Agricultural pumping efficiency in India: the role of standards

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The end-use efficiency of agricultural pump sets in India is dismally low. The agricultural power tariff is highly subsidised and is usually linked to the connected load (not consumption). Farmers therefore have little incentive for efficient use of electricity. Nearly 500,000 pumps are added each year to the stock of functioning agricultural pumps, and most of these are not efficient. This paper evaluates ways in which they can be made efficient. The role of efficiency standards in achieving this goal and the appropriateness of existing standards is evaluated. The implementability of modified standards and their possible benefits are quantified.

Pump efficiency standards need substantial improvements. Raising the minimum allowable efficiency and allowing for the effect of deterioration in pump efficiency, which changes with operating conditions, are the important issues. Standards for pipe-sizing need to be revised. Past work has not considered the full implications of better standards. Improved standards for agricultural pumps alone can save India over US$ 129 million per year through the avoided expansion of the power generation and distribution system and fuel-saving. These savings are far greater than is commonly believed. The incremental investment necessary for this is just over one-tenth of the savings.

1. Introduction
The Indian power sector is facing severe capital and capacity shortages. Scheduled and unscheduled power cuts are common in most parts of the county. The low power tariffs for irrigation pump sets (IPS) are said to be the major reason for the poor financial health of the power sector. The electricity subsidy for IPS was Rs. 101.13 billion (US$ 2.89 billion) in 1995. The subsidised power tariff (based on the connected load) and poor efficiency of pumping systems is a cause of concern for the power sector. In the last two decades, the growth rate of electricity use by IPS has been about 12% per annum. This growth rate is twice as high as that of other sectors. In 1995, IPS consumption, as claimed by the power sector, was 28% of total sales (Planning Commission 1995).[1]

And nearly 500,000 IPS continue to be added to the number in service each year.

The efficiency of IPS is dismally low. Field studies and pilot projects have demonstrated that IPS electricity consumption can be reduced by 30 to 50% by simple measures, such as the use of higher efficiency pump sets and pipes of larger diameter. The payback period for such investments is 1 to 2 years [NABARD, 1984; Patel and Pandey, 1993]. But past efforts have been mostly directed towards rectification of old IPS and a lot needs to be done to ensure efficient installation of half a million new IPS each year.

This paper evaluates the role of efficiency standards in ensuring installation of efficient IPS. The first section of the paper describes the factors affecting the efficiency of IPS. The second and third sections evaluate the appropriateness of the standards, i.e., whether standards are sufficiently stringent or need to be improved. Since Indian efficiency standards are not mandatory, it is important to evaluate whether the improved standards would have a real impact in the field. The last two sections examine this issue and quantify the likely benefits.

1. Typical IPS installation and factors affecting efficiency
A typical configuration of IPS, as shown in Figure 1, consists of a piping system (foot valve, suction and delivery pipe) and the pump set. Centrifugal monobloc pump sets installed on open dug wells are most common. This paper mainly deals with centrifugal pumps.

The efficiency of a pumping system is a function of the efficiency of its components, i.e.,

\[ \eta_{\text{system}} = f(\eta_{\text{pump set}}, \eta_{\text{piping}}) \]  

(1)

1.1. pump set
Pump efficiency characteristics are represented as total head vs. discharge, as shown in Figure 2. The total head (the vertical axis in the figure) is the sum of the suction head, delivery head and the frictional head due to piping. With increasing total head, the flow rate decreases. The pump efficiency is also plotted against flow on the same graph. With increasing discharge (or decreasing head) the pump efficiency first increases and then falls. The highest efficiency point is referred to as the “best efficiency point” (BEP).

The efficiency characteristics of the pump also depend on the suction head. The broken lines in the figure show the pump characteristics at a higher suction head. It can be seen that pump efficiency deteriorates as suction head increases.

