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REALISTIC ESTIMATE OF AGRICULTURAL POWER IN ANDHRA PRADESH (INDIA) - A CASE STUDY

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ABSTRACT

Energy supply to agriculture is gaining importance in many states in India. Average increase in number of tube wells for irrigation by many folds has raised the agricultural demand on the grid which is not being metered or monitored. This consumption is considered as residue in the process of estimation of Transmission and Distribution (T and D) losses by utilities every year. Hence this paper finds its importance while estimating actual electrical energy consumed by agricultural sector. Experiments are conducted near the pump sets in fields to find actual electricity consumption at various pumping rates. Along with the drawbacks of current methods of arriving at agricultural demand, the paper proposes a conceptual method to estimate actual agricultural energy consumption by agricultural sector. The results are compared with the actual consumptions from Annual Revenue Requirements (ARR) filed by distribution companies of Andhra Pradesh.

Keywords: Agricultural power consumption, estimation, agricultural load, available head, pumping rate.

1. INTRODUCTION

Power supplied to agriculture is subsidized in all the Indian states and is free in Andhra Pradesh. It has been alleged that high consumption by the agriculture sector and subsidies pumped in to this sector are the culprits behind the decline of power sector resources. But a keen examination of this sector shows that the picture is otherwise [1]. As the amount of energy supplied to agriculture is not metered the consumption of this sector is arrived by elimination process. From the total amount of distributed energy, energy consumed by metered sections is deducted. From this difference the energy that the Board wants to show as T and D loss is deducted. The remaining energy is shown as consumed by the agricultural sector. No scientific method is used till today to arrive at the magnitude of T and D losses. Amulya K. N. Reddy and Gladys D. Sumithra's comment on Karnataka situation [2] holds good for Andhra Pradesh also: Unfortunately, the technical losses have not been measured or derived from the T and D system diagram by standard electrical engineering computations. Instead, all the T and D losses (including the technical losses) are being obtained as a residue [3]. Several studies conducted by Government and Non-Government organizations have strengthened this [4-6]. Authors in [7, 8] identified the necessity of proper estimation/accountability for the energy that is consumed in agricultural sector. Put together, the tariff structure, poor combination of technology and management are responsible for water loss, unsustainable exploitation of ground water and high energy losses associated with the distribution and end-use of electricity in irrigation water pumping. A common methodology must be followed by all the DISCOMS to arrive at the agricultural consumption.

The paper finds its interest in evaluating the power consumption when the discharge through pump set is known. Power input to the motor depends on water output from the pump set. Experiments are conducted on pump sets in various regions to know the actual power consumption at various discharges.

2. ISSUES IN ESTIMATION OF AGRICULTURAL CONSUMPTION

Major issues involved in estimating the energy consumption in agricultural sector are:

- Assessment of average connected load (3HP / 5HP/ 7.5HP/ 10HP/ 15HP)
- Type of pump sets connected (Jet / submersible / centrifugal / mono block)
- Assessment of actual number of operating hours
- Total number of pump sets energized

In estimating actual power consumption, the data is very vague - different studies shows different picture. Because of subsidized nature and thumbs down metering different estimates have their own deficiencies.

2.1 Power consumed in agriculture

Table-1 shows the percentage of consumption by agricultural sector and estimated system losses for various years [9].

Table-1. Percentage of agricultural consumption and distribution system losses.

Year	2007-08	2008-09	2009-10
Agricultural consumption	22.04	21.61	21.18
Losses	29.24	28.44	29.00

From the above table it can be seen that half of the energy that is being generated in the country is shown under Agricultural consumption and losses which is just estimated with out metering.

Increased number of pump sets year to year necessitates the continuous monitoring of consumption which is not at all done because of variety of reasons. This component is significant and should be evaluated exactly for estimating system losses. Table-2 shows the losses specified by distribution companies of Andhra Pradesh and the process of computing losses is mentioned in the respective websites.

Table-2. T and D losses in Andhra Pradesh.

Year	2006-07	2007-08	2008-09
APCPDCL	17.89	17.90	17.43
APSPDCL	17.07	15.33	14.44
APNPDCL	19.18	14.58	15.45
APEPDCL	12.90	9.01	9.16

Agricultural consumption projections and projected losses by the four utility companies of Andhra Pradesh for the year 2009-2010 are listed in Table-3.

Table-3. Agricultural consumption and T and D Losses for the year 2009-2010.

