Pilot Agricultural Demand Side Management (Ag- DSM) Project at Muktsar & TaranTaran, Punjab

Detailed Project Report

March - 2010

PREPARED FOR

ENERGY IS LIFE
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Bureau of Energy Efficiency

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LIST OF ABBREVIATIONS

AT&C	: Aggregate Technical & Commercial
BEE	: Bureau of Energy Efficiency
BEP	: Best Efficiency Point
CER	: Certified Emission Reports
CT	: Current Transformer
DISCOM	: Distribution Company
DPR	: Detailed Project Report
DSM	: Demand Side Management
DTR	: Distribution Transformer
ECM	: Energy conservation measures
EEPS	: Energy Efficient Pump Sets
ESCO	: Energy Servicing Company
GHG	: Green House Gas
GI	: Galvanised Iron
GPS	: Global Positioning System
HDPE	: High Density Polyethylene
HP	: Horse Power
HT	: High Tension
HVDS	: High Voltage Distribution System
IRR	: Internal Rate of Return
LD	: Liquidated Damage
LT	: Low Tension
M&V	: Monitoring and Verification
PSERC	: Punjab State Electricity Regulatory Commission
PSEB	: Punjab State Electricity Board
MU	: Million Units
NGO	: Non Government Organisation
PPP	: Public Private Partnership
PVC	: Polyvinyl Chloride
R&M	: Repair & Maintenance
UNFCCC	: United Nations Framework Convention on Climate Change

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This Detail Project Report has been compiled by the committed effort and team work of serval engineering professionals of TUV SUD South Asia Pvt Ltd.

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EXECUTIVE SUMMARY

Project Background

1. In order to accelerate Demand Side Management (DSM) measures in agriculture sector, Government of India approved a scheme on Agricultural Demand Side Management (Ag DSM) to be implemented by Bureau of Energy Efficiency (BEE), Ministry of Power. The objective of the scheme is to create appropriate framework for market based interventions in agricultural pumping sector by facilitating conducive policy environment to promote Public Private Partnership (PPP) to implement projects.

2. First Pilot Ag DSM project was launched in Maharashtra at Mangalwedha subdivision of Solapur Circle. In second phase four states viz Gujarat, Rajasthan, Haryana & Punjab were selected. BEE initiative has been taken and in line with that, agricultural pumps on six feeders (Channu, Punjawa, Sehnakhera, Muthianwala, Ramsinghwala, Talwandi) in two Districts Muktsar and TaranTaran of Punjab, INDIA has been chosen.

3. The Detailed Project Report (DPR) is prepared after an exhaustive survey and detailed energy audit study for each and every pump. 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.

4. This detailed project report provides an insight to distribution utility / Energy Service Company (ESCO) for making investments in implementing energy efficiency measures on a rural pump set feeder. The intervention would lead to lower energy supply on the feeder, and hence, could result in lower subsidised energy sale by utilities and lesser subsidy to be paid by the State Government.

5. The main report contains detailed analysis and recommendations emerging from the study. A summary of the major findings has been given in the following sections.

Pump Set Efficiency Performance Evaluation

6. Pump set operating efficiency was evaluated for all the pump sets, based on the measurement of parameters. Out of total 2186 pumps, 1782 pumps were actually tested on site.

7. The **overall average operating efficiency** based on weighted average of HP rating for all the existing pump sets is **33%**.

8. **The overall average operating efficiency for new Energy Efficient Pump Set (EEPS) is 56%.** Head and flow data for each consumer / pump set has been

considered along with the site water level variation and changes in cropping pattern to select an EEPS from the manufacturers of STAR rated pump sets.

Estimates of Energy Saving Potential

9. The overall consumption of existing pump sets is estimated to 20.06 Million Units (MU), where as with energy efficient pump sets the consumption will go down to 12.67 MU based on the annual average operating hours of 1350 . This will lead to energy savings of 7.38 MU per annum.

Project Financing and Business Models

10. In line with BEE's objective "To create appropriate framework for market based interventions in agricultural pumping sector through Public Private Partnership (PPP) mode", the Ag DSM project funding could be from ESCOs with repayment over time from the stream of project benefits.

11. PSEB can also take up the implementation of this pump set efficiency improvement project with direct funding from financial institutions & due approval from the state commission.

12. Apart from these financing options, Tariff Regulations specified by the State Commissions for determining the ARR and Tariff, should have exclusive provisions under which the utilities can book the expenses incurred by it on DSM measures. Suitable provisions in the Tariff Regulations to allow recovery of DSM related expenditure as a part of Annual Revenue Requirement is one of the simplest way to create necessary funding for the implementation of DSM programs.

13. All the Direct costs associated with Ag DSM programs including design, implementation, monitoring, evaluation and incentives can be recovered through creation of a **special DSM fund** approved by the state commission. This ensures reasonable certainty of cost recovery, as failure to recover any costs directly impacts utility/ESCO earnings, and sends a discouraging message regarding further investment.

14. After considering the possible financing options, different business models have been developed and categorised as DISCOM Mode, ESCO Mode & HYBRID Mode as described below:

15. PSEB will finance and implement the replacement of old inefficient pumps with new higher energy efficiency pump sets and contract out repair and maintenance of pumps and certain aspects of project works to a project contractor **(DISCOM Mode)**

16. An ESCO (energy services company) which has a contract with PSEB finances and implements the project; the ESCO would borrow the project debt and repay it from project revenues **(ESCO Mode)**

17. The project is financed and implemented through an ESCO. The DISCOM will support the capital expenditure and other operating expenses through annual payment

from special DSM fund & share of energy savings resulting from the project **(HYBRID Mode)**

18. A detailed cost benefit analysis has been carried out and financial model has been developed to estimate IRR for all three business models. The following sections will summarize the various costs incurred & benefits derived from implementation of pilot project.

19. **Capital Cost:** The total capital cost estimate for the Ag DSM Pilot Project in Punjab, is Rs. 4.22 Crores. Different cost parameters are tabulated below.

Table 1: Details of Project Costs

Particulars	Value in Rs Lakhs
Cost of Energy Efficient Pump Sets	405.96
Cost of dismantling existing pump set and installing EEPS	9.598
Cost of replacing foot valves for monoblock pump sets	7.13
Total Capital Cost	**422.7**

20. **Repair and Maintenance (R&M) Cost:** The annual R&M Cost (post warranty period) for all the 2186 pumps is around 36.09 Lakhs. For sustaining the savings, repair and maintenance should be provided for 4 years (after warranty period of 1 year). The total R&M cost for 4 years after warranty is Rs. 144 Lakhs.

21. **Overall Project Cost:** The total project cost estimate for the Ag DSM Project in Punjab, is about Rs. 567 Lakhs.

22. **Monetary savings to PSEB:** Agricultural consumers are supplied energy for free with state subsidy share of Rs 2.48/kWh, whereas average revenue realization from sale of saved energy to other category of consumers is Rs 3.34 / kWh. Hence PSEB will be benefited due to reduction in agricultural energy consumption. The total annual benefit resulting from the sale of saved energy is estimated at INR 24.67 Million

23. The detailed project financial analysis for a period of 5 years has been carried out for project implementation through ESCO Mode, DISCOM Mode & HYBRID Mode. The summary of benefits for all three business models are provided in sections below.

ESCO Mode

24. In this case the project is financed and implemented through an ESCO. The energy savings resulting from the project will be the source of revenue. The financial model analysed for a project cycle of five years indicates the economic viability for implementation of Ag DSM pilot project through ESCO Mode with **Equity IRR of 29.49%** and **payback Period of 3 years.** Also in this mode of implementation 5% of the annual benefit (savings) is retained with DISCOM and 15% of savings is shared

with the state govt. which in turn accounts for 20% reduction in the subsidy burden borne by the state.

DISCOM Mode

25. In this case the project is financed by a DISCOM. The implementation can be contracted out to an ESCO.

26. The saved energy could be sold to other consumers at an average rate of Rs. 3.34 per kWh. The detailed financial analysis based on the above details shows a **payback period of 3 years**. The **Project IRR** for a term of 5 years **is 31.36%.** Also in this mode of implementation 15% of savings is shared with the state govt. which in turn accounts for 20% reduction in the subsidy burden borne by the state.

HYBRID Mode

27. In this case the project is financed and implemented through an ESCO. The annual payment from special DSM fund & share of energy savings resulting from the project will be the sources of revenue. The detailed financial analysis based on the above details shows a **payback period of 2 years**. The **equity IRR** for a project term of 5 years is **31%.** Also in this mode of implementation 50% of the annual benefit (savings) is retained with DISCOM and 15% of savings is shared with the state govt. which in turn accounts for 20% reduction in the subsidy burden borne by the state.

28. Given that the project is techno-economically viable and the detailed financial analysis for provides attractive returns within a reasonable payback period, the project will have several ESCOs interested for its implementation through ESCO & Hybrid Modes. However in the ESCO Mode entire revenue from the project is exposed to subsidy risk resulting from the uncertainty in continuation of subsidy from the state govt. This risk is being mitigated in Hybrid Mode where only a part of revenue is exposed to subsidy as the other part comes from a special fund approved by GERC.

29. Over all, the project is well conceived and conceptualised, with sound commercial viability. The expected financial returns are quite satisfactory. Similar agriculture pumping efficiency improvement projects in other states are now techno commercially proven in India. All perceived risks have adequate safe guards. The project is recommended for equity participation and lending by financial institutions and PSEB as well.

30. All the technical risks have been discussed and mitigated. The energy savings are assured considering that almost all the pumps have been actually tested and efficiency levels verified. The above facts should give PSEB enough confidence to implement this Ag DSM pilot project on their own.

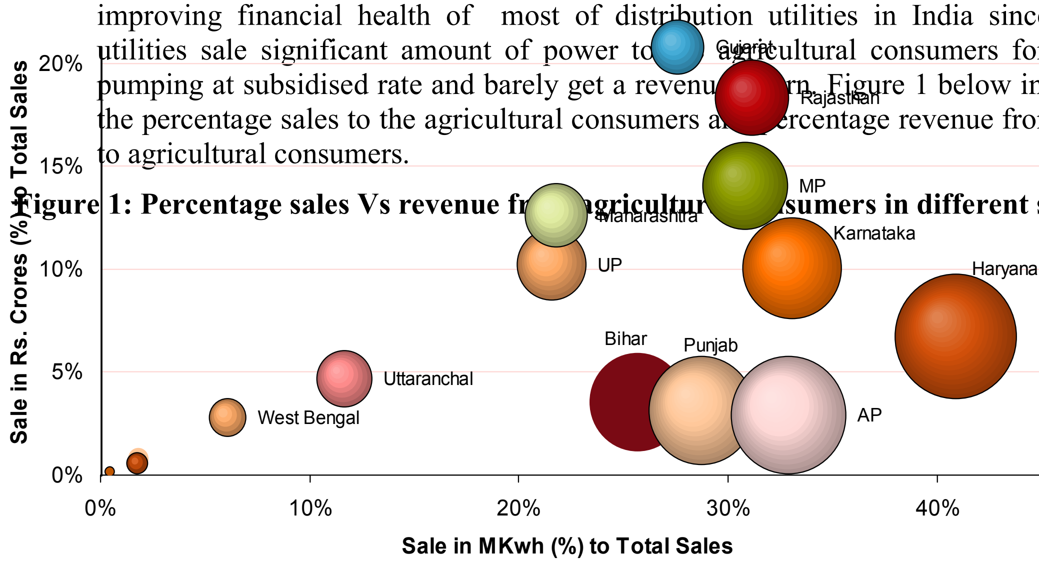
A1: INTRODUCTION

1.1 The 8 % GDP growth for India, which is being targeted by the five year plan, crucially hinges on the growth of power availability at close to 15% per annum. If India is to meet this growth target for power availability, its entire requirement cannot come solely from generation / supply augments. A major contribution will have to come from savings through better demand management and improvement in the end use efficiency.

Preamble

1.2 The agriculture sector is one of the major and inefficient power user in India and provide immense opportunity to save energy through better demand side management techniques. Implementing agricultural DSM is also important for improving financial health of most of distribution utilities in India since these utilities sale significant amount of power to agricultural consumers for water pumping at subsidised rate and barely get a revenue return. Figure 1 below indicates the percentage sales to the agricultural consumers and percentage revenue from sales to agricultural consumers.

Figure 1: Percentage sales Vs revenue from agricultural consumers in different states



1.3 The problem is further compounded by the fact that of the total water used in India – 25 bcm – 83% goes for irrigation and of this amount half comes from the exploitation of the ground water resources. This not only creates stress on the water table but also is highly energy intensive. Energy intensity of pumping is increasing further because of falling water table.

1.4 This has implication for the sustainable development and its impact on the persons below the poverty line. This is because even today more than 60% of the work force in India is employed in farming activity and almost 70-80% of the poor in the country are either marginal farmers or the land-less labourers.

1.5 Besides the above, the inefficient water pumping in the agriculture sector also has its impact on global warming and climate change though the emission of the green house gases (GHG). Carbon-dioxide (CO2) constitutes almost 90% of the total GHG emitted by burning of fossil fuel. In India, burning of coal in power plants emits nearly 50% of the total carbon emissions. This has both global as well as local implication.

1.6 The irrigation pump sets used are generally very inefficient with operating efficiency level of 33% or less is common. The pump sets are more often oversized so as to suck water from increasingly declining depths and also to withstand large voltage fluctuations. The energy consumption is high mainly due to

(a) Improper selection and installation,
(b) Use of high-friction piping, and
(c) Lake of proper maintenance.

1.7 Experience in India has established that the electric energy required to deliver a given quantity of water can be reduced by about 20% to 30% simply by replacing the inefficient pump set with more efficient, right-sized pump set and installing a low-friction foot valve & piping.

1.8 With this background, the Ministry of Power along with Bureau of Energy Efficiency has taken initiative for improving agriculture pump efficiency as a Pilot project in two District (Muktsar& TranTaran) in Punjab with a view to implement the model in other areas based on its success. Six agricultural feeders namely Channu, Shenakheda, Punjawa, Muthianwala, Ramshinghwala & Talwandi have been selected for preliminary study & replacement potential of inefficient pumps with energy efficient pumps.

Objective

1.9 The study involves measuring the present operating efficiency of the 2186 agriculture pumps identified at the six feeders in two districts (Muktsar & TranTaran) in Punjab region and recommend new energy efficient pump replacements for the same.

1.10 In agriculture sector, most of the irrigation pump-sets operate at poor efficiency. There are many other parameters such as water table variation, irregular maintenance, use of non standard pumps, improper pump sizing etc., which could affect the efficiency of the pump-sets. The broad objective of this study is to study the impact of those external parameters on overall average operating efficiency and to estimate the energy saving potential. The detailed objectives of this study are as provided below,

(a) Identifying operating efficiency of all the pumps considered in pilot study,

(b) Identify the major causes of low operating efficiency and recommend improvements / better operating practices,

(c) Study external parameters that could affect the efficiency and there impact on operating efficiency,

(d) Cost benefit analysis for various options for saved energy due to pump set replacement,

(e) Identify agencies to service and maintain efficiency of replacements undertaken,

(f) Propose a Monitoring & Verification Protocol to measure and quantify the savings incurred.

Scope of Work

1.11 In line with the above objectives DPR is framed to provide an overview of existing facilities and current operating system like electrical distribution system, metering system, agricultural tariffs and subsidy, electricity availability, seasonal as well as historical water level variation pattern and watersheds available in the Muktsar & TranTaran region.

1.12 The detailed energy audit / survey is undertaken to collect detailed information (about all agricultural consumers considered in pilot project) such as details about pumps (number, type, make, age & rating), water requirements/ consumption, status of meter installation, number of harvesting cycles, underground water level in different seasons, power supply pattern, tariff, willingness to participate in the project and socio economic conditions.

1.13 DPR provides overview of energy and water consumption pattern in different seasons for all six feeders forms the boundary line for the project. Feeders and number of pumps connected thereof are listed below,

- Channu Feeder : 268 Pump sets
- Shenakheda Feeder : 548 Pump sets
- Punjawa Feeder : 428 Pump sets
- Muthianwala Feeder : 417 Pump sets
- Ramsinghwala Feeder : 254 Pump sets
- Talwandi Feeder : 271 Pump sets

1.14 Detailed energy audit (performance evaluation) for all pump sets is carried out by measuring the suction & discharge head, power input and water flow to evaluate operating efficiency of all the pump sets. Based on audit study an efficiency index for the existing pumping system is prepared. During the audit, other parameters and site conditions like delivery valve position, working of foot valve and type of piping etc., are also studied.

