Evolving an integrated approach for improving efficiency of ground water pumping for agriculture using electricity: A few pointers from the field

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1. INTRODUCTION

Energy supply, in the form of electricity, is a vital input in groundwater agriculture in many states in India. In Andhra Pradesh (AP) and other south Indian states, about 50% of irrigated area is under groundwater irrigation. Average increase of number of tube wells in Andhra Pradesh is around 50,000 per year with trends of further increase.

The demand for electricity in groundwater agriculture is increasing rapidly with an increase of about 30% over last 5 years. Power supply to agriculture is subsidized (is free in AP) and often not metered. Utility neglects rural power supply and often exaggerates the agriculture power consumption to hide its inefficiency including pilferage. The poor state of maintenance has been responsible for electricity shocks and accidents. Rural power supply quality is poor with frequent interruptions and low voltages. Increasing number of tube wells is over-loading the Distribution Transformers (DTs). These cause motor / DT burnouts resulting in economic losses to farmers.

Energy use in agriculture has a bearing on water use efficiency also. Poor attention to water use efficiency has been leading to lowering of water table levels. Quality and timely power supply will help farmers to schedule irrigation properly and save groundwater. On the other side, lower pump efficiencies and low voltages at pump-sets result in low discharges while consuming the same or more amount of power from the distribution network.

Table 1 summarizes the scenario of power supply in agriculture sector. It can be seen that all actors feel victimised, often by some other. As a result, all actors - farmers, utilities, State and society are trapped in a low level of equilibrium. Actors hold the other responsible for the situation. It is difficult to clearly identify the cause-effect relationships and pin-point primary responsibility. Farmers and distribution companies (DISCOMs) are the main actors. Their relationship borders on mutual suspicion, lack of trust, lack of respect and even hatred. There is very little room for constructive engagement between these actors.

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Table -1: Power supply scenario – from the looking glass of different actors

Actors	Situation
Farmer	- Poor quality of supply and service leading to high cost - Low water use efficiency due to improper pump & crop selection, inefficient irrigation, low awareness and motivation to implement energy efficiency - Resistant to any tariff increase due to existing crisis and lack of faith in distribution company - Resistant to metering for fear of possible harassment by distribution company staff - Competitive well deepening resulting in high cost to farmers, losses due to failure and lowering of water table leading to cascaded increase of the crisis - State subsidy not targeted well – little benefit to very poor farmers
Distribution Company	- Low revenue to utilities and hence limited interest on agriculture power supply - Shortage of field staff leading to poor rural maintenance - Political pressure makes it difficult to increase agriculture tariff - Low awareness and motivation to implement energy efficiency measures - Exaggerates agriculture power consumption estimates so as to reduce loss figures. Hence not very keen to take serious steps to measures the agricultural power consumption
State Government & political parties	- Subsidies have become burden on the State - State not able to implement ground water regulations - Political parties take the easy path of short sighted competitive populism – announcing measures after measures like free power, grant for bore wells, etc
Society	- Overuse of ground water leading to fast depletion of this resource - Growing inequalities in groundwater access and distribution leading to social conflicts

During October-November 2007, the crisis in electricity sector deepened with increased power cuts to domestic, agriculture and industrial sectors. Drastic reduction in power production seriously affected the supply to these sectors. Political parties and farmers organizations started agitating against the Government and demanding the quality and reliable power supply. In few districts, farmers attacked electricity DISCOM offices and ransacked them for irregular and limited hours of power supply resulting in withering of winter crops.

At this juncture, the present study was contemplated in Andhra Pradesh, to explore possibilities of local energy and groundwater management with the involvement of farmers to make a constructive contribution to improve the field situation in electricity supply and groundwater management.

Following are the major objectives of the study:

- To gain insights (grass-root as well as State level) on electricity use and water management in agriculture
- To develop a simple methodology to collect base line field data, analyze it towards improving the efficiency in a strategic way in consultation with farmers
- To explore for possible areas of interventions in future

This report presents the process of the study, initial findings and interventions in 2 villages as well as State forums. We conclude with few lessons and ideas for further work.

