Case Study of Agriculture Consumption in Rural Maharashtra: Analysis of Losses and Corrective Methods

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ABSTRACT

In Maharashtra, there is near about 68% population lives in villages & major occupation of villagers is agriculture. Since last 3 years farmers are faced the problem of shortage of water for agriculture as well as for drinking water. Because of continuous drought hit, there are badly effects on crop production quality of production. Also, Maharashtra faces the problem of electricity supply as there is significant difference between generation and demand of electricity therefore it is essential to save water and energy to solve above said problems. For water and energy saving study regarding conventional agriculture technology & opportunities of new innovative techniques is required. Whole economy of Maharashtra state is concentrated around the Agriculture field & near about 68 % population is lives in rural area whose major occupation is Agriculture. Basically, electrical generation and transmission systems are installed and regulated by modern technology. Generation system is regulated to maintain economy and plant use factor by control system and automation. Transmission system is also working with full efficiency by using EHV Transmission system. Only distribution system is present with old assembly having large amount of losses. As much amount of load is in the form of agriculture pump sets, it is focused on losses in the Agriculture feeders, pump sets and theft in agriculture.

Keywords

AgDSM, DISCOM, SEB, ESCO, Panchayats STAR rated pumps.

1. INTRODUCTION

20% electricity in Maharashtra is used for the Agriculture sector which is nearly equal to 10000 Million unit's consumptions annually. Tariff in this sector is Rs. 150/HP/year for regions where the electricity consumption is less than 1300hrs/HP/year and Rs. 180/HP/year where the electricity consumption is more than 1300hrs/HP/year. With issues related to depletion of ground water table, the agriculture pumping in the state of Maharashtra will be under higher stress. In this paper, it is discussed the present status of agriculture losses in Maharashtra and new innovative technics to improve agriculture efficiency [1-2]. In the last 13 years, the Maharashtra State Electricity Distribution Company (MAHADISCOM) had hidden electricity theft of Rs.60,000/- crore behind the exaggerated agriculture consumption and this is the core reason of high per unit consumption tariff in Maharashtra [3]. Over 41 lakh agriculture power connections were recorded in Maharashtra by December 2014[4]. There are 20 million 'irrigation structures' including canals, tube wells, wells, and water storage tanks in India. The rapid deployment of tube well technology has contributed to improving the number of farmers [5-7]. However, it is increasingly clear that underground aquifers are being depleted and the free power policies that helped enable the lifting of ground water have imposed a ruinous financial burden on the country's erstwhile State Electricity Board (SEB)[8-9]. Unfortunately, there is neither enough water nor enough electricity to allow the continuation of the practices of the past three decades for another three [10]. Reversing the policies of the past might not be enough to restore equilibrium and create conditions that would allow sustainable growth. Worse, the consequences of an abrupt reversal could be devastating for the millions of small, poor farmers who comprise most of rural India. Now a day, India's agricultural sector 30–40 per cent consumes of total electricity, up from 10 per cent during the 1970s [11-12].

2. HIGHLIGHTS ABOUT PROJECT

Case study to agriculture consumption in Maharashtra includes following points for agriculture study:

1. Voltage on each phase
2. Current on each phase
3. Power factor on each phase
4. DTC Survey
5. Substation Level information related to AG Feeder
6. Water head
7. Cropping pattern
8. Pumping hours
9. Info about AG pump billing
10. Issues related to power supply for AG consumers
11. Status of metering system

By using this survey data analyses of the power losses related to agriculture as follows:

1. Voltage interruptions
2. Power factor issue
3. Electricity theft in agriculture
4. Traditional methods of irrigation
5. Water wastage by default electrical energy.

3. CONTRIBUTION OF GOVERNMENT AND NGOs IN AGRICULTURE STUDY

The Agricultural Energy Efficiency Program will improve the end-use energy efficiency in the agricultural sector by changing pumping machinery through a joint effort of MSEB and MEDA using a variety of activities including promotion, training and capacity building of artisans in rewinding shops Average cost realization from the agriculture sector is 51% (MERC through the Indian Pump Manufacturers Association **(**tariff order FY 2003-04). Agriculture sector also faces issues related to the time of supply of electricity to the farmers and social aspects linked with the night-irrigation. MSEB's measures linked to feeder segregation has also lead to distortion in the system due to illegal conversion of single phase to three phase supplies with the phase converters. Adverse power factor because of non-standard pumping equipment and non-reliable supply voltage (with variations up to minus 30%) have resulted in system failure at the feeder and end-use. On an average, the pump-sets need to be rewound at least in a year resulting in higher cost factor inputs to the farmers. Frequent rewinding also results in inefficient pumping machinery used in the field, resulting in higher losses at the end use.

