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Green Panchayat – the way forward towards achieving the target of net-zero emissions and sustainable rural electrification

Green Panchayat means powering the rural Indian households by harnessing the renewable sources of energy. India has set target of achieving Net-Zero emission by 2070 and the set target cannot be achieved without the inclusion of the rural households as more than half of our country population lives in rural areas. Rural electrification is considered the backbone of the rural economy but it has come up with many challenges such as availability of 24×7 power supply, power wastages due to subsidized electricity and losses to State Discoms. The paper illustrates the case study of energy consumption pattern of villages Amro, Kochwa and Budgada and it proposes a solution to provide reliable power using PV-micro-grid and solar roof top installation on public buildings.Further, detail sizing (battery, inverter, panels) of the proposed PV system to meet the energy demand (1196.91 kWh/day) of the considered villages is also determined. The economic analysis is also shown in terms of payback period to reflect the project feasibility. The paper also illustrates the energy conservation measures to be taken up in the rural households to achieve the energy savings by use of energy-efficient appliances. In a nutshell, this paper will be helpful to the power system planners and decision makers for possible implementation of Rural Electrification project which has a vital role in achieving Net-Zero emissions and sustainable development

Keywords: Microgrid, rural househols, energy-efficient, solar insolation, rooftop solar

1.0 Introduction

Electricity is an essential requirement for all facets of our life and it has been recognized as a basic human need. It is the key to accelerating economic growth, generation of employment, elimination of poverty and human development especially in rural areas. Rural Electrification ("RE") is viewed as the key for accelerating rural development. Provision of electricity is essential to cater for requirements of agriculture and other important activities including small and medium industries, khadi and village industries, cold chains, health care, education and information technology. Access to electricity on 24×7 basis for all its citizens has become synonymous to cause of social equality. It means much more than merely an act of infrastructure development to any nation and thus this issue has acquired significant dominance on the national as well as state agenda. The notable initiatives taken by the Government of India for electrification of the rural areas are listed below [8]:

1. Rural electrification under Minimum Needs Programme launched in 1974.
2. Kutir Jyoti Yojana to provide single point light to below poverty level (BPL) families in rural India launched in 1988.
3. Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY): Launched in 2005, this programme aimed at providing energy access to all by 2009 and at least one unit of electricity per household per day by 2012 as envisaged in NEP (National Electricity policy) 2005. All earlier programmes were merged in RGGVY.
4. In 2009, MoP launched Decentralised Distributed Generation Scheme under RGGVY to electrify un-electrified villages through mini grids. This also included villages which receive less than six hours of electricity per day
5. In December 2014, government announced Deendayal Upadhyay Gram Jyoti Yojana (DDUGJY) with major modifications in RGGVY.
6. Our nation has launched Saubhagya Yogana to achieve the target of 100% electrification and International Energy Agency (IEA), 2018 has acknowledged that "India's move to energize every village in the country with electricity is one of the greatest success stories in the world in 2018."

Problems in Rural electrification

1. Lower recovery due to highly subsidized tariff and low level of tariff collection.
2. Non-availability of 24×7 power and supply rationing in peak hours.
3. High operation and maintenance costs.
4. High transmission and distribution of losses due to line expansion and power thefts.

Rural Subsidies and Losses of the Distribution Sector

The consumption of electricity in the agricultural sector

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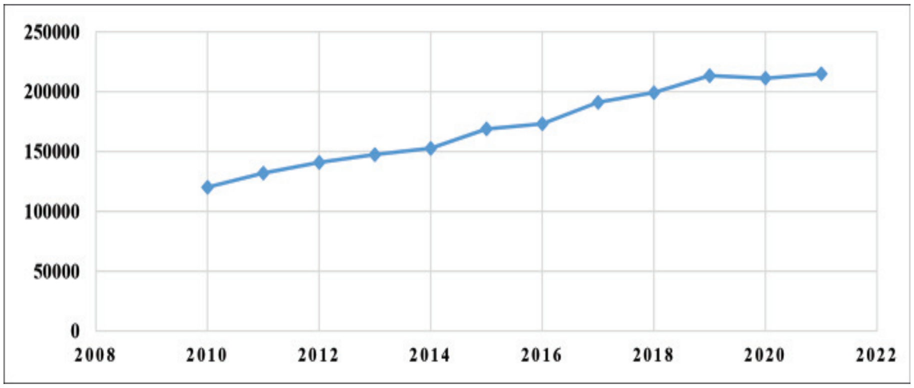


