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ISSN 2063-5346

IRRIGATION ENERGY CONSERVATION THROUGH CENTRALIZED PUMPING USING AN OUTLET MANAGEMENT SYSTEM (OMS)

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Abstract- Irrigation is vital for agriculture, allowing crop diversification and increased yields. However, traditional irrigation systems consume significant amounts of energy, contributing to India's overall electricity consumption. In 2020-21, agriculture accounted for 17.5% of India's total electricity usage, with irrigation comprising 70-75% of that. The primary reliance on electric pumps for irrigation, along with inefficient practices, further escalates electricity consumption. To address this, the Indian government promotes energy-efficient irrigation systems like micro lift irrigation, such as drip and sprinkler methods, which deliver water directly to crop roots, minimizing evaporation and runoff. Incentives are provided for adopting micro-irrigation projects. Individual farmers' use of distributed pump sets for irrigation livestock results in 91% of water withdrawal in India, with 50% wasted due to conventional methods. This trend drives India towards water scarcity, predicted by 2025. Energy for irrigation pumps is a major cost for farmers, yet many are unaware of potential savings from efficient energy use. The centralized pumping scheme integrates individual pumps into a pump house near reservoirs or dams, reducing energy consumption for each farmer and preserving groundwater for drinking purposes. River water is utilized for irrigation, and centralized pumping irrigation systems effectively distribute water to crops through gravity and outlet management systems. The current practice of installing oversized pumps leads to wasteful spending and energy usage. Moving away from this approach, akin to placing an oversized motor in a car, can result in cost and energy savings, as well as reduced groundwater depletion.
Keywords: Centralized & Decentralized pumping, Outlet Management System (OMS), SCADA

1 INTRODUCTION

In India, agricultural pump sets contribute significantly to irrigation costs and account for about 18.5% of the country's energy consumption. This consumption is projected to increase by 54% from 2015 to 2022, emphasizing the need for energy efficiency. Locally manufactured pump sets used for irrigation result in extensive water waste and higher energy usage. Implementing pressurized irrigation systems enables efficient utilization of limited water resources. By diverting river water for irrigation instead of letting it flow into the sea, reliance on groundwater is reduced, preserving water reserves for essential drinking purposes. This approach optimizes water usage, promotes sustainability, and conserves precious groundwater supplies, contributing to overall water resource conservation and addressing water scarcity challenges responsibly. One major constraint in this sector is farmers' dependence on irrigation pumps, including grid-connected and diesel/fossil fuel-driven pumps. Studies indicate that this sector consumes nearly 20% of India's installed power. The high cost of diesel fuels and electricity shortages impact decision-making for irrigation network managers, who must balance water and energy requirements for crop irrigation.

Several problems are associated with irrigation in India:

1. **Overuse of Groundwater:** Increasing irrigation demands have depleted groundwater resources, leading to declining water tables and aquifer depletion, particularly in areas without access to surface water for irrigation.
2. **Poor Water Management:** Outdated irrigation techniques, inadequate maintenance of infrastructure, and limited electricity supply in rural areas result in inefficient water use, causing waterlogging, soil salinity, and reduced crop yields.
3. **Inequitable Water Distribution:** Water allocation for irrigation often favors large farmers and landowners, creating social and economic disparities compared to small farmers and landless laborers. This imbalance frequently leads to conflicts over water resources.
4. **Climate Change:** Changing weather patterns, such as droughts and floods, disrupt the availability and distribution of water resources, posing challenges for farmers to plan and manage their crops effectively.

