Sustainable Water Management Program for Buchkewadi Village

Using

DATAMATRIX TECHNOLOGY

Implemented by Green Energy Foundation

Under NABARD FIPF

DATAMATRIX

SUSTAINABLITY REPORT

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Executive Summary

Buchkewadi Village is situated in Junnar District, Maharashtra – India. The water requirement of the village is met through a Minor Irrigation Dam built under a USAID Program. As per an agreement, the water in the Dam is shared between Buchkewadi and the nearby Village at a sharing ratio of 40:60 respectively. The Dam water is used by Buchkewadi village using 18 Pumps under 8 cooperative societies for water management. Green Energy Foundation identified an opportunity to improve the sustainability of the Buchkewadi village, leveraging Datamatrix Technology.

Datamatrix Technology was deployed at Buchkewadi village under a grant from NABARD under the Farming Innovation Project Fund, by Green Energy Foundation. The technology has captured the real time operational data of the pumping infrastructure of the Buchkewadi village. A detailed analysis is made on the data captured by the Datamatrix System and further Research conducted on the data with the advanced simulation and performance modeling feature of the technology has led to the preparation of this Sustainability Report for Buchkewadi.

The report quantifies Water-Energy resources of the village, and identifies the water energy footprint of each farmer. It is observed that the village uses only 32.18% water as against 40% water entitled for the village, due to the absence of any precise water measuring device at the discharge point of the dam water to the nearby village. Further Datamatrix System assessed the individual water withdrawal by each pump and the respective cooperative society to draw a water balance. It was observed that there is a huge disparity in the water usage against irrigated land area between the farmers, leaving huge opportunity to optimize water use, avoiding wastage through excess irrigation. This can reduce the water usage by 27.57%.

This report provides detailed methodologies for measuring water and energy and correlates their interdependences for a sustainable water energy resource management. This report also provides a clear roadmap for sustainability of the village, through continuous improvement water and energy efficiency by reducing the wastages through smart monitoring and effective controls. The daily water and energy use will be closely monitored by the water committee.

The village currently uses electricity for pumping water to the tune of 80759.47 KWH with an annual water use of 288.97 ML. The sustainability in water energy and environment can radically improve the livelihood of the villagers, and mitigate the risk of climate change.

The key benefits of the project are highlighted below.

- Meter Monitor Audit and continuously Optimize Water and Energy use
- Improve water availability for effective utilization by 71%
- Immediate energy savings of 27.57% and an overall saving potential of 67%
- Reduction in CO_2 emissions by the village by 35 Tons/annum.
- Improvement in livelihood and income by 33% with additional employment and income of 4 months, with an increase in the income of the village by Rs.6,340,000/-PA.

The data generated may be used for further research for evolving the best strategies for sustainable agriculture. A sustainability plan for Buchkewadi is detailed in Section-4 of this document.

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TERM	DESCRIPTION
BEE	Bureau Of Energy Efficiency
BEP	Best Efficiency Point
D-RMU	Datamatrix Remote Metering Unit
IPMVP	International Performance Measurement & Verification Protocol
ISO	International Standard Organization
MI	Minor Irrigation

1 Background

1.1 About this Program

Oasis is a program for sustainable water management initiated under the Green Energy Foundation, an NGO dedicated to sustainable water-energy and environment. Green Energy Foundation identifies scalable technologies that can radically improve the energy and water efficiency and also implement them. This program leverages Datamatrix Technology for Integrated Water-Energy Resource Management with continuous audit and optimization.

India has the largest irrigation infrastructure in the world with ironically the lowest water and energy efficiency. The agricultural sector accounts for 85% of the water usage and 27% of the electricity usage of the country. The current irrigation and energy efficiency is abysmally low, leaving a huge opportunity to improve irrigation water and energy efficiency. By and large, water is used as available in India and no water management practices are in place for a sustainable water management. 80% of the cost of the water is mainly on account of the energy cost for pumping water. The energy performance will in turn depend on the water pumping infrastructure and the optimum usage. A sustainable water management program shall integrate water-energy-infrastructure to optimally manage the resources. The key to sustainable water management for agriculture will depend on metering monitoring and reducing the wastage on all fronts.

Datamatrix Technology facilitates total integrated metering of water and energy consumed by each agricultural pump and identifies the opportunities for optimization on a real time basis, with continuous energy and water audits. The unique feature of this technology is that all operating parameters of the pumping systems are identified based on the energy input to the motor. The technology is successfully deployed at some of the largest water and waste water utilities in India.

1.2 NABARD Support for the Program

NABARD has several programs devised for the improvement of the agricultural sector as well as rural development. The most pressing issues facing the country in the agricultural sector is the sustainable water and energy management. NABARD after evaluating the project proposal for Buchkewadi Village, has provided a grant of Rs. 10 Lakhs through Green Energy Foundation for deploying the Datamatrix Technology for Buchkewadi Village under the Farming Innovation Project Fund (FIPF).

1.3 Buchkewadi Village

Buchkewadi Village located in Junnar taluka, Maharashtra has a population of 1625. The water requirement of the entire village is met through a minor irrigation dam built under a USAID program. 18 Pumps ranging from 5 to 15 HP irrigate the entire village, under eight cooperative societies. The village uses the pumps by rotation under each society to irrigate the individual land holdings. The pumps are generally in service during the month of October to March.

FIGURE 1: AERIAL VIEW OF THE MINOR IRRIGATION DAM AT BUCHKEWADI

1.4 Deployment of Technology

The site survey was conducted in the 1st week of February 2011 and detailed test of only 11 pumps were conducted out of total 18 pumps at site from 28th February 2011 to 22nd March 2011; as the remaining pumps were not in service since the water level at the dam had fallen below the limit set for irrigation. The pumps in service were hooked on to the Datamatrix system for real time monitoring.

Again when pumps where started from October 2011, the retesting of pumps where conducted from 13 November 2011 to 22 December 2011 to cover the pumps which were not tested earlier. At present none of the pumps are in service. All pumps are set to be monitored from the next pumping season starting from Oct. 2012.

The real time data of the first batch of pumps commissioned are captured by the Datamatrix system. The Water and energy scenario of the entire village could be simulated using Datamatrix Technology, using the supply conditions and usage pattern captured by the system. All pumps will be made available on real time monitoring through the Datamatrix Technology for the current operating period of pumps.

1.5 Buchkewadi Water Committee

The village has formed a Water Committee under the village Panchyat to tackle its water crisis. The committee comprises one representative from each society and is headed by the Sarpanch of the village. All actions towards water usage or conservation are directed by this committee. The committee decides as to when the pumps should be disabled in the dry season and how much water should be withdrawn from the dam. But with no tool to measure the usage of water by each society and absence of any accurate measuring device to estimate how much the water should be discharged from the dam, the committee is unable to take any significant steps to improve the water scenario at Buchkewadi.

FIGURE 2: INTERACTION WITH THE BUCHKEWADI WATER COMMITTEE

1.6 Water Allocation

The water collected in the Minor Irrigation Dam caters to the water need of two villages. Buchkewadi is entitled to 40% of water and the nearby villages share 60% of the water through a controlled water canal under an agreement. Ninety percent of irrigation need of Buchkewadi is met by the minor irrigation dam. The ground water usage is estimated to be to the extent of 10%, apart from the water directly pumped from the dam. The availability of water in the bore wells is dependent by and large on the water level of the minor irrigation dam.

The MSEDCL Power supply is available for 6 to 8 hours a day and the pumps are pressed into service according to the availability of the power supply. The water supplied is assessed based on the number of hours of running the pump. The assessment of water delivered is vague using this method, making it difficult for an equitable water distribution.

The farming activity comes to a standstill during the peak summer due to the non availability of water. A sustainable water management program that can optimize the water usage can increase the water availability leading to higher productivity of the village. The farmers are facing problems for equitable water distribution and sustainable water management.

1.7 Technology Implementation

The over arching need of the hour at Buchkewadi is a sustainable water management, accounting for the water used by each farmer for equity in water use. Datamatrix technology will continuously assess the water availability and cost effectively Meter & Monitor the Energy and Water at each point of withdrawal. The farmers look forward to an equitable water distribution and embark on greater productivity through optimum water and energy utilization.

The following pictorial view shows the pump locations and the Datamatrix Remote Metering Unit (DRMU) deployed in Buchkewadi village.

FIGURE 3: PICTORIAL VIEW OF DATAMATRIX D-RMU LOCATIONS AND CONNECTED PUMPS

Datamatrix provides a suite of innovative software technologies for integrated performance management of pumping utilities. The unique feature of this technology is that it will eliminate the need for expensive instrumentation. It can virtually meter the critical system parameters including pump-wise flow and efficiency. This system will dynamically indicate the losses against each machine and facilitate a continuous energy audit based on the inputs from energy meters connected to each motor pump set. The Datamatrix Virtual Pump Station works on the principle of calibrated simulation based on the site test data and validation of the simulated data using continuous energy mass balance.

The Datamatrix virtual pump station has the facility to remotely manage the pumping network with total visibility over all the operating parameters to the minute detail with its performance levels. It can also carry out performance simulations and analytics to arrive at the optimum solutions, conserving water and energy.

The Datamatrix Technology will meter and monitor the quantum of water delivered by each pump on a real time basis with daily account of water and energy use. The system will identify all opportunities for optimization of water, energy and machine performance on a real time basis. This web based technology will enable remote monitoring and a team of experts will provide the necessary advice for continuous improvements.

The technology uses a new paradigm of virtual metering (Datamatrix Patent No. 236496) that enables the measurement of all hydraulic parameters and dynamic efficiency of a pumping system from the energy signature of the motor. This will drastically bring down the instrumentation cost in metering monitoring audit and optimization of pumping utilities.

The following pictorial view shows a Pumping System with Datamatrix and its core functions.