1.15 The capacity and type of new energy efficient pump sets that can replace the existing pumps for the same discharge has been decided based on field studies after evaluating the existing pump set performance and operating efficiency.

1.16 The achievable energy saving potential that can be achieved by replacing existing pumps with that of best efficiency pump set is quantified based on the analysis of the measurements.In addition to this various technically sound and economically viable measures to improve the end-use energy efficiency like optimum sizing of pump sets for the same discharge, change of foot valve and change of piping system etc are also provided in this report.

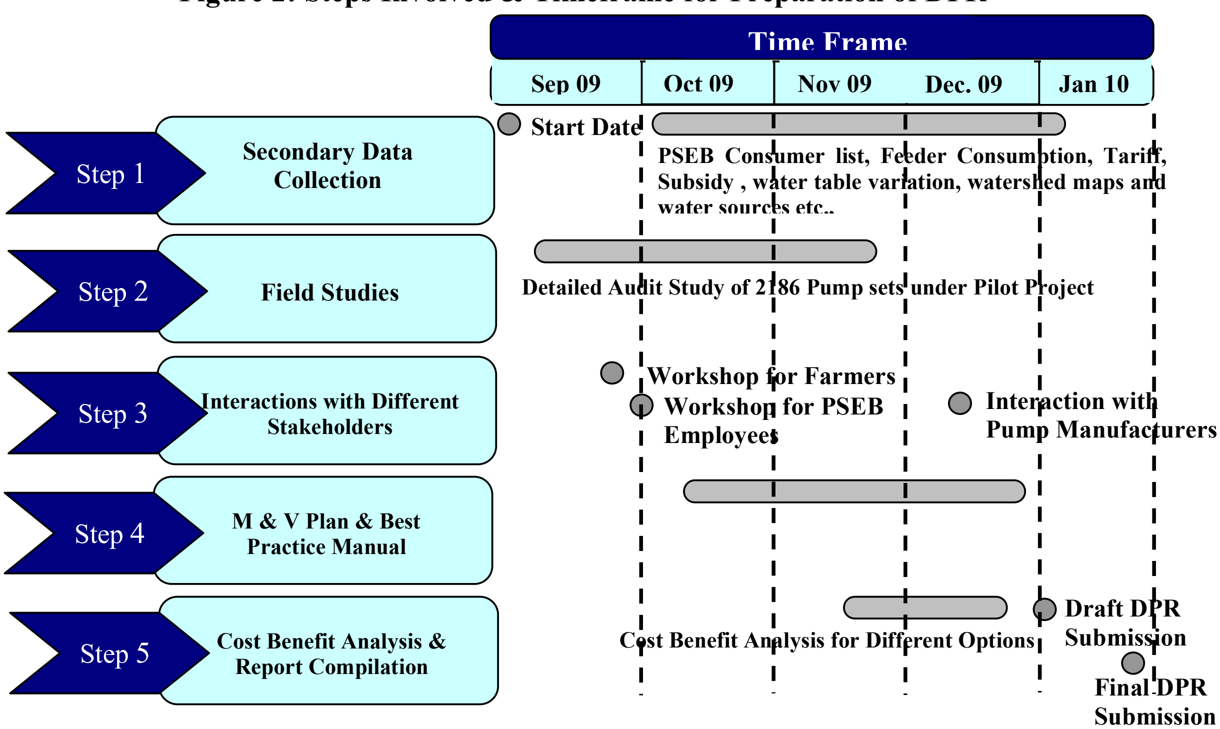
1.17 DPR also provides detailed cost benefit analysis associated with the implementation of each of the proposed energy conservation measure. In order to ensure the sustainability of the savings, Monitoring & Verification Protocol is also been provided for post implementation of pilot project through Public Private Partnership (PPP) mode.

1.18 As an effort to review and study other good practices in water pumping, a manual on best practices is also prepared which covers best operating and maintenance practices, supplies of spare parts, list of companies for repair of recommended new energy efficient pump etc.

Overall Approach for DPR Preparation

1.19 Overall approach adopted in preparing the DPR along with detailed timeframe is provided in Figure 2 below and activities carried out in different steps are briefed in section below,

Figure 2: Steps Involved & Timeframe for Preparation of DPR



Step 1: Secondary Data Collection

1.20 Secondary data required for preparation of DPR is collected from various organisations such as Punjab State Electricity Board (PSEB), Ground Water Survey Agency, Bore well agencies and farmers in the Region, Pump Manufacturers etc,

1.21 The secondary data collected was comprised of electrical distribution system, agriculture metering system, agriculture tariffs and subsidy details, feeder wise electricity consumption pattern, seasonal water level variations and watershed numbers in the region, number of harvesting cycles, feeder details etc,.

Step 2: Field Studies

1.22 Detailed audit study for each and every pump set is carried out. The objective of detailed audit is to determine the existing pump set efficiencies, which mainly involves measurement of water discharge, suction and discharge heads, piping type and length and pump set input power.

1.23 In addition to this additional information like name plate details of existing pump sets, delivery valve position, foot valve status / condition, willingness of owners to participate in the project, other socio economic conditions and cropping pattern etc, is also collected after interviewing the individual farmers.

Step 3: Interactions with different Stakeholders

1.24 For awareness of Agricultural Demand Side Management Pilot project at Lambi subdivision & Khemkaran sub division of Muktsar & Tarantaran districts respectively, farmers' open house meetings are conducted at several villages, where about 700 + farmers participated and discussed about the issues associated with the pilot project. Farmers Open House Meetings in both subdivisions were arranged in coordination with village heads (Sarpanch), local political heads and PSEB officials.

1.25 As a part of Ag DSM programme, workshop for PSEB employees in Muktsar & TranTaran region is conducted on 3rd September 2009. The objective of the workshop was to make utility employees aware about the BEE Ag DSM project and benefits of the scheme to PSEB.

1.26 Various pump manufacturers / suppliers are also interacted to understand the 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 labelled 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

1.27 DSM and energy efficiency practices under implementation and operation and maintenance practices in other regions are reviewed and incorporated in the Best Practices Manual. In order to provide a ready reference to the ESCO's, manual also provides list of pump manufacturers / suppliers of spare parts and repair companies.

1.28 Energy Service Companies / Distrbution utilities are being encouraged to under take implementation of these DPRs with the help of financial institutions. The ESCO/ Utility would invest in energy efficiency measures on a agricultural pump sets and will get paid though the additional revenue from sale of saved energy to other consumers at an average tariff and part of the savings in the state government subsidy.

1.29 However to ensure the energy savings, appropriate monitoring and verification protocol need to be in place. Detailed monitoring and verification protocol is provided to ring fence 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

1.30 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.

1.31 Cost benefit analysis for investments made in replacement of pump sets and saved energy thereof is estimated from PSEB point of view based on sale of saved energy to all other consumers at an average tariff of electricity. In addition to this various financing options are also explored.

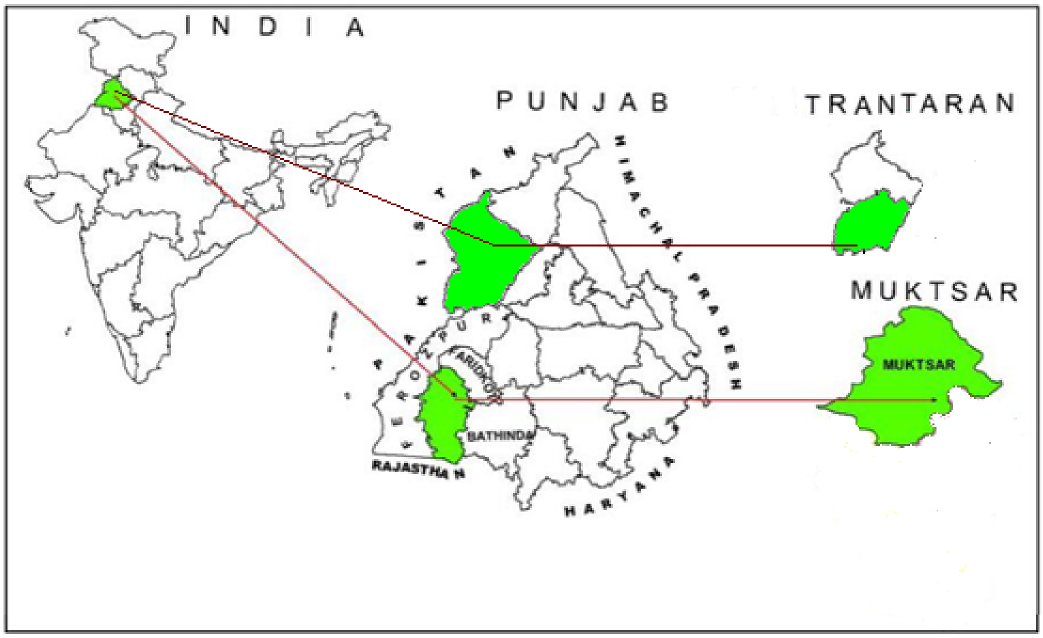
A2: PROJECT AREA OVERVIEW AND ANALYSIS

Location and Accessibility of the Project Area

2.1 Punjab state has earned the name "Food Basket of Company" and grainery of India. Total cropped area in the state is 7932 thousands hectare. The cropping intensity in the state raised upto 185.78 in year 2007-08. Area under major crop viz Wheat, Rice , Cotton, Miza, Sugarcane & potato was 3481, 2647, 509, 154,86 & 68 thousands hectare with production of 14695, 10437, 2088, 422,517 and 1400 thousands metric tone respectively. Total area under food grain cereals, pulses and oilseeds was 6347,6311,90 and 36 thousands hectare and their respective production was 25662, 25635,100 and 27 thousand metric tone.

- According to population census 2001, total population of the state was 243.59 lac and out of which 66.08 percent were living in village. The literacy rate in the state was 69.7 percent. All towns and villages are well connected by roads and were electrified. Punjab was the largest surplus state in India in term food grains production. Punjab has 1.56 percent of the geographical area of entire country. Punjab leads the other state in term of contribution of wheat & rice to the central pool by contributing 55.0 percent of wheat; 37.2 percent of rice to the central pool in 2007-2008. The total contribution of wheat and rice to the central pool had increase from 115.6 lakh tons in 1990-91 to 176.0 lakh tones during 2007-08 (P). Punjab state has been awarded National Productivity Award for Agriculture Extension Service for consecutive 10 years from 1990-91 to 1999-2000. Six agricultural separated feeders namely Channu, Shenakheda, Punjawa, Muthianwala, Ramsinghwala & Talwandi selected for pilot Ag DSM project. Three agricultural feeders Channu, Shenakheda, Punjawa are in Distic Muktsar and Muthianwala, Ramsinghwala & Talwandi are in TranTaran Districts. Channu Shenakheda and Punjawa feeder supplied from substations located at block Lambi and Muthianwala, Ramsinghwala & Talwandi feeder supplied from substations located at block Valtoha

Figure 3 : Location Map for Pilot project Study Area



2.2 **Mukatsar** district come into being 15th district of Punjab. Its total land area is 2,63,393 hectare was for agriculture out of which 218786 hectare was irrigated. It's cropping intensity is 175%. Bathinda is situated south of Mukatsar and Ferozepur in north. Faridkot was situated in east and in west is again Ferozepur district.Mukstsar was in 29-5''-30-20 East longitude 29-50-51 north longitude. Mukatsar is linked to kotakpura and fazilka by rail line. Total number of villages is 236 in the district. Lambi block has some barren land. Giddarbaha paved a way for crop diversification by planting aromatic plants. Malout block produce pady and cotton of line quality. Malout is also famous for manufacturing agriculture tools.

- About 95% land of the district is irrigated by canals and remaining 5% part of land was irrigated by tube wells. Cotton, sugarcane, moogs and paddy are prominent crop in kharif and wheat barley, mustard and gram are prominent rabi crops. Grapes, guava and kinnow fruits are produced here. Lambi is smallest block of the Mukatsar district and Mukatsar block is the biggest in this district.According to 2001 census, population of Mukatsar was 7,76,702 which was 3% of state's total population, female population was 3,64,981 and male population was 4,11,721. According to survey 75% lives in village and 25% in town and cities. Animals are prominent capital of Muktsar and animal population is 2,78,835. There are 43 veterinary hospitals and 63 dispensaries in Mukatsar. Here are 4 milk plant in this district .Four regular markets, 27 sub yard working in the district.

Table 2 : Block wise Land use Information District Muktsar Year 2004-05 (Area in ha)

Sr. No.	Perticulars	Muktsar	Malot	Giddarbha	Lambi	Total
1	Number of village	90	52	44	**50**	236
2	Total Geo. Area	82967	56941	63094	**60931**	263933
3	Cultivated area	73893	52982	59335	**56779**	242989
4	Total sown area	126584	91192	101086	**94840**	413702
5	Crop Density	171	172	170	**167**	170
6	Net Irrigated area	65944	47655	54530	**50647**	218786
7	Canal Irrigated	61504	45045	52500	**49630**	208679
8	Tubewell irrigated	4440	2620	2030	**1017**	10107
	Net Total	120344	90405	99285	**92285**	402319

- Due to high dependence on cotton-wheat or paddy-wheat rotation, excessive use of chemicals fertilizer coupled with flood irrigation with poor quality underground water, the soil fertility has been affected calling for measures for improvement in soil health.

2.3 **Tarn Taran** lies in the Northwest frontier of Punjab and is bounded by District Amritsar in the Northeast, District Kapurthala in the East and district Ferozepur in the southeast .The District comprises of 3 tehsils, 4 subtehsils and 5 assembly constituencies and 1 Lok Sabha constituency.lt lies between 31°7' and 32°3' north latitude and 74°29' and 75°23' in the east longitude and has about 105 Km international boundary with Pakistan. It is bounded by river Beas in the south eastern side. The geographical area of this district is 241449 hectares, out of which 217541 is under cultivation. Of the cultivable area of the district 99.9 % isirregated . Out of total irrigated area 65% is irrigated by canals and 35% by tubewells. The cropping intensity of the district is 177%.

Table 3: Land Use Classification of District Tarn Taran

No.	Perticulars	Hectare
1	Geographical area	241449
2	Net sown area	217541
3	Area sown more than once	167000
4	Total cropped area	384541
5	Non agriculture use	18239
6	Area under forest	5176
7	Area under pasture	98
8	Area under horticulture crops	1624
9	Area under vegetable crops	7744
10	Barren and uncultivable	230
11	Net Irrigated area	217541
12	By canals	130249
13	Tube wells	87292

Table 4: Block wise Information about Geographical Area and No. of Villages

Sr. No.	Name of the Block	Geographical Area (ha)	Number of Villages
1	Bhikhiwind	31970	59
2	Chohb Sahib	26725	50
3	Gandiwind	16201	33
4	Khadaur Sahib	28805	73
5	Naushehra Pannuan	29242	51
6	Patti	35777	80
7	Tarn Tarm	36122	85
8	**Valtoha**	**36607**	**59**
	Total	241449	490

- Although, the figures in Table 3 shows that only 40% area is irrigated through tubewells, but in the recent past, the rainfall intensity was very less and also the trend of the farmers to grow early varieties of paddy and non rational use of irrigation water put high pressure on ground water . Also, most of the water structures in the villages are destroyed by the farmers. The free power facilities to the farmers further worsens the condition .These all reasons motivate the farmers to draw more and more water from the ground and percentage of ground water development increased considerably. As for as poor ground water quality is concerned, farmers has started to convert their shallow tube well to deep tubewell. As a result of this the quality of irrigation water has considerably improved

.

Climate & Rainfall

2.4 In Muktsar district climate lies in the South-western region of the State and is far away form the Shivalik ranges in the North of the state, it is the nearest to the Thar Desert of Rajasthan and also far away from the Major river lines that run through the state. Therefore, climatically the district Mukatsar experiences extremes of climate situations. Summers are extremely hot and winters are very cold. The average minimum and maximum temperature recorded was 5.7°C and 40.8°C in 2000, 3.7°C and 41.9°C in 2005 and 4.5°C and 39.9°C in 2007 respectively. The minimum temperature touches the freezing point occasionally and maximum temperature sometimes reaches up to 46.5°C. The corresponding relative humidity varied from 47-71%, 34-73% and 42-76% in the year 2000, 2005 & 2007 respectively. The year may be divided into three seasons. The cold winter (November to February) the hot dry summer (March to June) and the mild rainy season (July to September). Dust storms are a regular feature in summer season.

