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Decentralising India's Power Sector: Opportunities, Challenges and the Feasibility of a Distributed Energy Future

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ABSTRACT: Decentralized power generation is strongly supported by India's fast rising electricity demand, regional variety, rural energy needs, and dedication to low-carbon development. Decentralized power generation generates electricity closer to the point of consumption, in contrast to the traditional electricity paradigm, which produces electricity in big centralized power plants and transports it over extensive transmission and distribution networks. Such a decentralized electrical architecture may be built on solar photovoltaic systems, rooftop solar, biomass plants, small wind systems, solar agricultural pumps, battery-supported microgrids, and hybrid renewable energy systems. Decentralized renewable energy (DRE) has already received substantial policy backing in India. According to the Ministry of New and Renewable electricity (MNRE), DRE systems are a crucial way to supply dependable, reasonably priced, and clean electricity, especially to underprivileged and distant populations. Decentralized generation is no longer only a theoretical idea, as seen by initiatives like PM-KUSUM, rooftop solar projects, and off-grid solar programs. This article explores the possibility of decentralized power generation plays a significant role in India's electrical system that helps to attain clean energy and Viksit Bharat @ 2047.

KEYWORDS: Decentralised power, Distributed networks, off-grid solar, Roof top solar & MNRE.

I. INTRODUCTION

World's greatest scientist, innovator and pioneer in the field Thomas Alva Edison opened first commercial electricity plant in 1882 in New York, USA[1]. Edison Electricity plant mainly works with Direct Current (D.C) which cannot travel more than 4kms without much power loss. Due to the reason early days electricity distribution is restricted to small regions. So, this laid to the foundation to decentralised concept in 1882. It is the first decentralised power supply in USA. In 1896 Niagara Falls hydroelectric plant successfully transmitted Alternated Current for Long distances. It has been transmitted up to 20 miles with high AC power. [2]

In the year 1879 in India first publicly electric power was demonstrated by street lamp in Kolkata by P.W. Fluery & Co.[3] In 1897 India's first hydroelectric power station was opened in Darjeeling. By 1899 India's first thermal power plant was opened in Kolkata and supply began. The first railway electrification was started in the year 1925. By April 2018 India announced 100 percent village electrification. Power supply can be done through centralisation and decentralisation. The centralisation of electricity mainly depends upon large scale power plants like coal, nuclear, gas, hydro and wind powers. Large scale electricity plants produce power at lower cost per unit, balanced grid, voltage regulation, manage power output and input supply. Monitor the power supply, maintain and upgrade can be done at regularly. The major disadvantages of centralised electricity involve transmission losses, single point failure, high investment and environmental impact. India's peak electricity demand is approximately 1000 Gigawatts. This article explores all possibilities to transform India into developed economy.

II. DECENTRALISED POWER GENERATION

Decentralisation of power generation produces electricity closer to where the public lives.[4] The localized systems are also known as distributed energy resources. Roof top solar power, micro grids, small wind turbines are the examples. When power travels shorter distances the transmission and distribution losses are reduced to greater extent. Clean energy support and energy independence are the advantages. Consumers would become as producers.

MNRE itself defines decentralised renewable-energy systems as systems that generate renewable electricity close to where it is consumed.[5] Such systems can reduce dependence on fossil fuels and long transmission and distribution networks while supporting households, institutions, enterprises and communities.

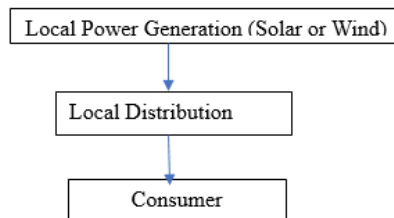


Figure 1: Flow chart for distributed power supply chart.

Table 1: Applications of different Hybrid Renewable Energy Systems [6].

SL. NO	Hybrid Renewable Energy Systems	Usage / Application
01	Roof Top Solar	Residential Homes, Commercial, Industry buildings, Public Infrastructure & Agricultural works.
02	Solar microgrids	Rural electrification, Critical health Care facilities, Telecom towers and Military strategic bases.
03	Bio mass	Combustion power plants, Gasification, Residential heating and Bio diesel.
04	Solar pumps	Agriculture Irrigation, Aquaculture, Fish farming, Domestic water supply.
05	Small hydro turbines	Rural Electrification, Irrigation and farming, Municipal water supply and Mini Grids.
06	Small wind power	Water Pumping, Grain Milling, Telecom towers and home energy, Solar integration.
07	Battery storage	Renewable energy integration, load shifting, Grid stability and backup power.