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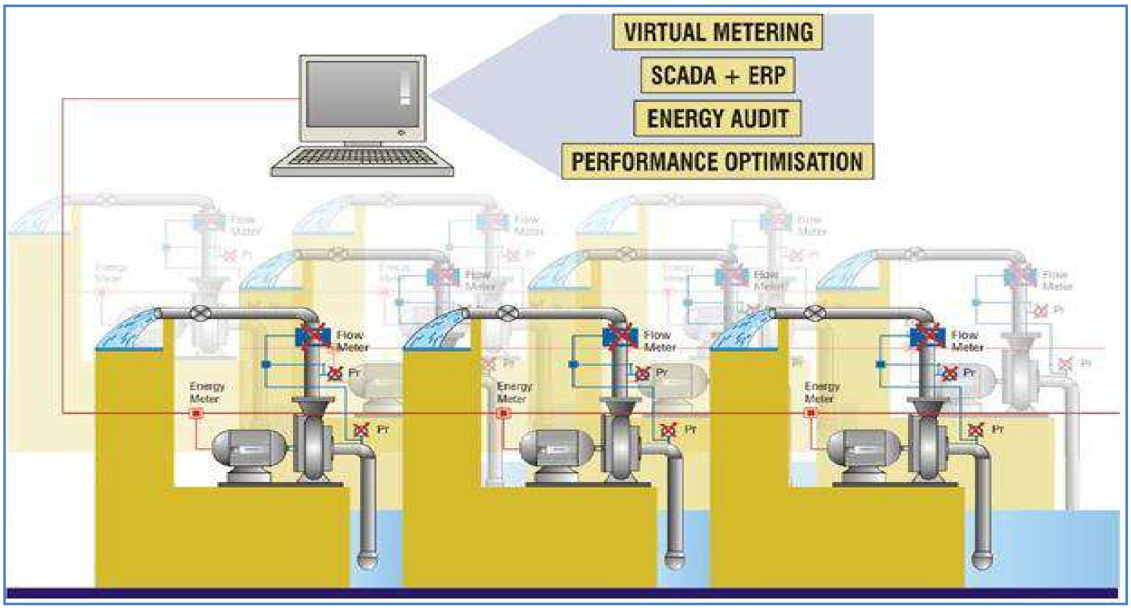


FIGURE 4: DATAMATRIX TECHNOLOGY - PICTORIAL VIEW OF CORE FUNCTIONS

The Datamatrix System will essentially consist of a smart energy meter with data communication arrangement that can transmit the real time energy data to a web server. The Datamatrix web server will continuously interpret the data into real time performance parameters that can be monitored by various stake holders as depicted in the following figure.

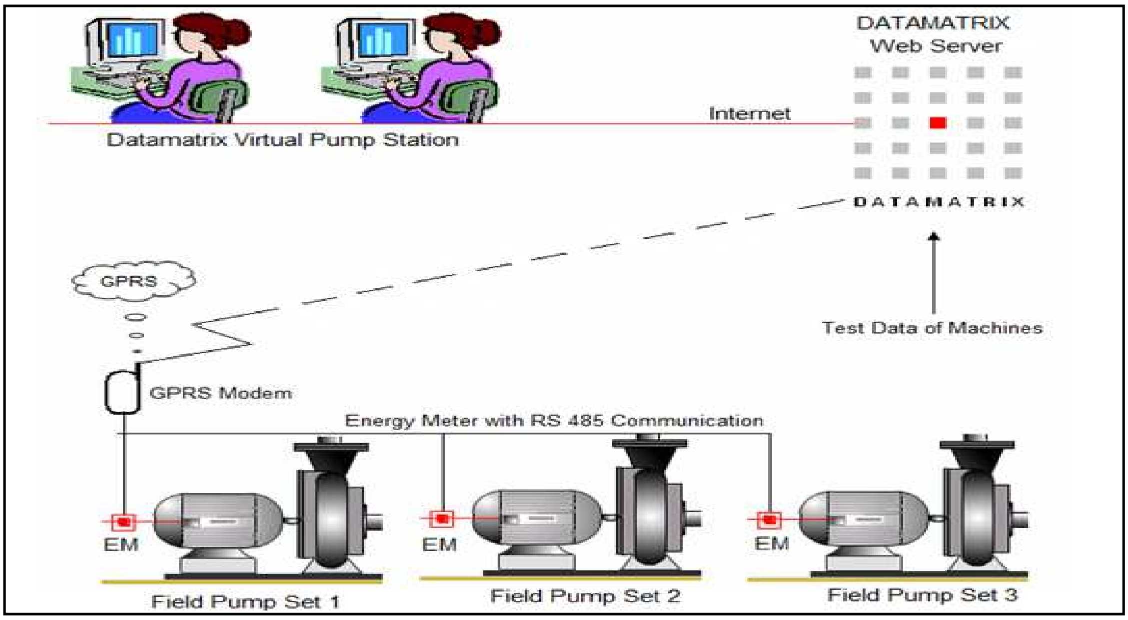


FIGURE 5: DATAMATRIX TECHNOLOGY - METERING & COMMUNICATION

2 Water Management

2.1 Present Scenario of Water Management

The water allocation is done under the Village Panchayat through eight cooperative societies and the farmers get the water supply by rotation. The pumps at Buchkewadi are allowed only for a period of five months and during this period, each society operates their pump sets depending on the number of farmers in that respective society. The pumps are disabled to preserve water for the drinking water and live stock needs of the village, during the remaining time. The year 2011-12 is considered as the base line year, and the water management is done business as usual, without giving access to the technology for villagers.

2.2 Datamatrix Approach

Datamatrix System uses calibrated simulations as per IPMVP (International Performance Measurement & Verification Protocols) to meter and monitor energy and water. The water has a relationship with the energy. Datamatrix Technology builds mathematical model of each pumping system based on the test data at site and continuously simulates all hydraulic parameters and the performance of the system against the energy inputs.

FIGURE 6: TESTING AND CALIBRATION IN PROGRESS AT BUCHKEWADI

The testing and calibration methodology conforms to the best Energy Audit Practices and as such all performance parameters can be independently verified or implemented by a third party energy auditor and verifier.

2.3 Pumps Hooked to Datamatrix

Datamatrix System was connected to total 11 pumping sets available for testing (others disconnected due to low dam level) in year 2011 with real time data dumping of energy data that continuously meters and monitors the pumping system throughout the year. The following image shows the Datamatrix Remote Metering & Communication arrangement deployed at site.

FIGURE 7: DATAMATRIX METERING & COMMUNICATION UNIT AT BUCHKEWADI

The pumping units around each communication unit are connected to the DRMU located close by and the data is continuously transferred to the Datamatrix Web server. Datamatrix System remotely monitors the pump wise water and energy usage and efficiency as shown in the following screen view.

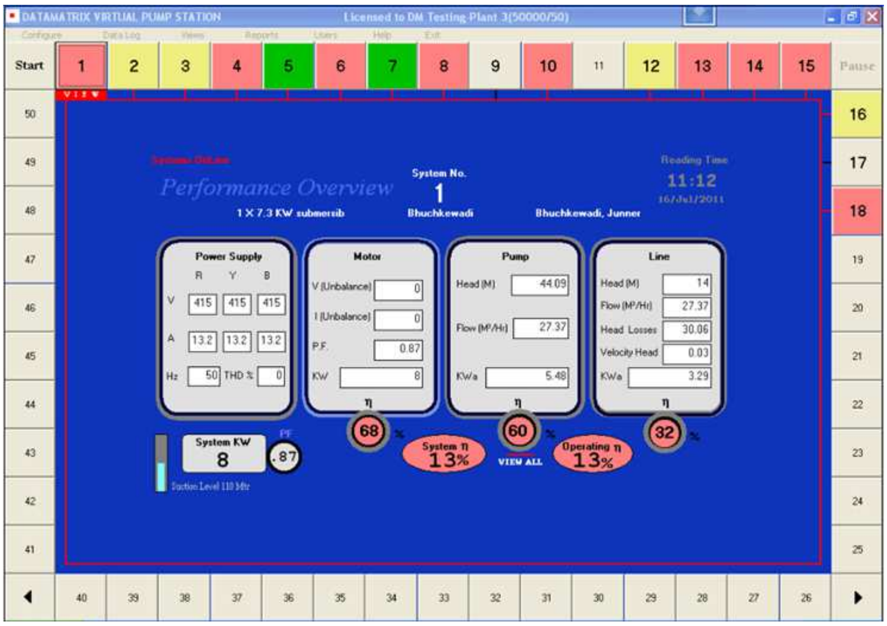


FIGURE 8: DATAMATRIX DASHBOARD FOR BUCHKEWADI

The detailed analysis feature of the Datamatrix Technology with simulation and modeling facility was used to further simulate and validate the water and energy use by pumps. It is also used for identifying the opportunities for optimum performance and water and energy efficiency at Buchkewadi village.

2.4 Accounting Water Use

The power supply to the village is provided for few hours of the day according to a prescheduled timing for each week. The pumps are pressed into service as soon as the power supply is available. Datamatrix System will simulate the precise water use by each pump set based on its real time energy data transmitted continuously to the web server. The technology can also compute the energy requirements of each pump based on the water levels in the dam; subject to the availability of supply conditions from any one pump in the vicinity. The month wise consolidated water and energy use for Buchkewadi against each pump is indicated in the Appendix -1 of this document.

The detailed simulation reports for an instant during the mid pumping season (Jan 2012); Appendix-1 helps to identify the operating point of the pumps and the reasons for its performance status.

The following figure indicates the simulated water usage at Buchkewadi throughout the year2011-2012.

