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Harnessing Solar Power for In-house Electrical Energy Requirements of ISRO

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***Abstract* — Solar energy, a clean renewable resource with zero emission has got tremendous potential which can be harnessed using a variety of devices. With recent developments, solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance. The National Solar Mission is a major initiative of the Government of India to promote ecologically sustainable growth while addressing India's energy security challenge. The immediate aim is to set up an environment for solar technology penetration in the country both at a centralised and decentralised level. ISRO, in its ever growing ambitious space programmes has to meet the widening supply-demand gap for electrical energy in the country. In line with this, initiatives have been taken for harnessing solar energy. This paper elucidates the recent initiatives of ISRO as a utility in harnessing solarpower.**

***Index Terms* — Photovoltaic Cells, National Solar Mission.**

I. NTRODUCTION

Commenced in 1963, Indian Space Programme sailed through a magnificent journey during past five decades. Started in a modest way with small launch vehicles of *Rohini*series and experimental satellites such as *Aryabhatta*, *Bhaskara*and *Apple*, Indian Space Research Organisation (ISRO) has made a giant leap to bigger launch vehicles suchas PSLV, GSLV, GSLV Mk-III and major operational satellites like INSAT, IRS etc.

To accomplish advancement of Space programme, establishment of strong infrastructure from inception was highly challenging. The requirements included facilities for the development of satellites and launch vehicles including testing facilities, telemetry, tracking and command network, data reception and processing systems for remote sensing.

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Ensuring highly reliable and quality electricity supply for these activities had been one of prime requirement during infrastructure development. With the ever widening supply-demand gap of electricity, grid based conventional power sources will not meet the ever growing demand of electricity. Hence, with the constrained availability of electrical power-both in quantity and quality, it has become imperative for utilities to explore the new renewable sources and integrate to internal generation to the possible extent. This paper discusses the initiatives of ISRO in this direction.THE ENERGY STATUS ANDDEFICIENCY In tune with the advancement of space programme, power requirements had to be repeatedly augmented at all ISRO Centres/Units. From total power requirement of 1000 kW During early seventies to the present total requirement of 50000 kW is an indication of the load growth which has occurred at ISRO Centres. The profile of load growth in ISRO is depicted in Figure1.

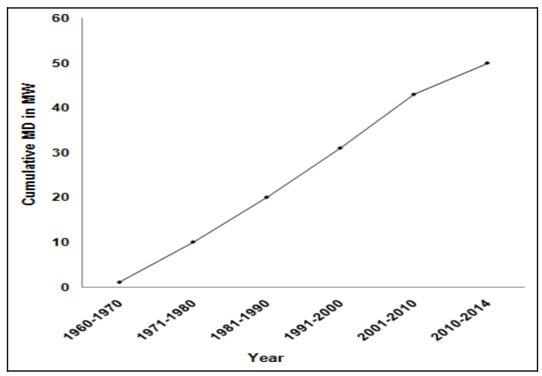

Fig. 1. Load Growth in ISRO from 1960 to 2014

Of late, establishment of 66/11 kV substation for ISRO Satellite Centre at Bengaluru for environmental testing/clean rooms for assembling of satellites, 110/11 kV substation at VSSC, Thiruvananthapuram for supporting Hypersonic Wind Tunnel Facility/Plasma Research Facility, 110/11 kV sub- station at IPRC, Mahendragiri for semi-cryogenic facilities are testimonies to the growing power requirements at ISRO Centres. Presently, the total power requirement for all ISRO Centres works out to 50 MW and the energy bill for the Department amounts to ` 90 crores per year. The Centre-wise power requirement at ISRO Centres is depicted in Table I.