In field conditions, due to changing water level and, at times, change in the water delivery point, the suction and...
the total head change. Hence, most IPS operate with varying total head and suction head. Therefore, the in-field pump efficiency depends on:

1. BEP efficiency, and
2. the change in pump efficiency with changing suction and total head.

Squirrel-cage induction motors are generally used for IPS. The difference between the efficiencies of a standard motor and an efficient motor (available in the market) ranges from 5 to 11 percentage points. Efficient motors are suitable for IPS operation but standard motors are used because of cost considerations.

### 1.2. Piping

The piping efficiency can be defined as:

\[
\eta_{\text{piping}} = \frac{\text{useful energy output}}{\text{total energy input}} = \frac{(H_s + H_d)}{(H_s + H_d + H_f)} \quad \ldots (2)
\]

where

- \( H_s \) = static suction head
- \( H_d \) = static delivery head, and
- \( H_f \) = frictional head loss in pipe and accessories (in metres of water column)

The frictional losses in the pipe (\( H_f \)) can be estimated by following equation:

\[
H_f = 1.213 \times 10^{10} \times (Q \div C)^{1.852} \times (L \div D)^{4.87} \quad \ldots (3)
\]

where

- \( Q \) = rate of discharge in litres per second (lps)
- \( C \) = Hazen Williams’s constant, a function of pipe surface
- \( D \) = inside diameter of pipe in mm
- \( L \) = length of pipe in m

It can be seen that, for a given discharge and length of pipe, the piping efficiency can be increased (i.e., frictional loss can be reduced) by:

1. Using a low friction pipe, such as rigid PVC (RPVC) pipe;
2. Proper layout to reduce the pipe length; and,
3. Increasing the pipe diameter.

The foot valve (a non-return valve) is the most important accessory in piping. The loss of head due to friction in the foot valve (\( H_{fv} \)) is proportional to \( K \) and \( V^2 \)

where \( K \) = foot-valve characteristics (determined by material, construction and design of footvalve), and

\( V \) = flow velocity (m/s)

The \( K \) value of the foot valve ranges from 13 to below 0.8 [Patel and Pandey, 1993]. For a given flow velocity the frictional loss is directly proportional to the \( K \) value.

### 1.3. Efficiency standards for agricultural pumping systems

The Bureau of Indian Standards (BIS) and the National Bank for Agriculture and Rural Development (NABARD) have laid down standards/norms for various aspects of the pumping system.

BIS, a statutory body of the Government of India, has developed standards for a number of industrial and do-

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**Figure 1. Typical configuration of IPS on well**

The figure shows a typical configuration of a monobloc IPS on a well. The suction and delivery pipe as well as the suction/ delivery head (static) are also shown. The change in water level (drawdown) during pump operation is indicated.
Adoption of BIS standards is voluntary for appliance manufacturers. BIS has prescribed elaborate standards and testing procedures for pumps, motors, pipes and foot-valves. Manufacturers conforming to BIS standards get an ISI mark, a logo indicating a quality product.

NABARD is a public sector developmental bank. It extends loans for agricultural schemes such as digging wells, installation of IPS or land preparation. It operates mainly by refinancing the loans extended by other commercial banks to these schemes. NABARD has also prepared norms for selection of IPS system components. All farmers availing themselves of NABARD credit have to abide by these norms. For small pumping systems, NABARD has adopted the BIS norms. But for large pumping systems, NABARD has evolved its own norms for pipe sizing, layout, and pump selection.

2. Evaluation of BIS standards for pumps

For achieving high operating efficiency in a pump, two factors are important: (1) proper pump selection, and (2) high pump efficiency. This section analyses BIS norms for pump selection and pump efficiency.

2.1. Selection of pump

Pump selection involves specification of head as well as the flow rate, head selection being the most important aspect. The Indian standard for “Recommended pumping system for agricultural purpose” (IS 10804:1994) says:

“The pump should be selected in such a way that it shall operate at near maximum efficiency during peak demand period in the ranges of discharge and head. It should also be capable to discharge in summer season (when the head is likely to be the maximum).”