Fig.1: Rural energy consumption (in Gwh)

as per the CEIC data agriculture data is reported at 215,000.000 GWh in 2021. This records an increase from the previous number of 211,295.000 GWh for 2020. The data reached an all-time high of 215,000.000 GWh in 2021 and a record low of 4,470.000 GWh in 1971. Fig.1 depicts the rise of energy consumption of the agricultural sector since 2011. The current energy consumption pattern of rural is mired by inefficiency and is the major cause of losses to Discom's. Discoms reported a loss of 65000 crores in the year 2018-19 as per NITI Aayog report. Despite the people of rural area mostly being dependent on the sun for most farming activities irrigation usually happens quite late at night. This is due to the practice of supplying subsidized electricity to farmers during the midnight hours. Moreover, during our survey of the villages illustrated in the paper, it was found that people were least concerned about the use of energy efficient household appliances which may be due to the financial issues or lack of awareness about energy efficient appliances. India's agricultural sector is responsible for the consumption of over 18% share in the national electricity usage. However, its contribution to the GDP in just over 5%. This discrepancy has been prevalent since the 1970s, the Green Revolution. Most of the states either provide free or highly subsidized electricity to the rural areas which not only adds to severe losses in the distribution sector but also severe wastage of energy sources.

2.0 Case study of three villages Armo, Kochwa and Budgada

Armo, Kochwa and Budgada were selected for the study based on demographic dividend and scale of economic growth. During the case study door to door survey was conducted to get a knowhow of energy appliance used in the villages and their rating to calculate the energy consumption of the villages. Also the survey was aimed to get an idea of the awareness among the people towards the energy conservation and the difficulties of the people in the area in absence of electricity. The demographic and social demography of the three villages are illustrated below:

Armo

1. Location: Located in Bokaro District in Jharkhand state.
2. Population: 500 (approx.)
3. Per-capita Income: Rs.1.0 lakh/year
4. Govt. Buildings: Middle school, High School, Primary school, Community Centre and Health centre.
5. Solar Installations: Three solar water pumps and five solar powered street lights.
6. Awareness towards Energy Conservation: About 80% of population is not aware about energy conservation.
7. Literacy: About 80% people are literate.
8. Problems: Due to seasonal variation when the solar powered pumps are not working there is problem of availability of drinking water and non-availability of 24×7 power.

Kochwa

1. Location: Located in Bokaro District in Jharkhand state.
2. Population: 250 (approximate)
3. Per-capita Income: Rs 30000/year
4. Govt. Buildings: Primary school.
5. Solar Installations: One solar powered LED light and one solar water pumps at a distance of 1 km.
6. Awareness towards energy conservation: As most of the families lie in below poverty line, they are least aware about the energy conservation.
7. Literacy: Only 10% people are literate.
8. Problems: There is acute water crisis in the village and the nearest water source available for them is at a distance of 1 km and non-availability of 24×7 power.

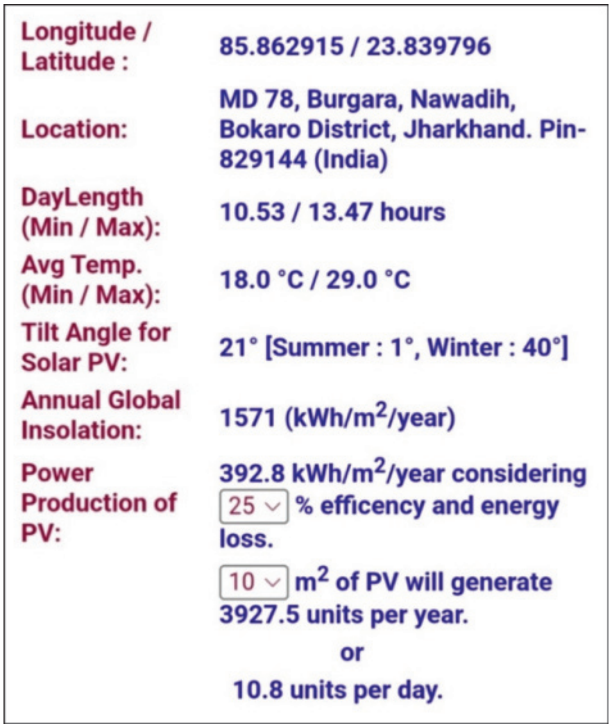
Budgada

1. Location: Located in Bokaro District in Jharkhand state.
2. Population: 300 (approximate).
3. Govt. Buildings: Middle school, Primary school and Community Centre.
4. Solar Installations: Three solar powered LED light.
5. Awareness towards Energy Conservation: About 60% of population is not aware about energy conservation.
6. Literacy: About 80% people are literate.
7. Problems: Non-availability of 24×7 power.

