Students' Diary

Sustainable energy and Indian villages

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At the beginning of the 20th century, Mahatma Gandhi had declared: **"The soul of India lives in its villages"**.

Ambitious pledges towards carbon neutrality by mid 21st century were made under the Paris agreement, by all emerging economies including India. The potential of Indian villages to catalyze the country's pace to decarbonization and towards a green and circular economy is huge. India's rural electrification program has made huge strides in the power sector. With the culmination of Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY), electricity reached all of India's 597,464 villages, achieving universal electrification. Despite this milestone, the last-mile supply still remains a distant dream. Streamlining distribution is a task, which is impeded by several factors, geographical disparity being one. The remoteness of the location and grid connectivity poses itself as a major problem.

On the other side of the picture, India is primarily an agrarian country that possesses abundant renewable energy sources, most of which are untapped. Grievances regarding grid connectivity and the ever-increasing dependency on conventional sources might have overshadowed the possibility of connecting these two dots more often than not. Making the village's energy self-sufficient would prove a solution to India's intermittent nature of rural electrification.

The idea could be achieved in a more decentralized approach by harnessing the locally available non-conventional resources. Tapping these effectively, would not only deliver to the rural energy requirements but also, provide a comprehensive and circular approach where the concept of waste is nonexistent.

The plan is to be tailor-made to suit the nature and resources availability of the village in question. This is dependent on the demography, occupation, spatial distribution of land, extent of agrarian and domestic residues, and the energy requirement of the village. The load profile is not as high as that of urban areas, and the energy demands basically come under agricultural, domestic, and community.

India's vast agricultural potential provides a huge opportunity in the bioenergy sector as agro-residues, which can be used to meet energy needs both in heat and power applications. Biomass gasification, combustion, efficient cookstoves, biofuels are some methods of harnessing the available renewables, which, unlike fossil fuels, are pollution-free and the raw materials readily available to agrarian households.

Depending on the cultivation pattern and land use distribution, the plan is to integrate the fragmented farmlands by promoting multi-cropping and encouraging animal husbandry(dairy farming, poultry, piggery, etc). On the boundaries of the farm, based on land topography, Jatropha, cassava, switchgrass, and other biofuel generating plants can be grown. In addition, this practice helps in better farm management and brings down overall cost on input. To optimize and monitor crop growth operations, agricultural drones can be used. This phytogeomorphological approach would be useful in assessing the agricultural growth stability with respect to topological terrain attributes. The well-defined decision support system for farm management is a good practice towards precision agriculture.

A high amount of residues, plant and animal wastes (dung, food wastes), ie the slurry from the farms, which are usually carelessly disposed off and cause environmental pollution, are collected.

The crop residue transformed using gasification or anaerobic technology can be used to generate sustainable, non-polluting electricity. The crop residues and organic wastes of low heat value, taken as feedstock can be converted into combustible gas and then fed into a generator for electricity generation. This can be a greater alternative to the conventional open field mass burning, which is environmentally hazardous and unmindful to the prospects of energy generation from the resources.

A powerplant with an oil expeller, filter press, and a boiler can be used to extract biofuel from the fuel plant produce. In addition, the oil wasted from cooking can be filtered and transesterification is performed to generate biofuel, using an automated biodiesel processor.

In the areas where biogas production is constrained due to the limited availability of locally produced resources, solar energy can be developed into two alternative options as hybrid and standalone electricity systems. Concentrated solar cells concentrate direct solar energy to heat using a reflector and concentrator. The amount of energy received per area of solar collector depends on the concentrator design, and when the design is efficient, it is a better alternative to traditional cooking stoves in terms of energy efficiency and eco-friendliness.

In arid and semi-arid areas, solar photovoltaic cells with good conversion efficiency can be used to satisfy the appliance electricity demand. But the limiting factor for solar PV adoption in rural areas is cost. Due to economic inconceivability and low voltage applicability, large solar PV panels may not always be a feasible option when individual households are concerned.

But a combination of both concentrated and PV cells together could cater to the cooking demands of a lower unit such as a household.

A solar water pumping system finds significant applications in meeting village water supply and irrigation purposes. The viability is subject to variation of solar radiation and water table condition can enable replacement of diesel operated water pump sets.

Another means of harnessing solar energy is through a water heating system which can be installed on the ground, terrace, or rooftops. When the sun rays penetrate through a toughened glass and fall on the absorber, the heat of the sunrays is absorbed by the cold water inside, thereby increasing its temperature. This is an energy-efficient and cleaner alternative to firewood and other conventional resources. Environmental pollution is greatly minimized.

India's great solar energy potential with about 5000 trillion kWh energy incidents per year over the mainland, from an energy security perspective, presents itself as the most secure of all renewables. The proper harnessing of a fraction of the irradiant energy offers capacity addition and power generation on a decentralized scale. Application of the same has benefitted villages by catering to their heating, lighting, and cooking demands. According to the estimation done by the National Institute of Solar Energy, India's solar potential scales to about 748 GW if 3% of the wasteland area is to be covered by Solar PV modules. Employing hybrids of geographically available renewable sources offers a stable energy supply and optimum utilization of localized resources. The electricity demand of the village can be met by itself, by integrating the abundant renewables and exploiting the potential of energy generation from residues usually wasted away. This would surely be a stride towards self-reliance and a circular economy, wherein the aim lies to replace dearth with sufficiency.