The standard does not specify a procedure for pump selection, and in practice, pump selection is totally arbitrary. Farmers are rarely aware of the importance of proper pump selection or even the relation of head with flow. Our observations of pump purchase deals (at pump dealer shops) revealed that farmers usually decide pump power (kW) and the pump dealer implicitly decides pump head. For proper pump selection, which is one of the toughest tasks and also the most important, the following conditions need to be satisfied:

- Farmers as well as pump dealers (authorised as well as unauthorised) need to be made aware of the importance of proper pump selection relative to head.
- The technical literature written for this purpose needs to be simplified.
- Most importantly, farmers need a clear incentive for efficient pump use (such as consumption-based power tariff).

Hence, the standards have little role in proper pump selection.

2.2. Pump efficiency

The BIS standards for minimum pump efficiency (for agricultural use) were introduced in the late 1980s. Pumps are tested at the design head (BEP head) with a suction head of 6m. This is a one-point test. But, as discussed earlier, the in-field operating efficiency of a pump depends on three aspects:

1. pump efficiency at the design head (at BEP);
2. change in efficiency with change in total head; and
3. Change in efficiency with change in suction head. The following sections deal with these three aspects.

2.2.1. Pump efficiency at design head

The BIS-specified minimum pump efficiency varies from 55 to 70% depending on the rated duty point (of head and flow). The BIS standards were expected to be upgraded every 3 years. But the efficiency standard for monobloc agricultural pumps, IS-9079, has not been revised since 1989. About the appropriateness of these standards, the Chairman of the Technical Committee of the Indian Pump Manufacturers’ Association (IPMA) says: “There is a wide gap between the minimum efficiency required for ISI certification and [the efficiencies] achieved by reputed manufacturers, which are very near international efficiencies. So, there is a big scope for improving the efficiencies of pumps manufactured in the country.” [Jain, 1994]

This gap in efficiency is 8 to 10 percentage points, implying an energy-saving of 12 to 14% by the efficient pumps [Boothra and Bajaj, 1994].[4] The BIS standards need to be upgraded to remove this gap.

2.2.2. Change in efficiency with change in total head

The declared efficiency at BEP represents the maximum achievable pump efficiency. When the operating head is different from the head at BEP, the pump efficiency is lower than the declared efficiency. For well-designed pumps such fall in efficiency can be small, i.e., the efficiency curve is flat in relation to variation in total head. Figure 3 shows the change in efficiency of two sets of pumps with change in total head. All four pumps conform to the BIS standards. Pumps A-1 and A-2 are designed for low head, while pumps B-1 and B-2 are designed for medium head. The BEP efficiency of these pumps as well as their design heads are different from one another. To eliminate such differences, the figure shows efficiency as a percentage of BEP efficiency and the head as percentage of maximum head. It can be seen that pumps A-1 and B-1 show lower deterioration in efficiency compared to their counterparts (i.e., pump A-2 and B-2 respectively).

Considering pump operation evenly spread over the head range, pumps A-1 and B-1 would perform better. The average operating efficiency of pump A-1 and A-2 would be 95% and 87% of their rated efficiency (at BEP). Hence, even if the rated efficiency of both pumps (A-1 and A-2) was to be identical, pump A-2 would consume 10% more energy than A-1. For pumps B-1 and B-2, the average efficiency works out to be 92% and 90%. Hence, pump B-2 would consume 2% more energy than B-1, just on account of its non-flat efficiency curve.[5]

2.2.3. Change in efficiency with change in suction head

As seen earlier, pump efficiency also deteriorates at high suction heads. The maximum suction head of a pump depends on its net positive suction head (NPSH) characteristics. When the suction head approaches the maximum suction head, the pump efficiency can dramatically fall. The maximum suction head of ill-designed pumps can be substantially lower than that of well-designed pumps. For open dug wells, the change in water level (and hence the suction head) can frequently be 3 to 4m. Figure 4 shows the change in efficiency for two pumps with change in suction head. To eliminate the difference in the rated pump efficiency (at BEP), here the efficiency is represented as a percentage of rated efficiency. In the shown range of suction head, the average (simple average) efficiency of pump A is 92% of its BEP efficiency. For pump B it is only 79%.[6] Hence, even if both pumps had the same rated efficiency, pump B would consume 16% more energy than pump A for the varying head operation.