There are three transformers of rating 100 kVA, 63 kVA and 50 kVA installed to supply power to these three villages. As illustrated above all the three villages are facing the problems of unreliable power and the problem of water crisis the basic necessities of rural development. The solar installations also are unreliable source as they are susceptible to seasonal variations as no battery storage is provided in the solar pumps installed. Moreover, the energy consumption in the area is higher given the use of non-energy efficient household appliances.

3.0 Solution

Installation of micro-grid: The paper proposes the methodology of micro grid installation for catering the load of three villages Armo, Kochwa and Budgada. Based on calculations and illustration shown in Table 1, the peak household energy consumption per day is approximately



Longitude / Latitude :	85.862915 / 23.839796
Location:	MD 78, Burgara, Nawadih, Bokaro District, Jharkhand. Pin-829144 (India)
DayLength (Min / Max):	10.53 / 13.47 hours
Avg Temp. (Min / Max):	18.0 °C / 29.0 °C
Tilt Angle for Solar PV:	21° [Summer : 1°, Winter : 40°]
Annual Global Insolation:	1571 (kWh/m^2/year)
Power Production of PV:	392.8 kWh/m^2/year considering 25 % efficency and energy loss. 10 m^2 of PV will generate 3927.5 units per year. or 10.8 units per day.

Fig.2: Details of Solar Production Potential in the Burgara area. Source: ISRO Solar Calculator App.

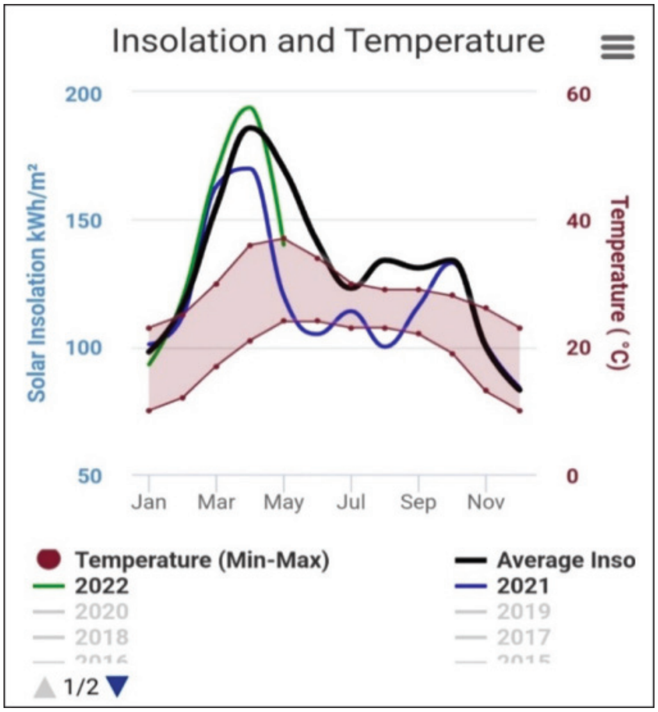


Fig.3: Details of Solar Insolation and Temperature profile of the Burgada area. Source: ISRO Solar Calculator App.

140.55 kWh. in Fig.2. The micro grid will provide reliable power supply and also the additional power to be stored via battery storage and the same can be utilized during the low solar insolation hours. Green hydrogen storage may also be tried to store the electricity for longer term.

Roof top solar installation on public buildings: The other option is installation of PV panels along with battery storage on the roof top of public building to power the schools, street lights and public places. As the availability of water is major problem is to be resolved by installation of solar powered pumps which will operate throughout the year and will be helpful in making the lives of people better. Table 1 calculates the potential of roof top solar installation in the public buildings, calculations are based on MNRE [7] roof top calculator.

TABLE 1 : CALCULATION OF HOUSE HOLD ENERGY CONSUMPTION OF THREE VILLAGES

House hold Electrical equipment in use	No. of item in use in BUDGADA	No. of item in use in AMRO	No. of item in use in KOCHWA	Per day use (Hr.)	Power Rating (In Watt)	Elect. Cons./ month (KWH)
Submersible pump	5	13	0	2	350	378
Bulb (Led)	70	200	16	6	10	1716
Bulb (Incandescent)	280	800	144	6	100	73440
Ceiling Fan	140	400	60	10	70	25200
Table fan	7	20	0	6	25	202.5
Colour TV	7	20	2	3	100	261
Total Energy Consumption in KWH/Month						101197.5
Total Energy Consumption in KWH/Day						3373.25
Total Household Load						140.55