2. PROCESS OF THE STUDY

2.1 Introduction

The study was done at two levels, one at the grass-root level in 2 villages and the other at the State level in the form of interactions and sharing of study results with different government and non-governmental actors. Study was conducted by the Natural Resource Management (NRM) desk of Centre for World Solidarity (CWS), Prayas Energy Group and two local NGOs – CROPS and Nava Jyothi, working in the 2 villages.

Following are the major steps in the study. These are not one-time actions carried out in a sequence, but rather the major steps, often repeated in an iterative fashion.

a) Scoping: Interactions with various actors at local and State levels. Local actors include farmers, DISCOM employees, pump-set repairers, electricians and NGO partners. Discussions were to understand their perceptions about the present electricity use scenario in agriculture context, issues faced and Demand Side Management (DSM) measures such as use of capacitors. State level actors include leaders of farmers' organizations, technical experts, sympathetic electricity staff, senior social analysts etc. This iterative process helped to fine tune the methodology.
b) Field observations: Measurement of key electricity parameters, such as voltage, current, power, power factor at the DTs and selected pump-sets to understand the quality of power and consumption by pump-sets. Measurement of hydraulic parameters such as discharge, total head etc., to relate hydraulic power with power consumed by the pump-set. Inputs from farmers, local electricians, repair shops, local DISCOM staff on issues.
c) Field intervention: On power and water use efficiency by making trial interventions (such as installing voltage & current meters, capacitors on all pump-sets),
d) State level intervention: Presentation to DISCOM, APERC, sharing the findings with other civil society organizations and analysts.

2.2 Scoping

The action study was done in 2 villages, Mylaram in Chinna Kodur Mandal of Medak district and Enabavi in Lingala Ghanpur mandal of Warangal district, both in Andhra Pradesh. In these villages, 1 Distribution Transformer (DT) in each village, were studied. There are 50 families in Enabavi and 229 families in Mylaram. Agriculture is predominantly rain-fed in these villages. Groundwater is the major source of irrigation for about 30% of the total cultivated area in these villages. Paddy, Cotton and Vegetables are the major crops cultivated in these villages. Table 2 gives details of DTs and pump-sets studied:

Table 2: Details of DTs studied

Village	Total no. of DTs in the village	Total agricultural pump-sets in the village	DT studied	No. of pump-sets connected to the DT
Mylaram	10	166	1	19
Enabavi	1	29	1	29

A discussion session on groundwater based irrigation was organized at CWS conference hall on 05th March 2008 to share the on-going action study in two villages and take inputs on improvements and possible future interventions. 15 persons from various organizations including the local partners, sector experts and members of farmer organisations participated in the discussion session. Discussions were held to list and prioritise the problems and plan the solution. Problems included low voltage, frequent power failures, occasional motor burn outs and DT burnouts. Approach to the solution was to take field measurements to understand the problem, get local opinion on possible solution. After a presentation on activities done so far in villages, various possible areas for future intervention under the following broad heads were identified as:

- Field Observations (one time and repetitive)
- Local interventions
- Policy and regulatory interventions

During the discussion, participants gave suggestions on various activities that can be taken up as a part of piloting in two villages. Following are the major points of discussion:

- Define clearly the objectives of the exercise (Eg: Reduce motor burnouts, reduce electricity consumption etc.) in order to get more clarity on what data is to be collected and how activities are to be planned

- DT area as one unit of operation has its own advantages and disadvantages. Consider taking up an aquifer area as one unit (including all those DTs falling within that area). 11 kV feeder and all the DTs on it may also be taken as a unit

- Run a pilot project with clear framework and objectives. For example, clean and timely power supply may be offered for following social regulations in power and water use. This may be done in collaboration with the Discom

- One person having institutional expertise may also be included in the team involved in this study to strengthen the institutional perspective

- Connecting the capacitors before the starter in the circuit can create problems such as surges in voltages when power goes-off and comes again in a short span of time. Instead, consider connecting the capacitors after the starter in the circuit to over-come such problems

Numerous discussions were held with the local partners, farmers and sector experts at subsequent stages as well - after capacitor installation, after second round of field measurements etc.

2.3. Field Observations

Basic information about the type of well, pipe length, motor horse-power etc., were collected by the local partners. Static water levels at the well locations have also been recorded. Plan for a separate set of measurements were planned as part of this study – this included electrical and water related parameters.