- The monsoon generally starts in the first fortnight of the July the mean annual rainfall fluctuate around 425 mm. Most of the rainfall occurs in the month of July. August and September with few showers of rain during winter months. The rainfall data shows that there was maximum rainfall of 607 mm in the 2005 and minimum 188 mm in the 2002. Thus we can say there is no regularity and certainty in the weather condition in this district. The month wise data of maximum and minimum rainfall of different years and days of rainfall are presented in

Table 5: Rainfall Data of District Muktsar for Years (2003 to 2007)

Month	Rain fall (mm)									
	2003	Days	2004	Days	2005	Days	2006	Days	2007	Days
January	6.3	2	28	3	31.5	4	14.4	2	6	1
February	68.5	6	6	1	89.5	8	0	0	10	1
March	10	1	0	0	80.5	7	37.2	2	48	3
April	0	0	3	1	12.9	1	0	0	0	0
May	7	2	49.1	4	9.6	4	35	3	0	0
June	33	3	107.3	5	85.9	2	95.6	7	63.2	2
July	49	5	93.4	4	198	6	81.6	6	39.6	2
August	72	3	23	2	16	2	33.3	2	142	5
September	23	4	5	1	68.2	5	91	4	5	1
October	0	0	10	1	15	1	6.1	1	9	1
November	0	0	0	0	0	0	14	1	0	0
December	0	0	0	0	0	0	6.6	1	5	1
TOTAL	268.8	26	324.8	22	607.1	40	414.8	**29**	327.8	**17**

2.5 Tran Taran district experiences extremes of climatic conditions. Summers are extremely hot and winter is very cold .The year may be divided into three seasons. The cold winte(November to February), the hot summer (March to June) and monsoon season (mid June to mid September). The average minimum and maximum temperature. is 0.8° to 1°C and 41.8° to 46.9°C in winter and summer respectively. Monsoon generally starts in the first week of July. The mean annual rainfall fluctuate around 650 mm, the major part of which is received during the month of July, August and September with a few showers of rain during *the* winter months. The rainfall data of the district is presented in below table

Table 6: Rainfall Data of District Tarn Taran for year (2004 – 2007)

Month	Rain fall (mm)				
	2004	2005	2006	2007	Average
January	36	21.3	5.6	-	15.73
February	7.8	45	-	97.8	37.65
March	-	31.6	17.7	82.3	32.9
April	10.3	4.6	1.6	-	4.13
May	15	10 6	20.3	-	11.48
June	30.1	11.6	42.5	73.3	39.38
July	76.3	155.3	164.9	25.6	105.5
August	35.6	134.3	41.1	38.8	62.45
September	-	164.7	145.4	24.2	83.5T
October	46.6	-	27.7	-	18.57
November	1.6	-	9.7	-	2.8
December	2.3	-	5.6	-	1.9 ,

Table 7: Minimum and Maximum Temperature and Relative Humidity in Different Months in District Tarn Taran during Year 2005 and 2006

Month	Temperature (oC)						Mean Relative Humidity at 8 am (%)		
	Max			Minimum					
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
January	24.2	25.1	24.6	-0.7	-0.5	-0.6	90	86	88
February	28	30.2	29.1	-0.8	-0.8	-0.8	75	75	75
March	34.1	32.5	33.3	5.6	6.1	5.8	72	76	74
April	40.7	37.3	39	10.1	12.3	11.2	58	64	61
May	'46.2	42.5	44.3	18.5	20.2	19.3	69	73	71
June	46.8	44.7	45.7	22.3	23.9	23.1	58	56	57
July	36.3	37.1	36.7	21.6	20.5	21	87	81	84
August	37	36.3	36.6	23	22.4	22.7	78	76	77
September	36.1	342	35.1	18.1	17.8	17.9	77	75	_ 76
October	34.9	32 .1	33.5	12.2	‘11.1	11.6	76	80	78
November	32.8	30.4	31.6	7	8.2	7.6	79	85	82
December	25.3	24.7	25	4.1	3.7	3.9	89	91	90

Soil

2.6 Muktsar district falls in southwestern alluvial plain zone. The soil of Mukatsar district varies from sandy to loam in texture with occasional presence of sand dunes in block Lambi. Pure sandy texture soils are pre dominant in Lambi block where as, heavy textured are present in AES and AES comprising of village Abul khurana, Takhat Mulana, Babania. The soil is low in Organic Carbon, low in Phosphorus, high in Potassium, low in Zinc and other micronutrients.

2.7 The soil of district Tarn Taran is sandy loam to loam. Patti, Gandiwind, and Bhikhiwind blocks of the district have alkaline soils. The blockwise information of the soil in'the district has been presented in table

Table 8: Information about Soil in Different Blocks of District Tarn Taran

S.No	Block	Texture	Reaction	Micronutrient deficient in soil
1	Bhikhiwind	L-M	Alkaline	Zn,Mn,Fe
2	Chohla sahib	L-M	N-A	Zn Mn Fe
3	Gandiwind	M-H	alkaline	Mn,Zn
4	Khadaur sahib	L-M	Normal	Mn,Zn
5	Naushehra pannuan	M-H	Normal	Zn,Mn
6	Patti	M	alkaline	Zn,Fe
7	Tarn Taran	L-M	N-A	Zn,Mn,Fe
8	**Valtoha**	**M**	**N-A**	**Zn,Mn**

L-light M-Medium H-Heavy N-A-Non alkaline

Logging Problem of Punjab Particularly MuKtsar District.

2.8 Punjab state is characterized with two distinct topographical and hydrogeological settings: high yielding fresh groundwater regions in northern and central districts and the saline groundwater regions in southwestern districts. While ground water is declining alarmingly in fresh water regions, it has risen steadily in saline groundwater regions in Mukatsar, Bhatinda and Faridkot districts. During the last two decades, water table has risen by more than 10 m in 30 % area of Mukatsar. The problem is widespread over all blocks (Malout, Mukatsar, Lambi and Giddarbaha) of Mukatsar district, the water table rises virtually to the surface in a number of villages during raining season causing serious damage to standing crops. The problem of Water Logging and Soil Salinity are particularly severe in depressional locations which have inadequate or non- functional surface drains. The original cotton/ bajm/ maize - wheat/ gram system has been replaced by rice- wheat rotation resulting from leveling of extensive sand dunes and conversion to irrigated fields. The area under cotton has ben affected by the rising water table and farmers are not keen to grow cotton. River Satluj in the western part of these districts is the main drain for the area.

- The introduction of canals made the state of Punjab surplus in food grains but at the same time, this also led to the development of water logging and subsequent salinization, rendering large chunks of land unproductive. Remote Sensing and GIS (Geographical Information System) techniques can be extremely useful in accurate mapping and quantification of waterlogged area and salt-affected soils, thus helping in preparing a sound database required for taking up various reclamative and preventive measures. In visual interpretation of satellite data, the area affected by water logging is found to be 1116.13 ha (0.42%) and 1802.42 ha (0.68%) respectively during pre and post monsoon season. The land affected by salinity during pre monsoon is 1320.91 ha (0.50%). The water logging follows a north-east to south-west direction and is predominant along the western side of twin canals (Sirhind and Rajasthan Feeder). Gidderbaha tehsil with 387.15 ha (0.58%) during pre monsoon and Mukatsar tehsil with 695.18ha (0.77%) during post monsoon is most affected by water logging, while Mukatsar tehsil with 774.01 ha (0.86%) is most affected by salinity during pre monsoon season. Improper alignment of canals, canal seepage, drainage congestion, brackish groundwater, faulty irrigation practices and cultivation of high water requirement crops are some of the factors contributing to the problem. These problems are further compounded by natural factors such as existence of topographic depressions, buried palaeochannels, absence of natural drainage and incessant rains.

2.9 Ground water balance of most of the blocks of District Tarn Taran has been overexploidedas shown in the table 9. As a result of increasing ground water exploitation over the years there has been a continuous fall in the water level in the region. The data given in the table 9 indicate that the water table is going approximately 0.20 m down every year if we take average of ten years At is evident that depletion of ground water table is really a serious cause of concern as supply of water is imperative for any agricultural production.

Table 9: Decrease in Ground water Table in District Tarn Taran

Decrease in the Interval of Ten		Decrease During the Year	
Interval	Decrease in water table (m/year)	Year	Decrease in water table (m)
1995-2005	0.2	2005	0.46
1994-2004	0.2	2004	0.18
1993-2003	0.24	2003	0.51
1992-2002	0.26	2002	0.65
1991-2001	0.21	2001	0.62
1990-2000	0.23	2000	1.2
1989-1999	0.11	1999	0.44

Table 10: Blockwise ground Water Resourse Data of District Tarn Taran

Sr. No.	Block	Net GW Availability (HAM)	Allocation for Domestic and Industrial Use (in HAM)		Existing Draft Irrigation (HAM)	GW Availability for Future Irrigation Development (HAM)	Present stage of GW Development (%)	Category of Block	Type of Formation
			Existing	Future Provision					
1	Bhikhiwind	20022	291	456	26075	-6509	132	OE	Allu.
2	Chohla sahib	10458	242	380	15065	-4987	146	OE	Allu
3	Gandiwind	20328	288	452	26547	-6671	132	OE	Mu.
4	Khadaur sahib	15899	303	475	24148	-8724	154	OE	Allu.
5	Naushehra pannuan	10031	255	399	14943	-5311	152	OE	Mu.
6	Patti	11994	251	393	22469	-10868	189	OE	Allu.
7	Tarn Taran	14837	751	963	28914	-15040	200	OE	Allu.
8	**Valtoha**	**12595**	**230**	**361**	**21510**	**-9276**	**173**	**OE**	**Allu.**

OE - Overexploited Allu – Alluvial

Table 11: Blockwise Information on Irrigated Area (Source Wise) in DistrictTarn Taran

Sr.No	Block	Irrigated Area (ha)			
		Major (Canals)	%	Minor (Tubewells)	%
1	Bhikhiwind	18144	72	7056	28
2	Chohla Sahib	14224	57	10730	43
3	Gandiwind	10620	38	17326	62
4	Khadaur Sahib	9997	37	16751	62
5	Naushehra	12036	44	15317	56
6	Patti	21306	72	8285	28
7	Tarn Taran	17800	52	16432	48
8	**Valtoha**	**24043**	**81**	**5639**	**19**

- The Average size of agricultural holding in district Tarn Taran was 3.41 ha in year 2000-01 .against 3.29 ha in 2005-06 .The total number of operational, holdings recorded in the district in year 2000-01 is 60149 as compared to 61766 in year 2005-06. Like the whole Punjab state, rice-wheat crop rotation is the main rotation of the District. Data in Tables 12 and 13 shows that district contributed 5,21 percent and 5.14 percent production of Wheat and Rice respectively to the state pool .

Table 12 : Land Use Pattern of District Tarn Taran

Sr.No.	Crop	Area of Districts	Area of state	Percentage of State (%)
1	Wheat	185	3488	5.3
2	Oilseed	1.5	56	2.67
3	Rice	171	2610	6.5
4	Cotton	3	604	0.5
5	Lentil	0.1	1.2	8.3
6	Sugarcane	2	-	-
7	Maize	1	453	0.22
8	Moong	1.8	11.7	15

Table 13 : Cropwise Production of Tarn Taran District and Percentage

Sr. No.	Crop	Production of District	Production of State	Percentage of State
1	Wheat	819	15720	5.21
2	Oilseed	23	1041	2.2
3	Rice	539	10489	5.14
4	Cotton	10	2355	0.42
5	Lentil	0.1	0.6	6
6	Sugarcane	11	-	-
7	Maize	3	521	0.57
8	Moong	1	8.4	11.9

Overview of Existing Facilities in Project Area

Electricity Distribution System in Study Area

2.10 Electricity is delivered to consumers through 11kV feeders downstream of the 33kV substation. Each 11kV feeder which emanates from the 33kV substation branches further into several subsidiary 11kV feeders to carry power close to the load points (localities, villages, etc). 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).

2.11 All six feeders namely Channu, Shenakheda, Punjawa are supplied at 11 kV from 33 / 11 kV substations comes under Lambi in Muktsar Districts and Muthianwala, Ramshinghwala & Talwandi are supplied at 11 kV from 33 / 11 kV substations comes under Toot Substation in Tarantaran Districts. All the six feeders are segregated agricultural feeders, feeding power to mostly agriculture pumps under the service areas.

Power Supply & Consumption of Pilot Project Feeder Lines

2.1 The hourly demand data for pilot project feeder lines from January 08 to December 08 is analysed to study the electricity availability hours. It is observed that the availability of supply for different feeders is in the block of 5 to 6 hours and for different periods of time in a day. In addition for each feeder, time block for supply availability shifts for different periods of time in rotation.

2.2 Monthly and annual hours of supply availability for each feeder line of pilot project are provided in the table below.

Table 14 : Feeder wise Monthly Supply Availability Hours

Year - 2008	Feeder Name					
	Channu	Shenakheda	Punjawa	Muthianwala	Ramsinghwala	Talwandi
January	201	202	202	160	165	165
February	190	187	187	0	162	160
March	187	196	196	0	165	164
April	131	135	135	0	163	160
May	118	113	113	0	160	162
June	198	196	196	0	209	208
July	248	248	248	220	220	219
August	248	248	248	220	219	218
September	234	234	234	220	221	220
October	164	161	161	170	170	171
November	150	151	151	190	190	189
December	168	175	175	170	169	168
Monthly Average	186.42	187.17	187.17	112.50	184.42	183.67
Annual Hours	2237	2246	2246	1350	2213	2204

A3: PUMP SET PERFORMANCE EVALUATION & COST BENEFIT ANALYSIS

Field Study Objectives and Overview

3.1 The following objectives were set to evaluate the efficiency of the 2186 pump sets connected on the six project feeder lines in two sub division Lambi & Khemkaran of respective districts Muktsar & TranTaran in Punjab.

- Performance evaluation and approach to improve efficiency of these pump sets
- Recommendation for pump efficiency improvements and cost benefit analysis

3.2 Detailed field study is undertaken to collect various parameters associated with 2186 pump sets connected on six project feeder lines. Field studies were undertaken by a 4 teams comprised of 4 personnel in each team. Each team was equipped with a set of power measuring instruments, flow measuring meter / stop watch & calibrated drum, measuring tape, GPS instrument etc.

3.3 All the four team members are made familiarise with the procedures to be followed at site during the measurements and provided with a standard data collection sheet attached as an **Appendix I**. A senior engineer monitored all the team and scheduling of measurement and activities in co ordination with PSEB personnel and local support.

3.4 The entire team was stationed at site for a period of 4 months for completing all measurements including verification and correction of abnormal results.

3.5 The field studies involved noting all pump set details and other data as per standard data collection sheet. The farmers were also interviewed for basic data like acreage of the farm, age of pump, R & M undertaken, normal pumping hours, seasonal variation in pumping, water table, cropping pattern etc. The pump sets were started and allowed to stabilise for few minutes before commencing flow and power measurements. The team co-ordinated the flow and power measurements.

Approach and Methodology

Overall Approach

3.6 The conventional method of evaluating pump set efficiency is by taking sample measurements of water flow, electrical power consumption, and total head comprised of suction and discharge head and the pipe dimensions along with number of elbows and bends etc. The overall approach in evaluating the pump performance is indicated in flow diagram provided in Figure 4 below,

Figure 4 : Overall Approach for Pump Performance Evaluation

Standard Data Collection Sheet	Standard data collection sheet was prepared and finalised prior to the commencement of the study to be filled-in at site.
Pump Specifications	All pump specifications and observations were documented and entered in the data sheet.
	Location for each pump was recorded with the help of GPRS navigational tool carried by site personnel during the study
Measurements	Motor input power consumption by power analyser, discharge measurement by volumetric flow method
	The suction length of tube well water table depth was recorded from farmer's data and also verified from boring agency in the region
	The discharge length of all piping was measured and also verified from farmers data at site
	Pipe inner diameter was measured at the suction and discharge end with the help of measuring tape
Measurement Precautions	Pump was started and flow allowed stabilizing for few minutes. The readings were verified two to three times to minimise errors.
	Minor leakages at few places were recorded. However, leakage rates were very small and overall impact on flow was found negligible.
	Power consumed by the pump was simultaneously measured during all measurements with the help of a 'clamp on' energy meter to measure and record kWh, KVA, current, voltage, power factor,
Stakeholder Consultation	The pump curves were collected for few makes and efficiency value's compared at different water levels.
	Energy efficient pumps are selected with help of pump manufacturers

Measurement and Technical Analysis

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

3.8 Water discharge measurement was expected by using ultrasonic flow meter. However due to site constraints it was not possible to meter hence same is been carried out by volumetric flow meter. Whereas portable power analyzer has been used for electrical parameter measurements.

