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Agricultural Demand Side Management: A Case Study of Mandya District, Karnataka, India.

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Abstract- **Irrigation system in India has turned out to be progressively reliant on groundwater. The pumping of ground water to irrigate crops consumes around five hundredth of ground water resources and about thirty fifth of the electricity generated in the country, with the resulting sways on groundwater accessibility and on vitality use for its extraction, efforts have been made over the past three decades – from local pilot projects, to state wide program – towards improving the efficiency with which groundwater is pumped, and, more recently, for its re-charge and conservation.**

This paper provides detailed energy audit study of the pump sets in the pilot area. The study involves measuring the present operating efficiency of 1337 agricultural pump sets which were identified in the two feeders of Malavalli Taluk, Mandya District, Karnataka and recommend new energy efficient pump replacements for the same. During the energy audit study detailed information (about all the agricultural consumers) such as details about pumps (number, Type, make, age and rating), water requirements / consumption, status of meter installation, number of harvesting cycles, cropping pattern, underground water level in different seasons, power supply pattern and socio-economic conditions etc. is collected and analyzed.

This detailed project report provides an insight to concept of Demand Side Management & Energy Service Company for making investments in implementing energy efficiency measures on rural pump set feeders. The involvement would lead to lower energy supply on the feeder, and hence, could result in lower subsidized energy sale by utilities and lessen the subsidy to be paid by the State Government.

Keywords – Demand Side Management

I. Introduction

Agriculture sector is a standout amongst the most vital part of Indian economy. Agriculture sector plays a critical part in the general financial improvement of India or we can say socio-economic development of India. There are around 20 million pump sets which are being energized and expected an yearly expansion of 0.25 to 0.5 million pump sets in this sector. Agriculture sector uses 20-22% of total electricity consumption [1]. Overseeing horticultural burden is progressively turning into a test for power utility in India. Subsidized tariff generate a perception of zero marginal cost of electricity use and consequently, efficiency in consumption is ignored. Updating of existing pumping frameworks introduces a quick need and an extraordinary open door. Usage of this system is urgent as Energy bills for horticultural pump sets are being paid by Govt. as endowment.

Low or free power combined with high inefficiencies adds to adoption of local made inefficient and unreliable pump sets, results in gigantic water wastage and higher v utilization of energy. The average efficiency of existing in-efficient pump sets is in the scope of 20% - 30% while efficiency scope of new star appraised Energy Efficient Pump sets (EEPS) is 40% - 50% [1]. Subsequently, there is a need to tap the immense vitality investment funds potential guaranteed in agriculture pumping division.

II. Agricultural Demand side management

In Energy and Power sector, Agricultural Demand-side Management (AgDSM) comprises of those exercises, methodologies, awareness, policy and technologies and advances that impact farmer behavior and Changes their (agriculturists) energy utilization patterns.

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The objective of the AgDSM program is to reduce peak demand and to reduce the total usage of energy consumption. The AgDSM suggestion is exceptionally straightforward i.e. substitution of inefficient agricultural pump sets with BEE five star rated and high efficiency pump sets to diminish the measure of power expected to pump water in agribusiness part. Thus, power utilization can be diminished [1]. In the event that the investment funds from the diminishment in power utilization can be supported and the aggregate expense of the power spared surpasses the aggregate introduced expense of the pump sets over its valuable life, there will be a net monetary increase.

The agriculture sector is one of the major and inefficient power user in India and gives huge chance to spare vitality through better demand side management techniques. Executing AgDSM is additionally imperative for enhancing money related soundness of the majority of the appropriation utilities in India since these utilities offer noteworthy measures of influence to the agricultural customers for water pumping at subsidized rate and scarcely get an income return. Albeit 71% of the earth surface is secured with water, less than 1% of the world's water is promptly available for watering system, where 83% is for irrigation and agricultural use. The utilization of energy pattern in agriculture sector is expected to expand. The high growth rate of development in rural power utilization results from forceful rustic jolt combined with an arrangement of giving power at sponsored or at totally allowed to ranchers. The after effect of high share of aggregate power utilized for agricultural pump sets and low efficiency and very low revenue generation on agricultural sales" has made an undeniably unsustainable circumstance and further because of low efficiency of the pump sets has further expanded the weight on the conveyance organizations and this gives a chance to lessen vitality utilization in irrigation pump sets through better DSM strategies. The issue is further aggravated by the way that of the aggregate water utilized as a part of India – 83% goes for watering system and of this sum half originates from the abuse of the ground water resources. This makes weight on the water table as well as is exceedingly vitality escalated.