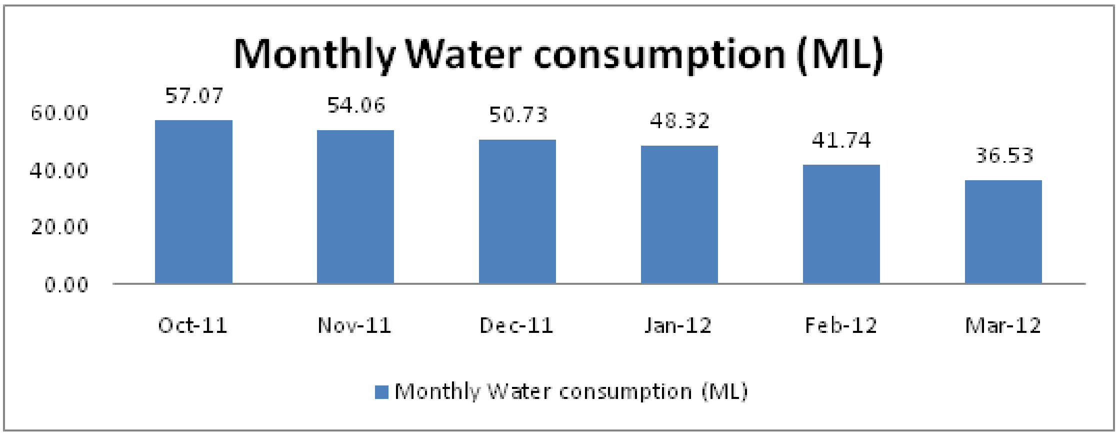


FIGURE 9: MONTHLY WATER CONSUMPTION

2.5 Equitable Distribution of Water

There seems to be a huge disparity in the water usage by different societies against the percentage of cultivated land holding. The farming community is interested in the concept of equity in water management. The major hurdle is measuring the water by each farmer.

The following table shows the water usage against the land holding under each society with water requirements, estimated as a proportion of the cultivated area.

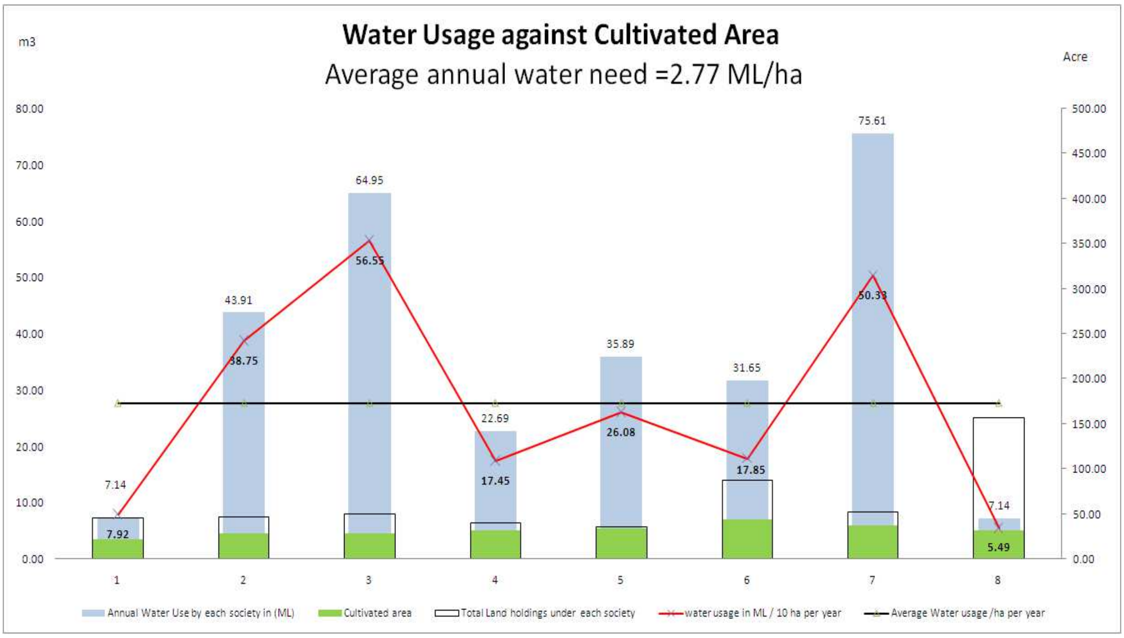


FIGURE 10: WATER DISTRIBUTION PATTERN ACROSS BUCHKEWADI

The above figure indicates the irrigated land and the water usage. The average line is drawn taking into account the average water use per hectare. This excessive water usage above the average is considered as the excessive irrigation. The societies 1 & 8 have a common pump for lifting water from Dam. They also have a private pond for supplementing the irrigation from the Dam.

The water allocation can be done based on the land holding, cultivated portion and the specific water need estimated under each pump set. This can lead to substantial water savings with a resultant saving in energy.

Key Observations:

- The above figure clearly indicates the present inequity in water distribution.
- Equitable distribution will save substantial water and energy required to deliver it.
- The annual water usage per society/acre is calculated by taking the ratio of the total amount of water consumed and total irrigated land used by each pump.
- The excess water consumption above the average can be avoided.
- The water and the corresponding energy savings (by avoiding the excess water usage from average) through equitable water distribution is estimated to be 27.57%.

2.6 Dam Water Sharing

According to a sharing arrangement under the US AID Program, Buchkewadi Village is entitled to 40% of water and the nearby villages share 60% of the water through a controlled water canal.

One of the key benefits of this program is that it would ensure Buchkewadi gets its entitled share; as many villagers complain that they get less than their entitled percentage i.e. 40%.

Based on detailed survey and testing and real time monitoring, the total water usage by Buchkewadi village is tabulated below. The percentage of water withdrawal by the pumps under each society from current usage is also detailed below.

TABLE 1: ANNUAL WATER USAGE BY EACH SOCIETY

Sr. No	Name of each society	Pumps Under each society	Total Land holdings under each society (in Acres)	Cultivated area in each society (in Acres)	Annual Water Use by each society in (ML)
1	Gajanan Upsa jalsinchan	P-8	45.08	22.25	7.14
2	Shreeram Upsa jalsinchan	P-1, P-2	46.95	28.00	43.91
3	Bhairavnath Upsa jalsinchan	P-3, P-4 , P-5	50.40	28.38	64.95
4	Vitthal Upsa jalsinchan	P-6, P-7, P-9	40.13	32.13	22.69
5	Shrikrishna Upsa jalsinchan	P-10, P-11, P-12	35.43	34.00	35.89
6	Dyaneshwar Upsa jalsinchan	P-13, P-14	87.83	43.83	31.65
7	Hanuman Upsa jalsinchan	P-15, P-16, P-17, P-18	52.03	37.13	75.61
8	Bhimashankar Upsa jalsinchan	P-8	157.18	32.13	7.14

It is observed that the net water usage by Buhchkewadi villages is less than their allocated share of 40% (i.e. 359240m3).

TABLE 2: TOTAL WATER USAGE BY BUHCHKEWADI FROM OCT-11 TO MARCH-12

Total working days	Gross storage of Dam (m3)	Amount of water withdraw/Year (m3)	% Withdrawal of water from Dam
For 120 days	898100	288973.55	32.18%

If equitable water distribution is adopted with the average daily usage of 18 pumps of 2326.45m^3; (drinking water consumption is neglected) the pumping season which typically lasts 120 days can be extended to 160 days and the water availability can be extended throughout the harsh summer months.

2.7 Recommended Initiatives

As discussed in previous sections, equitable water distribution and ensuring that the allocated water (40% dam water allocated for Buchkewadi) is made available is critical for the sustainability of Buchkewadi Village. will ensure that the current consumption of water which stands around 288.97 ML per annum is reduced to 209.30 ML and if 40% water i.e. 359.24 ML of water is withheld by the village then the current pumping season can be extended from 5 months to almost 9 months. (359.24/41.86; considering the average monthly water is brought down to 41.86 ML by equitable water distribution and no water demand during rains) This will make the village sustainable; with water availability throughout the year.

The following points in close coordination with the water committee shall be implemented as a sustainable water management program.

1. To implement a monitoring program to measure the quantity of water withdrawn at each point of withdrawal, using Datamatrix Technology. This is crucial element for establishing equitable water distribution.
2. To install a flow measuring device to ensure 40% quantity of dam water is held back with Buchkewadi; currently only an estimated 32.18% of dam water is used by Buchkewadi, due to the lack of any appropriate measuring device.

The following figure shows the projected transition from water current crisis to ample supply of water through the above two initiatives.

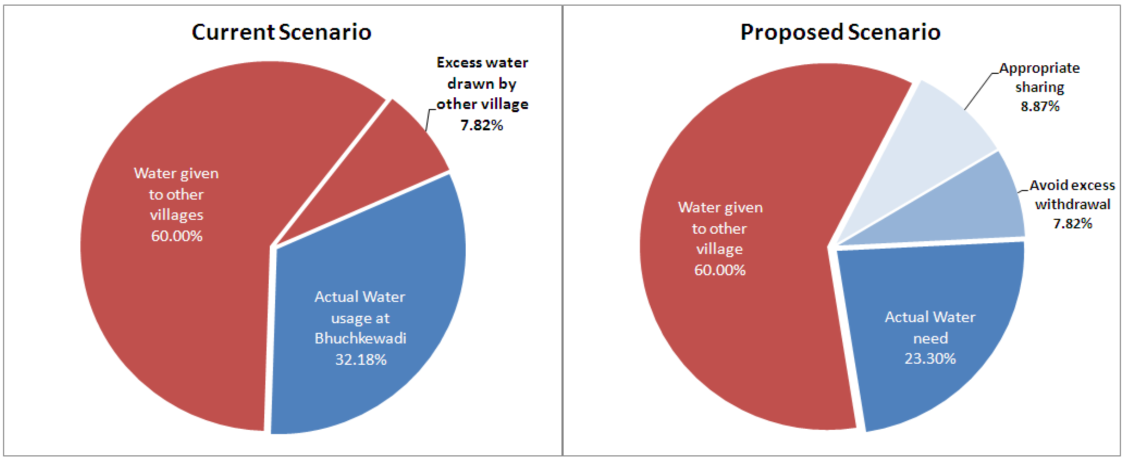


FIGURE 11: PROPOSED TRANSITION OF WATER UTILIZATION AT BUCHKEWADI

3 Energy Scenario

3.1 Power supply conditions

The power supply feeder has seven villages to feed power and Buchkewadi is at the far end of the feeder. Voltage loss occurs when more and more load is brought online than the designed capacity of the power lines. Buchkewadi being at the extreme end maximum variation in voltage is observed. The poor supply condition at site has taken a toll on the performance of pumps set with very high failure rates at Buchkewadi.