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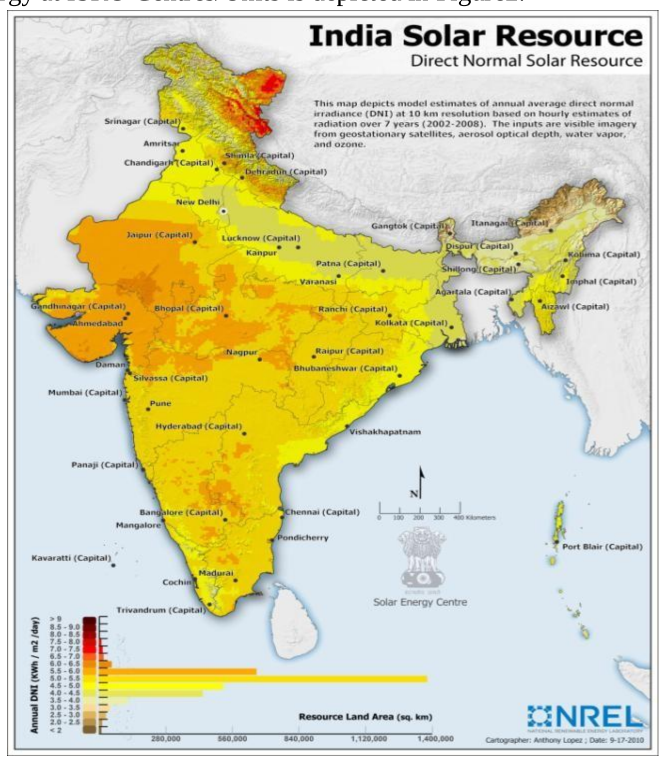
With future space programmes on the anvil, ISRO has to necessarily utilize renewable energy sources such as solar, wind, biomass etc. to meet additional power requirements. Amongst these renewable energy resources, ISRO decided to harness the most feasible – solar energy, to meet its energy demands. Disclaimer: The views expressed here are solely that of the authors and not necessarily that of the organisation they represent TABLEI. CENTRE WISE POWERDEMAND

Sl. No.	ISRO Centres/Units	Approximate Maximum Power Demand (MD) in kW
1	Thiruvananthapuram	12500
2	Bengaluru	7700
3	Sriharikota	7500
4	Ahmedabad	8000
5	Chandigarh	4000
6	Mahendragiri	5000
7	Hyderabad	2500
8	Hassan	800
9	Dehradun	550
10	Lucknow	550
11	RRSCs	350
12	Bhopal	250
13	Gadanki	250
14	Shillong	50
TOTAL		**50000 (50MW)**

Incidentally, there has been a growing concern globally over the adverse impacts of climate change and the dire need to take effective steps for reduction of greenhouse gas emissions (GHG). One of the ways to mitigate GHG emission is to promote generation of clean energy through renewable sources such as solar, wind and biomass. Government of India (GOI) in its obligation to reduce GHGs, under National Action Plan on Climate Change, launched Jawaharlal Nehru National Solar Mission (JNNSM) during Year 2010 to promote harnessing solar energy for power generation. Under JNNSM, GOI aims to establish 24000 MW by Year 2022 (22000 MW: Grid- connected + 2000 MW: Off-grid) of power generation through solar-photovoltaic (PV) technology. Thus, harnessing the potential of non-conventional sources to meet the internal electricity requirement also is firmly in line with the above Government's policies and also an integral part of corporate social responsibility.

II. SOLAR INITIATIVES OF ISRO

In accordance with JNNSM, Ministry of New and Renewable Energy (MNRE) under GOI issued circular to all Departments/Ministries to meet at least 15% of their internal energy requirement by harnessing solar energy and installing off-grid Solar PV plants on the available roof areas and on open land. Off-grid Solar Power Plants (SPPs) feed the power generated to the internal grid and do not export the power to the external grid. The technology of harnessing solar power is not new to ISRO as the source of energy for spacecrafts is solar and satellites are built with solar PV cells to harness maximum solar energy during their life cycle. However, varying parameters on the surface of earth such as erratic radiation levels with varying seasons, temperature, air-mass, dust etc. pose different challenges to harness solar energy. Most of our ISRO Centres are identified as hot spots as they receive annual global insolation above 5 kWh/m^2/day. Considering this insolation which is prevalent at most of the ISRO Centres/Units and based on nominal photo-conversion efficiency of PV modules available in market, there exist a substantial potential for harnessing solar energy. Solar resource map indicating the potential for harnessing solar energy at ISRO Centres/Units is depicted in Figure2.



Source: National Resource Energy Laboratory

Fig. 2. Solar potential at ISRO Centres

Based on the above aspects and directive from MNRE, ISRO decided to harness solar energy by installing PV based power plants at all Centres in a phased manner. It was proposed to utilize shade free roof area to the possible extent and open land available for installing SPPs.