Other than the over, the inefficient water pumping in the agriculture sector likewise has its effect on an Earth-wide temperature boost and environmental change however the outflow of the green house gasses (GHG). Carbon-dioxide (CO2) constitutes right around 90% of the aggregate GHG radiated by blazing of fossil fuel. In India, blazing of coal in force plants transmits about half of the aggregate carbon outflows. This has both global as well as local implication. The irrigation pump sets utilized are by and large exceptionally inefficient with operating efficiency level of 30% or less is basic. The pump sets are all the more regularly larger than usual to suck water from progressively declining profundities furthermore to withstand voltage variances. The vitality utilization is high primarily because of

- Improper selection and installation
- Local make and inefficient pumps
- Use of high-friction piping
- Lack of appropriate upkeep/proper maintenance.

Involvement in India has built up that the electric vitality required to convey a given amount of water can be decreased by around 20% to 30% essentially by supplanting the inefficient pump set with more productive, efficient, right-sized pump set and introducing a low-friction foot valve & piping.

Under this scheme of BEE, first Pilot Ag DSM project was launched at Mangalwedha subdivision of Solapur Circle in Maharashtra. This first pilot Ag DSM project covers 3530 agricultural pumps connected on five feeders (Bramhapuri, Nandeshwar, Borale, Bhose & Kharatwadi) in Mangalwedha & Pandharpur subdivisions. With this background, which studied, the Ministry of Power along with Bureau of Energy Efficiency took initiative for improving agriculture pump efficiency in agricultural pump sets as a Project in Malavalli, Mandya District of Karnataka with a view to implement the model in other areas based on its success. Two agricultural feeders namely Banasamudra & Halasahalli from Malavalli have been selected for preliminary study & replacement potential of inefficient pumps with energy efficient pumps.

III. Objective of the Study

The study includes - Measuring the present operating efficiency of 1337 agriculture pumps sets recognized in the two feeders of Malavalli Taluk, Mandya District and prescribe new energy efficient pump sets for the same.
In agriculture sector, the greater part of the irrigation system pump-sets work at poor efficiency. The goal of this study is to contemplate the effect of those external parameters, for example, water table variation, utilization of nonstandard pumps etc. on overall average operating efficiency and to estimate the energy saving potential. The point by point destinations of this study are as given underneath,. The detailed objectives of this study are as provided below,

- Identifying operating efficiency of all the pumps considered in the study

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- Identify the major causes of low operating efficiency and recommend improvements / better operating practices
- Study external parameters that could affect the efficiency and their impact on operating efficiency
- Cost benefit analysis for various options for saved energy due to pump set replacement

IV. OVERALL APPROACH

A. Steps involved in overall approach for implementing AgDSM -

Overall approach adopted, along with detailed timeframe is provided in Figure below and activities carried out in different steps are briefed in section below,

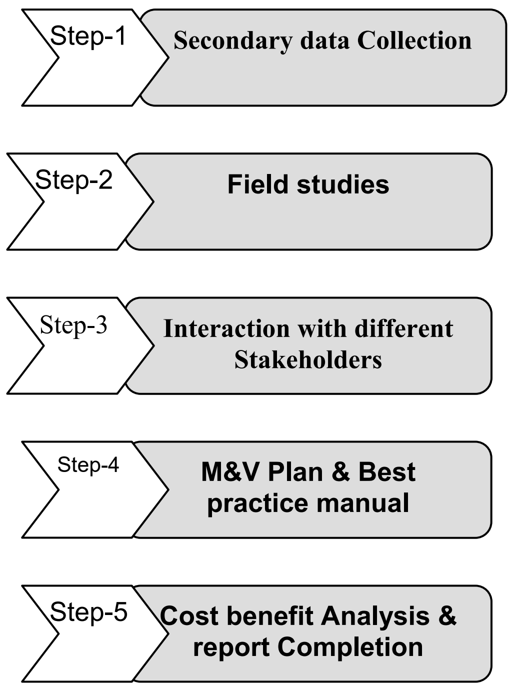

Figure 1. D *Steps Involved in overall approach for implementing Ag DSM*

Step 1: Secondary Data Collection

Secondary data required for preparation of DPR was collected from various organizations such as Karnataka Chamundeshwari Electricity Supply Corporation Ltd.(KACESCL), Ground Water Survey Agency, Agricultural department, irrigation department , local farmers, Pump Manufacturers etc. for Malavalli Taluk, Mandya district. The secondary data collected comprised of electrical distribution system, agriculture metering system, agriculture tariffs and subsidy details, feeder wise electricity consumption pattern, seasonal water level variations and number of harvesting cycles, feeder details etc.