Decentralized pumping involves individual farmers using their own pumps to irrigate their fields. Groundwater

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is extracted using submersible or vertical turbine pumps, while surface water is drawn using centrifugal pumps like split case pumps or end suction pumps. These pumps need to adapt to changing conditions above and below ground, affecting the required pressure and flow on a daily and seasonal basis. To ensure adequate pressure and flow at the nozzle, farmers often choose to oversize the pump to handle worst-case scenarios. However, this leads to the pump operating inefficiently at all times, generating excessive pressure and consuming unnecessary energy. This results in energy wastage, high electricity costs, and a low power factor due to excessive use of induction motors for irrigation. Additionally, this system indirectly harms the environment by relying on non-renewable energy sources to power the motor pumps. If we consider an agricultural irrigation system as a car and the pump as its motor, it would not make sense to drive the car at full throttle constantly and control the speed with the brakes. Yet, this is a common approach for irrigation pumps, leading to inefficiencies and wasteful energy consumption.

Centralized pumping involves integrating individual pumps into a unified system to irrigate a specific area. The process begins by sourcing water from groundwater or surface water channels.

The water is then distributed through chambers, and finally delivered to the crops using gravity and an outlet management system that monitors and controls water flow for each 30-hectare section. The current approach of installing oversized pumps, capable of providing excessive water at all times, leads to wasteful expenditure and energy usage. Using the car metaphor mentioned earlier, it is like buying an oversized motor for a car, resulting in unnecessary costs without guaranteeing a comfortable or fuel-efficient ride. In this centralized irrigation system, pumps serve a more advanced purpose than simply delivering water to the pipes. For instance, incorporating variable speed drives improves the efficiency of groundwater extraction when pumping directly into the irrigation system.

Irrigation energy conservation through centralized pumping using an Outlet Management System (OMS) is an area of research focused on optimizing energy usage in irrigation systems. The OMS is a control and monitoring system that regulates water flow and pressure in a centralized pumping scheme. By integrating individual pumps into a unified system, the OMS ensures efficient water delivery to the fields.

2 LITERATURE REVIEW

Mekala Nagajyothi, Sirisha, Automation of farm activities can transform agricultural domain from being manual and static to intelligent and dynamic leading to higher production with lesser human supervision. This paper proposes an automated irrigation system which monitors and maintains the desired soil moisture content via automatic watering. **Pavankumar Naik, Arun Kumbi, Kirthishree Katti, Nagaraj Telkar,** India is mainly an agricultural country. Agriculture is the most important occupation for most of the Indian families. It plays vital role in the development of agricultural country. **G. Sasi Kumar*†, G. Nagaraju*, D. Rohith* and A. Vasudevarao,** With India's population growing at a rapid pace, traditional agriculture will have a tough time meeting future food demands. Water availability and conservation are major concerns for farmers. **A. A. Okandeji, F. Onaifo, M. T. Kabir and K. Yakubu,** this work considered the design and implementation of an Internet of things (IoT) based irrigation system that encourages efficient and optimal use of water management practice. **V. B. Shinde1* and S. S. Wandre2,** Irrigation is a well-established procedure on many farms and is practiced on various levels around the World. It allows diversification of crops, while increasing crop yields. **Vahan Bagdasarian, Grundfos,** Modern agricultural irrigation is a complex interplay of sustainable energy consumption, water use, market conditions, and the application of experience and knowledge to ensure the best design for irrigation applications. **Lingli Zhao,** this paper studies the design of water-saving irrigation system based on Internet of things. **B.I. Bakare, T.C. Ewunonu, S.A. Bruce-Allison, and Ekele Eke,** Advancement of technology has led to the automation of Irrigation system which has helped to solve a lot of problems encountered by the various non-automated types of irrigation syatem. **Cafer GENÇOĞLANa, Hayri ŞAHANb, Serpil GENÇOĞLAN,** Hydrocyclones are used as pre-filter to reduce suspended particles in irrigation water on the subsequent filters. **Yuthika Shekhar, Ekta Dagur, Sourabh Mishra, Rijo Jackson Tom and Veeramanikandan. M, Suresh Sankaranarayanan,** Agriculture has a major impact on economy of the country. Lot of Research been carried out in automating the irrigation system by employing wireless sensor and mobile computing. **Shitu, Tadda, and Danhassan**, Management and control of water resources is an issue on the rise around the globe, as agriculture lead other activities in terms of percentage usage of water whereby more than 50% is wasted due to evaporation as a result of many factors like. **Yigrem Solomon, P N Rao, Tigist Tadesse**, Utilization of solar photovoltaic powered (PV) as a power source in water pumping systems has emerged as one of the valuable solar applications. Solar PV water pumping system (SPVWPS) is used to fulfill the demand of water in the field of irrigation and domestic use. **Prof. Mangesh R. Dhage, Prof. Vaibhav S. Girnale, Prof. Chetan P. Patil,** Agricultural technology is changing rapidly. Farm machinery, farm building and production facilities are constantly being improved. **Ms. Sahaya Sakila, V. Dinesh Udayakumar, Chandrasekar Rajah, M Karthikeyan,** an automated irrigation system was developed for optimized usage of water in agriculture. The system has a distributed wireless network of soil moisture, humidity and temperature

