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# Distributed Solar Generation Applied to Agriculture Sector in Andhra Pradesh - A Case Study

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**Abstract—***In this paper, the impact of solar power generation for supplying power to agricultural motors is discussed by which additional capacity addition with clean power can be achieved within a short period. Capacity addition is decided based on the estimation of actual energy consumed in agriculture sector. Actual energy requirement or consumption is taken based on crop patterns in the regions considered. Further, the surplus energy may be fed back to the utility grid to bridge the supply demand gap to some extent. This also ensures availability of power to farmers during daytime, which is convenient for them.*

## 1. INTRODUCTION

Free or subsidized power to agricultural sector overstressed the distribution lines of the system. In Andhra Pradesh state, the electrical power distribution is still under the control of Government owned or controlled by distribution companies. With the free and non-metered power in the state, accountability to power usage is missing and a portion of power losses and theft is also accounted under agricultural consumption.

Wide and increasing gap between supply and demand in Andhra Pradesh is seen year by year. It is said that power is purchased at higher costs for powering agricultural sector in addition to domestic and industrial sectors. As result of this, the investment on the grid is increasing every year and it appears to be still increased in the forth coming years.

## 2. NEED FOR SOLAR ENERGY IN ANDHRA PRADESH

As on January 2013, installed capacity of India has reached 2,11,766 MW [1] and many parts of the country are still either unpowered or suffering from severe power outages, which leads to low productivity and ultimately affecting the country's economic growth. Energy requirement and Energy availability along with percentage deficit are shown in Fig.1 for Andhra Pradesh state since 2006 [2].

It is evident from Fig.1 that a supply demand gap always exists in Andhra Pradesh and has increased a lot by the year 2012-13 because of low additional capacity additions. According to 18th Electric power survey report of India, there will be energy demand of 1, 29,767MU and peak power demand of 22,445MW by the end of 12th five year plan for Andhra Pradesh. This means an additional energy of 30,033MU or a capacity addition of 11,748MW is required to meet the rapidly rising demand by 2016-17.

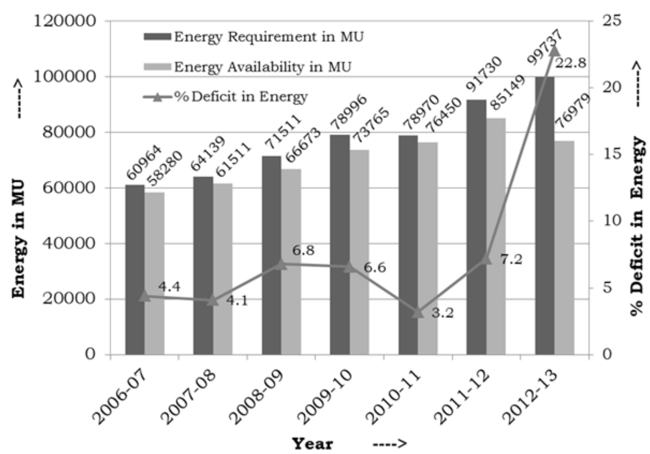


**Fig. 1: Annual energy required, availability for Andhra Pradesh before bifurcation.**

When we look at the distribution network power losses in Andhra Pradesh they are higher than the tolerated value [3] even though they are less than Nation's average. When the losses of the system are controlled, capacity additions can be reduced. Localized generation is another option to reduce the transmission & distribution losses of the system.

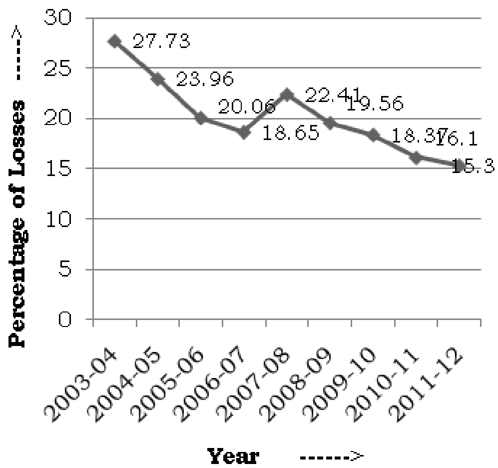


**Fig. 2: AT&C losses percentage in Andhra Pradesh before bifurcation**

As on March 2013, out of 2, 23,344MW of total installed capacity of the country, renewables occupy only 27,542MW (12.33%) [1] where wind has reached almost its full potential in various states of the country and the energy left to explore or to use is solar energy.