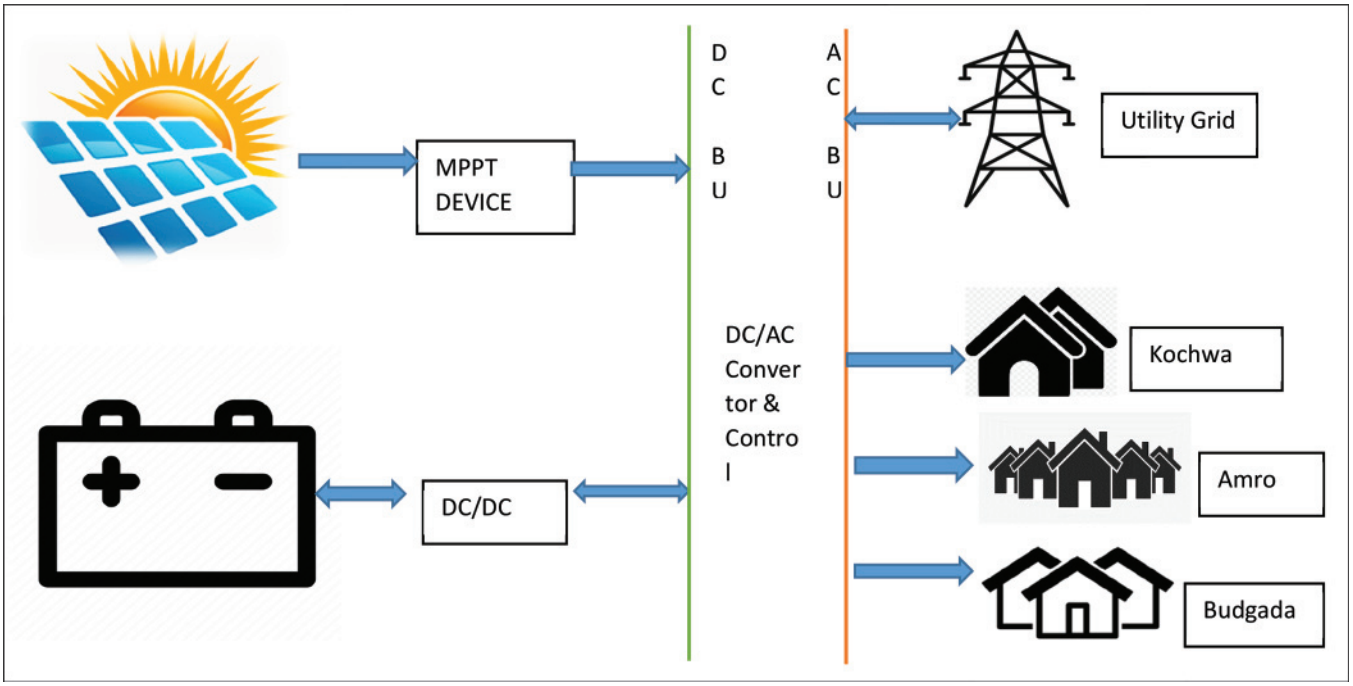


Fig.4: Model of Micro grid in Budgada area to supply power to Amro, Budgada and Kochwa using PV installations

TABLE 2: CALCULATION OF FEASIBLE ROOF TOP SOLAR CAPACITY OF PUBLIC UTILITIES

Public building	Floor area BUDGADDA	Floor area AMRO	Floor area KOCHWA	Total floor area	Total effective floor area	Feasible plant size as per roof top area (In KW)
Primary school	450	550	400	1400	1120	101
Middle school	0	600	0	600	480	43
High school	0	750	0	750	600	54
Panchayat bhawan	500	625	0	1125	900	81
Health centre	0	900	0	900	720	65