Electrical: Power input to the motor, voltage and current were measured at pump-set locations and DT low-voltage side using a clamp-on-meter (MECO make, model 3510, true RMS). This meter is capable of measuring 3-phase power using the 2-Wattmeter method. Line to line voltages (3 values), phase currents (3 values), three-phase active power (1 value calculated using 2 measurements) and three-phase reactive power (1 value calculated using 2 measurements) were measured. Power factor was calculated using active and reactive power measurements.

When capacitor was fixed to the motor (after the starter, just before motor terminals), current and power flows to the capacitor was also measured (though this may not be accurate as the meter does not support power factor less than 0.5).

Water flow: Discharge rate was measured at the pump-set location. The objective of measurement was to calculate the hydraulic power output. The methodology is given in Annexure I & II.

One round of visits to villages has been completed during Dec 2007-April 2008. Measurements of Voltage, Current, Power, Reactive Power Interactions, discharge from the pump-set were noted before the installation of capacitors.

Another round of visits was in October 2008 after installation of capacitors. During the October visit, representatives of the DISCOM (APCPDCL) also participated.

In addition to measurement of these technical parameters, there was regular feedback from the local partners, and discussions were held with farmers, electricians etc., during the visits.

2.4. State level Interventions

Participation in APERC public hearing:

Andhra Pradesh Electricity Regulatory Commission (APERC) conducted public hearing on the Retail Tariff Proposals of Andhra Pradesh Central Power Distribution Company Ltd. (APCPDCL) on 28th February 2008 at Anantapur. Mr. Rama Mohan participated in the public hearing and made a presentation on the 'Social Regulation of Ground Water' initiative of CWS. He also shared about the field study done in Mylaram and Enabavi villages and observations made. He highlighted that there are about 1,18,000 shared wells in Andhra Pradesh and they facilitate equitable access to groundwater for many small and marginal farmers. It was shared that they also contribute to energy saving and efficient water use.

Following are the major recommendations made to the APERC:

- Recognize "group wells" as a separate category in agricultural energy use
- Give incentive to encourage new group wells by farmers
- Regularize existing un-authorized connections free of charge, if farmers come as a group to share water
- Saving of energy due to group wells is much more than what is earned by charging regularization fee
- Piloting may be tried in few DTs / villages

APERC, in its tariff order (2008-09) issued on 20th March 2008, recommended to APCPDCL to consider these suggestions.

Presentation to Power Companies

Presentations on findings and observations of the study done (before installation of capacitors) were made to the senior management of DISCOM and APTRANSCO in July 2008. Presentation to DISCOM was attended by the CMD, Directors and many field engineers. Our specific requests were:

- Partial subsidy / incentive for regularisation of unauthorized connections (around 15 nos.)
- Upgrading the existing DTs after regularization
- Installing meters on 2 DTs for data generation on electricity use and awareness generation among farmers
- Improvements / replacement of LT wires
- Frequent interactions of DISCOM engineers with farmers and better O&M support

The CMD was positive about the study and expressed willingness to support the pilot initiative. But, he was not in favour of giving 50% subsidy from the company to farmers those who are coming forward for regularization.

Presentation to APTRANSCO was attended by CMD and the senior officers on similar lines. CMD showed interested in this work and suggested to think of taking up the work like a franchisee. We expressed that we are more interested in efficient energy and water management than establishing franchisees. Further, we expressed that we would like to add this dimension to existing franchisees based on the experience derived from our work in 2 DTs.

There were no immediate direct outcomes of these 2 meetings, but these helped in the further interactions with DISCOM field staff.

3. FIELD OBSERVATIONS

Initial field studies were done during December 2007 to April 2008 in 2 study villages. Apart from discussions with farmers and DISCOM staff, measurements of various electricity as well as hydraulic parameters were done. Following table 3 gives basic details and key parameters for the two villages.