For agricultural operations the total head as well as the suction head is highly variable. Hence, operating efficiency can be substantially lower than the rated pump efficiency. For well-designed pumps this deterioration in efficiency would be far less than for ill-designed pumps. The present BIS norms based on a one-point test neglect

Figure 3. Change in pump efficiency with variation in total head

For a varying head operation, the average operating efficiency of A-1 and B-1 would be superior to that of their counterparts. This is reflected in 2% to 10% more energy consumption by the inferior pumps, just on account of non-flat efficiency curve. Data for pumps A-1, A-2 are based on measurements reported by Boothra and Bajaj [1995] and data for pumps B-1, B-2 are from the manufacturer’s literature.
the change in efficiency with change in total as well as suction head. Hence, in addition to increasing the minimum rated efficiency (at BEP), the BIS standards should also consider these issues.

As mentioned earlier, the problem of improper pump selection can only be addressed by education and incentives and not by standards. Even with improved BIS standards, improper pump selection can continue. But a pump with better suction characteristics and flat efficiency curve (in relation to head) would show better performance than an inefficient pump even in case of improper selection. In other words, the inefficiency due to improper pump selection can be reduced by better pump standards.

3. Evaluation of BIS and NABARD standards for pipe sizing

Piping system efficiency mainly depends on the pipe size and also on the quality of accessories such as foot-valve, bends and piping layout. This section evaluates the appropriateness of pipe-sizing standards of BIS and NABARD. The issue of accessories and foot-valves is covered at the end of the section.

For pipe sizing, the BIS and NABARD each have a set of norms. Depending on the flow rate, BIS specifications require the pipe frictional loss to be lower than 3.5 to 9.5m (of water column) per 100m of pipe length (IS 10804:1994). NABARD norms specify much higher pipe size; they allow frictional loss of only 3 to 4m per 1,000m of pipe length [NABARD, 1991]. Hence, 100m of pipe sized as per the BIS norms would offer the same frictional loss as 1,000 to 3,000m of pipe sized as per the NABARD norm.

For a given flow rate, the frictional loss in pipe decreases if the pipe size is increased. And correspondingly, the electricity usage and the pump power needed to overcome the friction also decrease. Hence, with increasing pipe size, the running cost of electricity and investment cost of pump decreases but the investment cost of pipe increases. It is important to minimise the total cost, comprising the running cost and the annualised investment cost (of pump and pipe). There exists an optimum pipe size at which the total cost is minimum. The following sections calculate such optimum pipe sizes for various flow rates and compare them with the BIS and NABARD piping standards.

3.1. Calculation of optimum pipe diameter

Figure 5 shows the calculations to arrive at the optimal pipe size for a flow rate of 20 litres per second (l/s). For this flow, the frictional head loss per metre of pipe is calculated using Equation 3. The electricity usage to overcome the frictional loss is calculated for the typical pump efficiency, and annual pump operation of 2,000 hours per year. The running cost (of electricity) is calculated for the average cost of electricity supply in Maharashtra. The investment cost has two components: the pipe cost and the incremental cost of pump to overcome pipe friction. The pipe cost is based on the prevailing price of RPVC (rigid PVC) pipes. The investment is annualised to make it comparable with the annual running cost.

Figure 5 shows the change in (a) annualised investment cost (of pipe and pump), (b) running cost of electricity use, and (c) the total cost (i.e., a+b). The costs are shown

![Figure 4. Effect of suction head on pump efficiency.](image)
as a function of pipe size. With increasing pipe diameter, electricity cost decreases rapidly, but the investment cost increases. The optimum pipe size, which minimises total cost, can be arrived at from the figure. This calculation is based on the average cost of electricity supply (in Maharashtra) but farmers do not pay the full cost of electricity. Hence, the above calculation reflects the optimum pipe size from the social point of view. The assumptions made are listed below:

1. economic life of RPVC pipe and pump = 10 years,
2. pump set cost = Rs. 1,876 (US$ 50.7) per kW,
3. pump set efficiency = 60%,
4. electricity cost Rs. 1.73/kWh (4.7 US cents/kWh) [Planning Commission, 1994],
5. 12% (real) discount rate.

