration, which is generally treated as a hierarchical control. Micro-grid is very advantageous as First of all, a micro-grid is capable of operating in grid-connected and stand-alone modes, and handling the transitions between these two modes. So that it provides good solution to supply power in case of an emergency and power shortage during power interruption in the main grid. In the grid-connected mode, ancillary services can be provided by trading activity of micro-grid and the main grid. In the islanded mode of operation instead, the real and reactive power generated within the micro-grid, including the help of energy storage system should be in balance with the demand of local loads. In islanding mode, there are intentional (scheduled) or unintentional in which intentional islanding can occur in situations such as scheduled maintenance, or when degraded power quality of the host grid can endanger micro-grid operation or because of economical reason. On the other hand, unintentional islanding can occur due to faults and other unscheduled events that are unknown to the micro-grid. Both of those situation can be dealt actively by using micro-grid. All of above mentioned points and by means of modifying energy flow through micro-grid components, micro-grid allows and facilitates integration of renewable energy generation such as photovoltaic, wind and fuel cell generations without requiring re-design of the distribution system. The best example of micro-grid city is of Les Anglais, Haiti where a wirelessly managed micro-grid is deployed in rural Les Anglais, Haiti. The system consists of a three-tiered architecture with a cloud-based monitoring and control service, a local embedded gateway infrastructure and a mesh network of wireless smart meters deployed at 52 buildings. Non-Technical Loss (NTL) represents a major challenge when providing reliable electrical service in developing countries, where it often accounts for 11-15% of total generation capacity. An extensive data-driven simulation on 72 days of wireless meter data from a 430-home micro-grid deployed in Les Anglais, Haiti has been conducted to investigate how to distinguish NTL from the total power losses which helps energy theft detection.

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