Step 2: Field Studies

Detailed energy audit studies were undertaken for all the pump sets. The objective of detailed energy audit was to evaluate the efficiency of the existing pump sets, which mainly involved measurement of water discharge, suction and discharge heads, pipe material, diameter & length of the pipeline distribution, and pump set input power. The additional information like name plate details of existing pump set, foot valve status / condition, willingness of owners to participate in the project, other socio economic conditions and cropping pattern etc.,

Step 3: Interactions with different Stakeholders

For awareness of Ag DSM project farmers' open house meetings were organized at few villages, where several farmers participated and discussed about the issues associated with the project. The objective of the workshop was to make farmers aware about the BEE Ag DSM project and benefits of the scheme to them. Interaction with various

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pump manufacturers / suppliers were also made to understand the selection criteria, impact of changing water levels on the pump set efficiencies, input power and to study the pump curves. During the interaction the efficiency range of different types of star labeled pumps along with technical details, budgetary quotes, suppliers of spare parts etc. is also discussed.

Step 4: Preparation of Best Practices Manual and Monitoring & Verification Protocol

Energy Service Companies / Distribution utilities are being encouraged to undertake implementation of these DPRs with the help of financial institutions. However to ensure the energy savings, appropriate monitoring and verification protocol needs to be in place. Detailed monitoring and verification protocol is provided to limit the uncertainties in the savings. From transparency point of view local NGO's and agricultural institutes might play an important role of Monitoring and Verification.

Step 5: Cost Benefit Analysis and Financing Options

Replacement of existing pump sets with correctly selected, better designed energy efficient pumps having higher efficiency for the same head range will give same water output and consumes lesser power. Cost benefit analysis for investments made in replacement of pump sets and saved energy thereof is estimated from CESC point of view based on avoided power purchase cost. In addition to this various financing options are also explored

B. Project area overview and analysis-

Location and accessibility of the pilot area - Mandya district is situated in Karnataka. Total geographical area of Mandya District is 4,98,244 hectare out of which 1,74,529 hectare is irrigated and 2,53,067 Hectares forms the sown area. More than half of the total land area in the district is put to agricultural use. The two feeders under the Ag DSM project study are located in Malavalli taluka's. Two agricultural separated feeders namely Banasamudra and Halasahalli selected for the Ag DSM project. The boundary of the Ag DSM project is restricted to 17 villages. The two agricultural feeders Banasamudra and Halasahalliare supplied from 66 KV substations located at Malavalli in Mandya district.Electricity is delivered to consumers through 11kV feeders downstream of the 66 kV substation. At these load points, a distribution transformer (DTR) further reduces the voltage from 11kV to 400V to provide the last-mile connection through 400V lines (also called as Low Tension or LT lines) to individual customers, either at 240V (as single-phase supply) or at 415V (as three-phase supply).Two feeders namely Banasamudra and Halasahalli selected under Ag DSM project are supplied at 11 kV from 33/11kV substations.

On the basis of such considerations, the algorithm uses a different color image multiplied by the weighting coefficients of different ways to solve the visual distortion, and by embedding the watermark, wavelet coefficients of many ways, enhance the robustness of the watermark.

Figure 2. Location Map for the Project Study Area

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Climate and soil type - The district temperatures ranges between 16 ^{0}C and 35 ^{o}C. The normal rainfall of the district is 623mm. The soil of Mandya district is derived from granites and gneisses interpreted with occasional patches of schist in SR Patna, Mandya and Pandavapurataluks.

C. Agricultural Tariff And Subsidy in the State-

KACESCL agricultural consumers are categorized into low tension (LT) agricultural consumers. The LT agricultural consumers are further categorized into metered consumers and un-metered consumers. All LT metered consumers are levied energy charges for actual metered consumption, whereas un-metered consumers are charged on connected HP basis. For I.P. Sets Up to and inclusive of 10 HP, Fixed charge & Energy charge free.For IP sets above 10 HP, fixed charge Rs. 30 per HP per month, energy charge 125 paisa per unit .Private Horticultural Nurseries, Coffee and Tea plantations of sanctioned load up to and inclusive of 10 HP & above 10 HP, fixed charge Rs. 20 per HP per month, energy charges 125 paisa per unit. As per the details collected from the CESC and our physical verification of the agricultural pump sets site and panel, 100% of the pumps installed are not metered in both the feeders and no charges are collected from the farmers and supplied at free of cost.