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sensors placed at the root zone of plants. **Bharath D.A., S. Amith Nadig, Manjunath G.S.,** To realize IoT promise in commercial-scale applications, integrated Internet of Things (IoT) platforms are required. The key challenge is to make the solution flexible enough to fulfil the demands of specific applications. **Kizito Masaba, Amini Ntakirutimana and Taha Selim Ustun,** although water, in some parts of the world is as abundant as the air that we breathe, it is still a precious resource in dry regions. Such regions must use it carefully and efficiently because of its scarcity. **iaofei Hu, Xia Sun* , Qinghong Li, Qianqian He, and Yajun Li,** in view of the problems existing in traditional irrigation, such as high time cost, poor reliability, waste of water resources. The intelligent irrigation system based on STM32 and BC95 is designed and implemented. **Houshuai Dai, Ruoshui Wang, Li Chen, Lisha Wang,Chang Xiong , Xin Wang and Meng Zhang,** Intercropping systems reduce ineffective evaporation between trees but also intensify interspecific competition and reduce productivity. **H. J. PARMAR, N. R. PATEL, T. M.V. SURYANARAYANA,** the present study is carried out to determine the relationship between pressure head and discharge for a given set of sprinkler irrigation system. **J J Wu1 , R Huang2 , T Y Fang1 and Y Han,** Developing the high-efficiency agriculture is the strategy of agricultural sustainable development, and rational allocation of irrigation water resources is an important way in improving the efficiency of agricultural resources utilization. **K Sreenivasa Reddy, Somanath Nayak, Sunil Mandi, Kirttiranjan Baral and Y S Shivay,** Micro-irrigation not only saves water, but also saves money by lowering fertilizer use, labour costs and other input costs, as well as increasing farmers' income.

3 METHODOLOGY/PLANNING OF WORK

During the micro irrigation project, decentralized irrigation with 5-10 HP pumps resulted in high electricity bills. We compared centralized and decentralized pumping in Koteshwar Imlipada, Ratlam. Centralized pumping is more cost-effective and energy efficient. Factors like pump type, efficiency, irrigation area, and scheduling affect energy consumption. Centralized systems use larger, efficient pumps, optimize water distribution, and minimize waste. Decentralized systems lack engineering optimization. To improve energy efficiency, use efficient pumps, match sizing, and implement drip/sprinkler systems. Field distance, power availability, and water resources influence system choice. Local analysis is crucial for efficient irrigation.

SCOPE OF WORK

Koteshwar (Imlipada) Micro Irrigation System Command area is in Koteshwar Tehsil of Ratlam District of M.P. Supplying of water from Kundal dam by lifting and delivering at farmers field at duty 0.325 liter/sec/ha and maintained up to 30 ha chak, keeping the discharge of minimum the duty at 1 ha and at least 20 Meter Residual Head at each 1 ha chak for Micro Pressurized Irrigation (Drip/Sprinkler) by rotation management system through pressurized pipeline system for micro irrigation in the Culturable command area of 1,800 hectare out of Gross command area of nearly 2,130 hectares for Koteshwar (Imlipada) Micro Irrigation System. It includes all activities starting from survey, investigation, designing, engineering, construction, laying, installing, energizing, etc. of pumping system, Electrical Panels, Valves for OMS (Outlet Management System) and RMS Rotation Management System) including rising and gravity mains, distribution network, controlling and regulation system etc. for supply of water for irrigation under pressure with SCADA and automation in Rabi Season.