All fatal pump failures recorded at Buchkewadi are on account of burning of motor winding and it takes considerable time and money for repairing. Moreover due to the downtime of machines the farmer is incapable of supplying required quantity of water in their fields; with severe repercussions to the farmer's productivity and his farms yield.

The following figure represents the total cost of ownership of the water pumping system for a farmer at Buchkewadi.

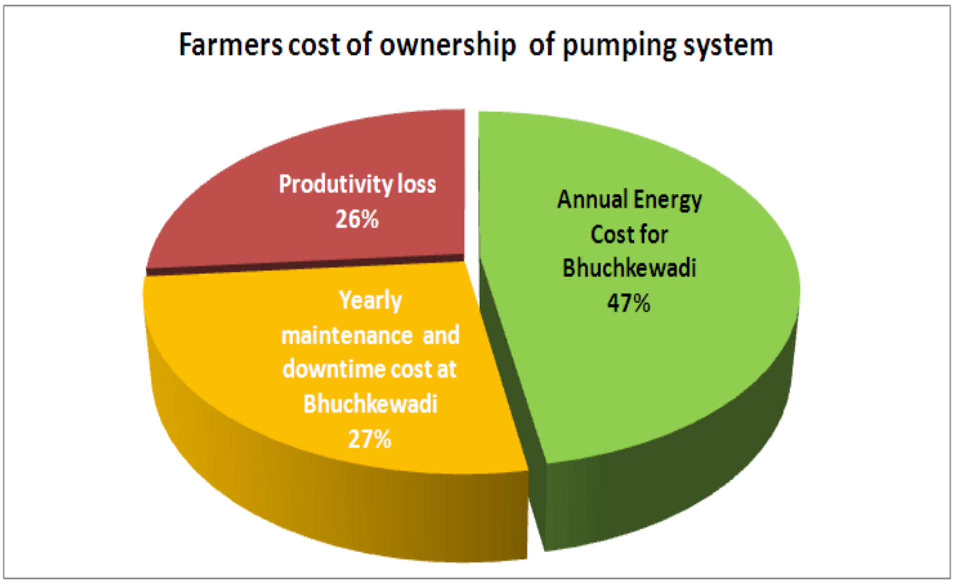


FIGURE 12: FARMERS COST OF OWNERSHIP OF PUMPING SYSTEM

Observations:

- Frequent Pump failure is one among the most wasteful expenditure and efforts for Buchkewadi.
- Thus a major chunk of the expenses in a farmer's expenditure can be simply saved by improving the power supply conditions.

3.2 Energy losses

Buchkewadi village is characterized by substantial voltage variation and an average variation observed is -22.58% from rated voltage and the peak voltage variation is 52%. The loss on account of voltage variation has the following three components.

- High Line Losses
- Increased Loss in the motor
- Wasteful Expenditure in Repair
- Down time and productivity loss

Further poor selection of pump often results in a mismatch between the operating head and design conditions; resulting in higher losses. The situation creates a vicious circle of the increasing pump failure rates. The continuous deterioration of the pumping machinery will also increase the losses steadily over a period of time until the next replacement and there is a compelling need to balance the pump life cycle against the mounting losses.

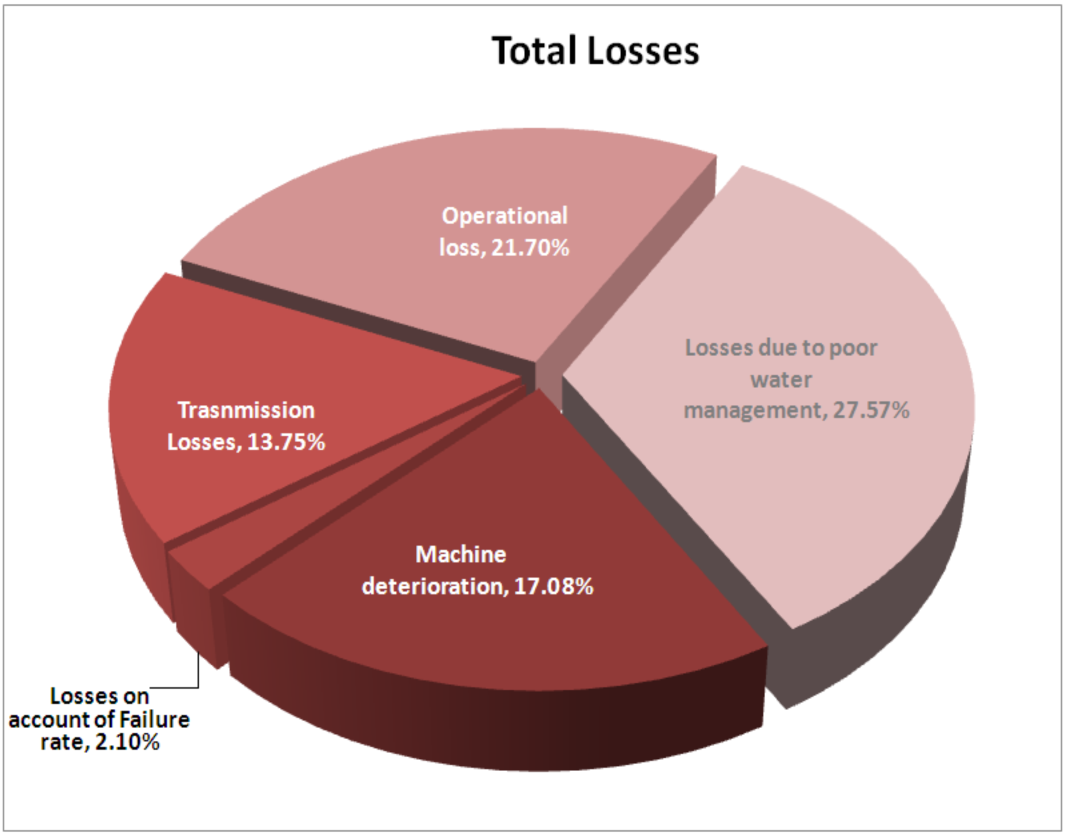


FIGURE 13: OVERALL LOSSES AT BUCHKEWADI

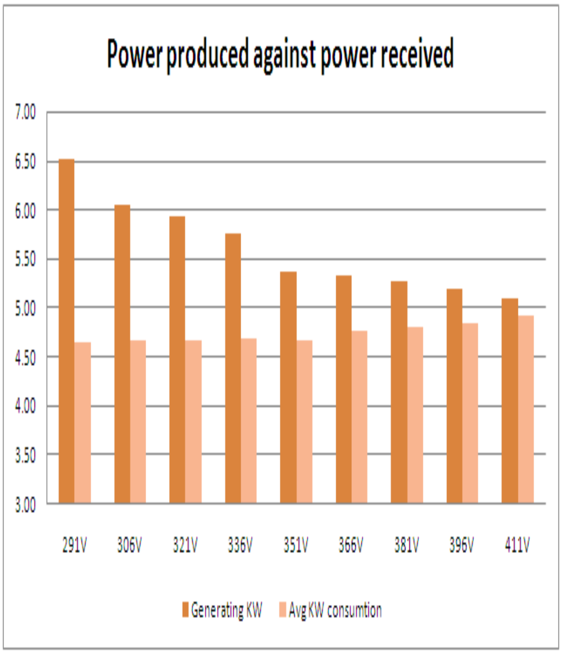
The above figure shows the overall losses at Buchkewadi

3.3 Supply side Losses

The power supply side loss comprise mainly of the transmission losses and the other indirect losses on account of poor supply conditions.

3.3.1 Low Voltage Line Losses

The following figure represents the daily average voltage profile observed at Buchkewadi, with the power dispatched by the substation and received by the village.



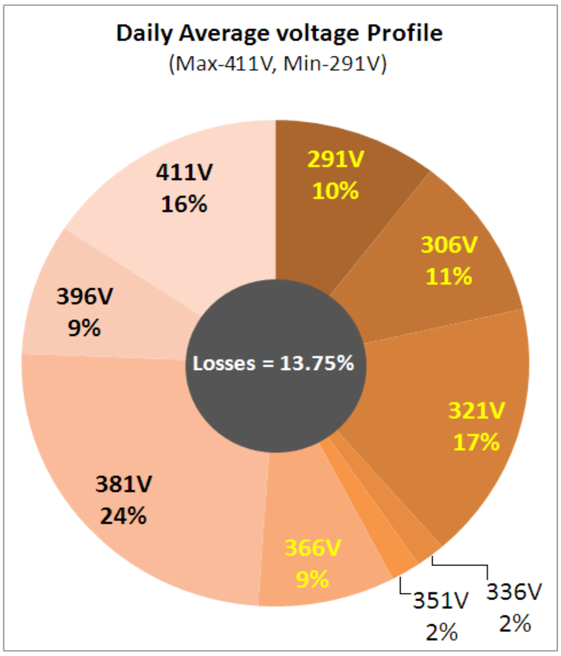


FIGURE 14: TRASNMISSION LOSSES

The dark columns above indicate the power being dispatched by the nearest substation and the columns in light color indicate the power received by the village. The differences between these two columns indicate the transmission losses as I^2R loss. The voltage profile at the village is represented by a pie diagram on the right side with light colors indicating the power received at Buchkewadi close to normal voltages.