Table 3: Key Parameters measured in two villages

Parameter	Mylaram village	Enabavi village
DT rating	63 kVA	100 kVA
Total wells connected to the DT	8 open wells and 11 bore wells	6 open wells and 23 bore wells
DT connected load	~ 73 kW	~ 190 kW
DT measurements		
kVA	89	124
Power Factor (PF)	0.84	0.97
3 ph Voltage	429, 429 & 428 V	360, 364 & 364 V
% over load	141%	124 %
Pump-set measurements		
Voltage change[3]	372 V (near DT) to 250 V (tail-end)	309 V (near DT) to 225 V (tail-end)
Voltage unbalance[4]	1 to 2 %	2.5 % to 10%
PF	0.9	0.8 (worst: 0.54)
Hydraulic efficiency	measurement not done	Open well :33% Bore well :39-49 %

[3] As per the Standard of Performance regulations, the voltages are to b within 8% of rated, which means that voltage should be in the range of 380 – 450 V. This is near impossible and with practical considerations, 15% was taken as low limit (350 V)

[4] Voltage phase unbalance is calculated using the 3 line to line voltages as = ($V_{max} - V_{min}$)/$V_{average}$. High unbalance cause temperature rise and literature specified 1% as the ideal figure and 5% as the limit.

Interactions with farmers and data measurements revealed the following broad trends:

- Both the DTs are over-loaded by 25-30% in terms of connected load
- Unauthorized connections exist to the extent of 30% of total pump-set connections. They are the major cause of over-loading of DTs
- There is alarmingly low voltage conditions (around 250 V as against 415 V) at 30-40% of pump-sets which are mostly located at the ends of power lines from DTs
- Hydraulic efficiency is estimated to be around 33% for open wells and ranging between 39-49% for bore wells. Total head used in calculating the hydraulic power could not be measured accurately in the field. Observing that suction and delivery pipes, which are of HDPE material, taking multiple but semi-circular bends throughout the length, total length of pipes is taken as closest estimate of total head. This might have lead to higher values of hydraulic efficiency.[5]
- Low voltages and lower Power Factors (generally around 0.7) are correlating with lower discharges from pump-sets. Some pump-sets are yielding very less water and there are frequent switching-off due to low voltages
- Burning of wiring and motor starters have been observed during field study at pump-sets, which receive low voltage power supply. Burning of motors is reported frequently which was also confirmed by few repairers who are in great demand and making good money in this trade
- Farmers removed all the capacitors supplied by Government on subsidy, within few days of their installation. They developed a feeling that capacitors do not allow pump-sets to function smoothly and especially under low-voltage conditions
- While DISCOMs insist on regularization of unauthorized connections by paying the fee, farmers expect Discom to step-up the capacity of DT to over-come the low voltage conditions

As a follow up to the earlier visits and measurements made on 2 DTs in Mylaram and Enabavi, local partner NGOs, Navajoythi and CROPS, organized meetings with farmers and motivated them to come together. After few interactions, farmers agreed to install capacitors on all the pumpsets connected to the 2 DTs under study.

Capacitors were installed during March 2008 in Mylaram and during September 2008 in Enabavi village. The community organizers with the help of local private electricians installed the capacitors.

After the installation of capacitors:

- Voltages improved and even the tail end pump-sets were operational
- Current to the pump-sets dropped by 10-15%. This results in 20-25% reduction of distribution losses.

[5] For borewells, the typical hydraulic efficiency is around 30%.

- Power factor improved by about 0.1
- After installing capacitors, input power increased by about 3-5% but hydraulic power increased marginally due to marginal increase in discharge. This resulted in slight reduction in hydraulic efficiency after installation of capacitors

4. INTERVENTIONS

4.1. Thinking through together

The cornerstone of interventions was the joint planning exercise with local partners and farmers. This thinking through together was quite different from the conventional 'expert driven' approach, were solutions are presented to the farmers for unquestioned implementation. Discussions spread over months helped to understand the problems, prioritise them, evolve ideas to mitigate them and prepare short & long term plans. This was important due to many reasons.

- Farmers & partners had detailed knowledge about the problems
- They had evolved many innovative methods to manage the problems and had a good idea about the possible pitfalls in some proposed solutions
- There was not much precedence to look up to, which could have guided the solution. Even when there were ideas, they were quite dependent on the local situation. Therefore solution had to be found through discussions and joint thinking about innovative ideas. For example, prioritisation of problem is dependent not only on the seriousness of the problem, but also on the ease of implementation of the solution
- The solution had to be a sustainable one. This was possible only if there was consensus on the idea.