III. WHY DOES INDIA NEED DECENTRALISED POWER?

India is moving forward to become energy dependent and developed nation by 2047. The main reason transmission losses, cut the financial burdens, climate, local empowerment and geographical diversities.

(a) Electric power -transmission losses:

The transmission and distribution losses in India is approximately 17 to 20 % [7].The main losses are due to technical losses and commercial losses. Technical losses occur due to resistance and heat in transmission and commercial losses due to theft, defective metering and Discom revenue collection.

(b) Impact of climate:

India has diverse geography and climate. Change in climate will affect severely electricity losses. Increase of temperature can lead augment of Physical resistance of the grid. Extreme heat, overloading, Hydro and thermal non availability. [8]

(c) Modernize the battery grid and energy storage:

By deploying smart grids where the consumers become as producers can be achieved by deploying two-way power flows.

(d) Policy Regulations:

Stream line policy regulations is fundamental step that helps all for easy open accesses to all and integrate urban farming.[9]

(e) Energy accesses in remote and tribal areas:

Energy access in remote and tribal areas is one of India's biggest electrification challenges. Because of rough terrain, dense forests, and isolated locations, extending the central power grid to these pockets is often too expensive or physically impossible.[10]

IV. PRESENT STAGE

India does not have to begin from zero. The government has already implemented several decentralised-energy programmes. Central government is introduced different schemes for the achieving energy security or developed nation.

(a) Off grid decentralised solar programme:

MNRE's off-grid solar programme was specifically designed to provide solar applications where grid electricity is unavailable or unreliable. The programme included solar home lighting, solar street lighting, solar water pumps, solar power plants, solar lamps and mini grids. Earlier government programmes also supported solar microgrids in rural areas. For example, the Government reported 63 solar microgrids with an aggregate capacity of about 1,899 kWp under the decentralised solar programme by 2018.

(b) PM-KUSUM

Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyaan (PM-KUSUM) is one of the examples for decentralisation. The scheme directly connects renewable electricity with India's agricultural sector. Its components include decentralised renewable energy power plants, Solar agricultural pumps, Grid connected solar pumps and Feeder level solarisation. Under decentralised renewable-energy plants in the range of 500 kW to 2 MW can be established by farmers, farmer groups, cooperatives, panchayats, FPOs and other eligible entities. Consumers will be producers. This is significant because it changes the traditional relationship between farmers and the electricity system.[11]

(c) Roof top solar & PM Surya Ghar

India has crossed 30.74GW of grid connected roof top solar capacity.[12] If village microgrids represent rural decentralisation, rooftop solar represents urban decentralisation. The PM Surya Ghar programme is an important policy development in this direction. The long-term significance of rooftop solar is not simply the number of solar panels installed. PM Surya Ghar: Mufti Bijli Yojana launched in 2024 over 51.58 lakh households have installed rooftop solar allowing nearly 19 lakh households to achieve zero electricity bills.[13]

V. CAN DECENTRALISATION REPLACE CENTRALISATION TOTALLY IN INDIA?

The answer is no at present stage but by 2047 both the system lies as hybrid model to achieve energy independent country. The replacement is not possible because due to fundamental law of physics, infrastructure needs. By 2047, decentralisation[14] will successfully end our complete dependence on centralized plants for daily household needs. However, the centralised macro-grid will remain the essential backbone holding the entire system together. The advantages of decentralisation of power better for the country development is explained in using a flow char as Figure 2.

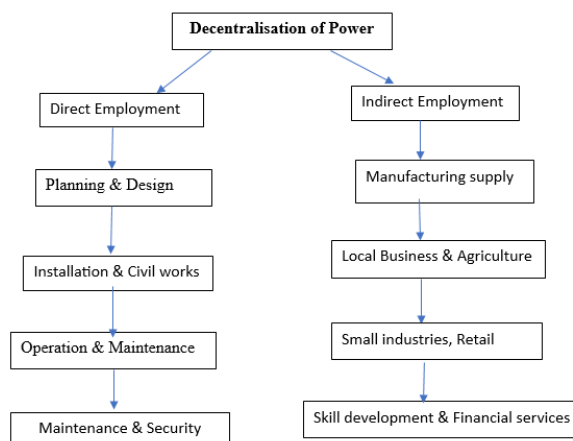


Figure 2: Flow chart of advantages of decentralised power.

VI. CONCLUSIONS

Decentralized power generation generates electricity closer to the point of consumption, in contrast to the traditional electricity paradigm. Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mah Abhiyaan (PM-KUSUM) is one of the examples for decentralisation. Decentralisation will successfully end our complete dependence on centralized plants for daily household needs. The centralised macro-grid will remain the essential backbone holding the entire system together.

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