BEE engages the services of Energy Efficiency Services Limited (EESL) to implement Ag DSM schemes using innovative business models. Figure provides an overview of a standard model, where EESL enters into a Maharashtra with DISCOM and conducts energy audits, pump replacements and M&V based on its own resources, and shares the energy savings obtained from efficient pumps with the DISCOM. The M&V agency shall test all the existing pump sets as well as the EEPS at the time of replacement

The manufacturers of high efficiency pumps stand to be big winners if this program is successful in developing a practical workable, replicable, and sustainable model. In addition to providing the best possible pricing, pump set manufacturers (IPMA) could also facilitate the process by contributing their know-how to support the development of a pump certification program, including the development of standards and specifications.

The Maharashtra State Electricity Distribution Co. Ltd. (MSEDCL) has entrusted IIT Bombay with a project to find a reliable and efficient methodology to determine unmetered agricultural consumption in the state. Currently there is some ambiguity in the measurement methodology and there are a substantial number (40%) of unmetered consumers in the state. The objectives of this project are:

- To find a reliable and efficient methodology to determine unmetered agricultural consumption through data analysis and a field validation exercise a methodology will be developed such that it can be repeated by MSEDCL periodically to assess consumption
- Improved methods for estimation of agricultural electricity consumption that can be implemented over time will be suggested.

4. PROJECT TO STUDY AGRICULTURE CONSUMPTION IN MAHARASHTRA

4.1 Detailed Audit of Feeder:

The detailed energy audit involves taking power consumption measurements at 80 consumers' pumps connected to 4 Distribution Transformers (DT) of an agricultural feeder, and filling a survey form with some information from each of the 80 consumers.

Some additional information is to be collected at the substation where the feeder begins, and some data to be collected at 4 DT over which these 80 consumers are connected. The area covered by the network of a distribution transformer is around 1 sq. km.

It is estimated that one can measure around 8 consumers in a day; hence 80 consumers will take about 10-12 days of field work. In addition, the data collection at the substation may be one day's work, and the information to be collected at the DT's (since it will need the help of the section office) may take another one to two days. Since power is supplied to agricultural feeders in the daytime for 3 or 4 days a week, the survey of one feeder should take 3 to 4 weeks. This work needs to be completed in March, so that all measurements are done while water is still available at the pumps.

Harmonic clamp meter is used for measuring power consumption if required. Some pictures of meters at various points will also be required, so the survey team should have a camera/smart phone

The accompanying survey forms will indicate what data needs to be collected at the consumer, at the substation and at the Distribution transformers.

4.2 High-Level Audit of Feeder:

The high-level energy audit involves collecting energy consumption data at the feeder level at the substation, and doing verbal surveys of 12 farmers on that feeder. No power consumption measurements are required; hence the surveyors can go to one or two villages and meet 12 farmers to collect data. It is estimated that this exercise will not take more than 3 days 1-day at the substation, and 1-2 days for the surveys.

4.3 Selection of Feeders:

Through some analysis of consumption data from MSEDCL for the year 2014-15, it is shortlisted the divisions in which feeders are to be surveyed. A detailed audit of 1 to 3 feeders in a zone depending on the consumption in that zone will be completed. A detailed audit will be done on 15 feeders and a high-level audit on 85 feeders in all for this project. A district and may cover 2-3 taluka, and a sub-division often coincides with a taluka. While it is selected the divisions, the feeder may be selected in any of the subdivisions. Generally, the exact feeder(s) will be selected in conjunction with the implementing institute. A division usually covers a part of a district and may cover 2-3 taluka, and a sub-division often coincides with a taluka.