The list of problems and possible solutions which evolved out of this thinking through, are given in Table 4.

4.2. Installation of Capacitors

Shunt capacitors were procured in bulk by the DISCOM and supplied to farmers at subsidised rates as part of the State-wide DSM program some time in 2005-06. They were not sized properly and there were doubts about their quality. Farmers did not become confident or convinced about using them. In fact many felt that capacitors will increase the probability of motor burn out. Farmers reported that after the capacitor was fixed, there were instances when the motor continued to run when supply on one phase failed, leading to motor heating and burnout. Few farmers who had connected the capacitors removed them after some days. Hence the capacitors were not connected to the motors, but remained at the houses, DISCOM offices or sometimes at the motor started boxes, not electrically connected to the motor.

Table 4: Problem Analysis		
Problem	**Analysis**	**Solution**
Tail end pump-sets sometimes do not work or have low discharge	- Low voltage at tail-end pump-sets - DT is overloaded – hence voltage regulation may be poor - Long service wires	- Install capacitors on **all** pump-sets - Optimise feeder routing from DT with multiple feeders - DT capacity has to be enhanced by DISCOM. This in turn needs farmers to regularise connections
Power supply fails very often	- Poor quality of wiring : low hanging LT lines, long service wires, motor location - DT fuse replacement done by farmers	- Improve wiring - Train farmers for local maintenance at LT side
Motor winding burnout	- Typically happens with 4 or 5 motors in each village in a year - Failure of one phase at DT and low voltages common - Starter does not trip since overload setting is high, single phase preventer not present, fuse wires do not burn since they are very thick	- Review starter overload settings and fuse wires once quality of supply improves
DT burnout	- Typically happens once few years. Farmers have to take it to DISCOM office for repair at their cost - LT faults due to poor quality wiring, sustained DT overload could be the reasons	- Regularise connections. Measures to improve wiring
Shock accidents at pump-set and other places	- No earth at pump-set location, no neutral wire from DT - Low hanging LT lines, long, low hanging service wires with no insulation cover at many places - One spell of power supply at night. No light at pump location	- Consider earth at pump-set location - Improve wiring - Install small wattage bulb at the switch board - Train farmers on basic safety precautions

Through discussions in the meetings, it became clear that if all farmers fix appropriate capacitors, the tail end farmers will definitely get benefited and there will be no adverse impact for those very close to the DT.

Capacitors of appropriate capacity and made by reputed manufacturers with ISI mark were procured. The problem of capacitor connection leading to motor burnout was traced to the mistake in the way the capacitors were connected[6]. Capacitors were fixed to all motors and the performance observed. It was clearly seen that tail-end voltage and water discharge improved with capacitor. In no case did the water discharge reduce and there were no cases of motor burn outs. Participation of DISCOM officials in this exercise added to the credibility.

4.3. Regularising connections

Measurements had shown that DTs were overloaded by 25-30% and nearly 30% of the pump-sets did not have legal connections. Most of these belonged to a category which could be termed as 'the other well', and the farmer does not think that the connection is illegal. When an open well dries up, farmer digs a bore well and uses

[6] Capacitor is to be connected to the motor terminals (after the fuse and starter, so that it gets discharged through the motor when motor is switched off), where as previously, it was connected between the fuse and the starter. In such a situation, when one phase fails, the starter does not drop if it is powered by a live phase and the capacitor acts like a 2- phase to 3-phase convertor.

the same electrical connection. During some part of the year, both wells have water and farmer uses both of them, using one legal connection. Similar situation arises when one bore well dries up and farmer digs another one close by.

DISCOM plans the DT capacity to cater to the legal connections and authorised connected load. Presence of illegal connections and increase in motor capacity leads to DT overloads. Augmentation of DT capacity is possible only if connections are regularised. After discussions, farmers were ready to regularise connections, provided the procedure is simple, connections are given under free power category, some amount of subsidy on connection charges (or at least provision of payment in instalments) and finally DISCOM gives a commitment to augment DT capacity as soon as connections are regularised.

Senior DISCOM officials (in the field or head office) were not ready to offer subsidy or instalment facility for regularisation. But in the discussions with farmers, they agreed to all other aspects. NRM project of CWS provided 50% subsidy, partner NGO & field DISCOM staff helped farmers with the procedure. Farmers were prompt in payment of the required charges and agreed to metered connection, since the months of joint work had convinced all that DISCOM staff will not use metering as an entry point for harassment.