The above diagram indicates the power dispatched and utilized at different voltage ranges. The summation of weighted average of these averages will give us the energy loss on account of poor supply conditions, estimated to be 13.75%; represented by the black circle in the centre of the pie diagram of Fig. 14, for the entire feeder. Buchkewadi contributes to far greater percentage of these losses, being at the far end of the feeder. As such more than a quarter of the energy sent to Buchkewadi is lost on the feeder lines between the substation and the village.

Observations:

- More than a quarter of the power sent to Buchkewadi from the nearest substation is lost on the electricity feeder lines.
- The loss of power on the feeder account of voltage variation is estimated to be 13.75%.
- Significant energy can be saved by staggering loads by operating pumps at different times.
- The power supply voltage affects the village water, energy and pumping infrastructure performance.

3.3.2 Losses due to frequent pump failure

The pumps at Buchkewadi receive low voltages on account of high transmission losses as discussed on preceding section. This severely affects the performance of the pump-sets resulting in less flow rate and high motor losses. Also poor selection of pumps has resulted in operational mismatch between design and site conditions resulting in substantial loss in efficiency.

The survey conducted at Buchkewadi reveals that the pump is generally taken out of service for repairs mainly for rewinding. The pump failures were analyzed with regard to the age of the pump and the data is represented in the following chart.

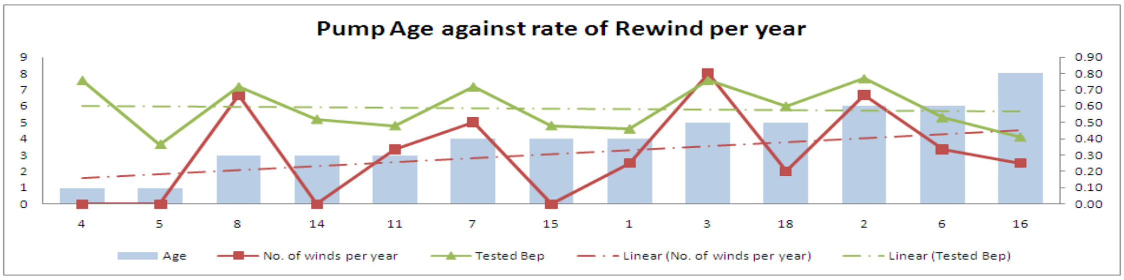


FIGURE 15: PUMP AGE AGAINST RATE OF REWIND PER YEAR

The Y- axis represents the age of the pumps (scale to the left) and X-axis represents the pumps in use with their age represented by the bar graph. The failure rate is represented as the average rate of rewinding per year as indicated by the dark dotted lines.

From the above figure it is observed that the rate of failure at Buchkewadi has an increasing trend against age of the pump. The following table indicates the average rewinding rate of motors per year per pump.

TABLE 3: AVERAGE RATE OF FAILURE OF PUMPS AT BUCHKEWADI

Total No. of pumps at Buchkewadi	Average age of Pumps at Buchkewadi	Average Number of Failures per Rewind/year/Pump	Failure Rate at 7.4 Years Rewind Per Year/Pump
18	7.4	0.3	0.5

The failure rate is greatly influenced by the power supply conditions at site. The following table represents the average fluctuations in power supply conditions observed along the peak power supply variation for Buchkewadi, with the corresponding failure rate.

TABLE 4: CORRELATION OF FAILURE RATE AGAINST SUPPLY CONDITIONS

Project	No. of Pumps	Average Age (Yrs)	Average failure Time at 7.4 (Yrs)	Average Voltage variation (%)	Peak Voltage Variation (%)
Buchkewadi	18	7.4	0.5	22.58	52.95

To be compared against the study on other villages.

It is observed that the voltage variation and the Pump failure rate at Buchkewadi is highest among the five locations studied.

The trend line in figure15 indicates the rate of failure at Buchkewadi increases by 2.10% every year while the effective efficiency of the pump decreasing by 0.18%. The increasing trend of failure rate can surely be reduced by improving the power supply conditions.

Observations:

- The slope of the trend line in figure15 indicates the rate of failure at Buchkewadi increases by 2.10% every year while the effective efficiency of the pump decreases by 0.18%.
- It should be noted that the average MTBF (Mean Time between Failures) at Buchkewadi is 2 years and is mainly due to burning of motor. In addition to the high cost of rewinding the down time is usually one week which has a direct bearing on the productivity of farmer and the actual loss to the farmer may be many times more than what really meets the eye.

3.4 Demand Side Losses

The losses on demand side can be broadly classified as losses on account of poor design, machine deterioration and losses incurred due to operational inefficiency. However it is observed that the single largest cause of energy loss is due to the inefficient use and wastage of water, as the embedded energy involved in the unutilized water.

3.4.1 Water Wastage

Substantial quantum of water is wasted on account of the lack of an equitable water distribution arrangement. This is due to the fact that the quantum of water used by each farmer cannot be measured at present. Datamatrix System provides a reliable and cost effective method of measuring the water and continuously monitoring the efficiency. This issue is discussed in detail in section 2.5 of this document.

It is observed that 27.57% water is used in excess due to inequitable distribution of water and an equal amount of energy will be saved through equitable water distribution.

3.4.2 Operational Inefficiency

Each pump is designed to work for a specific head and flow requirement. If there is a mismatch in the range in which the pump is operating against its design head, the performance of the pump will drop dramatically. More over the deterioration in pump further worsens the operating performance scenario by pushing the pump towards less efficient zones of performance.

The current practice of selecting the pump in the village is based on the feedback on the pumps used by other farmers in the vicinity. Some of the farmers select a pump based on the initial feel on the water level and head as advised by the local dealer, based on this preliminary information. This approach grossly ignores many factors influencing the performance of the pumps over a period of time leading to huge losses, resulting in inequitable distribution of water.

The pump performance is influenced by many factors such as the pump deterioration, the variation in the water tables, shift in the operating point due to these factors and the analysis can be quite complex.

The following figure represents the present losses on account of pump operation away from the Best Efficiency Point (BEP); resulting in pump operation at considerably lower efficiency.

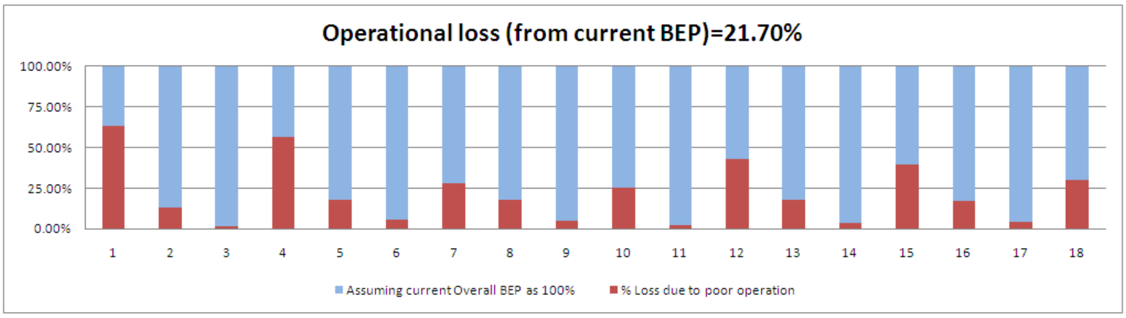


FIGURE 16: CURRENT OPERATIONAL LOSS

Going only by the current situation alone would be misleading in the long run, as all pumps are subjected to continuous deterioration. The challenge here is to accurately select a pump which will operate at the best possible efficiency during its lifecycle.

3.4.3 Losses due to Machine Deterioration

Pump replacement is the easiest way to achieve better efficiencies. However the dynamic factors such as the operating head, water levels, supply conditions makes the scenario quite complex. The following figure shows the current deterioration of pumps at site.

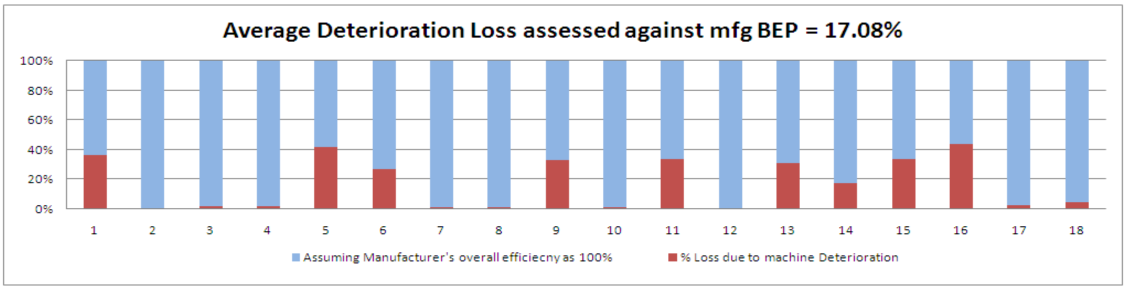


FIGURE 17: CURRENT SCOPE OF ASSENT MANAGEMENT

Observations:

- The current scope of replacement of pump is detailed in the following table.

TABLE 5: CURRENT SCOPE FOR IMPROVEMENT IN OVERALL EFFICIENCY

Average Age in yrs	Average Current Overall BEP eff.	Overall Efficiency of best performing pump	Total improvement in Eff. Over current level
7.4	41.59%	50.15%	17.08%

Combining the above two factors of operational in efficiency and pump deterioration, the total opportunity for improvement in pump efficiency is computed at 38.78% (21.70%+17.08%) over the current levels. The low energy tariff and the absence of any appropriate incentive scheme leave little influence for improving the energy efficiency. It is necessary to articulate the right policies to influence the stake holders to improve the energy efficiency.