Many Indian states especially Andhra Pradesh is lagging behind in exploring the solar energy in spite of its abundant availability. Severe power outages, technological advances and financial incentives to the usage of solar energy increased the general awareness from recent past. Utilization of solar energy at domestic level and at small commercial level adds to the reduction of distribution losses and benefits the utility companies indirectly which reduces the carbon footprint. For a significant positive change in the energy distribution scenario of utilities, large scale direct utilization of solar energy at far ends of grid in highly energy intensive sectors is the need of the hour.

An exponential increase in number of agricultural power consumers across the state has been observed since 1961. In 1961 number of agricultural consumers was 0.18 Million and in 2001 they were 1.9 Million [4]. By 2012 number of irrigation connections has crossed 3.0Millions with annual consumption of 14,449MU [5].

In view of this rapid increase in unaccounted power consumption at the far end feeders it is high time to think of the most abundant and unlimited resource, solar energy in long term perspective. Available technologies for solar panels, highly efficient energy conversion system of all capacities are making it possible to think of solar energy on distribution feeders. Another criterion that strengthens this choice in rural feeders is availability of free space that is exposed to sun and improved voltage regulation combined with reduction of distribution losses.

## 3. ASSESSMENT OF SOLAR POTENTIAL - PROPOSED METHOD

Irrigation water requirement perfectly matches with the load curve of solar energy. That is when the weather is dry and sunny, crops require water. Thus solar pump sets will certainly help in reducing the present power shortage situation across the state. They may be operated as on grid or off grid systems. It is suggestible to connect solar water pump sets as on grid systems, because there will definitely be surplus power available at each pump set because water is not required every day for the crops.

A scenario is considered where each agricultural pump set is fitted with solar powered system containing panels and converter for meeting the irrigation requirement through ground water. Energy required in MU / annum is computed from the estimate based on actual water requirement and available head. Table 1 for the year 2010-2011 to revisit the district wise details of agricultural motors under APSPDCL. calculations are performed with the details available before state bifurcation. Details of another two districts namely Anantapur and Kurnool shall also be considered for complete analysis to upgrade the calculations.

**Table 1: District wise number of motors and their average hp.**

| | **District** | | | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | **Krishna** | **Guntur** | **Prakasam** | **Nellore** | **Kadapa** | **Chittor** | |
| **No. of motors under category-V** | 75437 | 66840 | 101645 | 127613 | 111230 | 262994 | 745759 |
| **Average hp** | 4.67 | 4.72 | 5.18 | 4.28 | 9.01 | 6.17 | 5.67 |
| **Average hp (Rounded off)** | 5.0 | 5.0 | 6.0 | 5.0 | 10.0 | 6.0 | 6.0 |

Average solar panels capacity required in kWp for each borewell is adopted from the specifications of Original Equipment Manufacturers like Schneider, Delta etc.,[6].

$$\text{Capacity of panels required at each borewell in kW} = 1.1 \text{ x Average hp of motor (Rounded off)} \quad \text{-(1)}$$

$$\text{Capacity of Solar PV systems in each district in kW} = \text{C x n} \quad -(2)$$

Where C = Capacity of panels at each

re well in kW and

n = District wise number of motors

If 300 days of generation is considered at 5 Units/kW, then average generation in MU per annum becomes:

$$\text{Average generation in MU per annum} = \text{Capacity of Solar PV systems in each district in kW x 5 x} \quad -(3)$$

Entire generated power of panels as per Eqn. 3 may not be required for the irrigation. There may be some days where the pumps need not be run for irrigation purpose. In such case, additional energy availability on the distribution grid can be computed as follows with Eqn. 4.

$$\text{Additional energy availability on the grid} = \text{Average generation per annum in MU} - \text{Agricultural consumption in MU} \quad -(4)$$

Estimation of district wise energy required for the year 2010-11 is shown in column IV of Table 2.With details of Table 1, in view of powering each motor with solar energy, total capacity of panels or total capacity of Solar PV system to be installed is computed from Eqns. 1 & 2. Upon knowing the total capacity of the system, district wise average generation in MU per annum under six districts of APSPDCL is computed from Eqn. 3.

Thus there will be a potential of 7671.81MU of energy with capacity addition of 5114.54MW when six districts are considered under APSPDCL distribution system when all the motors under free power are replaced by Solar PV system. Upon meeting the consumption, additional energy of 6503MU will be available on the grid when the solar powered system is considered as on-grid system.