The optimum pipe size calculated above considers the average cost of electricity for the power utilities. But Indian farmers do not pay the full cost of electricity. Hence, they have no incentive to use the optimum pipe size. But the standards need to consider the social perspective and should try to minimise the total cost from this perspective. In other words the BIS norms for pipe size should be the same as the optimum pipe size calculated above.

3.2. Comparison of BIS and NABARD piping norms with optimum pipe size

Based on the above calculation, the optimum pipe sizes for different flow rates are arrived at after considering commercially available pipe sizes. The BIS and the NABARD piping norms are compared with the calculated optimum pipe size.

The running cost of electricity use is a function of duration of pump usage. Hence, the optimum pipe size also depends on the pump usage. For a given flow, optimum pipe sizes at different levels of pump usage have been calculated. Pump usage levels of 250, 2000 and 6000 hours per year have been considered. The results are shown in Figure 6.

NABARD has evolved piping norms for lift irrigation schemes, which usually operate for more than 3000 hours per year [NABARD, 1991]. For this level of operation, NABARD norms are close to the optimum. The BIS norms are targeted at small pumps. These norms are suitable for pump operation below 250 hours per year. Considering the national average for pump usage of 1700 hr/yr, the BIS norms need to be substantially upgraded.

3.3. Accessories and pipe layout

The foot-valve is the most important accessory in piping. The BIS norms for foot-valves specify that the K value of the foot-valve should be less than 0.8. Foot-valves made by small non-standard manufacturers have K values between 2.5 and 13 [Patel and Pandey, 1993, p. 31]. Researchers and manufacturers have developed ISI-marked foot-valves. These efficient foot-valves (of RPVC) are widely available in sizes up to 100 mm. Efficient metal foot-valves are available in higher sizes also.

As regards the pipe layout, the BIS standards specify that low-loss accessories such as “long radius bends” should be used; the number of bends and length of pipe
should be reduced. Hence, the BIS specifications are appropriate.

4. Possible impact of standards and norms on IPS energy consumption

The technical knowledge required for proper selection of pump set and pipe sizing is clearly out of the reach of farmers, who are the final consumers. Moreover, farmers have no incentive to reduce electricity consumption. On the contrary, for reducing the initial cost, farmers may resort to cheap, low-quality equipment. In addition, the BIS norms are not mandatory for IPS manufacturers. Due to these factors, it is usually believed that standards and norms have little role in improving the efficiency of new IPS installations. Even the World Bank expresses the same opinion [World Bank, 1996]. This section evaluates if this belief is correct.

About 350 pump manufacturers in India have opted for the ISI mark and do follow BIS standards. Most low-friction (PVC) pipes in the market carry the ISI mark. ISI-marked foot-valves are widely available. As such, the availability of ISI-marked IPS system components is not a problem.

Most large pumping schemes avail themselves of NABARD loans and are designed by NABARD-approved consultants. Hence, the NABARD norms are usually followed. Small pumping systems are usually not designed by consultants. An internal study conducted by NABARD observed that small pumping systems usually install ISI-marked pump sets but BIS norms for pipe size are not followed [NABARD, 1995]. Our discussions with farmers and dealers in Maharashtra also revealed that farmers do ask for ISI-marked pumps. Hence, improved BIS standards would have a direct effect on new pump installations.[7] But no information or analysis was available as to how the pipe size is decided. This issue was studied further, leading to the analysis given below.