Water flow measurement by ultrasonic meter

3.9 The ultrasonic flow meter is a non contact type online flow meter, having two sensors which are to be mounted on the pipe periphery as per the mounting method and pipe diameter.

3.10 The upstream side sensor transmits signal which is received by down stream side sensor. The signal is converted in to velocity and based on pipe diameter; the velocity is converted into flow. The instantaneous velocity and flow measurements were carried out and cumulative flow recorded.

3.11 However due to site constraint usage, ultrasonic flow meter is used for industrial applications.

Water flow measurement by volumetric flow method

3.12 During initial field visits at various agricultural pumps, it was observed that most of the water pipelines are of PVC and flexible, where ultrasonic flow meter can't be used. Hence, water flow has been collected in a barrel of known volume of 300 litres and time required in seconds to fill up the barrel has been measured.

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

$$\text{Water Flow } (m^3/hr) = \frac{\text{Volume of Barrel, } m^3 \times 3600}{\text{Time in Sec.}}$$

Actual head measurement

3.14 Since water pipelines are PVC & flexible, there is no provision for pressure gage / head measurement. Hence, head estimation by suction & discharge pressure measurement was not feasible.

3.15 Depth of water levels is noted based on farmers input and same has been verified from local boring agencies. Height of discharge from ground level and length & diameter of pipe were measured actually. All these constitute to actual pump head including losses.

Frictional / Pressure losses in pipes

3.16 Whenever water flows in a pipe, there will be some loss of pressure due to following factors:

a) Friction: This is affected by the roughness of the inside surface of the pipe, the pipe diameter, and the physical properties of the fluid.
b) Changes in size and shape or direction of flow.

c) Obstructions: For normal cylindrical straight pipes, the major cause of pressure loss will be due to friction. Pressure loss in a fitting or valve is greater than a straight pipe. When fluid flows in a straight pipe, the flow pattern will be the same through out the pipe. Valve or fitting, changes the flow pattern. This causes extra pressure drops. Pressure drop has been measured as per the following Darcy Weichbach equation.

$$H_f = \frac{4 \times f \times L \times V^2}{2 \times g \times d}$$

Where,

L = Length (m)
V = Flow velocity (m/s)
g = Gravitational constant (9.81 m/s²)
d = Pipe inside diameter (m)
H_f = Head loss to friction (m)
f = Friction factor (dimensionless)

Electrical Power Measurements

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

Pump set efficiency calculation

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

$$\text{Efficiency, \%} = \frac{(\text{Flow, m}^3/\text{hr x Head, m. x 9.81 x sp. gr., kg/m}^3)}{(\text{3600 x Motor Input Power, kW})}$$

Where,

Head = (Net Static Head + Velocity Head at Suction & Discharge + Friction losses due to fittings & length+ velocity head), (m)
Sp. gr. = Specific gravity of water, kg/m^3
Efficiency = includes efficiency of pump set i.e. pump + motor

Feeder Details

3.19 The six feeders selected for the study in two districts, In Muktsar district three feeders are Channu, Shenakheda, Punjawa and in TranTaran district three feeders are Muthianwala, Ramsinghwala & Talwandi. The feeder length, average hours of supply, avg. load, and no. of pumps on respective feeders are provided in Table 15. On an average power has been available for more than 4 hrs per day for each feeder.

Table 15 : Parameters Indicating Feeder Details

Sr No	Parameter	Channu	Shenakheda	Punjawa	Muthianwala	Ramsinghwala	Talwandi
1	Substation Name	Lambi	Lambi	Lambi	Toot	Toot	Toot
2	Voltage, kV	33	33	33	66	66	66
3	Feeder Length, km	50	80	55	51	45	47
4	Motor operated pump set, numbers	268	548	428	417	254	271
5	Feeder level Energy Meter	Available	Available	Available	Available	Available	Available

Pump set Details and observations

3.20 Agriculture is the main source of income and livelihood for the farmers of Punjab. Tubewells are the primary source of water for farming in this region followed by bore wells and open water sources. 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. The capacity range of tubewell water and submersible pump sets is 3 HP to 7.5 HP with a few handfuls of pumps of capacity greater than 7.5 HP.

3.21 Power for operating the pump sets is supplied by PSEB at supply voltage of 11 kV. The six feeders being studied under the pilot project are necessarily agriculture feeders and as such the power consumed under the same are for water pumps in the region. However, fraction of the power is also consumed by farmers living in the fields and connected on agricultural separated feeders. A small share of the power is also consumed by pumps that are presently not registered as listed consumers but are on the waiting list or paid & pending list of the grid for want of supply connection. The same have been classified under AT & C losses.

3.22 Total water pumps 2186 pumps operating under study Area, around 66 % are of monoblock type, 34 % are submersible type.

3.23 The major pump makes are M/s Anil, M/s Jonson, M/s Texmo, M/s Lubi, M/s Kirloskar, M/s Ratna M/s CRI, M/s Pluga, M/s Varuna, M/s Unnati and a host of several other companies. Of these, a major share is of locally assembled pumps. The name plate details of such pumps were not available.

3.24 The existing pump specifications from the name plate details available for the pump sets were notified and provided in the pump performance evaluation sheet attached as **Appendix II**. The year of pump set installation, causes and number of motor rewinds, any complete replacement done, overhauling frequency, maintenance costs etc, discussed with farmers and recorded as per standard data collection sheet (Appendix I).

3.25 In addition methodology of pump set selection adopted by the farmers namely criteria of varying water suction levels, stretched supply distance, pipe diameter and material, suitability to operate at low voltages, choice of several makes in the market, etc, has also been discussed with the farmers and recorded.

3.26 During field study, it is observed that most of the agricultural pump sets are in the range between 3 HP to 7.5 HP.

3.27 Major observations during the site study are listed below,

- Centrifugal pumps are commonly used for both surface mounted as well as submersible pump sets.
- Monoblock pump sets are installed in small wells or on ground level and where as submersible pump sets are installed in bore wells. In case of monoblock type pump its work like tubewell, tube are inside the ground similar like submersible pumps, accurate head measurement was not possible.
- Flexible P.V.C. pipes were commonly used for both suction and delivery sides.
- Due to varying water level, the pump-sets were on a platform which could be shifted to different levels to match the suction head.
- It is found difficult to note down the specifications of few existing pump-sets, as the same were installed inside the wells.
- Most of the pump motors (60-70%) have been rewound one or two times.
- The workmanship quality for pump set installation was poor. In feeders Channu Shenakheda & Punjawa few capacitors connected to agricultural pumps but in Muthianwala, Ramsinghwla & talwandi no capacitors connected to agricultural pumps.

- Even though the power availability is for 10 to 12 hours, intermittent power failures are observed frequently.

- Service wires and fuse protections are not appropriate size for several pump sets which has lead to frequent burning of the pump set motors.

3.28 *Pumps operated at site in auto mode:* The major reasons for pump set failure and lower discharge output was erratic power supply. 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.

3.29 *Actual Pump set rating higher than name plate rating:* It is also been observed that even though sanctioned demand is 3 HP or 5 HP, 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 farmers have rewinded the pump sets suitably to draw more power and deliver higher water discharge. Since in Punjab power is free no charge is taken from farmers. This is the major reason for no encouragement for deployment of more efficient pumps. It is difficult to make the farmers agree to have their pumps replaced, as it requires repeated efforts to make the farmers fully conversant to the objectives of the project. Hence social opposition is expected for metering of power supply at pump level. But there will not be that much opposition for metering at transformer level.

3.30 The farmers have reported extreme low voltage as the major cause for motor burnouts and lower pump output in the kharif season. The pump set selection by farmers is mainly driven by voltage constraint (Voltage imbalance) and water level variations.

3.31 *Pump set Installations:* The pump sets installation is inappropriate with lack of proper foundation and footings. The ground surface water pump sets are merely placed on wooden planks and not properly anchored to the ground. The pump sets are observed with high vibration levels, which also contribute to lower operating efficiency.

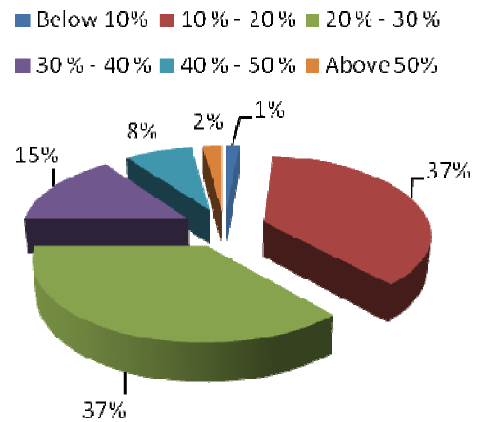
Operating Efficiency Performance Evaluation

3.32 Pump set operating efficiency was evaluated for all the pump sets, based on the measurement of parameters discussed earlier. Out of total 2186 pumps, 1782 pumps were actually tested on site. The operating efficiency is evaluated for the pumping system as a whole and not for the pump set alone. The entire pumping system is comprised off all the elements in between suction inlet foot valve to the discharge end of the delivery pipe at the field.

3.33 Due to the site constraints like motor burnouts or under repair, transformer burnout, theft of transformer & motors, the efficiency evaluation was not carried out for 404 number of pump sets.

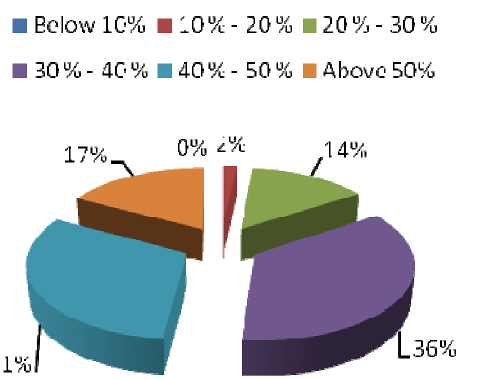
3.34 *Efficiency of Monoblock Pump sets:* Of the total 2186 pumps studied, 1188 are monoblock type pump sets. The efficiency measured for these pumps is in the range of 10 % to 40 %. Only a small fraction of pump sets have efficiency below 10 % and above 55%. Pumps with efficiency below 10% are due to a combination of several factors like use of frequently rewinded motors, non standard pumps, no maintenance, poor selection of pump, extremely low water depth to lower output and higher power consumption. Pumps with higher efficiency than 55 % are due to recent installations. Figure 16 gives the break up of efficiency range for monoblock pump sets.

Figure 5 : Operating Efficiency Range for Monoblock Pump Sets



3.35 *Efficiency of Submersible Pump sets:* Total number of submersible pump sets is 595. The efficiency measured for these pumps is higher as compared to tube well pump sets and has been in the range of 20% to 50 %. A small percentage of pumps have efficiency below 10 % and above 55%. Figure 17 gives the break up of efficiency range for submersible pump sets.

Figure 6 : Operating Efficiency Range for Submercible Pump Sets



3.36 The total number of pump sets lying in different range of operating efficiencies for different types of pump sets is also provided in Table 16 below. As discussed earlier due to various site constraint efficiency was evaluated only for 1782 pump sets.

Table 16 : Feeder Wise Operating Efficiency Range for Different Pump Types

Operating Range for Pump set efficiency	Type of Pump Set	Feeder Name					
		Channu	Shenakheda	Punjawa	Muthianwala	Ramsinghwala	Talwandi
Efficiency < 10 %	Monoblock	2	11	4	1	0	0
	Submersible	0	0	0	0	0	0
	Total	**2**	**11**	**4**	**1**	**0**	**0**
Efficiency > 10 % & < 20 %	Monoblock	84	171	176	6	1	0
	Submersible	1	2	0	2	1	4
	Total	**85**	**173**	**176**	**8**	**2**	**4**
Efficiency > 20 % & < 30 %	Monoblock	95	200	124	13	3	0
	Submersible	3	0	0	50	12	19
	Total	**98**	**200**	**124**	**63**	**15**	**19**
Efficiency > 30 % & < 40 %	Monoblock	31	70	33	29	14	2
	Submersible	0	0	0	96	46	71
	Total	**31**	**70**	**33**	**125**	**60**	**73**
Efficiency > 40 % & < 50 %	Monoblock	9	25	14	21	17	6
	Submersible	1	0	0	72	52	61
	Total	**10**	**25**	**14**	**93**	**69**	**67**
Efficiency > 50 %	Monoblock	1	5	4	1	11	4
	Submersible	0	0	0	38	33	31
	Total	**1**	**5**	**4**	**39**	**44**	**35**

Average Operating Efficiency and Average Power Input Estimates

3.37 Average operating efficiency and average power input for different types of pump sets with different HP rating are evaluated for 1782 samples (72 % of total) studied under pilot project. The overall average operating efficiency and Power rating is also estimated based on weighted average of HP rating for all the pump sets.

3.38 The operating efficiency and power input of the 404 samples (18 % of Total) those could not be studied due to the site constraints discussed earlier, the average operating efficiency and power input evaluations are allotted based on similarity of HP rating and pump type. For example the pump sets are classified as monoblock, and submersible type which are further divided on HP rating basis and an average operating efficiency & Power input evaluated from the 1782 pump sets actually tested is allotted for similar HP rating and pump type. Feeder wise and overall average operating efficiency evaluations for different ratings and types of pump sets are provided in Table 17 below. The unknown pumpsets (200 nos.) for which HP rating is not known is assumed monoblock pumpset are of 7.5 HP and submersible pumpset are of 10 HP.

Table 17 : Feeder wise Average Operating Efficiency for Different Ratings & Types of Pump Sets

HP Rating	Type of Pump Set	Feeder Name											
		Channu		Shenakheda		Punjawa		Muthianwala		Ramsinghwala		Talwandi	
		Average Efficiency (%)	Average I/P Power (kW)	Average Efficiency (%)	Average I/P Power (kW)	Average Efficiency (%)	Average I/P Power (kW)	Average Efficiency (%)	Average I/P Power (kW)	Average Efficiency (%)	Average I/P Power (kW)	Average Efficiency (%)	Average I/P Power (kW)
3 HP	Monoblock	0	0	0	0	0	0	32.81	4.60	0	0	0	0
	Submersible	0	0	0	0	0	0	40.14	8.55	0	0	32.89	8.10
5 HP	Monoblock	22.62	4.81	23.14	4.51	21.81	4.68	38.85	5.90	41.51	6.24	46.47	5.72
	Submersible	27.09	4.99	15.93	5.54	0	0	42.03	7.25	43.58	7.51	44.27	6.83
7.5 HP	Monoblock	24.65	5.61	25.69	4.82	20.02	4.68	33.44	6.19	44.17	6.19	46.27	6.53
	Submersible	0	0	0	0	0	0	37.83	8.49	42.08	7.48	40.24	7.84
10 HP	Monoblock	26.08	4.46	21.26	5.81	32.93	4.87	0	0	0	0	0	0
	Submersible	0	0	0	0	0	0	41.68	9.45	44.27	7.42	38.79	8.09
12.5 HP	Monoblock	0	0	32.44	4.36	0	0	0	0	0	0	57.21	7.94
	Submersible	0	0	0	0	0	0	44.10	10.87	0	0	33.05	11.67
15 HP	Monoblock	20.90	6.20	15.46	4.77	31.37	5.16	0	0	0	0	0	0
	Submersible	0	0	0	0	0	0	0	0	0	0	0	0
20 HP	Monoblock	0	0	15.30	5.29	0	0	0	0	0	0	0	0
	Submersible	0	0	0	0	0	0	0	0	0	0	0	0

The overall average operating efficiency for all 2186 pump sets under pilot project study has been thus arrived at around 33 %.