	Agricultural consumption MU (%)	**T and D losses MU** (%)
APCPDCL	7319 (23.08)	5215 (18.25)
APSPDCL	4167 (26.48)	2043.7 (14.03)
APNPDCL	4140 (37.97)	1701 (15.43)
APEPDCL	1812.66 (16.92)	905.02 (8.44)

All the actuals/projections mentioned above are higher than Andhra Pradesh Electricity Regulatory Commission (APERC) prescribed values. The consumption shown in this sector is increasing every year by around 5%, and this consumption shown would have been subjected to availability of power and availability of ground water. It is well known that in many regions in the state of Andhra Pradesh, ground water is not available abundantly to exploit. Higher values of available head, non availability of ground water would definitely affect the amount of power that is being consumed and this factor seems to be just ignored while calculating or giving above figures.

2.2. Pump load scenario

Ground water scenario in the state of Andhra Pradesh varies from 30 feet to 500 feet depending on region. Capacity of pump set sanctioned to farmers depends on the average land holding and water availability. Total number of agricultural pump sets in Andhra Pradesh state has reached to 26.85 Lakhs by the end of April 2009 where as their number in 1999 was 18.85 Lakhs when the reforms process was initiated [AP Transco]. It is asserted that consumption of agricultural sector is becoming one of the major hurdles in achieving the reforms in state power utilities. In order to estimate the actual power consumed in this sector, analysis on pumping equipment needs to be carried out.

In Andhra Pradesh, power is fed for 7 hours in a day and is said to be absolutely free. Under certain farming conditions, for some farmers it is charged at Rs. 0.50 per unit and at Rs. 0.20 if capacitors are installed near pump sets.

Capacity of electric pump set is selected based on available head, amount of water required for crops etc., HP rating of motor required to pump water is given by:

$$HP\,of\ motor = \frac{wQH}{75\eta} \quad ---(1)$$

Where,

w= Unit weight of water
Q= Discharge to be delivered
H= Total head against which the motor has to operate
η = Efficiency of pump set usually taken as 65%

$$Friction\,loss\; h_l = \frac{4flv^2}{2gd} \quad ---(2)$$

Where,

f = Coefficient of friction whose value may be taken as 0.006
l= Pipe length
v= Velocity of discharge
g= Acceleration due to gravity
d= Diameter of the discharge pipe

Knowing the aquifer permeability k, draw down S, length of strainer L, discharge through the pump set Q can be computed from:

$$Q = \frac{2\pi kSL}{2.3\log_{10} R/r} \quad ---(3)$$

Where R and r are radii of influence and radius of well, respectively.

But in realistic conditions the discharge may not be measured with equations 2 and 3. Thus the method given in [10] is used to measure discharge from pump sets.

3. ESTIMATION OF ENERGY CONSUMPTION

It is supposed that the power consumed by motor depends on the actual discharge from the motor and not the capacity of pump set that is connected. Capacity of pump set selected depends on available head, amount of water required for irrigation etc.

3.1 Experimental procedure

Experiments are conducted by selecting the pump sets of different capacities in various regions with different ground water potential. It is identified from the experiments that the actual amount of power consumed by motors depends on discharge directly. In certain regions where the ground water is not abundant discharge became zero and motor has consumed no-load power.

Analysis has been carried out through data on pump sets with (i) continuous flow, (ii) reduced flow and (iii) with discontinuous flow. An analytical formula is derived which gives the estimation of power consumption depending on the ground water potential.

Results are discussed / presented with the energy consumption per hp per hour basis for the analysis.

3.2 Proposed method to find actual energy consumed

(i) Continuous flow

From the experiments it is found that, when abundant ground water is available, energy consumed by motor is more or less constant as the flow is continuous with full discharge. From the data that is analyzed it is found that motors are taking a real power of around 0.9kW/hp to 1.2kW/hp when they run on full load.

For presenting the results, full load power consumed by a motor 'P_0' is considered as 1.2 kW/hp. When it is operated for T hours a day, then the power consumption per hp becomes P_0T kW/hp.

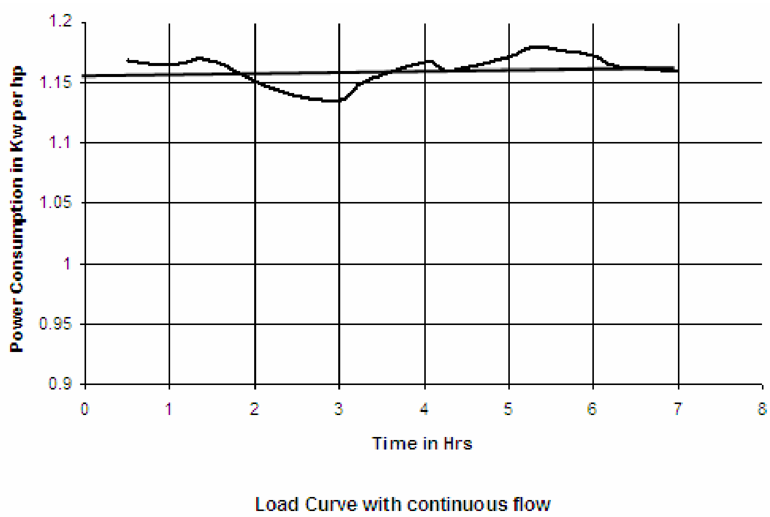

Figure-1. Daily load pattern with continuous flow.