Discussions with pump dealers revealed that farmers rarely select the pipe size. Usually, the dealer simply gives them a pipe that fits the pump flange size. This is also confirmed through analysis of data for 100 IPS. The Maharashtra Energy Development Agency (MEDA) has carried out thousands of IPS piping rectifications and has data for these IPS. An analysis of 100 randomly selected pumps was carried out. In 99% of the cases, the pipe used was of the same size as that of the pump flange. Table 1 shows details of the analysis.

![Figure 6. Comparison of optimum pipe size with NABARD and BIS norms](image)

The square and triangular marks indicate the NABARD and BIS-recommended pipe sizes for different flows. The lines indicate the optimum pipe sizes at three levels of pump usage. The BIS norms for pipe sizing are appropriate for pump operation of 250 hr/yr. Considering the Indian average pump usage of 1,750 hr/yr, BIS norms need to be revised upwards. The NABARD norms applicable for lift irrigation schemes, which usually operate for over 3,000 hr/yr, seem appropriate.

### Table 1. Analysis of pipe size data collected during rectification projects.

<table>
<thead>
<tr>
<th>Number of IPS analysed</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7 kW pumps</td>
<td>9</td>
</tr>
<tr>
<td>2.2 kW pumps</td>
<td>91</td>
</tr>
<tr>
<td>Pipe size same as flange size</td>
<td>99</td>
</tr>
<tr>
<td>Pipe smaller than BIS recommendation</td>
<td>94</td>
</tr>
<tr>
<td>- Before rectification</td>
<td>94</td>
</tr>
<tr>
<td>- After rectification</td>
<td>12</td>
</tr>
</tbody>
</table>
In the case of small pumping systems it can be generally assumed that farmers use pipes of the same size as that of the flange. Hence, the implementability of BIS piping norms depends on pump flange sizes. And, in turn, evaluation of the pump flange sizes becomes important. An analysis of flange sizes of 12 pumps (four pumps of three manufacturers each) was carried out.

The pipe fitting the pump flange size is assumed to be used. Most farmers now use RPVC (rigid PVC) pipes. Hence, the use of RPVC pipe is assumed. The likely pipe size used is compared with the BIS recommended pipe size (at BEP flow condition).\[8\] Pump operation of 2,000 hr/yr and the average cost of electricity supply for the utility has been considered for this calculation. Figure 7 shows the expected pipe sizes by bars and the BIS-recommended pipe sizes by square points. In the cases of 4 pumps, the flange is smaller than the BIS recommendations. As mentioned earlier, if the pump is improperly selected and operates at a head substantially lower than the BEP head, the conditions would be worse. Pump discharge would increase, requiring a higher pipe size as per the BIS standards. In that situation, the likely pipe size would be smaller than the BIS recommendation for 9 of 12 pumps.

In the light of the earlier conclusion that BIS piping norms need to be upgraded, it is important to compare the expected pipe size with the optimum pipe size. The calculated optimum pipe size (for the discharge corresponding to the pump BEP conditions) is shown in Figure 7 by hollow columns. For all pumps the flange size and hence the likely pipe to be installed is significantly smaller than the optimum size.

Government-sponsored projects have rectified the problem of undersized pipes in more than one 100,000 pumps in India. But there is an urgent need to prevent piping inefficiency in new pumps. Undersized piping seems to originate primarily from inappropriate flange sizes. Hence, this problem can be largely solved by upgrading the BIS norms for pipe and flange sizes. The pump flange size should correspond to the improved BIS-recommended pipe sizes.

5. Economic implications of improved standards
This section evaluates the expected increase in efficiency of new IPS due to the improved standards and the corresponding avoided expansion of power supply infrastructure. The modified BIS standards can improve the efficiency of only new IPS. Nearly half a million new pumps are added each year in India. It is assumed that the benefits of improved efficiency standards (higher pump efficiency and higher pipe sizes) can be achieved for only half of new IPS.