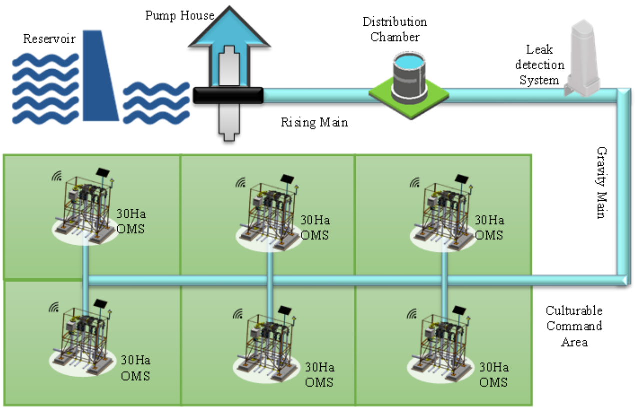

Figure 1 Koteshwar (Imlipada) Micro Lift Irrigation Scheme Overview

- Hydraulic analysis and pipe element design parameters computed using Water Gem/Modified Hazen Williams formula. Cluster division (3 to 11) enables efficient irrigation management and water distribution.
- Outlet Management Systems (OMS) installed at 30-hectare intervals in each cluster for regulated water flow.
- Consistent 20-meter head maintained for 1-hectare coverage, ensuring optimal water pressure. Fixed duty of 0.325 liters per second per hectare for consistent water delivery.

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- Rotation Management System (RMS) ensures fair water distribution among farmers based on land area holdings.
- 10% of the command area served at a time, optimizing water utilization. RMS allows simultaneous irrigation of 3 hectares at a time within each 30-hectare OMS coverage.
- Implementation of RMS promotes equitable water allocation and sustainability.

S/N	Village No.	Actual Area (Ha)	OMS Qty.	Total farmers
1	Cluster- 3	256.81	4	290
2	Cluster- 4	206.17	6	315
3	Cluster- 5	211.68	5	269
4	Cluster- 6	268.67	6	427
5	Cluster- 7	133.47	4	212
6	Cluster- 8	242.235	4	459
7	Cluster- 9	166.987	4	235
8	Cluster- 10	183.32	5	313
9	Cluster- 11	130	4	210
Total		**1799.34**	**38**	**2730**

Table 1 Koteshwar (Imlipada) Farmer Details

Pump & Motor Details –

1	VT Pump	102.08 KW, 3stage, 1460 RPM, 702 M3/Hr. discharge, 47.20 Rated head	3W+1S
2	Motor	125 KW/4P, 3 Phase AC Squirrel Cage Induction Motor, 415V	3W+1S

SCADA & Automation:

- Remote pumping station and irrigation system monitored and controlled via SCADA system.
- SCADA system displays pump health, flow rate, pressure, and electrical parameters.
- OMS data shown flow, pressure, valve status, door status, battery voltages, communication.
- SCADA system allows operators to adjust set points, detects alarms, and ensures communication uptime.
- SCADA system controls industrial processes and responds to emergencies and water supply changes.

4 ANALYTICAL PROCEDURE:

Ratlam Pump House Electricity Bill

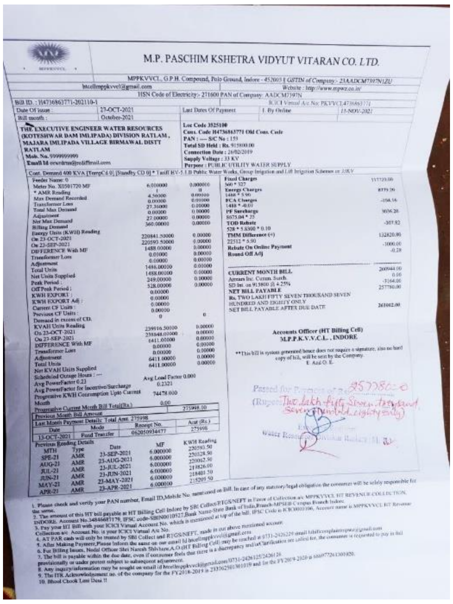
M.P. PASCHIM KSHETRA VIDYUT VITARAN CO. LTD.