For Baramati circle following feeders are selected:

Detailed Feeder Audit:

Division	Substation	Feeder Name	Distance	AG Consumers	Metered consumers
Baramati Division	33/11 KV Pandare Substation	11 KV Pandare, 1-Ph	30 km from Someshwar	665	242

High-Level Audit: **Table 1: Selection of feeder**

Division	**Substation**	**Feeder Name**	**Distance**	**AG Consumers**	**Metered consumers**
Daund Division	Yawat Sub-Station	22 KV Yawat Feeder	55Km from Someshwar	2855	1547
Saswad Division	33/11KV Murum	11 KV Karkhana Single Phasing	5Km from Someshwar	196	83
Saswad Division	33/22 KV Nira Substation	22KV Nira (U) AG	08Km from Someshwar	909	436
Baramati Division	33/11KV Nimgaon Ketki	11KV Indapur	90Km from Someshwar	306	141
Baramati Division	33/11 KV Kazad S/Stn.	11KV Bhawaninagar	40Km from Someshwar	330	188

5. OBSERVATIONS NOTED ON THE FIELD

A survey was conducted on the selected feeders/DTC. Following observations are found:

1) Pump ownership with 2 – 3 families is one of the biggest hurdles for entering into pump replacement agreement.
2) Farmers fear that metering of the pumps power consumption will be later bill to them.
3) Farmer by-passes the energy meters post installation of the new pump and energy meter.
4) Farmers are reluctant to have their pump HP reduced. The agreements for replacements have been signed only if the new pump HP is nearer to old pumps HP.
5) Low voltage issues, voltage and water level variations at several installations. Due to water level variations, it was felt to provide a higher head operation pump set to farmer for future trouble-free operation purpose.

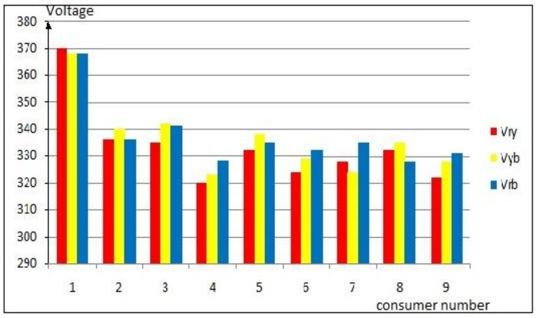

Figure 1 Voltage Profile

6) Farmer's reluctance to enter into an agreement for pump replacement as this is the first time where a pump replacement scheme involves having an agreement.
7) At several locations, it is imperative to replace at free of cost all pump set accessories with new ones like panel box, auto starter switch, fuse carrier, wiring/cable, suction pipe, bends, nipples, clips, tin cover, flanges, foundation board, footing, Nylon rope, NRV, etc. to achieve desired results of replacement with efficient pump. Pump starters at several places have been replaced at no cost to convince farmer's regarding the scheme's advantage.
8) Few farmers are reluctant to give back the old pumps as replacement and hence difficulty to enter into the agreement

Selected Photographs:

6. POWER FACTOR IMPROVEMENT OF AG PUMP SETS

Low power factor is a major challenge faced by utilities in supply for agricultural feeders. High power inductive loads with no proper policy for maintaining power factor results in very low power factor in this feeder. Low power factor added with the problem of distribution lines extending to large distances results in large distribution losses and voltage drop problems. The attempt made in this project is to develop a sustainable procedure for ensuring satisfactory power factor in these feeders. Although there are different methods of power factor improvement like installation of capacitors at HT side and reactive power supply through decentralized generation, the reduction in losses possible through installation of capacitors in LT side at each customer level is analysed in this project. The reduction in losses possible though such an installation is quantified. Economic feasibility of a project where utilities covering the expense of capacitor installation is also analysed. Such an investment by utilities is justified in terms of low period of economic recovery through losses reduction. The project also helps the end user thought improved voltage profile and maximizes system capacity. Although voltage profile could be improved by voltage boosters, the solution is costly and utilities don't generally adopt such a solution in agricultural feeders.

6.1 Theory of Power Factor Improvement

In case of inductive loads (motor, transformer etc.) associated conductors demand lagging reactive power along with real power to do work. As a result, in the absence of any other source, reactive energy must be supplied by the source, causing technical losses in the line. During this condition, total power delivered to the load consists of a real and a reactive component. Total power is measured in kilovolt-amperes (kVA). Power factor is defined as the ratio of real power (kW) to total apparent power (kVA). So effectively when inductive load is high power factor would be low. Lagging reactive load can be cancelled by a capacitor placed in parallel to the lagging reactive load demand. The leading current developed by capacitors can effectively cancel the lagging current demanded by the inductive load components. The Graph 3.1 shows the change achieved in power factor with variation of reactive power demand for a 3HP pump. From the Graph 3.1 it can be observed that for a 3 HP pump for improvement of PF from 0.75 to 0.95 there needs to be a reduction of 1.24 KVAR. Since fixed capacitors are usually available only as integer values in the market (1KVAR, 2KVAR etc.) Use practically goes for a 1KVARcapacitor.