TABLE - 1 Feeder Wise segregation of metered and un-metered consumers

Metering Status	Feeder Name		***Total connection***
	Halasahalli	Banasamudra	
Unmetered	643	694	1337
Metered	0	0	0
Total	**643**	**694**	**1337**

D. Measurement and technical analysis-

. Pump performance has been evaluated by undertaking water flow measurements, power consumption measurements and head & loss estimation in pipe lengths.

Feasibility of water flow measurement using ultrasonic flow meter was tested. However due to site constraints it was not possible to use ultrasonic meter hence same has been carried out by using volumetric flow measurement method. A portable clamp-on type power meter has been used for electrical parameter measurements.

Height of discharge from ground level and length & diameter of pipe were measured. All these constitute to actual pump head including losses.

Whenever water flows in a pipe, there will be some loss of pressure due to following factors: Friction, Changes in size and shape or direction of flow, Obstructions

Water flow has been collected in a barrel of known volume of 100liters and time required in seconds to fill up the barrel has been measured using a stop watch. In order to minimize the human error the measurements were repeated for 2 to 3 times.

The water flow can be calculated with help of following formula,

$$\text{Water flow}\left(\frac{m^3}{hr}\right) = \frac{\text{volume of barrel} * 3600}{1000 * \text{Time in sec}} \quad \text{... (1)}$$

The electric parameters like current, voltage, power factor and active power for agriculture pumps were measured by online single CT portable power meter. The power meter being used is "Nanovip" and Meco make.

The pump set efficiency has been calculated with the help of following formula,

$$\text{Pump efficiency} = \frac{\{Q * h * \rho * g\} * 100}{(1000 * 3600 * kW)} \quad \text{... (2)}$$

Where,

Q = Volume flow rate (m^3/hr.)

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h = (Net Static Head + Velocity Head at Suction & Discharge + Friction losses due to fittings & length), (m)
ρ = Density of the fluid (kg/m^3)
g = Acceleration due to gravity (9.81 m/s^2)
kW = Motor input power

Pumpset details - Bore wells are the primary source of water for farming in this region followed by open wells. Well water is pumped basically by electrically operated pump sets of either monoblock or submersible types. Water from bore wells is pumped by submersible pump sets. Water from canals is pumped by monoblock pumpsets. Out of the 1337, 888 (66.4%) are bore well submersible pumps and balance 400(30.0%) are monoblock pumps and 49 (3.67%) are untested pumps.

Major observations during the site study are listed below

- The submersible pumps are installed for majority of the bore wells.
- Monoblock pumps are installed for canal irrigation.
- Flexible P.V.C. pipes were commonly used for both suction and delivery sides.
- As most of the pumps are of locally assembled pumps and the nameplate specifications are not available.
- Most of the pump motors (65%) have been rewound one or two times.
- Even though the power availability is for 6/8 hours, intermittent power failures are observed frequently, especially during rainy season
- Service wires and fuse protections are not appropriate size for several pump sets which has lead to frequent burning of the pump set motors.
- Most of the pump sets and distribution boxes are provided without earthing.
- The major reasons for pump set failure and lower discharge output was erratic power supply and cases of extreme low voltage. Due to huge gap in the demand – supply situation of the state power grid, the agriculture feeders are faced with severe load shedding. Thus, whenever power is available most of the pump sets are automatically switched ON to supply water for irrigation. The farmers have made provisions for automatic starting of pumps. This is carried out either by auto-starter or starter is kept in on condition, continuously during the season, defeating interlocks.
- Due to erratic power supply, the farmers were also provided with the dual mode operation, the pumps are operated either in single phase or three phases as per the electricity availability.

It is also been observed that even though sanctioned demand is 3 HP or 5 HP in Mandya, power rating of most of the pump sets is higher than sanctioned demand. The reason for measured power consumption rating higher than sanctioned demand is that most of the pumps are fitted with heavy windings to draw more water and to withstand against low voltage supply

E. Operating and Average operating efficiency performance evaluation

Due to the site constraints like temporary connections, motor burnouts or under repair the efficiency evaluation was not carried out for 49 number of pump sets out of 1337 pump sets.