Also, as depicted in Figure 3, the load at most of the facilities at ISRO Centres is predominantly due to Air- conditioning which occurs during summer when the SPPs also function at their peak, reduction of peak load during day time will benefit utility companies as power shut downs can be minimised which will result in socio-economic advantages

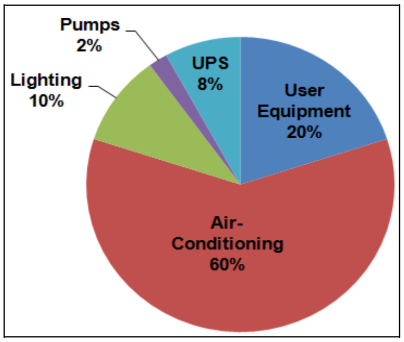


Fig. 3. Approximate electricity consumption pattern of ISRO

III. SOLAR ENERGY PROPOSAL FOR ISRO

ISRO centres spread across fourteen Centres/Units have numerous infrastructure/buildings. The roofs of these facilities are potential locations for installing Solar PV modules. Also, some Centres have ample ground area. Hence, it was felt feasible to plan harnessing of solar power for in-house requirement which will ultimately cater to our requirements and make, ISRO a true 'grid independent' utility. As aprelude, it was proposed to install off-grid SPPs totalling to capacity of 3 MWp under Phase 1. It was ensured that all Centres/Units get their share for harnessing solar energy and with this scheme, the performance of Solar Plants at all locations can be well tested and validated. The installation of SPPs at all ISRO Centres/Units totalling to 6MWp is under rapid progress and is likely to be completed by March 2019. Under peak activity, the SPPs are likely to meet 12% of the total electricity requirement apart from deriving other benefits.

IV. IMPLEMENTATION

The proposed SPPs are off-grid type and the generated power will be used for internal requirements only and adequate loads are available during day time so that the total generation from SPPs is fully evacuated. Optimum capacity of SPV module has been specified and worked out in order to utilize the available roof/open land areas. The SPV modules are with poly-crystalline cells and will have high photoelectric conversion efficiency to achieve optimum generation. Module degradation to the extent of 10% at the end of twelve years and 20% at the end of twenty five years has been considered. As the power generated by PV cells will in DC form, the same has to be converted to AC for utilising the same at internal grid. For this purpose, string inverters are proposed. String inverters possess the advantages of higher reliability and efficiency as compared to central inverters. By providing multiple string inverters, single point failure will be avoided. Also, availability of solar power is ensured through the remaining inverters incase of failure of anyone string inverter. The inverters will synchronise with the Low-tension distribution **panels for evacuating the generated power from SPPs.**

To derive the final and tangible benefit of solar plants, guaranteed generation in Units/kWp/year has been stipulated based on the location of installation which is in the range of 1200-1500 kWh-units per kWp installation per year. Finally, maintenance of the plants plays a pivotal role and in order to ensure this, effective annual maintenance contract for a period of 15 years has also been concluded.

V. COST ANALYSIS ANDPAYBACK

Apart from saving on electricity bills up to ` 2.25 crores per year, greenhouse gas emission up to 6 Tons can be mitigated. The payback period for investment made in establishing 6MWp of Solar Plants will be 8-10 years. The life of Solar PV modules will be around 25 years and further benefit can be utilised even after the payback period. This is apart from the numerous intangible and societal benefits accrued out of the scheme.

VI. SCOPE FOR REMAININGPHASES

With the completion of pilot project of installing 6MWp, augmentation of solar plants will be taken up in short-term plan in subsequent phases to meet at least 20% ofenergy requirement by installing off-grid solar power plants. Depending on the performance of PV based solar plants, it may also be prudent to install Solar Parks with grid connected plants in future where vast land areas are available in locations such as Sriharikota, Mahendragiri to derive substantialbenefits of solar energy.

VII. CONCLUSION

With growing concern on environment, constant rise in electricity requirements at Centres, downward trend in the cost of SPP in the market and constant improvement in the efficiency of PV cells, use of renewable energy will be a norm in the future. It may be highly essential to make provision during planning of infrastructure facilities for installing solar power plants. ISRO has a long way to go in reaping the benefits of space technology and establishment of infrastructure facilities backed up with green features such as solar backed power generation plants. These features will at large aid in all-round development and achieving National goals.

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