(ii) Reduced flow

When recharge rate of an aquifer is less than outflow rate then a reduction in water stream is observed at the outlet of pump set. This type of discharge can be observed in certain regions where more number of motors is being operated. And there exists certain water belts where recharge rate is less compared to discharge rate.

In such regions it is found that water discharge has been reduced slowly and hence the power consumption. Thus, for the purpose of analysis, in order to achieve at a good estimate, power consumption at the end of T hours 'P_1'in a day need to be measured.

Shaded area in Figure-2 clearly indicates reduced energy consumption compared to (i). By observing the load pattern, slope 'm' with which actual power consumption is being reduced can be obtained. A new factor for the rate at which power consumption of a motor reduces with discharge may be termed as "Water bed factor" (α).

Where $\alpha = (P_0-P_1)/T$ ..... (4)

If P_1 is measured at the end of time't' then α may be taken as $(P_0-P_1)/t$

Hence amount of energy consumed is:

$$P_0T - \frac{1}{2}\alpha t\, T \text{ kW/hp/day} \qquad \text{..... (5)}$$

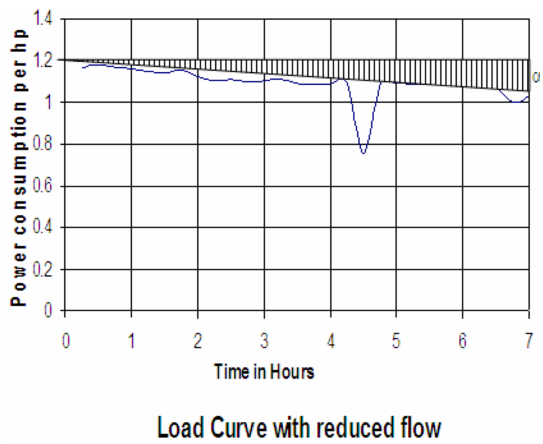

Figure-2. Daily load pattern with reduced flow.

(iii) Discontinuous flow

In certain ground water irrigation regions, water availability is very less and the discharge is observed as bursts. The amount of power consumption of motor during very little or low discharge has gone to no load condition 'Pnl'of the motor.

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It is also observed that a duty ratio 'D' of 0.4 to 0.6 is maintained between pumping cycles. This value again may be dependent on capacity of pump set, depth of water level, recharge rate etc.

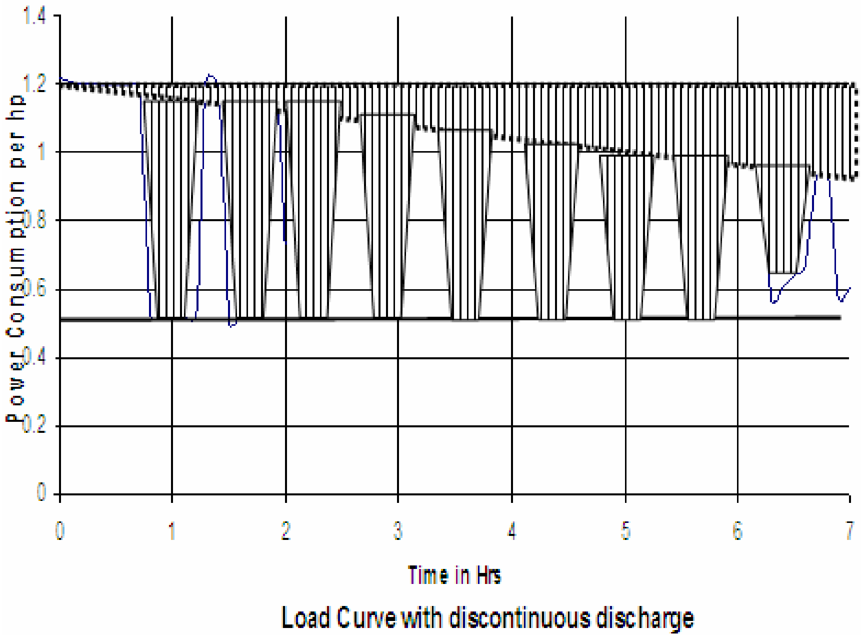

Figure-3. Daily load pattern with discontinuous flow.