Parameters Affecting Pump Set Efficiency Performance

3.39 There are various parameters that could affect the pump set efficiency performance. Parameters identified that could affect the pump performance are listed below and discussed in detail in subsequent sections,

- Energy Inefficient Pump Sets
- Improper pump selection and usage.
- Undersized pipes.
- Suction head Variations and large discharge lengths.
- Inefficient foot valves and piping system.
- Motor rewinding and low voltage profile
- Water table variations
- Other common causes

Energy Inefficient Pump Sets

3.40 Due to lack of awareness about energy efficiency and flat HP based tariff structure for agricultural sector, energy aspect is overlooked by the farmers while selecting the pump sets.

3.41 For conventional pump sets the efficiency variation with respect to change in flow and head is very high. At both the extreme ends of the pump curves (head Vs flow) the efficiency of the pump set is low. However better designed Energy Efficient Pump Sets (EEPS) have a flat top efficiency characteristic, so that any reduction in efficiency away from the 'Best Efficiency Point' (BEP) is small. As guaranteed by energy efficient pump manufacturers the difference in best efficiency of a good design is marginal and at the most up to 3% to 4%. The energy efficient pump sets could be selected to match the capacity and head requirements and to operate at BEP during the normal operating conditions. This will result in maximum energy savings, as compared to present inefficient pumps.

Improper Pump Selection and Usage

3.42 The educational level of the Indian farmers is not adept in understanding the technological aspects of pump operation. This leads to lack of awareness on pump selection, operation & maintenance. The improper selection and operation leads to poor efficiencies and wastage of energy.

3.43 Field study has indicated that average overall efficiency of the pump sets is around 33 %. Major reason for pump set efficiencies lesser than the optimum efficiency is because the pump sets are not operating in the high efficiency range of flow and head. This is due to large range of suction & discharge heads for which the pump has been selected.

3.44 The lower efficiency is also due to improper selection of pumps and mismatching prime movers and due to inferior quality of the pumps being marketed. The selection of the pumps should be governed by the characteristic curves i.e. the efficiencies in the various ranges of flow and head valves and for normal operating condition, the efficiency should be maximum.

Undersized Pipes

3.45 Selection of appropriate piping size plays important role in system efficiency. If pipes of smaller diameter are used, the initial cost will be less but the frictional head loss and the operational cost will be more. On the other hand, if pipes of larger diameter are used, the initial cost will be more but the frictional head loss and thereby the operational cost will be less.

3.46 The optimum pipe diameter will have minimum total cost which comprised off initial cost and operational cost. The farmers, while selecting the pipe size considers initial cost only without bothering about the extra operational cost which they have to pay every year in terms of increased energy bill. It is a general practice that with 100 x 100 mm pump, the suction and discharge pipes of 100 mm diameter are used, which is incorrect. The exit velocity at the pump discharge is generally high as compared to velocity in the delivery pipe line. The pipe line should be sized taking into consideration the total discharge length. As a thumb rule, the velocity in the pipe line should not exceed 5 ft/sec.

3.47 The energy requirement of a pumping system operating over a period of time 't' can be expressed as,

$$E_p = \frac{t \text{ X } Q \text{ X } \Delta P}{\text{Efficiency } (\eta)}$$

Where,

t is time in sec

Q is the volume flow rate, m^3/sec

ΔP is the total pressure drop,

η is the motor pump set efficiency.

3.48 Assuming that the only losses are due to friction, ΔP is proportional to the square of volume flow ($\Delta P \sim Q^2$). Therefore, the power required to overcome friction increases as the cube of the volume flow. This relationship can be used to quantify the effect of diameter on energy costs.

3.49 For a given volume flow rate, the above expression for (ΔP) indicates that pumping energy is inversely proportional to piping diameter raised to the 5th power and directly proportional to friction factor. Since the friction factor also has a slight dependence on diameter, the pumping energy required to overcome friction in piping for different diameter is ,

$$E_{P1} / E_{P2} = (D_2 / D_1)^{4.84}$$

3.50 As per the Darcy Weichbach equation for frictional factor (H_f) estimation, for frictional loss to be minimum pipe diameter should be as large as possible. The suction pipe length should be short, just adequate to keep the foot valve submerged and straight with minimum bends.

3.51 Bends wherever unavoidable, should be of long radius. The coefficient of friction is less in case of PVC pipes. The friction loss will increase drastically in GI pipes, as they are prone to corrosion as compared to PVC pipes. The latest low friction loss PVC pipes will be installed in place of GI pipes, wherever applicable, to reduce the frictional loss on a sustained basis. The problems of erosion, corrosion and resultant clogging will also be avoided.

3.52 Thus, it will always be economical to select a PVC pipe and having a diameter a next size higher than the pump discharge size so as to have lower pressure drop and pipe resistance. The general practice is to select a pipe diameter that is able to maintain a water velocity between 3 to 5 ft/sec. Table 18 below indicates maximum water flow rates for a given pipe diameter so as to restrict the water velocity up to 5 ft/sec.

Table 18 : Pipeline Selection with Respect to Flow Requirement

Sr. No.	Pipe Diameter Inch	Flow Rate	
		m^3/hr	Lpm
1	0.5	0.693	11.56
2	0.75	1.561	26.02
3	1	2.775	46.25
4	1.25	4.336	72.27
5	1.5	6.243	104.07
6	1.75	8.498	141.64
7	2	11.100	185.01
8	2.25	14.048	234.15
9	2.5	17.344	289.07
10	2.75	20.986	349.78
11	3	24.975	416.26
12	3.25	29.311	488.53
13	3.5	33.994	566.58
14	3.75	39.024	650.41
15	4	44.401	740.02
16	4.25	50.124	835.42
17	4.5	56.195	936.59
18	4.75	62.612	1043.55
19	5	69.377	1156.28
20	5.25	76.488	1274.80
21	5.5	83.946	1399.10
22	5.75	91.751	1529.19
23	6	99.903	1665.05

Suction Head Variations and Large Discharge Lengths

3.53 Some of the pumping units have extra-ordinary high delivery point. This is especially true for well mounted pump sets with varying levels of water every season. Also, excessive length of discharge pipe creates additional friction head and causes extra energy consumption.

3.54 The pump should be installed as near as possible to the water level in the well to reduce suction head. The scope for reducing suction head is dictated by site conditions and the type of pump sets used. Due to seasonal water level variation it is observed that most of the monoblock pump sets in the region have temporary foundations so that the pump may be lowered in the well to enable proper suction and avoid cavitations.

3.55 However, with present trends of installing monoblock and submersible pump sets, there is no need for priming and no requirement for foot valve, thereby, leading to better efficiency of pump and longer life. Also, since there is no suction piping, the friction loss is limited to the friction in strainer.

Inefficient Foot Valves and Pipe Fittings

3.56 During the site study it is observed that the fittings provided by most of the farmers are very poor resulting in increased losses and leakages. Head losses in a poor quality foot valves are very high. Similarly head losses in sharp bends are also high. The farmers are mostly ignorant about the operational quality of these components.

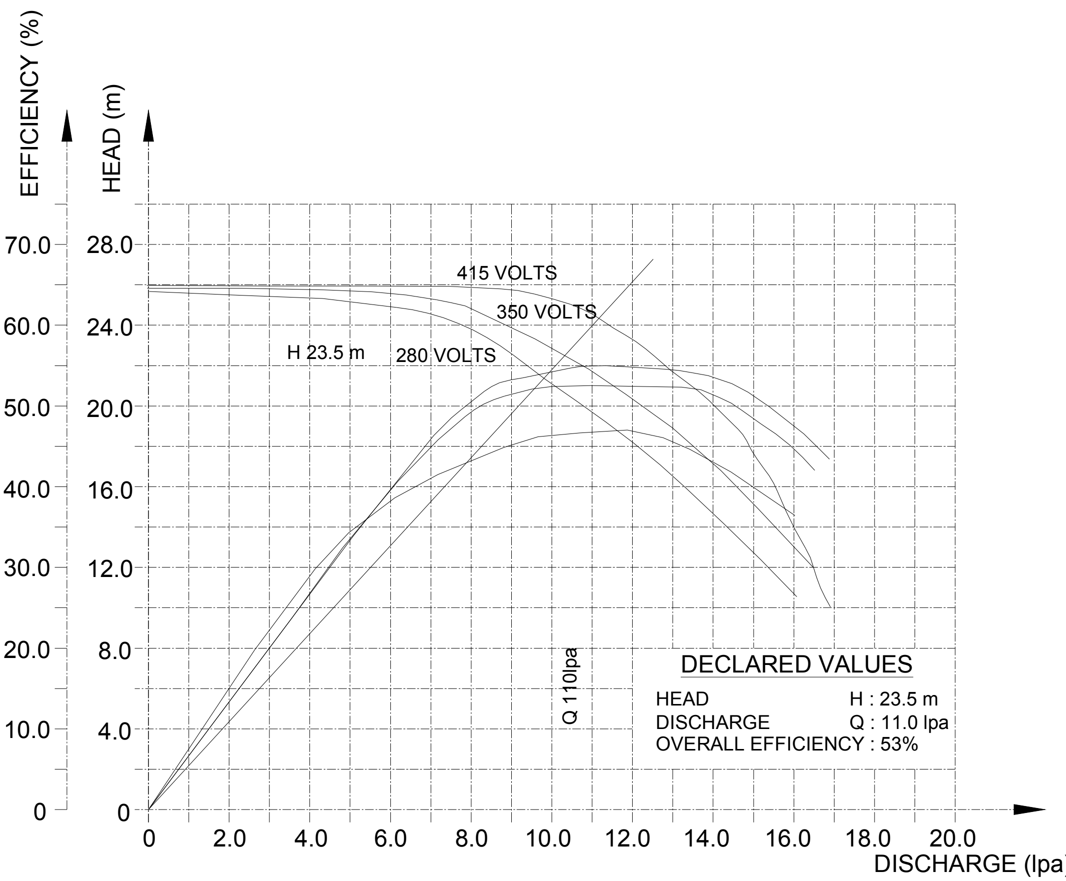
3.57 A foot valve should be designed to have a frictional co-efficient of less than 0.80 and should confirm to IS: 10805. The foot valve should have a bell-mouth profile to minimise the entrance and frictional losses substantially. To ensure the energy savings, foot valves of surface mounted monoblock pump sets could be replaced with low resistance design confirming to IS standards.

Motor Rewinding and Low Voltage Profile

3.58 For better pump set efficiency, motor driving the pump should be of proper size. Pertaining to the power supply issues in the region, it is observed that the farmers go for higher capacity motors which run at part load pulling the pump set efficiencies down. During the field study it is also observed that most of the pump sets have been re-winded several times due to frequent burn-outs.

3.59 The efficiency of a pump set also varies with input voltage. The consumer end voltage levels observed at project feeder lines varies from 390V to 440 V. Figure 7 below graph indicates variation in pump set efficiency with respect to supply voltage. The performance curve of a monoblock pump set (rated for about 24 m head, 11 litre/sec flow & overall efficiency of 55% at 415 V) at three different voltages is presented in Figure 7.

Figure 7 : Performnnce Curves for Monoblock Pump Operating at Different Voltages



3.60 Figure 7 shows that at a lower voltage level of say 350 V, there is an overall efficiency drop of 2.5%, drop in head by about 1.3 m and drop in discharge by about 1 lps, as compared to that of 415 V. Similarly, at further lower voltage levels of 280 V, the overall efficiency drops by 9%, drop in head is 3.3 m and drop in discharge by about 2.5 lps.

3.61 The efficiency and life of a motor can be increased by achieving low iron loss, copper loss, windage loss and suitability for operation at low voltage levels. Hence motors for agricultural pumps are always designed for a wide voltage band. The improvement in the quality of power in terms of frequency and supply voltage by implementing HVDS can significantly improve pump set efficiency and realise energy savings.

3.62 The efficiency of motors in EEPS is higher due to low iron, copper & windage losses. Better design and quality control have resulted in development of energy efficient pump sets. To overcome the issues of lower voltage operation, the new motors are also designed for a voltage fluctuation between 300V to 440 V.

Water Table Variation

3.63 The change in water table will have a significant impact on all existing agriculture pump sets operating efficiency. Selection of pump-sets according to water levels / head plays an important role in the context of overall efficiency of the pump-set.

Figure 8 : Variation of Efficiency with respect to Water Table

3.64 The Figure 8 above presents a typical head Vs efficiency range for centrifugal monoblock pump set of 5 HP. From the graph provide, it is observed that the overall efficiency of the pump-sets is max (> 42%) at water levels / head in the range between 23 m and 27 m approximately. *(Source: M/s Kirloskar Brothers Ltd.)*

3.65 It is observed that the average discharge head (for tube wells) at feeders Muthianwala, Ramsinghwala & Talwandi is in between 10 m and 20 m. For this head range, overall efficiency is found to be in the range of 15 % to 35 % as per the graph above.

3.66 Thus the EEPS could be appropriately sized based on measured head and flow for maximum efficiency for maximum operating period. As has been discussed with leading pump suppliers, the maximum water requirement period is the Karif period during which water and energy consumption is at peak. Hence the pump set replacement should be necessarily sized and rated for maximum efficiency and water demand during this period.

Other Common Causes

3.67 In addition to above there are other common reason affecting the pump set efficiency performance. Some of the more common causes of unsatisfactory performance and their remedies are discussed below, 3.68 *Impellers that are out of adjustment*: Both pumping rates and efficiency are reduced because water is re-circulated around the impellers instead of being pumped into the irrigation system. This is the easiest and least expensive problem to correct. However impeller adjustment is especially critical with semi-open impeller pumps. Impellers may be out of adjustment because of improper initial adjustment or because of wear.

3.69 *Pump bowls designed for a higher pumping rate* than the water availability in the well is one of the most common reasons for poor pumping efficiency. Overestimating well yield often results from poor testing of the well after drilling. If well testing is inadequate, the yield of the well may be less than anticipated. In other cases, the pump supplier recommended oversize pump bowls in order to require fewer stages, thereby reducing initial cost. Furthermore, declining water tables in some areas have reduced well yields. In this situation, a pump is forced to operate at a lower flow rate and higher lift than that for which it is designed. If for any of these reasons the pump capacity does not fit the well characteristics, a high pumping plant efficiency can be achieved only by replacing the bowls with new (not rebuilt) bowls that match with the well yield.

3.70 *Damaged impellers* also result in poor performance. Three common causes of impeller damage are cavitations (low temperature boiling of pumped water), sand pumping and improper impeller adjustment. Sometimes only the impellers need to be changed, but more often the permanent solution is to replace the entire bowl assembly. If this is done, it is likely that a different model of pump bowls should be used to fit present well conditions.

3.71 *Failure to perform required maintenance* is often a cause of low efficiency in pumping systems. Proper check for motor and pump alignment, coupling wear out, checking foot valves and plugging leaks should be regularly undertaken to improve overall efficiency.

Appropriate Sizing of New Energy Efficient Pump Sets

3.72 As per detailed field study, the overall average operating efficiency for existing 2186 pump sets under pilot project is 33%. The lower efficiency is due to a host of reasons like average 15 years age, frequent rewinding, improper selection, local make, no maintenance, low voltage etc. The main objective of the pilot project is to replace existing in-efficient agricultural pump sets with new high energy efficient pump sets without affecting the water discharge. To obtain maximum energy efficiency & savings margin, it is very much necessary to size the proposed Energy Efficient Pump Sets (EEPS) correctly on the basis of measured head and flow after considering water level variations.

3.73 The existing pump set efficiencies are calculated based on actual site measurement for all 2186 samples. As discussed in chapter 2, additional information such as water level variation, cropping pattern and harvesting cycles etc analysed to study the maximum variation in the operating head and peak time for pump sets operation. The data has been analysed with leading pump manufactures and a replacement arrived at based on their most suitable / matching 4 STAR & 5 STAR pump sets model.

3.74 Head and flow data for each consumer / pump set has been considered along with the sites water level variation and changes in cropping pattern to select an EEPS from the manufacturers STAR rated pump set models. This exercise has been carried out for all the pump sets audited. Budgetary costs for the proposed EEPS have also been received from the pump manufacturers. Selections of EEPS along with parameters driving the selection and improved efficiency figures are provided in **Appendix III**. The overall average operating efficiency for Energy Efficient Pump Sets is 56%.

Baseline Energy Consumption

Base line energy consumption of 2186 pump sets connected on 6 pilot project feeder lines is estimated for FY 2009-10 as Base year. The approach adopted is based on detailed audit study & the estimate of average annual operating/running hours of the pump sets installed in the distributional jurisdiction of PSEB.