3.5 Advanced Simulations

Pumps are subjected to continuous deterioration; a better understanding of the pump performance deterioration enables selection of the optimum pump for the optimum performance across its life cycle. To strike a golden mean between the ad hoc pump selections as practiced today; a simulation exercise is carried out on each pump, using Datamatrix Technology to derive the optimum head and replacement age based on the prevailing deterioration at site.

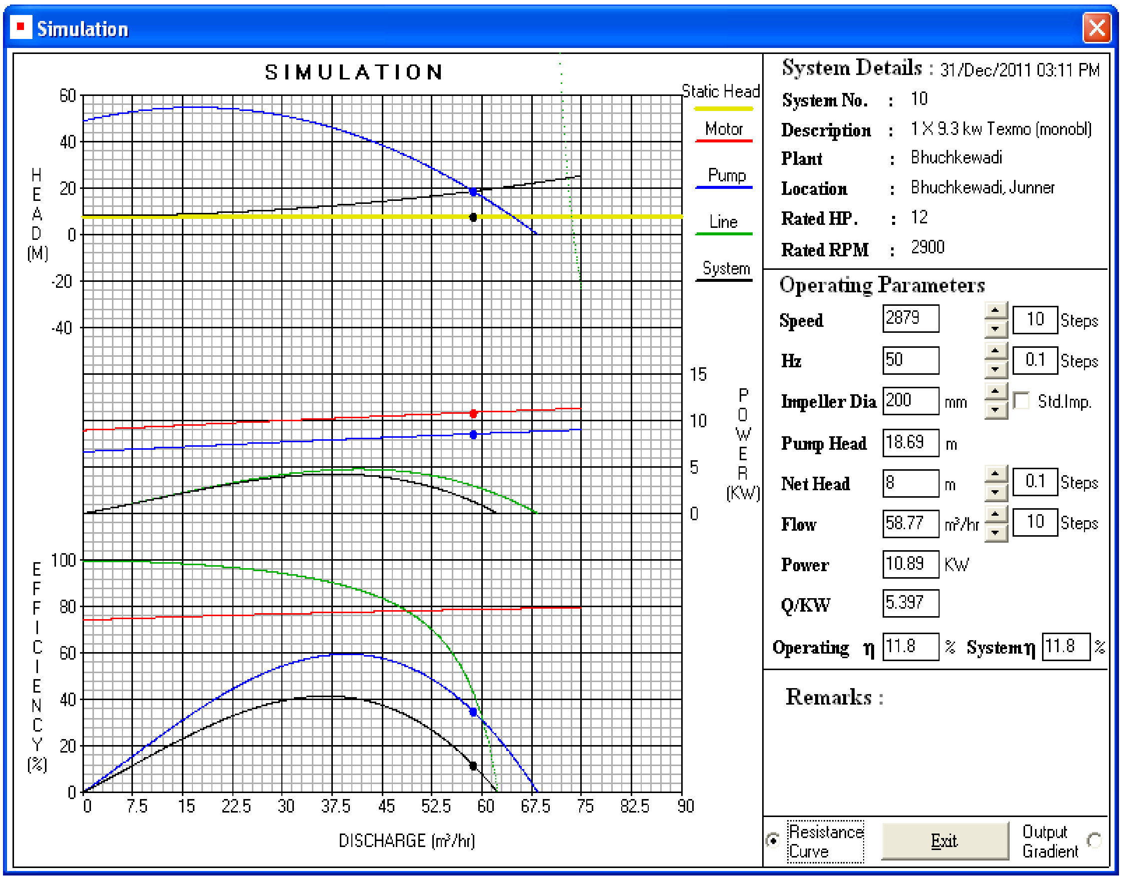


FIGURE 18: PERFORMANCE SIMULATION FOR AN OPERATING INSTANT

3.5.1 Optimum Design Head

Much of the energy is lost due to the fact that the pumps operate away from its best efficiency points due to the mismatch in the operating head and the design head. The scenario becomes complex with changing water levels are continuous machine deterioration. The following analysis helps to arrive at the optimum design head for Buchkewadi village.

The following Figure indicates the BEP of installed pumps at Buchkewadi with its corresponding efficiency (operating efficiency in blue). The graph also indicates the BEP against the proposed head of (excess 30% head above BEP suggested) indicated in Red. The current BEP efficiency levels are indicated in green.

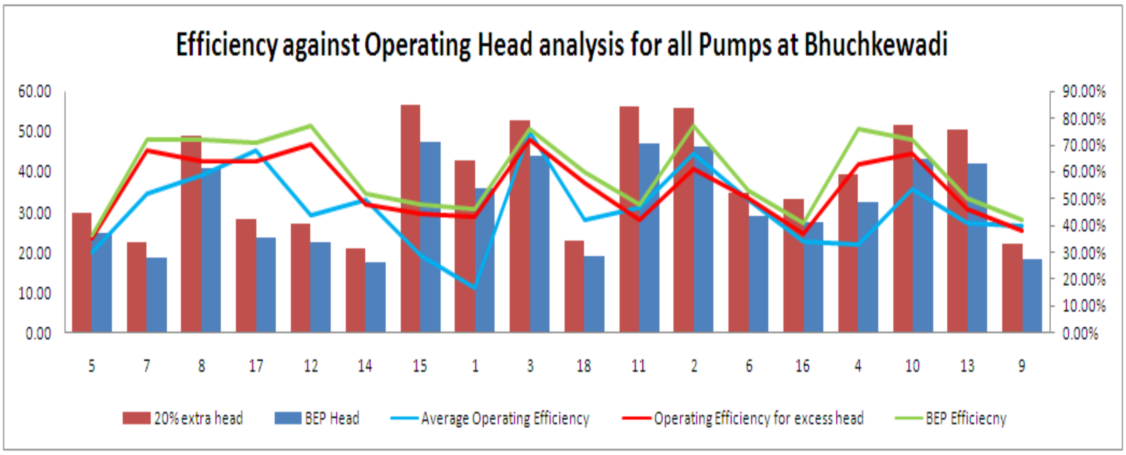


FIGURE 19: AGE-WISE DETERIORATION OF CURRENT BEP AND PROPOSED BEP PUMPS

The existing scenario has an average 13.19% operational loss (due to operations away from BEP). Incase if the pumps are selected with 30% higher head from the BEP, it will have an operational loss of only 5.64% (due to operations away from BEP), effectively across the entire operating life, saving 6.55% energy.

Observations

- It is observed that the head producing ability of a pump drops substancially as its age increases causing the operating point to shift away from its BEP.
- If a pump is selected having 30% more head producing capacity, it will run more efficiently over the operating years as represented in the above figure.
- From the above figure, the current operating efficiency (indicated in Blue) is operating at an average of 13.19% away from the BEP (indicated in Green) while the proposed 30% excess head (indicated in Red) will be is only 5.64% away from BEP.
- It is estimated that the operating point of oversized pumps will be only 5.64% below BEP as compared to 13.19% below BEP on the current situation.
- The improvement in efficiency on account of selecting pumps 30% additional head from BEP is estimated as (13.19% - 5.64%) = 6.55%.

3.5.2 Use of multi speed motors

Buchkewadi village water requirements are met through a Minor Irrigation Dam. There is a substantial variation in the operating head during the seasons, particularly for low head pumps. There could be significant savings if the speed of the pump is reduced to match the low operating head of the pump, when the water levels are high. Though the VFD could be an ideal technical solution, it may be unviable for a typical agricultural pump due to the high capital cost. Dual speed pumps would be a very cost effective solution for low head pumps with significant level variations.

The following figure highlights the speed reduction and its effect on the operating head, flow and the corresponding efficiency of the tested pumps. The speed reduction will be achieved by providing 2 speed motors having 2 pole and 4 pole options.

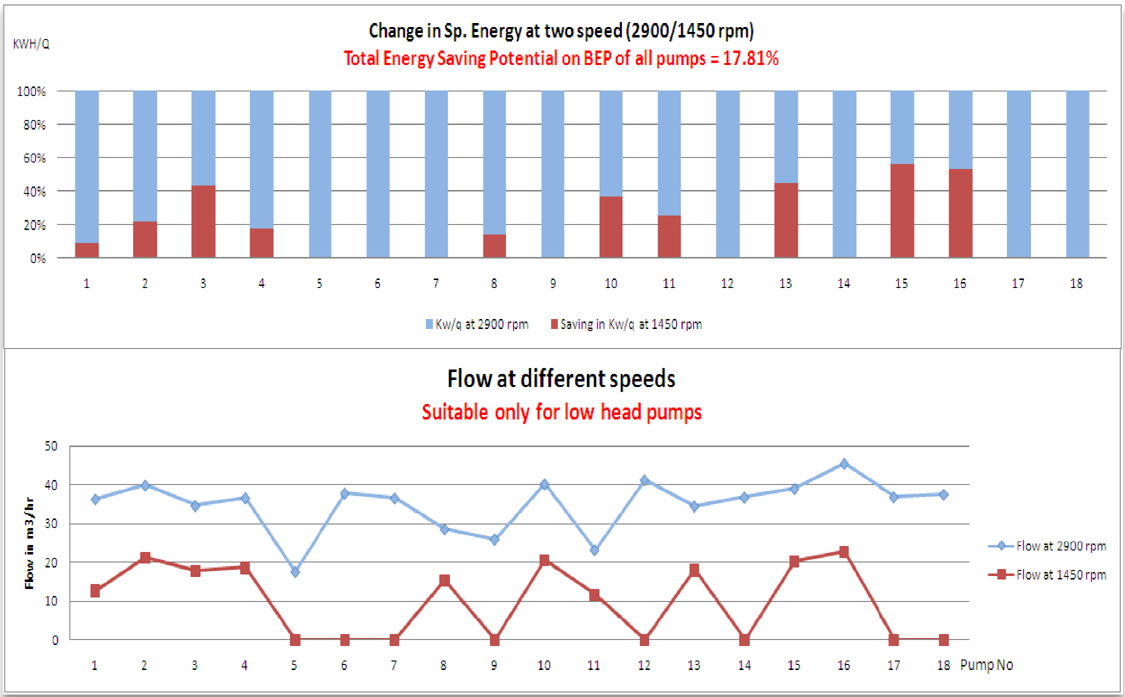


FIGURE 20: EFFECT OF SPEED REDUCTION ON BUCHKEWADI PUMPS

Observations:

- The use of 2-speed motors will bring in a substantial savings for low head pumps
- Two Speed Motors are not suitable for high head pumps
- The low operating head during the wet season has a tendency to discharge more water during wet seasons as against lower water requirements. Use of two speed motors will also correct the reverse trend of water use as against the water need from wet to dry season.
- Power and flow values were simulated for BEP at both 2900 and 1450 rpm (speed) using Datamatrix virtual pump station and the overall saving potential is observed as 17.81%

3.6 Recommended Initiatives

The dynamics of energy performance are too complex for the farming community to understand and continuously react to all opportunities for optimum performance. Hence a policy based simplified approach is needed to improve efficiency to the best possible extent under the given scenario.