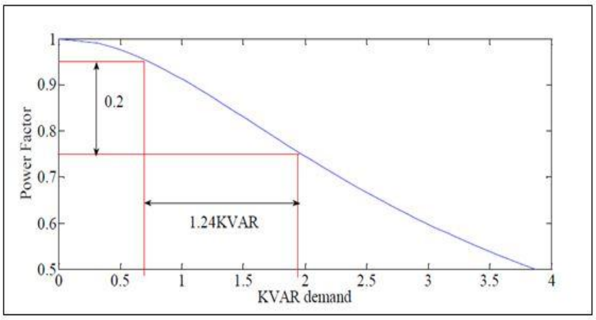

Figure 2: KVA ratings

6.2 Method of Capacitor Installation in Pumps

The capacitor should get introduced to the network only when pumps are active. Hence capacitors need to be placed between the starter and the motor. The method of capacitor placement is shown in figure. In many cases capacitors are wrongly placed before the starter or even before the main switch. Hence capacitors are present in the network even when load is not. In this case meter might still be running and it may result in increased bills in case of metered farmers, also due to the leading current introduced by the capacitor in the network, a voltage rise may occur which is not required by the network and leading to complications like equipment damage. The best thing about capacitor installation at load is that it gets introduced and removed from the network with respect to the demand.

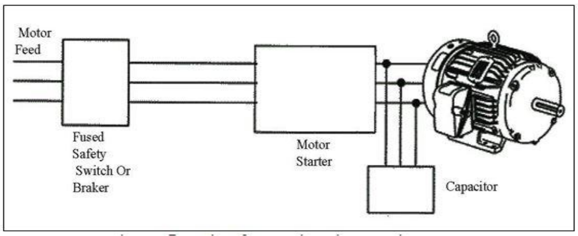

Figure 3: connections of capacitors

6.3 Results after Capacitor Installation:

The measurements made in 'Sola Amba' transformer during the period may to June 2016 showed a low power factor of 0.66 (graph 8.1). However the readings taken just before capacitor installation showed a power factor ranging from 0.77-0.83.The improvement achieved in power factor through capacitor installation is plotted in Graph8.1. The graph 8.1 is based on 7 days power usage data before and after installation procedure with samples taken at half an hour interval. As it can be observed from the graph 8.1 that power factor was improved from the range of 0.77-0.89 to 0.9-0.99. The normalized graph 8.1 for the collected sample is overlapped over the histogram and it clearly shows that peak of the normalized curve shifted from 0.8 to 0.95.

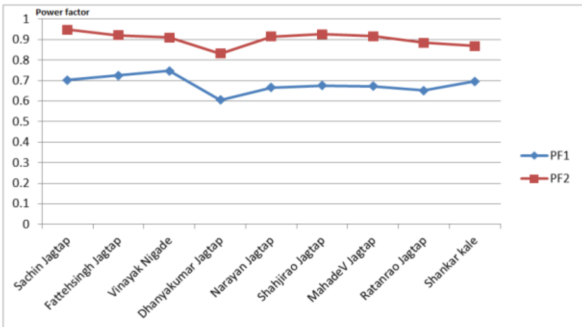

Figure 4: Power Factor Improvements

7. POWER SAVING USING MULTISTAGE INDUCTION MOTOR

In India agricultural electrical motors load is near to 30% of total load and the tariff of such loads is very low as compared to the other load systems, which results in losses for power providing industries to overcome such problems pump systems used for water pumping non required full load running should be controlled by using Multistage Induction Motor.