Approach: The average operating efficiency and average input power in kW, for existing pump sets of different types such as monoblock and submersible for different HP ratings are estimated after analysing the field study measurements.

The annual operating hours of pump sets in Badal and Bhikiwind division for last 2 years is collected & analysed. This data has been collected from the sample meters installed by PSEB in the target feeders. Based on the analysis of this data, the average annual operating hours of pump sets in the target feeders is estimated as 1482.37 hours.

Table 19 : Division Wise Annual operating Hours

Year	Badal	Bhikiwind
2007-08	1267.331	1628.856
2008-09	1447.732	1585.566
Average Running Hrs	1357.5315	1607.211
All Six Feeder Average Running hrs	**1482.37125**	

- As discussed in earlier sections, even though the supply is available for an average of 5 to 6 hours on daily basis, not all the pump sets operate continuously. The reasons identified for not operating continuously are, varying irrigation requirements, non availability of water in the well, non availability of farmer to switch the pump set on and pump sets under repairs. Hence annual average operating hours are used to estimate the baseline energy consumption of all the pump sets connected on project feeder lines.

- The annual average operating hours for all the pump sets connected in the jurisdiction of Badal and Bhikiwind division is estimated to be 1482 Hrs as given in Table 19. However on a conservative side for calculation purposes the average annual operating hours of pump sets in the target feeders is considered as **1480 hours**.

- The analysis of historical data for past several years with regards to water availability, seasonal variation and cropping pattern, indicate that the water availability and seasonal variation will remain the same in future years and will not have any impact on pump set operating hours.

- The annual average operating hours of 1480 is multiplied by the average input power per pump set and total number of pump sets categorised on the basis of rating and type to estimate the baseline energy consumption. **Appendix IV** shows the size & feeder wise categorisation of pump sets. The detailed estimates of base line consumption by using annual average operating hours of 1480 is provided in Table 20 below,

Table 20: Baseline Energy Consumption Estimates Based on Average Input Power and Operating Hours

HP Rating	Type of Pump	No. of pumps	Average existing pump Efficiency	Average existing Input Power(kW)	Total Average existing Input Power (kW)	Total Energy Consumption (kWh)
3	Mono Block	10	32.81%	4.60	46.01	68,091.85
	Submersible	2	36.52%	8.32	16.65	24,635.92
5	Mono Block	1,066	32.40%	5.31	5,661.51	8,379,028.88
	Submersible	101	34.58%	6.42	648.74	960,128.73
7.5	Mono Block	337	32.37%	5.61	1,891.36	2,799,210.49
	Submersible	576	40.05%	7.94	4,573.04	6,768,092.23
10	Mono Block	21	26.76%	5.05	105.95	156,798.71
	Submersible	48	41.58%	8.32	399.41	591,133.55
12.5	Mono Block	6	44.83%	6.15	36.89	54,592.41
	Submersible	13	38.57%	11.27	146.48	216,790.32
15	Mono Block	5	22.57%	5.38	26.90	39,811.91
20	Mono Block	1	15.30%	5.29	5.29	7,836.18
	Total					**20,066,151.17**

- Thus the baseline energy consumption based on the proposed approach is 20.06 MU. The baseline consumption estimated based on this approach is used in the subsequent sections to estimate energy saving potential.

Estimates of Energy Saving Potential

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

3.76 The partial rectification covers the options other than replacement of pump sets (Motor & Pump) as listed below,

- Replacement of inefficient foot valves
- Removal of unnecessary lengths
- Removal of unnecessary bends
- Reduction in height of pipe above the ground
- Replacement of GI pipes with HDPE/PVC pipes
- Installation of capacitor banks for improving power factor

3.77 With the partial replacement requires farmers benefit in terms of more water discharge from the existing pumping system. However the reduction in energy requirement is marginal.

3.78 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 along with the replacement of foot valves is considered.

3.79 The rating of energy efficient pump sets for the replacement of existing pump sets is arrived at after analysing the maximum possible head and current water discharge requirement. With the help of pump set manufacturers each pump set data is analysed to propose energy efficient pump set along with its efficiency value **(Appendix III)**. The energy efficient pump sets are selected in a way so as to operate in the range where the pump set efficiency curve is almost flat. As per the pump manufacturers, the maximum variation in the efficiency of these new pump sets will not be more than 3% to 4 %.

3.80 The overall average expected operating efficiency for energy efficient pump sets is 56%. For new energy efficiency pump selection we used new energy efficiency curve which is provide by the pump manufacturer for different type (Monoblock & Submersible type) of pumpset to estimate the energy saving potential by replacement of all 2186 pump sets.

3.81 The overall average operating efficiency of 56% is used to arrive at revised average input power rating for energy efficient pump sets as provided below,

$$\text{Average input power rating for energy efficient pump sets} = \frac{\text{Overall average operating efficiency for existing pump sets for different HP rating * Existing average input power in kW}}{\text{Overall average operating efficiency for energy efficient pump sets for different HP rating}}$$

3.82 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 detail estimates of energy saving potential are provided in Table 21. As indicated in Table 21 below the Overall consumption of existing pump sets is work out to be 200,66,151 units, where as with energy efficient pump sets the consumption will go down to 126,79,905 units for same average operating hours. This leads to the savings of 7.38 MU

3.83 The replacement of existing pump sets with energy efficient pump sets would lead to energy saving. The percentage energy saving is calculated based on estimates provided in Table 21. The calculations are provided below,

$$\text{Percentage Energy Savings} = \frac{(\text{Energy Consumption by Existing Pump sets} - \text{Energy Consumption by Energy Efficient Pump Sets}) * 100}{\text{Energy Consumption by Existing Pump sets}}$$

$$\text{Percentage Energy Savings} = \frac{(20{,}066{,}151.16 - 12{,}679{,}905.14) * 100}{20{,}066{,}151.16} = 36.81\ \%$$

3.84 Energy consumption by the pump sets after replacement is estimated at 12.6 MU, leading to the savings of 7.38 MU.

Table 21: Energy Saving Potential for Replacement of Existing Pump sets with Energy Efficient Pump sets

HP Rating	Pump Type	No. of Pump sets	Existing Energy Inefficient Pump Sets			New Energy Efficient Pump Sets			Energy Saving Potential (kWh)
			Average Existing System Efficiency (%)	Average Input Power (kW)	Existing Energy Consumption (kWh)	Average Expected System Efficiency (%)	Revised Input Power Rating (kW)	Revised Energy Consumption (kWh)	
3 HP	Monoblock	10	32.81%	4.60	68,092	56.00%	2.70	39,890	28,202
	Submersible	2	36.52%	8.32	24,636	56.00%	5.43	16,065	8,571
5 HP	Monoblock	1,066	32.40%	5.31	8,379,029	56.00%	3.07	4,847,721	3,531,307
	Submersible	101	34.58%	6.42	960,129	56.00%	3.97	592,920	367,209
7.5 HP	Monoblock	337	32.37%	5.61	2,799,210	56.00%	3.24	1,618,142	1,181,069
	Submersible	576	40.05%	7.94	6,768,092	56.00%	5.68	4,840,149	1,927,943
10 HP	Monoblock	21	26.76%	5.05	156,799	56.00%	2.41	74,916	81,883
	Submersible	48	41.58%	8.32	591,134	56.00%	6.18	438,883	152,251
12.5 HP	Monoblock	6	44.83%	6.15	54,592	56.00%	4.92	43,699	10,893
	Submersible	13	38.57%	11.27	216,790	56.00%	7.76	149,329	67,461
15 HP	Monoblock	5	22.57%	5.38	39,812	56.00%	2.17	16,049	23,763
20 HP	Monoblock	1	15.30%	5.29	7,836	56.00%	1.45	2,141	5,695
Total					**20,066,151**			**12,679,905**	**7,386,246**

A4: AG-DSM PROJECT FINANCING AND BUSINESS MODELS

4.1 The purpose of the exhaustive study on agricultural demand side management is to develop investment grade DPR. The term bankable DPR stands in the context of developing the business models to enable the financing of Ag DSM projects.

4.2 Implementations of Ag DSM projects offer opportunity to reduce overall energy consumption, cut down energy bill to the farmers, reduces subsidy burdens on the distribution companies and state governments and mitigate the energy short situation while improving the water extraction efficiency. However for sustainable investment in Ag DSM projects it is required to develop business models to assure sustainability of the savings for loan repayments and to provide adequate incentives to the investors.

Design and Development of Business Models

Guiding Parameters

4.3 To capitalise Ag DSM potential savings, it requires to develop effective financing and business models to create benefits and incentives for all stakeholders which includes distribution utilities, farmers, private sector participants (ESCOS) investing for implementation of Ag DSM projects, state governments etc.

4.4 To develop an effective business model, it is necessary to identify the clear roles and responsibilities and the risks associated with the project development. This is useful to develop appropriate structure and plan for project financing and risk mitigation mechanism for ring fencing the risks of project investors.

Project Risk Assessment and Mitigation

4.5 Project risks can be categorized as project development risks, project competition risks, equipment / system operations and performance risks, financial; contractual, and political / regulatory risks. The various risks and risk mitigation options are summarized in Table 22 below,

Table 22 : Risk Associated and Mitigation Measures

Sr. No.	Risks Identified	Mitigation Strategies
1	**Project development risks**	▪ BEE to provide resources for DPR development, awareness generation, training of local specialists and development of contract documents associated with the project. ▪ BEE to undertake step-wise project development; beginning with thorough feasibility report; developing a business model to implement the project

Sr. No.	Risks Identified	Mitigation Strategies
2	**Project completion risks** ▪ On time ▪ According to specifications	▪ Contractor or ESCO selected for the project will have capability to implement the project ▪ Turnkey contract with normal commercial protections will be used. ▪ Contract will include provisions with respect to installation schedule, complete equipment specifications, and commissioning and acceptance testing procedures
3	**Resistance from Farmers**	▪ Open house sessions are being conducted to create awareness about the program ▪ An NGO will be employed to educate farmers on project benefits during the project implementation. ▪ New pump set to provide the same or more water discharge ESCO to provide after sales service
4	**Theft / Replacement of Energy Efficient pump set**	▪ Farmer will not get free repair and maintenance service for the remaining period
5	**Regulatory risks**	▪ Brain storming session to be organized with regulator and other stakeholders to identify key concerns and provide the information needed for an affirmative decision ▪ Third Party monitoring and verification through local NGO
6	**Pump set performance Associated risks**	▪ Minimum efficiency of pump-sets will be included in the contract ▪ Pump sets with 4 star and above will be installed ▪ ESCO will have to demonstrate the minimum efficiency level based on the accepted testing protocols ▪ Penalty clause will be included in case efficiency levels are below the minimum ones
7	**Measurement & Verification risks**	▪ Savings will be estimated based on the Deemed Savings Approach ▪ ESCO will demonstrate efficiency of pump sets periodically during the course of the contract period ▪ Savings to be monitored based on the actual consumption by installing energy meters for each pump set
8	**Water table declines, rainfall, weather; all affecting water quantity pumped and head and hence energy consumption**	▪ Savings estimates based on conservative approach so that if/when these risks manifest, the project will still generate net benefits
9	**Payment risks to ESCO**	▪ ESCROW account as a payment security mechanism
10	**Contractual risks (parties fail to honor contractual commitments)**	▪ Contract to be provided with appropriate commercial/ contractual provisions
11	**Political risks**	▪ Project inaugurations through Local influential Politicians

4.6 In line with BEE's objective "To create appropriate framework for market based interventions in agricultural pumping sector through Public Private Partnership (PPP) mode", the Ag DSM project funding could be from ESCOs with repayment over time from the stream of project benefits.

4.7 PSEB can also take up the implementation of this pump set efficiency improvement project with direct funding from financial institutions & due approval from the state commission.

4.8 Apart from these financing options, Tariff Regulations specified by the State Commissions for determining the ARR and Tariff, should have exclusive provisions under which the utilities can book the expenses incurred by it on DSM measures. Suitable provisions in the Tariff Regulations to allow recovery of DSM related expenditure as a part of Annual Revenue Requirement is one of the simplest way to create necessary funding for the implementation of DSM programs.

4.9 All the Direct costs associated with Ag DSM programs including design, implementation, monitoring, evaluation and incentives can be recovered through creation of a **special DSM fund** approved by the state commission. This ensures reasonable certainty of cost recovery, as failure to recover any costs directly impacts utility/ESCO earnings, and sends a discouraging message regarding further investment.

4.10 After considering the possible financing options, different business models have been developed and categorised as DISCOM Mode, ESCO Mode & HYBRID Mode as described below:

(a) PSEB will finance and implement the replacement of old inefficient pumps with new higher energy efficiency pump sets and contract out repair and maintenance of pumps and certain aspects of project works to a project contractor **(DISCOM Mode)**

(b) An ESCO (energy services company) which has a contract with PSEB finances and implements the project; the ESCO would borrow the project debt and repay it from project revenues **(ESCO Mode)**

(c) The project is financed and implemented through an ESCO. The DISCOM will support the capital expenditure and other operating expenses through annual payment from special DSM fund & share of energy savings resulting from the project **(HYBRID Mode)**