**Table 2: District wise solar energy potential and Average energy generation**

| District | Capacity of solar PV systems in MW | Average generation per Annum in MU | Estimated Energy that should be made available for agriculture (MU) | Additional energy availability on the grid in MU |
|---|---|---|---|---|
| **Krishna** | 414.90 | 622.36 | 171.24 | 451.12 |
| **Guntur** | 367.62 | 551.43 | 148.56 | 403.17 |
| **Prakasam** | 670.86 | 1006.29 | 144.13 | 862.16 |
| **Nellore** | 701.87 | 1052.81 | 144.59 | 908.22 |
| **Kadapa** | 1223.53 | 1835.30 | 209.22 | 1626.08 |
| **Chittor** | 1735.76 | 2603.64 | 350.94 | 2252.70 |
| **Total** | 5114.54 | 7671.81 | 1168.68 | 6503.43 |

## 4. TECHNICAL AND ECONOMIC FEASIBILITY STUDY

Large amount of surplus power available on the grid after meeting the agricultural requirement is considered to be pumped into the grid and is valued at the bench mark price fixed by the AP Government at Rs.6.49/-. As this energy is owned by utility company, it will have a choice to fix its cost while selling to consumers adhering to the rules of APERC.

$$\text{Income from the pooled energy on the grid} = \text{Surplus power in Units available x Rs. 6.49} \quad -(5)$$

In the present power shortage scenario where new capacity is required to be continuously added to the grid, capacity avoidance at 2.0 times the agricultural energy requirement is considered with the proposed distributed solar generation. Cost of conventional power is Rs. 52.7 Millions/MW [7]. Agricultural energy requirement in MU is obtained by adding 12% [8] as T&D system losses. At least one third of pump sets are to be powered at any point of time and hence a diversity factor of 0.33 is reasonable to consider while evaluating additional capacity avoidance which is given in Eqn.6.

Additional capacity available in MW =

Total hp ratings of all the motors X 0.745

X 2.0 X diversity factor/1000 -- (6)

$$\text{Cost of additional capacity avoidance in Millions} = 52.7\text{xAdditional capacity avoidance in MW} \quad -(7)$$

Now, Net cost involved in realizing the above proposal is calculated by subtracting cost of additional capacity avoidance from net or total cost of solar power plant, which is stated by Eqn. 8.

$$\text{Net cost of Solar power plant} = \text{Cost of total solar power plant @120 per watt} - \text{Cost of additional capacity avoidance} \quad -(8)$$

As per Eqn.1 in simple payback period, total 1 year cash flows in this case are income from surplus energy exported to the grid.

**Table 3: Net cost of solar plants in all six districts under APSPDCL**

| District | Capacity avoidance in MW | Cost of capacity avoidance in Rs. Millions | Cost of Solar power plants in Rs. Millions |
|---|---|---|---|
| **Krishna** | 173.22 | 9,128.8 | 49,788.4 |
| **Guntur** | 155.12 | 8,175.0 | 44,114.4 |
| **Prakasam** | 258.89 | 13,643.5 | 80,502.8 |
| **Nellore** | 268.56 | 14,153.0 | 84,224.6 |
| **Kadapa** | 492.77 | 25,969.1 | 146,823.6 |
| **Chittor** | 797.87 | 42,047.7 | 208,291.2 |
| **Total** | 2146.44 | 113,117.2 | 613,745.1 |

Thus, Net cost of the solar power plant from Eqn. 8 becomes Rs. 500,627.9 Millions. From Eqn.5 revenue from surplus energy of 6503.43MU exported to grid works out to be Rs.

42,207.3 Millions. Accordingly, simple payback period works out to be 11 Years 10 Months. When the energy generated from renewables is sold at a price lower than the pooled cost, then that energy is valid to claim Renewable Energy Certificates (RECs). One REC is equivalent to a generation of 1MWh renewable energy. The metering and other statutory and legal requirements are to be fulfilled for realization of money from REC scheme.

Hence 7671.81MU of energy generated in 1 year is equivalent to 76,71,813 RECs. At a floor price of Rs.12,000/- for evaluating total 1 year cash flows, income from trading of RECs is calculated and is found to be Rs. 92,061.8 Millions. In this case, entire investment on solar powered distribution generation will get paid back in 3 years 9 months.

## 5. CONCLUSION

Constant supply demand gap and concern to maximize utilization of renewables led to development of this method for adoption of solar photo voltaic generation in distribution sector, in the perspective from utility. It is observed that there is a reasonable scope for financial feasibility with breakeven period varying from 9 years 10 months to 12 years 4 months. When the income from renewable energy certificates is also considered, breakeven is found to be within 3 years 9 months. Adoption of solar energy into distribution level will definitely beneficial to the utility in long term and this may be implemented in parts so that financial burden may be less on the utilities.

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