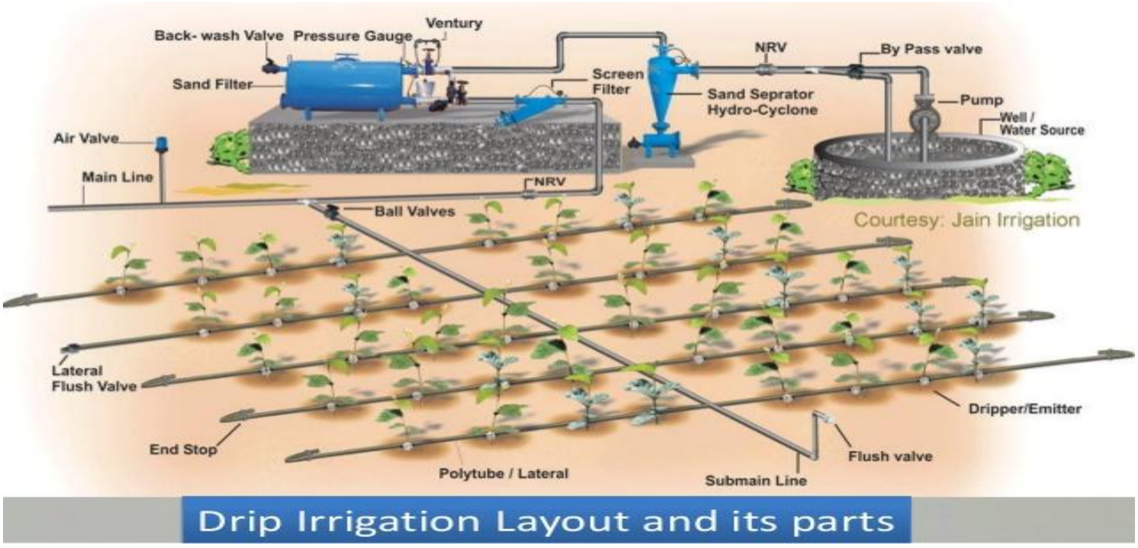

Figure 5: Wastage of water by using bypass valve

Generally, when motors run there are Many newer technologies to reduce the flow of water output from the pump but they are not affordable for farmers by implementing tap-changing motors it will able to reduce the power input of motor, as well as the flow of the water which reduces pressure of water, water wastage and provide farmers affordable way to reduce power wastage.

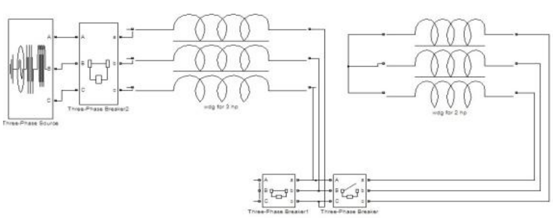

Figure 6: connection diagram for multistage IM

7.1 Design Development:

Proposed design of multistage induction motor is as shown in above figure. The windings of the 5HP induction motor are spit in to 2HP winding and 3HP winding. A change-over switch is placed between these two windings. Switch is moved according to the required power. Only disadvantage is that change the switch position is not possible in running condition of the motor. As the switch position is changed, there is jerk applied to the motor at the starting.

8. FUTURE SCOPE OF THE PROJECT

As discussed in last two chapters that are by placing the capacitors on the irrigation pumps improves the efficiency of pumps. And by using multistage induction motors it saves power & water wastage. Another some innovative technics possible to use for the agriculture pump efficiency and avoid losses on agriculture feeders.

1. For monitoring and verification, SCADA is used at distribution system.
2. At the time of rewinding focus on the standards of the motor.
3. Solar based pumps should be adopted.
4. Change the mentality of farmers towards energy saving in Agriculture.
5. Variable frequency drives are used for efficient and limited use of water for agriculture.
6. Modern irrigation technics should be adopted such as sprinkler & Drip irrigation technics.
7. Restructuring of distribution system is required as there is old assembly is used for the distribution system. Detailed survey is required for correction of agriculture load (HP ratings of the pumps)

9. CONCLUSION

Several studies in the agriculture sector have indicated benefits at various levels:

- Higher end-use efficiency with energy efficient pump-sets, with wide-voltage variation motors using different technics such as VFD’s and other conventional methods for control of motors.
- Increased reliability of electricity distribution with potential to increase the number of pumping hours, wastage of water and wastage of electricity.
- Energy savings potential of close to 20 to 25% is expected with the energy efficient pump sets. Intermediation in this sector will not necessarily result in reducing peak demand as the current supply to this sector is in the non-peak hours. By using water tanks, water is stored in rainy season and store electricity in the form of water.

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