Figure 2 Koteshwar (Imlipada) Pump House Electricity Bill

Six Months Calculation of Centralised Energy Consumption					
1. May 2021	**2. Jun 2021**	**3. Jul 2021**	**4. Aug 2021**	**5. Sep 2021**	**6. Oct 2021**

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Energy Meter Reading of					
April = 215209.5	May = 218401.5	Jun= 219826	Jul= 220062.5	Aug = 220328.5	Sep = 220593.5
May = 218401.5	Jun= 219826	Jul= 220062.5	Aug = 220328.5	Sep = 220593.5	Oct = 220841.5
Meter Units (KWH)					
=May 2021 - Apr 2021	=Jun 2021 - May 2021	=Jul 2021 - Jun 2021	=Aug 2021 - Jul 2021	=Sep 2021 - Aug 2021	=Oct 2021 - Sep 2021
Difference of Energy Meter Reading					
=218401.5-215209.5	=219826-218401.5	=220062.5-219826	=220328.5-220062.5	=220593.5-220328.5	=220841.5-220593.5
=3192	=1424.5	=236.5	=266	=265	=248
• MF = 6					
Unit Consumption (KWH) In centralized Pumping					
= Meter Units (KWH) x MF					
= 3192x6	= 1424.5x6	= 236.5x6	= 266x6	= 265x6	= 248x6
= 19152 KWH	**= 8547 KWH**	**= 1419 KWH**	**= 1596 KWH**	**= 1590 KWH**	**= 1488 KWH**
Unit Consumption (KVAH)					
PF=0.23					
KVAH = KWH x PF					
= 19152 KWH x PF=0.23	= 8547 KWH x PF=0.23	= 1419 KWH x PF=0.23	= 1596 KWH x PF=0.23	= 1590 KWH x PF=0.23	= 1488 KWH x PF=0.23
= 82516.	= 36824.64	= 6113.74	= 6876.34	= 6850.49	= 6411.02
Energy Charges per Month In centralized Pumping (Rs.)					
Per Unit Charges = 5.90 Rs					
= Unit Consumption (KWH) In centralized Pumping x Per Unit Charges					
= 19152 KWH x5.90 Rs	= 8547 KWH x5.90 Rs	= 1419 KWH x5.90 Rs	= 1596 KWH x5.90 Rs	= 1590 KWH x5.90 Rs	= 1488 KWH x5.90 Rs
= 112996.8	**= 50427.3**	**= 8372.1**	**= 9416.4**	**= 9381**	**= 8779.2**

Table 2 Six Months Calculation of Centralised Energy Consumption

Farmer Irrigation Electricity Bill

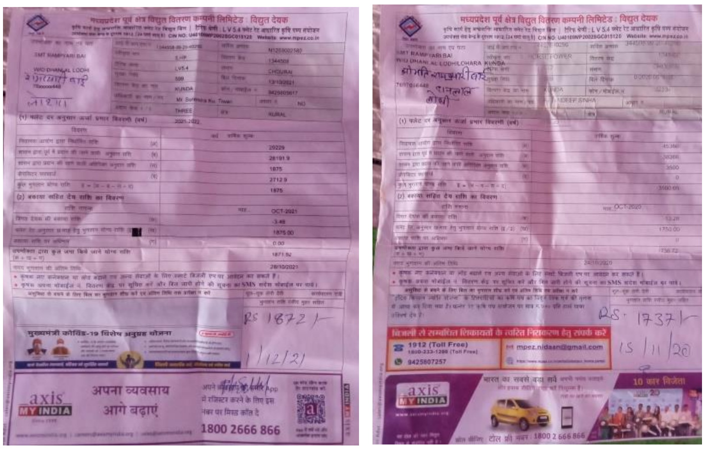

Figure 3 Farmer Electricity Bill

May Month	June Month	July Month	August Month	September Month	October Month
1. Total Farmers in 1800Ha CCA					
= 2730Nos (Approx) (Ref farmer list)					
2. Pump capacity					
Allowed to a farmer = 5HP (Ref farmer bill)					
Unit Consumption by each farmer -					