Efficiency of Monoblock Pump sets: Out of the total studied 1288 pumps studied, 400 are monoblock pump sets. The efficiency of the pump sets are ranging from 8% to 39.2%. Majority of the pumps has efficiency less than 20%.

Efficiency of Submersible Pump set: based on the physical inspection of the pump sets during field visit, the total number of submersible pump sets is 888. The operating efficiency of these pumps are ranging from 9.94% to 40.59%.

The average operating efficiency and average power input for different types of pump sets with different HP rating are evaluated for 1288 pumps studied during field visit. Out of 1337, 49 pumps were either disconnected or bore

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wells failure. The overall average operating efficiency and power rating is also estimated based on weighted average of HP/power input rating for all the pump sets.

Table - 2 Average operating efficiency for different ratings & types of pump sets

HP	Type of the pump	Initial no. of Pumps	Average old pump Efficiency	Average existing Input Power(kW)	Average Expected EEPS Efficiency	Revised Input Power (kW)
3	Mono Block	101	29.77%	2.27	42.60%	1.59
	Submersible	9	28.42%	3.42	46.60%	2.09
5	Mono Block	224	21.40%	3.51	43.10%	1.74
	Submersible	152	32.40%	4.22	49.70%	2.75
6	Mono Block	5	28.00%	3.93	40.30%	2.73
	Submersible	635	28.80%	5.77	51.40%	3.23
7.5	Mono Block	68	18.30%	5.17	44.50%	2.13
	Submersible	92	29.74%	5.64	52.00%	3.23
10	Mono Block	2	20.20%	7.31	44.80%	3.30
	Submersible	-	0.00%	0.00	0.00%	0.00
15	Mono Block	-	0.00%	0.00	0.00%	0.00
	Submersible	-	0.00%	0.00	0.00%	0.00
20	Mono Block	-	0.00%	0.00	0.00%	0.00
	Submersible	-				
Total		1288		41		23

The overall weighted average efficiency of the Monoblock pump sets of the two feeders is 23.53%.
The overall weighted average efficiency of the Submersible pump sets of the two feeders is 29.3%.
The overall weighted average efficiency of the pilot project study of the two feeders is 28.3%.
The Energy consumption for 1288 pumps audited and it comes to 100.7 Lakh units (10.07 MU).

F. Parameters affecting pumpset efficiency -

The various parameters identified that could affect the pump performance are listed below and discussed in detail in subsequent sections,

- Inferior design and inefficient pump sets
- Improper pump selection and usage
- Undersized pipes
- Suction head variations and large discharge lengths
- Motor rewinding and low voltage profile

G. Estimation of energy saving potential-

The energy could be saved by improving the overall system efficiency either by partial rectification or by complete replacement.

The partial rectification covers the options other than replacement of pump sets (Motor & Pump); Removal of unnecessary pipe lengths, Removal of unnecessary bends, Reduction in height of pipe above the ground, Replacement of GI pipes with HDPE/ HDPE pipes, Installation of capacitor banks for improving power factor. With partial replacement, farmers benefit in terms of more water discharge from the existing pumping system. However the reduction in energy requirement is marginal.

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The complete replacement also covers the replacement of existing pump set with energy efficient pump set along with the options covered under partial rectification. Even though the complete rectification requires huge investment it leads to significant energy savings and reduced line loadings. In this DPR the option of replacement of exiting pump sets with energy efficient pump sets is considered. The replacement of existing pump sets with energy efficient pump sets would lead to energy saving

$$\%EnergySavings = \frac{AvgOperatingEfficiencyofnewpumps - weightedAverageefficiencyofExistingpumps}{AverageEfficiencyofnewpumpsets} \quad ..(3)$$

The overall weighted average operating efficiency for energy efficient pump sets is arrived at 51% (submersible) and 55% (monoblock). The energy saving potential is estimated only for improvement in the system efficiency due to replacement of existing pump sets with energy efficient pump sets. The weighted average operating efficiency of all the existing pumpsets is 28.3% and the efficiency of the new proposed pumps is 51% (submersible) and 55% (monoblock). Hence, the achievable energy savings is estimated at 44.0% and in terms of quantum, the overall consumption of existing pump sets has been worked out to be 10.07 Million Units (MU). After installation of the proposed energy efficient pump sets, the consumption will reduced to 5.63 MU for annual average operating hours of 1610. This will lead to the energy savings of 4.434 MU which corresponds to an energy saving potential of 44 %.