Though partner NGO facilitated submission of applications, along with payment of required charges, DISCOM did not issue regularization letters to the farmers immediately. So far, farmers also did not receive bills from DISCOM for payment of monthly charges for free connections. Due to the change of a senior DISCOM official in the field, the earlier understanding between partner NGO, farmers and field DISCOM staff suffered and the promise from DISCOM to augment the DT capacity also was fulfilled till date.

4.4. Macro interventions-presentations to State utilities and Regulatory Commission

As mentioned before, presentations were made to State utilities (DISCOM & APTRANSCO) and APERC.

Presentation to State utilities helped to get exposure to the initiative and ensured support from ground level DISCOM staff. Presentation and representations to APERC gave wide publicity to the poor field implementation of DSM, introduced the idea of special tariff for shared wells and the need to integrate ground water regulation (like APWALTA) and electricity service connection release regulation. These interventions projected the possibility and potential of constructive engagement between DISCOM and farmers, perhaps facilitated by voluntary organisations to improve the agriculture power supply.

4.5. Planned interventions not carried out

In the course of the discussions, many ideas were suggested, but all could not be carried out. This includes:

a. Improving the motor starter panel: with ammeter/ voltmeter to give continuous indication of overload/abnormal voltage; provision of single phase preventer; correct setting overload limit; provision of good earth etc.
b. Use of standard motor: would be 2-3 times costly; is often not available on instalments from the local supplier; may not work in poor voltage conditions etc
c. Frictionless foot valves for open wells: Open wells were only few and hence not done.
d. Improving suction and delivery pipes: All farmers were using HDPE pipes and hence there was no case for replacement of pipes. Suggestions to reduce bends etc., were made and when possible, implemented
e. Sizing of pumps based on head: not done due to difficulties in measuring the head accurately
f. Improving the service wire: Reducing the length required additional poles by DISCOMs. Improving the quality of wire and stringing it is to be by the farmers.
g. Improving LT wiring: Neutral wires have been removed all over and DISCOM had no plans to provide them. Re-routing of the feeders based on geographical distribution and removing low hanging conductors were done to some extent
h. Training on O&M to local people: Possibility of providing basic training was explored and some youth were trained on motor winding etc. We could not identify agencies which would impart the required training
i. DT metering: Fixing up energy meter on the DT was suggested to the DISCOM, but has not been taken up since DISCOM has plans to monitor only few sample DTs (1/Mandal)
j. Franchisee: Farmers taking the rural distribution franchisee is a long term option

5. LESSONS

5.1 Grass-root:

- Agricultural power system is operating at sub-optimal level with relation between key stakeholders -farmers and Discom staff -strained and with mutual mistrust.

- Though the over-all situation is dismal, there are grass-root opportunities to improve the power supply to agricultural pump-sets, with positive and collective approach by Discoms and groups of farmers.

- Simpler interventions such as installing capacitors on pump-sets; reducing the length of LT service wires; proper location of LT poles; metering DTs and monitoring; training DT level groups in day-to-day maintenance can be implemented within in the existing policy framework

- There is scope for intervening at grass-roots, taking DT as the primary unit, by bringing together farmers connected to a DT; facilitate between the group and Discom and continuously following up with the group till they are fully convinced of the benefits of the interventions

- Positive approach from Discoms would help a lot to break the deadlock and mis-trust between the farmers and Discom staff
- Formal understanding between facilitating NGO, DISCOM and farmers help to ensure continuity of the initiative in the event of change of personnel.

- Interventions such as installing standard pump-sets, reducing the transmission losses and better service delivery at feeder and DT level are larger issues that involve larger funds, change in the mind-set; and policy support

5.2 Macro and Policy level:

- Free power policy in the State coupled with poor implementation of APWALTA pushed the agricultural power sector into negligence and low in efficiency

- Farmers as well as DISCOMs appear indifferent about energy-use efficiency, as the power is free to most of the farmer and the DISCOMs are reimbursed by government for supplying power to agricultural pump-sets

- Over-loading of DTs and motor burnouts / failures are grass-root problems farmers are facing but DISCOMs are only interested in maximizing their revenues by focussing on urban and industrial power supply

- Demand-side management and energy efficiency when integrated with efficient water management will certainly help not only to reduce the energy use in agriculture but also the efficiency and life span of pump-sets saving huge money to DISCOMs and farmers.