§ 1 HP = 745.7W					
§ 5HP = 3728W					
=3.728KW (Approx)					
§ 1hr x 3.728KW					
= 3.728KWH					
= 3.728 Units					
3. Pump Running Hours:					
According to the field practice for wheat crop every farmer use to run their individual pumps around 6-7 days/month continually in all 5 cycles.					
§ Single farmer = 31 days x 24hr	§ Single farmer = 25 days x 24hr	§ Single farmer = 10 days x 24hr	§ Single farmer = 10 days x 24hr	§ Single farmer = 15 days x 24hr	§ Single farmer = 31 days x 24hr
= 744 Hrs.	= 600 Hrs.	= 240 Hrs.	= 240 Hrs.	= 360 Hrs.	= 744 Hrs.
4. Monthly Energy consumption calculation use by single farmers					
Running Hr. May month- x Unit Consumption by each farmer -	Running Hr. June month- x Unit Consumption by each farmer -	Running Hr. July month- x Unit Consumption by each farmer -	Running Hr. August month- x Unit Consumption by each farmer -	Running Hr. September month- x Unit Consumption by each farmer -	Running Hr. October month- x Unit Consumption by each farmer -
= 744 Hrs. x 3.728 KWH	= 600 Hrs. x 3.728 KWH	= 240 Hrs. x 3.728 KWH	= 240 Hrs. x 3.728 KWH	= 360 Hrs. x 3.728 KWH	= 744 Hrs. x 3.728 KWH
= 2773.632 KWH	= 2236.8 KWH	= 894.72 KWH	= 894.72 KWH	= 1342.08 KWH	= 2773.632 KWH
5. Monthly Energy consumption calculation use by total 2730 farmers					
=Energy consumption of Single farmer in May Month x Total 2730 Nos Famrers	=Energy consumption of Single farmer in June Month x Total 2730 Nos Famrers	=Energy consumption of Single farmer in July Month x Total 2730 Nos Famrers	=Energy consumption of Single farmer in August Month x Total 2730 Nos Famrers	=Energy consumption of Single farmer in September Month x Total 2730 Nos Famrers	=Energy consumption of Single farmer in October Month x Total 2730 Nos Famrers
= 2773.632 KWH x 2730 Nos	= 2236.8 KWH x 2730 Nos	= 894.72 KWH x 2730 Nos	= 894.72 KWH x 2730 Nos	= 1342.08 KWH x 2730 Nos	= 2773.632 KWH x 2730 Nos
= 7572015.36	= 6106464	= 2442585.6	= 2442585.6	= 3663878.4	= 7572015.36
5. Actual Billable Amount (Rs.)					
§ Per unit rate = 5.60 Rs					
§ Total Billable amount of 2730 farmer through decentralized pumping					
= Energy consumption in May Month x Per Unit rate	= Energy Consumption In June Month x Per Unit rate	= Energy Consumption In July Month x Per Unit rate	= Energy Consumption In August Month x Per Unit rate	= Energy Consumption In Spetember Month x Per Unit rate	= Energy Consumption In October Month x Per Unit rate
= = 7572015.36 KWH x 5.6 Rs	= 12,21,292.80 KWH x 5.6 Rs	= 12,21,292.80 KWH x 5.6 Rs	= 12,21,292.80 KWH x 5.6 Rs	= 12,21,292.80 KWH x 5.6 Rs	= 12,21,292.80 KWH x 5.6 Rs
= 42403286.016 Rs.	**= 34196198.4 Rs.**	**= 13678479.36 Rs.**	**= 13678479.36 Rs.**	**= 20517719.04 Rs.**	**= 42403286.016 Rs.**