Table 3- Energy Saving Potential for replacement of existing pump sets with energy efficient pump sets

HP	Type of the pump	Initial no. of Pumps	Existing Energy Consumption, in MUs	Energy Consumption of EEPS, in MUs	Energy Saving in MU
3	Mono Block	101	3.69	2.58	1.11
	Submersible	9	0.50	0.30	0.19
5	Mono Block	224	12.66	6.29	6.37
	Submersible	152	10.33	6.73	3.59
6	Mono Block	5	0.32	0.22	0.10
	Submersible	635	58.99	33.05	25.94
7.5	Mono Block	68	5.66	2.33	3.33
	Submersible	92	8.35	4.78	3.58
10	Mono Block	2	0.24	0.11	0.13
	Submersible	-	0.00	0.00	0.00
15	Mono Block	-	0.00	0.00	0.00
	Submersible	-		0.00	0.00
20	Mono Block	-	0.00	0.00	0.00
	Submersible	-		0.00	0.00
Total		1288	100.73	56.38	44.34

F. Cost Estimates For Efficiency Improvement

TABLE 4 - Cost per pump set and total cost of energy efficient pump sets of Mandya District

HP	Type of the pump	Initial no. of Pumps	No of Pumps as per Proposed HP of EEPS	Cost per Pump Including VAT(Rs)	Total Cost of Energy Efficient Pump Sets
3	Mono Block	101			
	Submersible	9	101	12150	12.636
5	Mono Block	224	9	20250	1.823

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HP	Type of the pump	Initial no. of Pumps	No of Pumps as per Proposed HP of EEPS	Cost per Pump Including VAT(Rs)	Total Cost of Energy Efficient Pump Sets
	Submersible	152	224	15413	34.062
6	Mono Block	5	152	24806	37.706
	Submersible	635	5	19181	0.959
7.5	Mono Block	68	635	30122	191.274
	Submersible	92	68	25650	17.442
10	Mono Block	2	92	34875	32.085
	Submersible	-	2	30825	0.617
15	Mono Block	-	0	39938	0
	Submersible	-			
20	Mono Block				
	Submersible	-			
Total		1288			328.70

Each item of the total project investment has been arrived at based on budgetary offers from reputed suppliers and possible negotiation margins. The break of total project cost is discussed in detail in the sections below.

Cost of Energy Efficient Pump Sets of Mandya District: The cost of pumps has been received from the pump set manufacturers and has been arrived at after identifying the appropriate pump set for the replacement of existing pump set.

the total investment required for replacement of 1288 existing pump sets with energy efficient pump sets is Rs. 328.70 Lakh.

Cost of dismantling existing pump set and installing EEPS of Mandya District: The cost of dismantling existing 400 nos. monoblock and 888 nos. submersible pump sets has been estimated at Rs.7.416 lakhs (@ Rs.300 per monoblock pump set and Rs.700 per submersible pump set)

Cost of replacing foot valves for monoblock pump sets of MandyaDistrict:During the site study it is observed that the foot valves of monoblock pump set are inefficient due to locally made brands. Hence it is suggested to replace the same to optimize the performance of EEPS. The total numbers of foot valve replacements are around 401, costing at Rs.2.00 Lakhs (@ Rs. 500 per piece including installation cost)

Repair and Maintenance Cost: The Repair & Maintenance cost to ensure rated efficiency levels and sustaining the savings is estimated at about 10% of pump cost per year and the total cost for R&M works out to be Rs.29.21 Lakhs per year. During the first year the R &M is covered under the warranty by pump manufacturers and the ESCO has to taken care of R&M during post warranty period.

Overall Project Cost: The total project cost estimated for the Ag-DSM Pilot Project for two feeders at Malavalli subdivision of Mandya district, is Rs.328.60 lakhs during the first year and Rs.392.182 lakhs for five years inclusive of monitoring and verification expenses & Repair & Maintenance

V.CONCLUSION

The Paper concentrates in evaluating the efficiency of the existing and Energy Efficient Pump Sets (EEPS). This point by point venture report gives an understanding to idea of Demand Side Management and Energy Service Company for making interests in executing energy efficiency measures on rural pump set feeders. The inclusion would prompt lower energy supply on the feeder, and thus, could bring about lower sponsored vitality deal by utilities and reduce the endowment to be paid by the State Government.

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