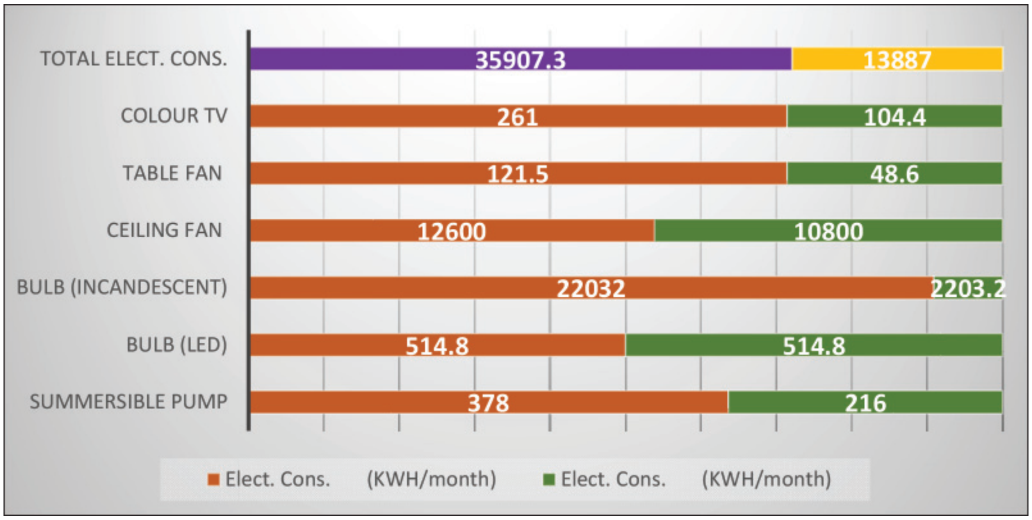


Fig.5: Electricity consumption present vs optimised condition

Energy Conservation Awareness Program: As it is evident from the study that there is rampant use of high energy consuming household appliances in the three villages and there is potential of savings of Rs.1.54 Lakh/month for saving electricity of 22020 kWh/month by the use of energy efficient appliances. Fig.5 shows how energy consumption decreases on using efficient appliances against high energy consuming appliances. The necessary steps to be taken are illustrated below:

1. As the use of high energy consuming incandescent bulbs are higher in the Kochwa village, the distribution of LED lights will help a lot in energy savings.
2. Providing incentives to the Gram Panchayat for energy savings work-based set targets of energy savings just like the scheme of perform, achieve and trade (PAT) in the industrial sector.
3. Just like the survey discussed in the paper, the identification of high energy consuming household. and irrigation appliances such as fans, bulb and pumps to be done and replaced by application of existing Govt. Schemes like LED distribution programme PM Kusum Yojana of distribution of solar pumps.

4.0 Techno Economic Analysis and system sizing

The technical parameters associated with rooftop system are number of PV panels, number of batteries, size of the inverter etc. All these parameters are evaluated one by one in this section.The detail sizing (battery, inverter, panels) of the proposed PV system to meet the energy demand (1196.91 kWh/day) of the entire considered village is illustrated in Table 3. The technical parameters are designed according to the methodology mentioned in [1]. We have considered the cost of battery Rs.12000 per battery [2], and the cost of inverter Rs.7.4 [3], per watt and cost of the 250 watt PV module is assumed to be Rs.13100 per module [4]. The life time of PV system is considered 25 years.

Table 3: Techno economic analysis of the proposed PV system

Total consumed energy/day in KWh	1197
PV module rating in KW	214
Required number of PV modules considering 250 W/per module	13100
Cost of each PV module in Rs.	855
Total cost of PV module in Rs. (C1)	11199658
Total number of batteries required (each battery 12V, 220A-h) considering 2 days backup	1662
Total cost associated with batteries (C2)	19948500
Inverter size in Watts	82676
Total cost of inverter (C3)	611806
Total cost of installation i.e., (C1+C2+C3)	31759964
Government subsidy in %	12703985
Total cost of installation considering subsidy	19055978
Total bill is to be paid for 25 years considering Rs.6/unit (if solar power not used)	65530823
Total profit (Rs.)	46474844
Payback period in years	7
Total CO_2 emission reduction in 25 years (In tonnes)	8955879

5.0 Conclusion and way forward

Electrification of 99.99% of the households in India is a major milestone towards attaining the Sustainable Development Goal target of providing universal access to affordable, reliable, and modern energy services by 2030. More than half of the India's population lives in rural areas and development of the nation cannot be achieved without the development of the rural areas. Electricity is most basic commodity required for development of the villages. Rural electrification is required for improvement in the area of farm productivity, health and education, communication and economic development. Rural electrification will also help in creation of employment in rural areas which is traditionally dependent on agriculture and the surplus power generated in the micro grid will an additional income generation source.

The reliable and effective implementation of rural electrification a unified model and integrated policy framework towards construction of micro grids in rural areas based on the load and demand. Micro grids will prove as a reliable and emission free source of power by harnessing the solar energy.

Power savings is equivalent to power generated. Energy conservation programmes and incentive as shown in the case study will prove to be the game changer in saving the power by making people aware about the ratings and efficiency of the household equipment's. This will also help in minimizing the losses of DISCOMS by making savings of the subsidised electricity.

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