Table 3 Six Months Calculation of Decentralised Energy Consumption

Six Months Summary of energy consumption by centralized & Decentralized Pumping

Month	Unit Consumption (KWH) In centralized Pumping	Unit Consumption (KWH) In decentralized Pumping
May-21	19,152.00	75,72,015.36
Jun-21	8,547.00	61,06,464.00
Jul-21	1,419.00	24,42,585.60
Aug-21	1,596.00	24,42,585.60
Sep-21	1,590.00	36,63,878.40

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Oct-21	1,488.00	75,72,015.36
Total	**33,792.00**	**2,97,99,544.32**
Energy Conservation Through Centralized Pumping	**2,97,65,752.32**	

Table 4 Comparison of Centralized & Decentralized pumping energy consumption

Six Months Summary of cost consumption by centralized & Decentralized Pumping

Month	**Energy Charges Per Month in Centralized Pumping (Rs.) (Calculated)**	**Energy Charges Per Month in Decentralized Pumping (Rs.) (Approx)**
May-21	1,12,996.80	4,24,03,286.02
Jun-21	50,427.30	3,41,96,198.40
Jul-21	8,372.10	1,36,78,479.36
Aug-21	9,416.40	1,36,78,479.36
Sep-21	9,381.00	2,05,17,719.04
Oct-21	8,779.20	4,24,03,286.02
Total	**1,99,372.80**	**16,68,77,448.19**
Energy Charges Saving Through Centralised Pumping	**16,66,78,075.39**	

Table 5 Cost comparison of Centralized & Decentralized pumping energy consumption

OUTLET MANAGEMENT SYSTEM:

An Outlet Management System is an automated system that manages the distribution of water through outlets in an irrigation system. In the Koteshwar Imlipada Irrigation Project, an OMS has been implemented to monitor and control the flow of water through outlets to ensure efficient water distribution. The OMS is equipped with sensors that monitor the water flow and the amount of water distributed to each outlet. The data collected by the sensors is used to control the flow of water through the outlets and to adjust the distribution to ensure that each farmer receives the right amount of water.

The cluster has been divided into 30 Ha chak based on area profile. These areas are marked as `2A', `2B' ... etc. This chak of 30 Ha is then sub divided into five chaks of 6 Ha each. The 6 Ha chak is then subject to "Rotational management System" or `RMS' through which each farmer shall be given 10 times of rated discharge, i.e. 3.25 Lit/sec per ha in place of 0.325 Lit/sec per Ha. To achieve this objective, it has been decided that two 12 hour shifts shall be operated each day (from Midnight to Noon and from Noon to Midnight). These shifts shall be operated for five days in a week (Monday to Friday) and rest two days shall be shut off to address any operational issues. SCADA controls shall be provided at 30 Ha and 6 Ha outlets and manual valves shall be provided at 1 Ha outlets. Thus, there will be 24 Hr. supply of rated discharge (3.25 Lit/sec) at 6 Ha arms and each farmer shall operate outlet valve manually on designated shift to receive water as per Contract terms.

5 CONCLUSION

In conclusion, the thesis demonstrates the significant impact of centralized pumping on energy conservation. The analysis shows a total energy conservation of 2,97,65,752.32 kilowatt-hours (KWH), resulting in savings of approximately 16,66,78,075.39 Indian Rupees (INR) in energy charges. This highlights the potential for substantial energy savings and cost reductions through the implementation of centralized pumping systems. These findings contribute to the understanding of energy conservation strategies and provide valuable insights for decision-makers in the field of sustainable energy management.

The analysis of data collected from the field shows that the outlet management system implemented in the Koteshwar Imlipada irrigation project has resulted in significant improvements in water distribution and energy conservation. The system has helped to reduce waterlogging, improve crop yield, and save energy.

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