A disconnected system of performance accounting makes it difficult to engage the experts to deal with the dynamic energy management of agriculture. A well directed research program is necessary to bring in the appropriate Measurement and Verification methodologies for continuous performance improvements in agricultural water-energy management.

A simple policy based approach for a sustainable improvement is evolved as follows based on the detailed analysis, under this program.

1. The pumps shall be selected based on the specific head and flow requirements on the following basis
    a. The present head requirement for the pump shall be clearly established, preferably through an approving agency.
    b. The change in the water levels and during the season as well as the depletion in the water level shall be considered on the selection process based on the established data.
    c. The rate of deterioration shall be established either based on the actual data analysis at site or the overall guidelines based on sample studies.
    d. Based on the discussed in the section above, it is observed that the pumps may be selected at 30% higher head from the operating head in the Buchkewadi scenario.
2. Develop a Measurement and Verification methodology to benchmark and monitor the energy efficiency for sustainable improvements.
3. Encourage the use of BEE star rated pumps.
4. Work out an incentive scheme for the farmer for timely replacement and maintenance of pump involving the stake holders.

3.7 Cost Benefit Analysis

The following table highlights the overall cost benefit analysis of implementing this sustainability program.

TABLE 6: PAY BACK CALCULATION

<table>
<tr><th>Options</th><th>Energy Saving Options</th><th>Investment</th><th>Savings in %</th><th>Annual Energy Savings (in KWH)</th><th>Annual Savings</th><th>Pay Back (In Years)</th></tr>
<tr><td rowspan="3">Without Investment (Immediate)</td><td>Water Allocation Management</td><td>0</td><td>27.57%</td><td>22,264.98</td><td>111,324.90</td><td rowspan="3"><u>Phase-I</u>
Implemented</td></tr>
<tr><td>Carbon Credits**</td><td>0</td><td>27.57%</td><td>-</td><td>9,587.86</td></tr>
<tr><td>Improvement in livelihood***</td><td>0</td><td>33.00%</td><td>-</td><td>6,340,000</td></tr>
<tr><td rowspan="2">With Investment (Short to Medium Term)</td><td>Pump Replacement</td><td>540,000</td><td>17.54%</td><td>10,259.01</td><td>51,295.07</td><td rowspan="2"><u>Phase-II</u>
2.81</td></tr>
<tr><td>Use of Multi speed motors</td><td>90,000</td><td>17.81%</td><td>10,416.94</td><td>52,084.68</td></tr>
</table>

****:** A 27.57% drop in energy consumption will lead to a generation KWH drop of 22.26 MWH (14 tons of CO_2 @ 0.65ton/MW) an annual saving at 10€ (662.5 INR) for one ton of CO_2 is estimated.
*****:** refer section 4.6

The program can be implemented effectively over a period of two years and the monitoring control and optimization can be achieved in the subsequent 3 years.

3.8 Critical Factors

The irrigation department releases 60% of water to the nearby villages. The present methodology is based on difference in dam water level before and after the release of the water, this is not sufficiently accurate for a precise water management program. This becomes a critical factor that can tilt the water sustainability of the Buchkewadi village.

The irrigation department shall be persuaded to provide an accurate measuring device at the discharge point of the dam for the nearby village. Since the government procedure takes too long a period to implement such a requirement it is advisable to explore alternative means to execute this critical requirement which has a pivotal role in the sustainability of Buchkewadi village.

The equitable water distribution is also quite critical for sustainable water management of Buchkewadi, without which water saved cannot be distributed appropriately.

It is also very important to educate the farmers on the benefits of water management.

3.9 Solving Water Energy Nexus

The project will help to create valuable knowledge in finding solutions to solve the water energy nexus issues of the country. The implementation of the project will create the first Integrated Water Energy Resource Management Project.

The most important aspect of the project will be to establish a Measurement & Verification Protocol acceptable to all stake holders, conforming to International Performance Measurement & Verification Protocol.

Datamatrix System is a highly advanced Energy Management System (EnMS), a critical technology requirement for Implementing ISO 50001, the latest International Standard for Energy Management. The project after a stringent implementation can qualify as the first ISO 50001 agricultural Project. However the certification process can be differed till a larger project is undertaken to absorb the cost involved in the certification process.

The project will offer numerous opportunities in understanding the Water-Energy Nexus and develop a protocol with Measurement & Verification Methodology for agricultural water and energy management. The latest Methodology approved by UNFCC for carbon credit of agricultural energy efficiency by replacing pumps involves a degree of performance simulation that can be accurately carried out by the Datamatrix System. It is also necessary to develop a methodology for carbon credit by improving Water-Energy efficiency and the project will create and validate the methodology. This will need further research with the use of the Technology.

4 Sustainability Plan

4.1 Sustainability Plan

Sustainability Vision for Buchkewadi

Buchkewadi Village will manage water and energy resources efficiently by measuring and monitoring, and managing water and energy use, continuously improving water availability throughout the year with improved agricultural productivity and prosperity in the village.

4.1.1 Sustainability Strategy

Measure, Monitor and Optimize Water & Energy resources of the village

4.1.2 Goal

Ensuring the availability of water throughout the year, with extended period of farming and employment.

4.1.3 Procedure & Protocols

The Sustainability program will be implemented by Metering, Monitoring Measurement & Verification, leveraging Datamatrix Technology, and optimally manage the water use under the supervision of the water committee of the village.

The Datamatrix System will be deployed, under the broad guidelines of the best international standards for Water & Energy and Environment Management.

- ❖ IPMVP – Performance Measurement & Verification
- ❖ ISO 50001 – Energy Management
- ❖ GRI – Environment Management Initiatives

4.1.4 Key Performance Indicators

The Key Performance Indicators are as defined below

Environment

- Water
    a. Total Water Collected in the Dam
    b. Water Share of Buchkewadi
    c. Water Withdrawals by Buchkewadi
    d. Excessive Water Use & Wastage

- Energy
    a. Energy Used By the Village
    b. Specific Energy Consumption
    c. Power Quality Index
- Infrastructure
    a. Efficiency Index of Pumping Machinery
    b. Average Age of the Pumping Machinery
    c. Fatal Pump Failures
- Ecological
    a. Area under Fertilizer Usage
    b. Area under Usage of Pesticides

Economic

- Cultivated Area
- Gross Agricultural Output *(proposed from 2012-13)*

Social

- Employment in the Village

4.1.5 Stakeholders

- Farmers - End Users
- Village Panchayat - Local administration
- MSEDCL - Power Supply
- NABARD - Agricultural Credit
- Irrigation Department - Water Allocation
- GSDA - Groundwater Surveys and Development Agency
- Central Government - Policy and research

4.2 Sustainable Water Management

The key issues and actions required for sustainable water management of the village based on the deployment and analysis of Datamatrix Technology is tabulated in the following sections. The water management is discussed in detail in section 2.5 & 2.6.

4.2.1 Water Sustainability issues

The lack of adequate tools for precise measurement of total quantity of water shared with the next village and absence of any Measurement and Verification (M&V) process for ensuring equitable water distribution has resulted in the present water crisis, despite sufficient efforts and initiatives by the villagers, through the Water Committee.

4.2.2 Sustainability solution

Datamatrix Technology enables the measurement of water at each point of withdrawal from the dam at Buchkewadi village. The water committee and members shall be informed of their daily water consumption to manage and reduce the excess water usage. Equitable water management can save 27.57%; from the current water usage.

A measuring device shall be installed at the discharge point of the dam for the water being shared with the nearby village. This can ensure that the excess quantum of water is not delivered to the nearby village in excess of the 60% water of the dam they are entitled. Currently Buchkewadi uses 32.18% of the water available in the dam as against 40% water entitled by the village.

The above two initiatives will make the water in the dam last throughout the year and will enable cultivation all through the year in Buchkewadi village.

4.2.3 Recommended Action

As discussed above, equitable water distribution and sharing of water as per agreement will ensure sustainable water management for the village. The following points in close coordination with the village water committee shall be implemented for sustainable water management.