4.11 The business models for DISCOM Mode, ESCO Mode & Hybrid Mode are provided in Figures 9, 10 & 11.

Figure 9 : DISCOM Mode Business Model

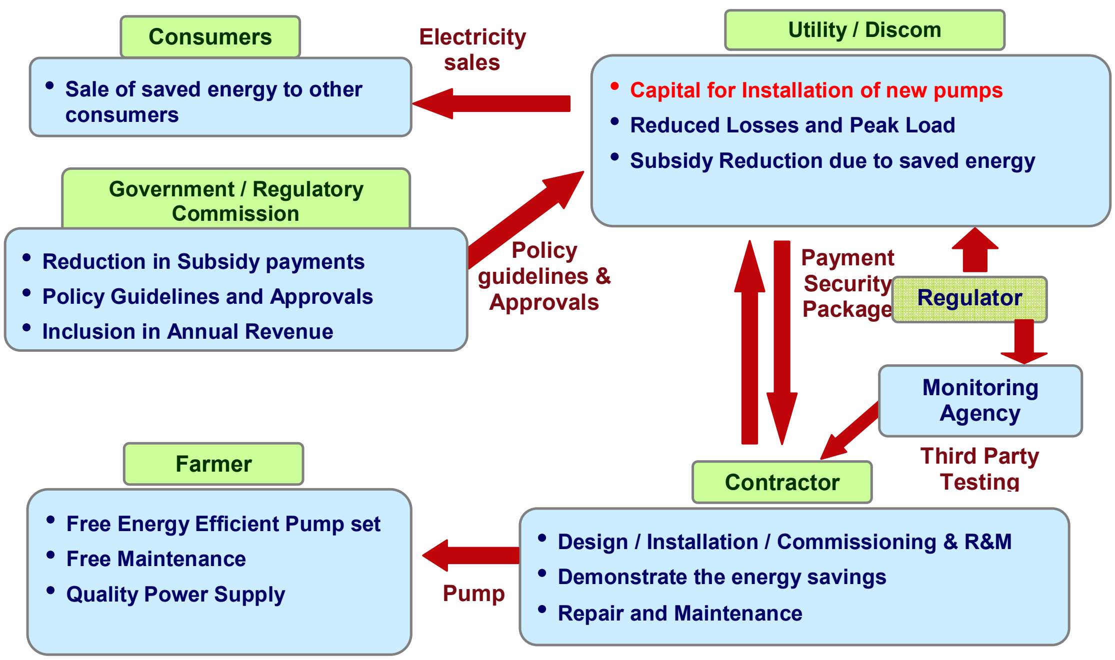


Figure 10 : ESCO Mode Business Model

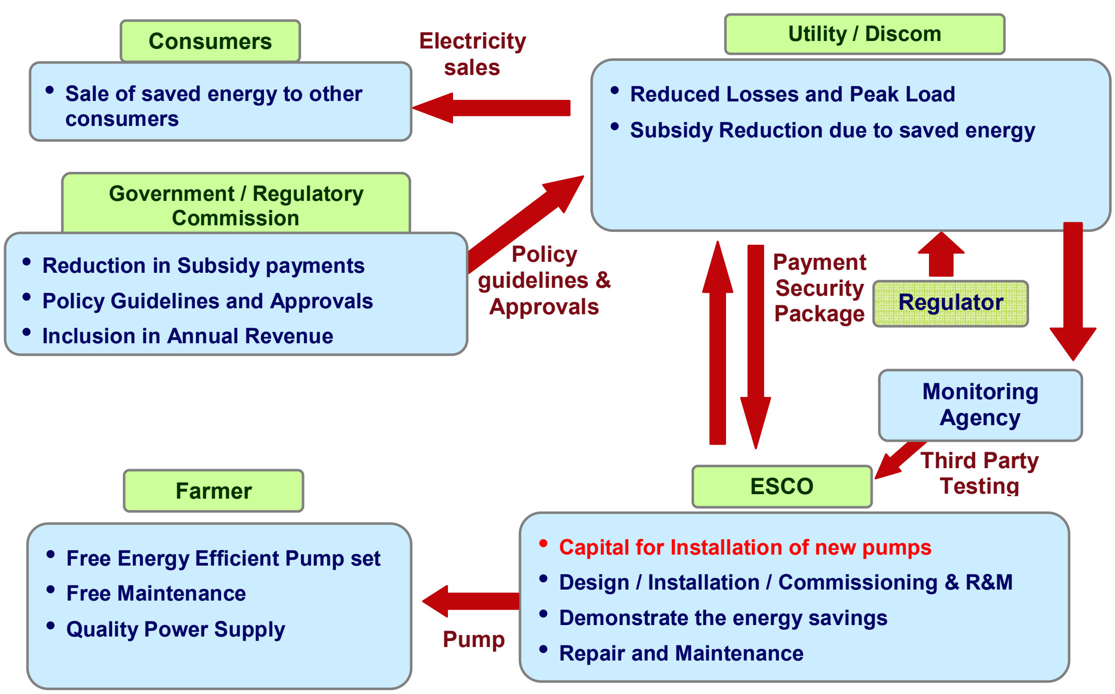
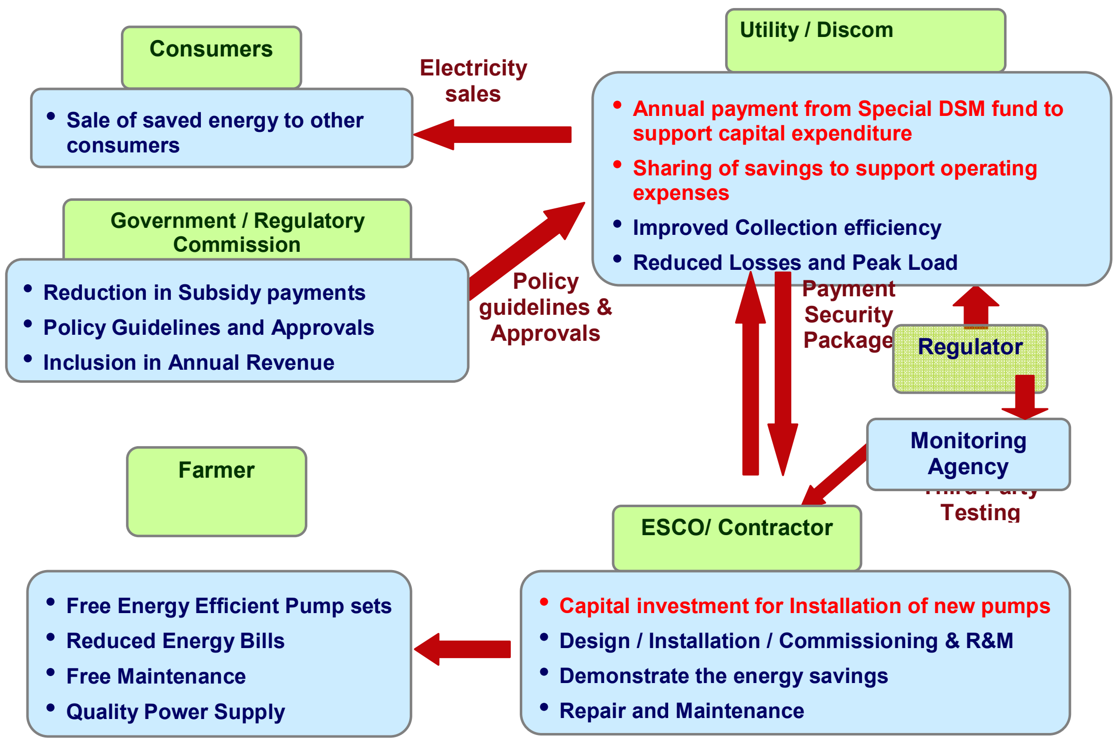


Figure 11: HYBRID Mode Business Model



Cost Benefit Analysis for Replacement of Existing Pump Sets

4.12 For successful implementation of Ag DSM projects it is necessary to carry out cost benefit analysis based on thorough assessment of project economics. Detailed financial model has been developed to implement the project through ESCO Mode and through DISCOM Mode. The financial model has been developed for both the business Models (ESCO Mode & DISCOM Mode) as provided in **Appendix V.** The financial model is designed to allow for sensitivity analysis of key project variables/assumptions.

Cost Estimates for Efficiency Improvement

4.13 Each item of the total project investment has been categorised as capital cost and operating cost. Various cost components of the pilot project are elaborated in subsequent sections.

Capital Costs

4.14 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.

4.15 **Cost of Energy Efficient Pump Sets:** 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 and details about the cost of the pump set for different types such as monoblock, submersible and flexible coupling and for different HP ratings is provided in Table below,

Table 23 : Cost per Pump set and Total Cost of Energy Efficient Pump sets

HP Rating	Type of Pump	No. of pumps as per proposed HP of EEPS	Cost, Rs/ Pump	VAT	Cost Per Pump Including Vat (Rs.)	Total Cost of Energy Efficient Pump Sets (Rs. Lakhs)
			b			
3	Mono Block	1,232	10800	12.50%	12150	149.688
	Submersible	5	18000	12.50%	20250	1.013
5	Mono Block	127	13700	12.50%	15413	19.574
	Submersible	271	22050	12.50%	24806	67.225
7.5	Mono Block	56	17050	12.50%	19181	10.742
	Submersible	343	26775	12.50%	30122	103.318
10	Mono Block	7	22800	12.50%	25650	1.796
	Submersible	102	31000	12.50%	34875	35.573
12.5	Mono Block	4	27400	12.50%	30825	1.233
	Submersible	35	35500	12.50%	39938	13.978
15	Mono Block	-	29150	12.50%	32794	0.000
	Submersible	4	40500	12.50%	45563	1.823
20	Mono Block	-	42900	12.50%	48263	0.000
	Submersible	-	45500	12.50%	51188	0.000
Total		**2,186**				**405.96**

4.16 As indicated in Table 23, the total investment required for replacement of existing pump sets with energy efficient pump sets is **Rs. 405.96 Lakh**.

4.17 **Cost of dismantling existing pump set and installing EEPS:** The cost of dismantling existing 1446 nos. monoblock and 740 nos. submersible pump sets has been estimated at Rs. 300 per monoblock pump set and Rs. 700 per submersible pump set, cumulating to **Rs. 9.598 Lakh** towards dismantling and installation.

4.18 **Cost of replacing foot valves for monoblock sets:** During the site study it is observed that the foot valves of monoblock type pump set are inefficient due to locally made brands. Hence it is beneficial to replace the same so as to not affect the performance of EEPS. The total no of foot valve replacements are around 1446, costing at **Rs. 7.13 Lakh** (@ Rs. 500 per piece. including installation cost).

Operating Costs

4.19 **Repair and Maintenance Cost:** The per pump R & M cost to ensure rated efficiency levels and sustaining the savings is estimated at about 10% of per pump set cost per year. The detail estimates of R & M cost are provided in Table 24 below. As provided in Table 24 the total R & M cost per year is around Rs.36.09Lakh. During the first year the R &M is covered under the warranty by pump manufacturers, however the ESCO has to carry out R&M for next for post warranty period.

Table 24 : Details of R & M Cost Estimate

HP Rating	Pump Type	Number of Pump Sets	Cost Per Pump Set (Rs)	Total R & M Cost Per year (Rs Lakhs)
		(A)	(B)	(D)= (A) * (B) / 10 ^ 5
3 HP	Monoblock	1,232	10800	13.31
	Submersible	5	18000	0.09
5 HP	Monoblock	127	13700	1.74
	Submersible	271	22050	5.98
7.5 HP	Monoblock	56	17050	0.95
	Submersible	343	26775	9.18
10 HP	Monoblock	7	22800	0.16
	Submersible	102	31000	3.16
12.5 HP	Monoblock	4	27400	0.11
	Submersible	35	35500	1.24
15 HP	Monoblock	-	29150	0.00
	Submersible	4	40500	0.16
20 HP	Monoblock	-	42900	0.00
	Submersible	-	45500	0.00
Total R & M Cost per Year				**36.09**

4.20 **Employee Costs**: The Man Power expenses for pooject management through ESCO route is provided in Table 25. As indicated in Table 25, the total manpower expenses per year are **Rs. 6.6 Lakh** per year.

Table 25 : Details of Man Power Expenses

Manpower Category	No.s	Cost per employee pm	Total Annual Cost (Rs.)
Project Manager	1	15000	180000
Accountant	1	12000	144000
Repair Workmen	2	10000	240000
Call centre executive	1	8000	96000

Total Employee Cost Per Year	**660000**

4.21 **Overall Project Cost:** The total project cost estimated for the Ag DSM Pilot Project at six feeders at Punjab, is Rs. 504.50 Crores. All the cost parameters discussed are tabulated below,

Table 26 : Details of Project Costs

Particulars	Value in Rs Lakhs
Cost of Energy Efficient Pump Sets	405.96
Cost of dismantling existing pump set and installing EEPS	9.598
Cost of replacing foot valves for monoblock pump sets	7.13
Total Capital Cost	**422.69**
Repair & Maintenance Cost per annum	36.09
Total Project cost	**567**

Monetary Savings/ Benefit to PSEB

4.22 Farmers would be major beneficiary of this Ag DSM project as EE pumps would provide either increased water discharge per unit of power consumed or same water discharge with lower power consumption.

4.23 PSEB would be benefited due to lower power consumption by energy efficient agricultural pumps due to sale of saved energy to other consumers.

4.24 PSEB revenue realized per unit is used as a proxy to average tariff. Average tariff realization for last 2 financial years is estimated from actual revenue from sale of power and actual energy sales to all categories of consumers except agriculture as provided in Table 27 below**.**

Table 27 : PSEB Average Tariff Realization

Parameters	2007-08	2008-09
Revenue From Sale of Power (Rs Crores)	7666.71	8718.06
Actual Sale to Consumers (MUs)	32122	32627
Average Tariff realized (Rs/ kWh)	**3.27**	**3.46**
Average		**3.34**

4.25 Agricultural consumers are supplied power supply free of cost whereas average Tariff realized from sale of power to other categories of consumers is Rs 3.34/ kWh. As the agricultural tariff is subsidised, PSEB also receives a subsidy from the State Government for power supply to agriculture consumers. The subsidy data for last 3 years was analyzed to find out the average subsidy realized per unit of agricultural consumption.

Table 28 : PSEB Agricultural Tariff

Sr. no.	Year	Subsidy in crore	Agriculture consumption	Average subsidy per unit
1	2007-2008	2285	10030	2.28
2	2008-2009	2296	9349	2.46
3	2009-2010	2804	10363	2.71
Average				**2.48**

4.26 As can be seen from the above table that PSEB received the subsidy for at an average rate of Rs. 2.48 per unit. The saved energy could be sold to other consumers at an average rate of Rs. 3.34 per kWh.

4.27 A detailed project financial analysis for a period of 5 years has been carried out for implementation through ESCO Mode, DISCOM Mode & HYBRID Mode. The summary of project cash flows and benefits for all three business models are provided in sections below.

Summary of Project Cash Flow and Benefits

4.28 The Table below provides the list of assumptions made in financial model for IRR estimation for all three business models. The Financial Model is attached as an **Appendix V**.

Table 29 : List of Assumptions for IRR Estimation

Assumptions:	Unit	Value
Project Scope and Unit Capital Costs:		
Savings Calculation Assumptions:		
kW per HP, conversion factor		0.7462
Annual deterioration in efficiency for new pumps	%	0%
Tariff(industry)	Rs	
Tariff (agri)	Rs	0
Per unit subsidy by state govt to agri	Rs	2.48
DISCOM's power purchase cost, per kWh	Rs	
Collection efficiency of subsidy from govt.	%	100%

Collection efficiency from farmers	%	0%
Distribution losses for Ag feeder	%	20%
Average distribution losses for discom	%	20%
Repair and maintenance cost as a % of pump cost	%	10%
No of average operating hours		1480
%age of new pumps added per month, as % of initial number	%	0%
Average cost of supply, (average tariff)	Rs/ Unit	3.34
Capital Costs:		
VAT	%	12.5%
Interest Rate	%	12%
Equity as a % of total costs	%	40%
Corporate tax rate	%	34%
Inflation Rate	%	0%
Manpoer cost escalation	%	5%
Depreciation rate	%	15%
Tariff Escalation Rate	%	0%
Cost of bend	Rs	50
Cost of GI pipe	Rs/m	150
ESCO Mode Business Model - Project Funding and Benefit Sharing		
Investment made by ESCO	%	100%
Initial funding provided by DISCOM	%	0%
Benefit sharing retained by ESCO	%	80%
DISCOM Mode Business Model - Project Funding and Benefit Sharing		
Investment made by ESCO	%	0%
Initial funding provided by DISCOM	%	100%
Benefit sharing retained by DISCOM	%	85%
HYBRID Mode Business Model - Project Funding and Benefit Sharing		
Investment made by ESCO	%	100%
Initial funding provided by DISCOM	%	0%
Benefit sharing retained by ESCO	%	35%

ESCO Mode

31. In this case the project is financed and implemented through an ESCO. The energy savings resulting from the project will be the source of revenue. The financial model analysed for a project cycle of five years indicates the economic viability for implementation of Ag DSM pilot project through ESCO Mode with **Equity IRR of 29.49%** and **payback Period of 3 years.** Also in this mode of implementation 5% of the annual benefit (savings) is retained with DISCOM and 15% of savings is shared with the state govt. which in turn accounts for 20% reduction in the subsidy burden borne by the state.

Table 30 : Summary of Cash Flow Statements for Project Implementation through ESCO Mode

IRR Estimation - ESCO Mode Business Model

	0	1	2	3	4	5
Initial Equity in Mn Rs	(16.91)	-	-	-	-	-
0	-	-	-	-	-	-
Units saved by deemed approach, in MUs (at pump level)	-	7.39	7.39	7.39	7.39	7.39
Loss of sale to discom from saved units, in Mn Rs	-	-	-	-	-	-
Revenue (Share of ESCO in savings), in Mn Rs.	-	19.74	19.74	19.74	19.74	19.74
Employee Cost, in Mn Rs	-	0.66	0.69	0.73	0.76	0.80
R & M Cost, in Rs Mn	-	-	3.61	3.61	3.61	3.61
Total Revenue expenditure, in Mn Rs.	-	(0.66)	(4.30)	(4.34)	(4.37)	(4.41)
Interest on debt, in Mn Rs	-	(3.04)	(2.66)	(1.90)	(1.14)	(0.38)
Tax in Mn Rs	-	(3.29)	(2.51)	(3.03)	(3.51)	(3.95)
Net Equity Cash Flow in Mn Rs	(16.91)	12.74	3.92	4.13	4.37	4.65
Cummulative cashflow in Mn Rs	(16.91)	(4.17)	(0.25)	3.88	8.25	12.90

Equity IRR	29%
Payback	3

DISCOM Mode

32. In this case the project is financed by a DISCOM. The implementation can be contracted out to an ESCO.

33. The saved energy could be sold to other consumers at an average rate of Rs. 3.34 per kWh. The detailed financial analysis based on the above details shows a **payback period of 3 years**. The **Project IRR** for a term of 5 years **is 31.36%.** Also in this mode of implementation 15% of savings is shared with the state govt. which in turn accounts for 20% reduction in the subsidy burden borne by the state.