- Models to operationalize energy efficiency need to be evolved within the existing free power policy framework instead of a radical shift to either metering of all pump-sets or changing to HVD systems, which involves huge investments.

- A well-designed scheme from DISCOM with a promise to augment DT capacity when farmers under a DT come together and regularize all unauthorized connections is essential to create a favourable environment for up-scaling of this initiative.

6. WAY FORWARD

- This is an exploratory pilot study over a short span of time and in few villages to figure out approaches at grass-roots to work on energy and water in an integrated manner

- This pilot study also helped to understand the scope for interventions towards improving the energy and water use efficiency in agriculture power sector

- Field level measurements, though for a limited number of times, helped to understand the changes in electrical as well as hydraulic parameters before and after the installation of capacitors
- The study dispels the doubts about the functioning and benefits of capacitors among farmers in general and specifically among few farmers' leaders and researchers.

- More detailed studies on fewer pump-sets, with more frequent measurements will help to understand the functioning of pump-sets under different power supply and groundwater conditions

- Taking a larger sample of villages will also help in generating data and experience from diverse socio-cultural and electric network conditions. Towards this end, CWS recently initiated energy-water interventions in tribal villages of Tummala Cheruvu panchayat in Aswapuram mandal of Khammam district in Andhra Pradesh. In this panchayat, currently there is a no three phase power supply for agriculture but there are number of open and bore wells with plenty of water. DISCOM and ITDA came forward to provide three phase supply lines and install DTs. CWS is currently involved in facilitating formation of farmers' groups for each well on a sharing basis.

- The idea of promoting demand-side management at grass-roots with the involvement of DT level farmers groups needs further refinement and packaging to make it economically attractive and up-scalable. Introduction of incentives at DT level for efficient energy use are needed to encourage farmers to adopt DSM measures

- Currently the schedule of power supply to agriculture is for 7 hours throughout the State. This is usually given in 2 spells, one in the day time and another at night. As has been suggested by many (eg. Tushar Shah), It is possible to improve the situation to arrive at different supply schedules depending on the area and time of the year after discussions.

- Separation of agriculture feeders from those supplying power to rural areas has been implemented in Gujarat and is under implementation in AP, Rajasthan, Maharashtra etc. This is done at 11 kV level. (In the study villages, separate LT feeder was used to supply households). This could increase hours of power supply to rural households and improve the quality of measuring power supply to agriculture.

- It was noticed that the farmers and local DISCOM staff have no knowledge of the regulations on Standards of Performance of DISCOMs, existence of Grievance Forums etc. There is urgent need to build this awareness especially among rural consumers. Unless there is pressure from the rural consumers to improve the quality of supply, rural supply would remain poor.

- Interaction with Bureau of Energy Efficiency (BEE), an organization involved in evolving energy-efficiency standards in the country, and sharing with other institutions / farmers associations to further develop this idea is required

- Laboratory study of different motors and pump-sets under controlled power supply conditions will help to simulate the field conditions with more control on the energy and hydraulic parameters
- Up-scaling of this experience can only be done with the committed involvement of grass-root NGOs / CBOs with positive support from DISCOMs and farmers. It has been very difficult to find NGOs or Farmers Association who are interested in taking up such grass-root work on larger scale. DISCOMs have expressed that they do not have manpower and resources to take up this social mobilization work. This is one of the major constraint in up-scaling this work.

- Agriculture power is a socio-political issue with linkages to cropping pattern, marketing of products, pricing & availability of inputs (seeds, manure etc), credit, support pricing etc. Only an integrated approach with all actors will yield sustainable results. Integrated Natural Resource Management approach should be promoted as opposed to short-term populism.