TABLE 7: SUSTAINABLE WATER MANAGEMENT PLAN

Sustainable Water Management Plan			
Sr. No	Recommendation	Action Plan	Expected Outcome
1	**To implement a monitoring program to meter the quantity of water withdrawn by each pump and the respective society.**	a) Benchmarking each societies water need based on the actual land holdings and cultivation b) Establishing appropriate water sharing limits c) All pumps lifting water at Buchkewadi needs to be monitored on a 24x7 basis to measure the quantity of water discharged from each pump. d) Water Committee and the farmers are informed of the daily water use e) A water management plan shall be implemented by the committee by systematically reducing the excess water use. f) A water management engineer / remote support team shall be provided for a period of one year, to support the village water committee.	I. Conserving water by preventing societies from drawing excess water from benchmarked value. II. Establishing an equitable water management program. III. Save energy & water IV. Achieve Sustainability
2	**To install a flow measuring device to ensure that only 60% Water is shared with the Near By Village and 40% water is available for Buchkewadi.**	a) Install a flow meter for measuring Water discharged from the dam. b) Provide wireless communication and integrate the data with Datamatrix System	I. Share the water as per the agreement

Equitable water distribution will ensure that the current consumption of water which stands around 288.97 ML per annum is reduced to 209.30 ML and if 40% water i.e. 360 ML of water is withheld by the village then the current pumping season can be extended from 5 months to almost 9 months.

The implementation of the above action plan will result in transition from current crisis situation to a sustainable water management as depicted in the following figure.

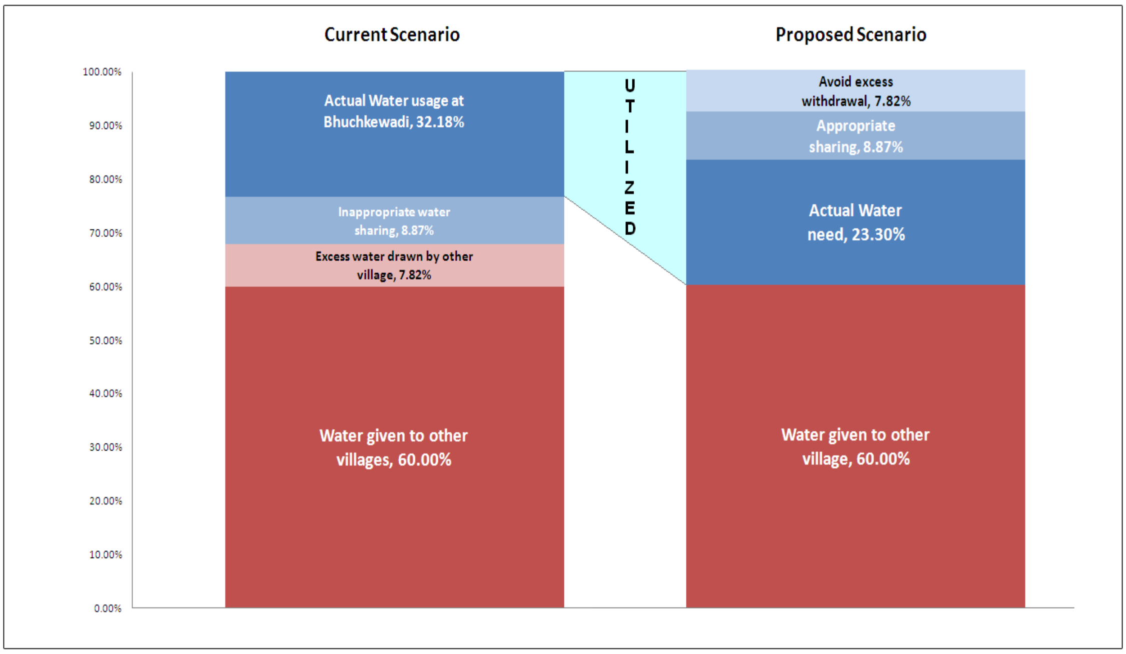


FIGURE 21: PROPOSED TRANSITION

4.3 Sustainable Energy Management

The energy management issues for Buchkewadi is quite complex at the moment with several dynamic factors affecting the performance.

Better clarity in the energy performance shall be brought through a clear energy performance measurement and verification plan and systematically reduce the losses. This will eventually involve an energy audit process identifying and attributing the losses to its root cause with remedies to continuously improve the energy efficiency.

Datamatrix Technology is capable of continuous energy audit with a stringent Measurement & Verification as per IPMVP (International Measurement & Verification Protocols). Datamatrix System is a powerful EnMS (Energy Management System); that can manage and continuously optimize the performance as per the latest and Best Practices of ISO 50001.

It is necessary to allocate the manpower for energy management and systematically improve the energy and water situation of the village. Energy management is critical, particularly the benchmarking monitoring, measurement and verification; as the accuracy of the water measurements are influenced by this exercise.

4.3.1 Energy Sustainability issues

The sustainable use of energy in Buchkewadi is influenced by the following factors.

1. Power Supply Conditions
2. Optimum Irrigation Design
3. Optimum Water Use
4. Operation & Maintenance
5. Asset Management

4.3.2 Sustainability solutions

Datamatrix Technology will integrate and automate the performance management with all the above functions. It can treat each machine as a profit centre by continuously improving the energy efficiency. Datamatrix Technology can be leveraged to analyze the performance in detail and arrive at the right policies to systematically improve the energy efficiency. A simplified energy management plan will be derived based on the detailed analysis.

4.3.3 Recommendations Action

Following action program has been defined based on the detailed analysis in the preceding section, to systematically improve the energy sustainability of Buchkewadi village.

TABLE 8: SUSTAINABLE ENERGY MANAGEMENT PLAN

Sustainable Energy Management Plan			
Sr. No	Recommendation	Action Plan	Expected Outcome
1	**Coordinate with MSEDCL to improve the supply conditions of Buchkewadi Village**	a) Build up facts and figures to urge MSEDCL to consider strengthening the power supply lines to Buchkewadi to reduce the losses. b) Depute an Engineer to discuss the matter with the utility at appropriate level.	I. Reduced Energy Loss II. Avoiding pump failure and the high cost of rewinding and down time III. Reduce Erratic Supply Conditions avoiding productivity loss.
2	**Benchmarking Performance and Providing Continuous Energy Audits**	a) Deploy on site manpower for testing performance benchmarking and energy audit b) Remote management and performance audits c) Evolve the best practices for energy management in Agriculture d) Deploy the best standards for performance management	I. Clear assessment of the energy situation with action plan
3	**Asset Management Plan**	a) Evolve an Asset Management Plan for the Village b) Provide a simple asset performance knowledge tool for the village based on the Data Analysis	I. Reduced Cost of Ownership II. Improved Performance III. Improved Return on Investments
4	**Policy advocacy with the stake holders**	a) Bring in the appropriate polices for systematically improving the energy efficiency, supported by data and analytics, with the stake holders (NABARD, MSEDCL, BEE, GSDA etc.) b) Bring in the appropriate credit mechanism for financing the pumping efficiency and asset quality	I. Easy Credit II. Better Repayment Capabilities III. Environment of continuous performance improvement IV. Maximize the return on investment V. Integrate all Stake holders with unified data

4.4 Environment

An estimated 51% of total electricity generation comes from burning of coal in India and thereby releasing huge carbon foot prints against the energy utilized. A saving in energy would in effect would reduce the carbon footprint accordingly.

The total reduction in carbon footprint at Buchkewadi is estimated to be around 35 tons Per Annum.

Compensation in the form of Carbon Credit for reducing 35 tons of CO_2 @ 0.65ton / MW is estimated to be Rs.23,508/ annum at today's market value.

4.5 Improvement in livelihood:

The total improvement in livelihood is estimated to be more than 33% as the farming season is now available throughout the year as compared to previous 5 months trend. The village income generating capacity is centered around availability of water and appropriate utilization of human resources leveraging knowledge on agriculture. This can result in substantial increase i.e. by at least 33% increase in income level of the population of Buchkewadi Village.

4.6 Risk and Mitigation

The major sustainability risks perceived are as follows:

a. Indiscriminate groundwater usage in close vicinity
b. Irrigation dept has to keep accurate flow measurement of water given to the nearby village
c. Equitable distribution of water is not practiced due to personal or political pressure

The Mitigation plans for the risk are as follows

a. The ground water pumps in close vicinity may be monitored to keep check of the amount of water withdrawal from each well.
b. The water distribution arrangement shall be audited by Datamatrix
c. An incentive program can be declared for improving the pumping infrastructure

4.7 Key Performance Indicators for 2012-13

The current year's performance and consumption is taken as the base line for performance. The Key Performance Indicators for Sustainability are as indicated below.

The key performance indicators for sustainability reporting are as follows

TABLE 9: KEY PERFORMANCE INDICATORS

Key Segments	Items	Key Performance Indicators Base Line 2011-12	2011-12	2012-13
Environment	Total Water Collected in the Dam (In ML)	1019.40		
	Water Share of Buchkewadi after losses (In ML)	359.24		
	Water Withdrawals by Buchkewadi (In ML)	288.97		
	Excessive Water Use & Wastage (In ML)	79.68		
	Energy Used By the Village (In KWH)	80759.47		
	Specific Energy Consumption (In KWH/Q)	0.286		
	Power Quality Index	37.77%		
	Efficiency Index of Pumping Machinery (In %)	32.95%		
	Average Age of the Pumping Machinery (In %)	7.40		
	Fatal Pump Failures (failures/year)	0.50		
Ecological	Area under Fertilizer Usage (In Acres)	From 2012-2013		
	Area under Usage of Pesticides (In Acres)			
Economic	Cultivated Area (In Acres)			
	Gross Agricultural Output (proposed from 2012-13)			
Social	Employment in the Village			

4.8 Way Forward

Any one of the following options can be chosen for the way forward:

- **Village Level Project:** The project shall be managed by the village under the financial support of a key stake holder.

- **Feeder Level:** The project shall be taken up on a feeder level with several villages connected under the same feeder. The program can be supported with a Research program that identifies the best Measurement & Verification Methodology options for scaling up.

- **IWERM:** Integrated Water Energy Resource Management on a single or multiple feeders with hydro geological mapping to identify the connected areas. The program can be supported with an extensive research program that identify Water-Energy-HydroGeology & Climate Change Linkages; besides establishing a robust Performance Measurement and Verification Methodology. Multiple research programs can be taken up with the project, taking advantage of the measurement of energy and water at each point of withdrawal.