Table 31 : Summary of Cash flow Statements for Project Implementation through DISCOM Mode

IRR Estimation - DISCOM Mode Business Model	0	1	2	3	4	5
Investment on new pumps in Mn Rs	(42.27)	-	-	-	-	-
0	-	-	-	-	-	-
Units saved by deemed approach, in MUs (at pump level)	-	7.39	7.39	7.39	7.39	7.39
Loss of sale to discom from saved units, in Mn Rs	-	-	-	-	-	-
Total revenue from sale of saved units, in Mn Rs.	-	24.67	24.67	24.67	24.67	24.67
Employee Cost, in Mn Rs	-	0.66	0.69	0.73	0.76	0.80
R & M Cost, in Rs Mn	-	-	3.61	3.61	3.61	3.61
Total Revenue expenditure, in Mn Rs.	-	(0.66)	(4.30)	(4.34)	(4.37)	(4.41)
Interest on debt, in Mn Rs	-	(5.07)	(4.44)	(3.17)	(1.90)	(0.63)
Tax in Mn Rs	-	-	-	-	-	-
Net Cash Flow in Mn Rs	(42.27)	20.31	16.67	16.63	16.60	16.56
Cummulative cashflow in Mn Rs	(42.27)	(21.96)	(5.29)	11.34	27.94	44.50

Project IRR	31.36%
Payback	3

HYBRID Mode

34. In this case the project is financed and implemented through an ESCO. The annual payment from special DSM fund & share of energy savings resulting from the project will be the sources of revenue. The detailed financial analysis based on the above details shows a **payback period of 2 years**. The **equity IRR** for a project term of 5 years is **31%.** Also in this mode of implementation 50% of the annual benefit (savings) is retained with DISCOM and 15% of savings is shared with the state govt. which in turn accounts for 20% reduction in the subsidy burden borne by the state.

Table 32: Summary of Cash flow Statements for Project Implementation through HYBRID Mode

IRR Estimation - HYBRID Mode Business Model						
Year	0	1	2	3	4	5
Initial Equity in Mn Rs	(16.91)	-	-	-	-	-
Units saved by deemed approach, in MUs (at pump level)	-	7.39	7.39	7.39	7.39	7.39
Loss of sale to discom from saved units, in Mn Rs	-	-	-	-	-	-
Total subsidy to discom from saved units, in Mn Rs	-	18.32	18.32	18.32	18.32	18.32
Total Revenue from sale of saved units, in Mn Rs.	-	24.67	24.67	24.67	24.67	24.67
Net Revenue from sale of saved units, in Mn Rs.	-	24.67	24.67	24.67	24.67	24.67
Payment from Special DSM fund, in Mn Rs	-	11.34	11.34	11.34	11.34	11.34
Share of ESCO in savings, in Mn Rs	-	8.63	8.63	8.63	8.63	8.63
Total revenue , in Mn Rs	-	19.98	19.98	19.98	19.98	19.98
0	-	-	-	-	-	-
Employee Cost, in Mn Rs	-	0.66	0.69	0.73	0.76	0.80
R & M Cost, in Rs Mn	-	-	3.61	3.61	3.61	3.61
Total Revenue expenditure, in Mn Rs.	-	(0.66)	(4.30)	(4.34)	(4.37)	(4.41)
Net Equity Cash Flow in Mn Rs	(16.91)	12.90	4.08	4.28	4.53	4.81
Cummulative cashflow in Mn Rs	(16.91)	(4.01)	0.07	4.35	8.88	13.69
Equity IRR	31%					
Payback	2.00					

4.29 Given that the project is techno-economically viable and the detailed financial analysis for provides attractive returns within a reasonable payback period, the project will have several ESCOs interested for its implementation through ESCO & Hybrid Modes. However in the ESCO Mode entire revenue from the project is exposed to subsidy risk resulting from the uncertainty in continuation of subsidy from the state govt. This risk is being mitigated in Hybrid Mode where only a part of revenue is exposed to subsidy as the other part comes from a special fund approved by GERC.

4.30 Over all, the project is well conceived and conceptualised, with sound commercial viability. The expected financial returns are quite satisfactory. Similar agriculture pumping efficiency improvement projects in other states are now techno commercially proven in India. All perceived risks have adequate safe guards. The project is recommended for equity participation and lending by financial institutions and PSEB as well.

4.31 All the technical risks have been discussed and mitigated. The energy savings are assured considering that almost all the pumps have been actually tested and efficiency levels verified. The above facts should give PSEB enough confidence to implement this Ag DSM pilot project on their own.

A5: MONITORING & VERIFICATION PROTOCOL

5.1 In the context of the agricultural DSM project, energy consumption in the baseline and project scenarios and consequently energy savings can be determined under two different approaches:

(a) One is the project **monitoring and verification (M&V) approach** that determines energy savings based on monitored values of efficiency parameters like head, flow and energy consumption.

(b) Other approach uses standard values of pumping efficiency (baseline and project pumps) and usage hours to arrive at energy savings called the **deemed savings approach**

5.2 **Measurement and Verification (M&V)** is the process of using measurement to reliably determine actual saving created within an individual facility/project by an energy management program. M&V activities include site surveys, metering of energy and independent variables, engineering calculations, and reporting. How these activities are applied to determine energy savings depends on the characteristics of the energy conservation measures (ECMs) being implemented and balancing accuracy in energy savings estimates with the cost of conducting M&V.

5.3 As the energy consumption of a pump depends on multiple factors like head, flow, efficiency, hours of operation and type and make of pump-set, monitoring all the parameters is likely to be impossible given the constraints of implementing such programs with farmers (particularly measurements involving electricity consumption) and is likely to be extremely expensive on account of number of pumps of different types covering vast geographical areas having different underground water levels and efforts and time required for head measurement.

5.4 In addition to the problems of monitoring the parameters, there are number of risks which are outside the ESCO's control. It includes farmer behavior, the amount of land under irrigation, cropping patterns, water table declines (potentially affected by adjacent farmers), weather and rainfall. All these factors can affect the quantity of water pumped and the head, which will cause energy loads to vary, even if the technical performance of the ESCO's installed systems perform as specified. Variations in power quality can also affect pump performance, useful life and maintenance and replacement costs. ESCOs and their lenders may not be able to accept full exposure to such uncontrollable risks.

5.5 The basis of successful energy efficiency and demand side management projects rest on the fact that electricity reductions can be determined to a degree of accuracy and trust that is acceptable to all stakeholders. The objectives of M&V are to provide an impartial, credible and transparent process that can be used to quantify and assess the impacts and sustainability of DSM and energy efficiency projects.

5.6 Contractually, ESCOs must stand behind technical performance and specific efficiency of the systems and equipment they install. These are key values in the M&V savings calculation. Other values in the savings equation, i.e., operating hours can be estimated using baseline energy consumption data and then stipulated in the project contract. In this way, the ESCO is not exposed to uncontrollable risks, but does assume responsibility for system efficiency. The Discom and State Government in effect, assume the uncontrollable risks. If the ESCO is paid based on the agreed value of its capital investment and delivered services, this formulation can produce equitable results.

5.7 For this reason, from the point of view of the ESCO and its lender, a **Deemed savings approach** may be appropriate. This would involve pre- and post performance demonstration of a sample of pumps by a third-party firm to estimate savings per pump set basis. This information is then be used to stipulate savings based on the operating hours estimated using baseline energy consumption data for the entire project area. Periodic sampling of pump set efficiencies during the course of the contract period is important to account for any deterioration of savings and to confirm that the ESCO is meeting its warranty obligations. Even if a Deemed savings approach is used to determine payments to the ESCO, the Discom can implement a monitoring and verification savings approach for all feeders and pump sets to gather the most accurate information.

Responsibilities of ESCO / Contractor

5.8 The primary responsibility of the ESCO are listed below,

- Procurement of EEPS as per the minimum specifications specified by BEE.
- Replace old pump sets, Install & commission the EEPS, provide O&M services for the project. O&M services shall include maintenance and repair or replacement of pumps, customer support to farmers to ensure optimum performance of pumps, monitoring of pump operation and efficiency and on-call emergency service.
- The ESCO will be responsible for planning EEPS procurement, installation, maintenance and repair/replacement. ESCO shall also be responsible for financing, implementing and operating the project. The ESCO shall procure ISI mark EEPS conforming to the guidelines of BEE and install them with the following minimum specifications;-
    i. Wide-voltage centrifugal, submersible pump and efficient delivery system. The discharge rate of the EEPS shall not be lower than the existing pumps of the farmers.
    ii. Low-friction foot valve and piping, conforming to relevant IS Standards specifications.
- After installation of the EEPS, services to be offered by the ESCO shall include maintenance of the installed systems over the contract period.

- The scrap value of the old pump removed shall be credited to PSEB as farmer's contribution against the cost-sharing payment.
- Training & Educating Farmers Regarding the Proper Use and Maintenance of EEPS

  i. The ESCO shall organize continuous periodical process of training, education and motivation of farmers / consumers for proper use and maintenance of the new pump sets, during the term of the project.

  ii. The ESCO shall obtain regular feedback regarding operation of the EEPS.

  iii. The ESCO shall send monthly reports to PSEB with feedback and remedial action, if any, to be taken as also suggestions / recommendations.

  - Removal and Disposal of Existing / Old Pump Sets
- The ESCO shall enter into an agreement with Farmers / Consumers, for replacement of existing pump sets with new ones and shall then ensure timely removal and disposal of old pump sets as per agreed time schedules with PSEB.

  i. The ESCO shall remove the existing old pump sets.

  ii. The ESCO shall dismantle and dispose off the old pump sets to prevent their use or installation anywhere in India.

  iii. The ESCO shall ensure that the disposed off pumps or any other old pump sets are not reinstalled / used by the participating farmers/customers.

  iv. The ESCO shall give written assurance and report to PSEB describing the manner of disposal of old pump sets.

  v. The ESCO shall assist PSEB's representative / appointed auditor to conduct audit to confirm the appropriate disposal of all old pumps and steps to ensure that they are not re-installed.
- Installation & Commissioning of Energy Efficient Pump Sets- The ESCO shall ensure that:

  i. The work will have to be executed as per the specifications at the locations identified by PSEB.

  ii. The EEPS installed should be capable of pumping the same quantity of water as compared to the existing ones.

  iii. Ensure replacement by and installation of all the 2186 new pump sets (plus additional as agreed), after execution of individual agreements, as per agreed time schedule and ensure that they are in proper working order and properly handed over to the concerned customer/farmer, and receipt obtained.
- Operation & Maintenance (O&M) Program / Services: O&M services by ESCO shall include the following,

  i. The ESCO shall set up & maintain an office at the site in Mangalwedha to provide O&M services with posted hours of opening along with posted procedures and phone numbers to obtain off-hours support.

ii. Undertake maintenance and repair or replacement of defective pump sets; maintenance of records regarding replacements; return of defective pump sets to the suppliers.

iii. Provide customer support to farmers to ensure optimum performance of pumps.

iv. Undertake monitoring of pump operation and efficiency.

v. Undertake on-call emergency service.

vi. Maintain inventory of spare pumps to be installed in the event of pump failure.

vii. Manage an ongoing communication and education program to encourage correct behaviours from farmers.

viii. Develop, obtain consent / approval from PSEB and farmers and manage a protocol to ensure that the initial efficiency gains are sustained.

- Procedure for Replacement under Warranty: The ESCO shall provide warranty for installed EEPS. An agreed procedure and format will need to be incorporated in the agreement letter between PSEB / farmer and ESCO regarding the replacements, if any. The procedures for EEPS replacement are as follows:

  i. In case of failure of any EEPS, the customer shall be required to return the failed EEPS to the ESCO, providing the reason of failure and submit the proof of installation as made under the above scheme. A copy of the agreement between ESCO and farmer shall be considered as a valid proof of installation.

  ii. The ESCO shall replace the EEPS and shall mark in the original letter confirming the issue of the replaced EEPS number and the date.

  iii. The ESCO shall keep a record of the EEPS and provide this information to the PSEB program administrator / Project Manager monthly as per agreed report Performa and procedure.

- **Monthly Progress Reports:** A monthly project report as per agreed format will have to be submitted by the ESCO for the entire duration of the project. Any additional project brief will also be prepared including barriers faced and resolved during and after installation of EEPS.

- **Inspection and Tests:** PSEB and BEE or their representatives can inspect any or all of the installations during the project term either independently or along with ESCO representative. In order to ensure that the replacements operate as per desired specifications and standards. The ESCO will be required to carry out tests on a quarterly / seasonal basis (as per different water levels) or in a manner specified by BEE / PSEB and submit the results. The results would be compared by BEE/PSEB and any difference or discrepancies detailed as compared to the specified standards so as to suitable correct the savings and payments due to ESCO. The reports will be prepared and submitted within reasonable time frame say about a week from conducting such tests. The ESCO shall incorporate comments as per the report and rectify defects and carry out remedial measures, if any, as given in the report and submit report to BEE/PSEB in this behalf.

- Bank Guarantee

  i. The PSEB shall require a Bank Guarantee from the ESCO as security against warranty obligations. Under such warranty obligations, the ESCO is required to promptly replace any EEPS that fails during the project period and inform PSEB accordingly.

  ii. Provide information on the progress of installation and, after implementation, of the operational performance of EEPS every month to PSEB.

  iii. Provide information on failure of EEPS under the program during the agreement period to PSEB.

- Carbon Credit Benefits

  i. The responsibility of registering the pilot project for availing carbon credits will be with the ESCO.

  ii. The ESCO shall prepare the Project Design Document and obtain required approval from the United Nations Framework Convention on Climate Change (UNFCCC).

  iii. All required and relevant data, technical support and necessary documents will be provided to the ESCO by PSEB on a timely basis to support the ESCO's application for carbon credit.

  iv. The benefits of carbon credits as applicable can be solely availed by the ESCO.

- Equipment Procurement / Purchase of New Pump Sets

  i. The ESCO has to purchase & install minimum 2186 EEPS after finalizing terms and conditions with PSEB including the terms for the warranty.

  ii. The ESCO has to check each of the pump sets received to ensure they are as per specifications and working.

  iii. The ESCO has to ensure that the EEPS meet the mandatory specifications.

  iv. The ESCO has to ensure that the warranty period is for minimum 12 months after installation of pump sets or longer as agreed by the ESCO and provided by the pump manufacturer, which is extendable up to a further period of 2 years at the option of the farmer/consumer.

  v. The ESCO has to assign separate serial numbers and markings in the pump casting and record and maintain the same.

  vi. The ESCO has to ensure that all EEPS installed have a unique serial number on the name-plate in addition to the marking in the castings for identification with the program and for warranty obligations. Such markings shall be readily visible above ground and duplicated if necessary.

vii. The ESCO has to provide the customer/farmer with a letter indicating the date of installation, service, serial number, capacity, make and the program under which it is installed. A copy of the letter shall be provided to BEE PSEB.

PSEB's Duties, Responsibilities and Obligations

- Project Commencement
  i. PSEB shall ensure good power quality and load management system in pilot project area. PSEB shall provide minimum 3000 hrs power supply to each feeder.
  ii. PSEB shall provide ESCO the data and support necessary for implementing the tasks as above.
  iii. PSEB shall be responsible for operation, maintenance and repair/replacement of power supply system (including energy meters) to EEPS.
- On Field Support : PSEB shall provide necessary support to the ESCO at the field level, as may be required by ESCO from time to time, including, amongst others, regarding access to consumer premises, replacement of existing pump sets, recovering old pump sets and signing agreement with the farmer/consumer.
- Maintenance of Power Supply System (line, transformer, capacitor, meter etc)
  i. PSEB shall be responsible for operation and maintenance of power supply system.
  ii. PSEB shall promptly attend to any break down including repair or replace or replacement of any equipment used/needed for maintaining electricity supply.
- Payment: PSEB will make payments on a monthly basis to the ESCO based on the savings formula derived from competitive bidding and any related negotiations.

Payment Terms and Conditions

- The payments will be made on a monthly basis to ESCO after the replacement of old sets / installation of EEPS as per agreed savings and its certification by BEE/PSEB. The ESCO shall ensure successful installation of all EEPS within agreed time frame subject to which Liquidated Damage (LD) charges will be made applicable as per agreed contract.
- The typical terms could involve ;
  i. Contract period years.
  ii. Name of feeders and its substation.
  iii. No .of pump sets to be replaced. Total no. of pump sets at the start of the pilot project. Estimated no. of pump sets to be added after project inception date.

iv. Estimate & confirm baseline energy consumption for present plus additional pump sets as per DPR.

v. The ESCO and PSEB can commence measurement of power consumed on the feeders under study and fix the baseline demand.

vi. Quantum of energy savings to be certified between ESCO and PSEB.

vii. Share of energy savings between ESCO and PSEB as per project agreement.

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