Upward revision of BIS standards for minimum pump efficiency would reduce pump consumption by 12 to 14%. The benefits of improved suction characteristics and flattening of the head-efficiency curve would be added bene-
fits. Thus it can be safely assumed that improved pump efficiency standards can result in 15% energy saving. Considering such improvement in half of all new pumps, the total saving would be 140 million kWh/year. This is equivalent to the useful energy generation of a 26 MW (base-load) power plant. [9]

Installing pipes sized as per the BIS standards can frequently reduce the electricity consumption by 20% or so [Jain, 1994; Patel and Pandey, 1993]. After improvement of BIS standards, flange sizes would be the same as the optimum pipe sizes, which would be higher than the present BIS standards. If half of all new pumps reduce consumption by 20%, the national saving works out at 186 million kWh per year. This is equivalent to the saving of a 35 MW (base-load) power plant each year.

Against such savings the incremental cost of the efficient pump and higher sized pipe would be about Rs. 2,000 per IPS [10]. Hence, the incremental investment cost for 250,000 efficient pumps would be Rs. 500 million (US$ 14 million). The total saving to the power sector would be 61 MW of installed capacity, implying an avoided investment of Rs 3.05 billion (US$ 87 million). This is a cost-benefit ratio of below 1.6.

In addition, the power sector will also save fuel corresponding to the energy not consumed. At present prices, the fuel cost of 326 million kWh/yr is Rs 260 million per year. Considering a pump life of 10 years, and a discount rate of 12% (real), the net present value of fuel saved is Rs. 1,470 million (US$ 42 million). This takes the cost-benefit ratio to 1.9!

In other words, each year’s delay in improving the BIS standards for IPS efficiency is costing India US$ 115 million!

6. Conclusion

The BIS norms for pump set efficiency need substantial improvements on the following accounts: (1) upward revision of minimum efficiency, (2) accounting for changing pump efficiency with changing suction and total head, (3) upward revision of recommended pipe sizes, and (4) appropriate flange sizes for pumps.

Contrary to the common belief, the improvements in standards can result in substantial reduction in IPS electricity consumption. Improvements in standards would result in a 326 million kWh/yr reduction in electricity consumption of the new IPS added each year. This amounts to avoided capacity expansion of 61 MW each year. Each year’s delay in improving the BIS standards for agricultural pumps is costing India US$ 115 million. The benefit would be higher if BIS standards were also made mandatory for all pump manufacturers.

The government, funding agencies, multilateral banks and the power sector, in general, need to appreciate the importance of standards and norms. Considering such favourable economics, the government and power utilities should spare no effort to upgrade the BIS standards.

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Notes

1. Most IPS are not metered. The tariff is linked to the connected load (kW). Hence, the sales to IPS are estimated by the power sector and have been a controversial issue.
2. This definition assumes no water leakage and neglects the velocity head of water, which is usually small.
3. The present literature specifies pump characteristics for total head. In effect, it expects the farmer/pump dealer to estimate the required flow and static head, and calculate the frictional loss to arrive at the total head. This is too complicated even for the pump dealer. Some manufactures already distribute simplified literature based on standard piping layout and corrections for deviation from the assumed layout.
4. This assumes the base efficiency of the pump to be 60%.
5. For a detailed discussion, see [Sant and Dixit, 1996].
6. For a constant delivery head of 7.5m considered here, pump B cannot achieve its BEP efficiency.
7. The pump manufacturers may need financial and technical support to improve the pump quality quickly. The utilities can easily give this support, and would actually benefit substantially from doing so.
8. The pump discharge is a function of the head. At low heads, discharge is high and at high heads it is low. For simplicity only the flow rate under BEP conditions has been considered in the figure.
9. This calculation assumes average pump usage of only 1,000 hr/yr (against the national average of 1,770 hr/yr claimed by the power sector). It is further assumed that a base-load power plant has a PLF of 80%, auxiliary consumption of 8% and T&D losses are 18%. The investment for generating plant and distribution network is assumed at Rs. 50 million/MW (US$ 1.4 million/MW).
10. This assumes an incremental cost of (i) 20% for efficient pump (i.e. Rs 1,000/- per pump) and (ii) Rs 1,000 for higher sized pipe (corresponding to an average pipe length of 30m).

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