7. REFERENCE:

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Annexure-I

Calculation of hydraulic power and efficiency:

Hydraulic power, power output of the pump in terms of observed discharge, is calculated using the following formula:

Hydraulic power (Kw) = (H * Q * 9.81) / 1000

H – Total Head (including suction and delivery heads) (in meters)
Q – Discharge (in litres /sec)

Further, pump hydraulic efficiency is calculated as shown below:

Hydraulic efficiency (%) = 100 * (Hydraulic power) / (Power taken by motor)

Where in,

Power taken by motor = Input power to motor (in Kw)
Hydraulic power = Power output from pump (in Kw)

Annexure-II

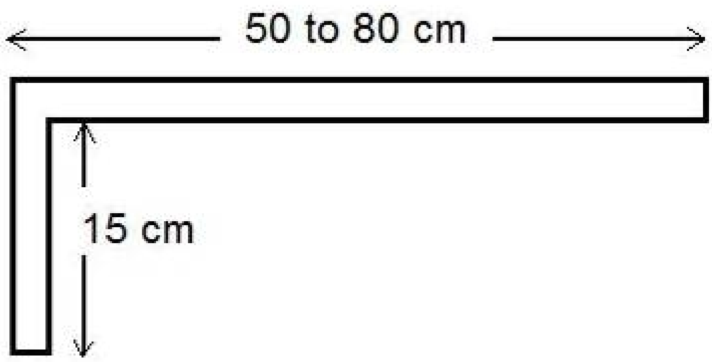
Discharge Measurement using a simple "L" shaped Gauge

Measurement of discharge from an open or tube well in the field is necessary in estimating the pump hydraulic efficiency. Simple techniques like drum and stop-watch method are frequently used in the field. But, this method has its own limitations of accuracy, in addition to the problem of carrying the drum from place to place for measurement.

Alternatively, if pump delivery pipe is installed above the ground level, there is a simple technique to measure water discharge of pump using a water discharge gauge. Using this gauge, discharge from delivery pipe can be measured in no time. Following pictures shows a gauge being used for measuring the discharge.

Construction of Water Discharge Gauge:

It is constructed by using one vertical and one horizontal thin plate, whose inner facing just touches at 90o angles. Inner length of vertical plate is kept 15 cm and horizontal plate length 50 to 80 cm. Width of plate may be 3 to 6 cm. Steel scales with centimeter markings may be cut and welded to the required lengths to fabricate this gauge.



Design of gauge is based on following empirical formula:

$$Q \text{ (litres per sec)} = (D^2 * x) / (59 * y^{½}) = (D^2 * x) / 228.5$$

Where -

Q = Discharge from the well (liter/sec.)
D = Delivery pipe diameter (cm)
x = Horizontal distance (cm)
y = Vertical distance (cm) (fixed as 15 cm)

Method of application:

For measuring water discharge from the well , put this gauge scale as sown in the photo on delivery pipe and slide it slowly forward. When inner lower point of the inner face of the vertical 15cm long plate (Y-Axis) just touches upper profile of flowing water, take the reading on the sliding scale (X-axis) placed on the delivery pipe. Measure the diameter of delivery pipe. Use the formulae given above to calculate discharge of water in liters/ sec. A ready reckoned water discharge table using measured values of X- and Y-Axis on the basis of that formulae are given in the table below:

Ready Reckoned table for water discharge rates from the tube-wells

Sl.	**Horizontal Distance (cm)**	**Water Discharge rate (litres/ sec) from pipes varying in dia.**				
		Delivery pipe diameter (in inches)				
		2”	**2.5”**	**3”**	**3.5”**	**4”**
1	5	0.55	0.86	1.23	1.68	2.19
2	10	1.09	1.71	2.46	3.35	4.38
3	15	1.64	2.56	3.69	5.03	6.56
4	20	2.19	3.42	4.92	6.70	8.75
5	25	2.75	4.27	6.15	8.38	10.94
6	30	3.28	5.13	7.39	10.05	13.13
7	35	3.83	5.98	8.62	11.73	15.20
8	40	4.38	6.84	9.85	13.40	17.50
9	45	4.92	7.69	11.08	15.08	19.69
10	50	5.47	8.55	12.31	16.75	21.88

Note extracted from:

Discharge Measuring Scale in Pipe Flow- A simple tool to measure water used in farmer participatory research by Er. S.N. Singh Chauhan, Assoc. Prof. (Agri. Engg.), K.V.K. Pilkhi Mau