In this particular condition, amount of energy consumed by motor is still less compared to condition in (ii). Now energy consumed in kW/hp/day is approximated

as = $P_0T - \frac{1}{2}\alpha t T - \frac{1}{2}(2P_0 - 2P_{nl} - \alpha t)T(1-D)$

= $P_0T - \frac{1}{2}\alpha t T - \beta T(1-D)$ ..... (6)

β depends on motor operating condition and water bed factor.

In order to compare the results with the annual Figures given by Andhra Pradesh state Distribution Companies, an average number of 160 days per annum is considered with 7 hours a day. The above said load patterns on a motor repeats for every day and the total operating time of motor per annum is taken as 1120 hours for verifying the effectiveness of the proposed methodology. This data is taken from the field measurements.

In addition to full load power consumption of 1.2 kW/hp, water bed factor of 0.05 and a reasonable value for no load power consumed is considered as 0.5kW/hp. Duty ratio is assumed as 0.6.

Results are presented with three cases

(a) When all motors run with full load
(b) When all motors run at reduced flows
(c) When 50% motors run with reduced flows and 50% with very low discharge rates.

Details of total hp under LT category - V, Power consumption in MU and Total input to distribution network in MU for the four distribution companies of Andhra Pradesh are collected from ARRs filed for 2010-11. With respect to the above said three cases of section 3.1, specific power consumptions are estimated first and then consumptions from the proposed method are computed. Results are presented in Tables (4)-(6) for FY 2009-10 and 2010-11.

Table -4. Comparison of results for FY2009-10.

	Total hp under LT category - V	Power consumption under LT category - V		Estimated consumption from the proposed method in MU		
				Case a	Case b	Case c
		Units / hp	MU	1344U/hp	1148U/hp	1030.4U/hp
APNPDCL	3323656	1246	4141.28	4466.99	3815.56	3424.70
APEPDCL	1198778	1512	1812.66	1611.16	1376.20	1235.22
APSPDCL	2751303	1515	4167.82	3697.75	3158.50	2834.94
APCPCL	4340765	1686	7319.5	5833.99	4983.20	4472.72

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Table -5. Comparison of results for FY2010-11.

	Total hp under LT category - V	Power consumption under LT category - V		Estimated consumption from the proposed method in MU Case a	Case b	Case c
		Units / hp	MU	1344U/hp	1148U/hp	1030.4U/hp
APNPDCL	3489839	1246	4348.34	4690.34	4006.34	3595.93
APEPDCL	1202448#	1512	1818.10	1616.09	1380.41	1239.00
APSPDCL	2888868	1447	4180.32	3882.64	3316.42	2976.69
APCPCL	4547526	1690	7685.32	6111.87	5220.56	4685.77

estimated with a growth of 5% from FY 2009-10

Table -6. Percentage difference in number of units reported for FY 2009-10 and 2010-11.

	APNPDCL	APEPDCL	APSPDCL	APCPCL
2009-10				
Total input to distribution network (MU)	10070	10714.5	15741.05	31932.81
Percentage of excess units reported				
Case a	-3.23	1.88	2.99	4.65
Case b	3.23	4.07	6.41	7.32
Case c	7.11	5.39	8.47	8.91
2010-11				
Total input to distribution network (MU)	11020	12097	17395.26	33893
Percentage of excess units reported				
Case a	-3.10	1.67	1.71	4.64
Case b	3.10	3.62	4.97	7.27
Case c	6.83	4.79	6.92	8.85

CONCLUSIONS

An empirical formula is derived to find the realistic estimate of actual energy consumed in agricultural sector which is not metered. Experiments are conducted on the basis of exact water availability and with some reasonable assumptions. The results are compared with the numbers filed by the distribution companies in Andhra Pradesh. From the results it is observed that amount of energy consumed in agricultural sector is just given as an estimate by utilities. The consumptions calculated on actual ground water availability basis are less compared to the estimates given by distribution companies except with NPDCL for case a. This demand for an immediate attention by the authorities to reduce pilferage and losses in the distribution sector which are included or said to be consumed under agricultural free consumption. An immediate attention is also required to take up demand side measures to improve voltage profiles of the distribution network at the far end from transformers. With reduced voltage profiles, the current in the lines is high resulting in high amount of distribution losses. A different method may be proposed to find actual power consumption based on water requirement for various crops depending on the soil properties.

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