Towards an Efficient and Low Cost Power Sector

Draft Chapter on Energy

Prepared for the Narmada Valley Task Force, Appointed by the Government of M.P.

By
Girish Sant and Shantanu Dixit

PRAYAS, Energy Group, Amrita Clinic, Karve Road,
Deccan Gymkhana, Pune 411 004
Tel. 020-341230, 230337
Email : prayas@vsnl.com

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As mentioned in chapter * the resources of the valley should be utilised with a principle that *"Development of the valley should be with the national perspective, meaning that the resources of the valley would be fully developed, to the extent possible to meet the needs of the (whole nation), with the needs of the local people getting the first priority. Further, this would be done in a manner so as to not be inconsistent with the interests and constitutional rights of the local people, and with the principle of sustainable development"*

Planning based on this principle necessitates distinction between needs of the local people and needs of the state / nation. Further the principle of sustainability implies that our dependence on the large generation projects is reduced. But it needs to be made clear that such transition can not be achieved overnight, it cannot occur automatically and we need to consciously plan for this. This chapter presents planning approach and policy options that need to be adopted to achieve this transition, while minimising the social and economic disturbance.

The first section addresses the issues related to energy needs of the local population and the second section elaborates on power needs of the state.

1. Energy Needs of Local People

Among the local needs, priority is to be given for securing the livelihood of people. The most important component to achieve this is to meet the irrigation and cooking energy needs of rural population.

1.1 Cooking Energy Needs: Fuelwood, agro-residue and dung are the main sources of cooking energy in the rural areas. The village surveys presented in the TF meeting dated 21 st to 27 Aug. 1998, indicate that cooking needs of the village can be easily met from the resources available in the village, if irrigation facilities are available in the village. This observation is in accordance with many other studies on rural energy needs. Further, with proper management of available resources and use of efficient equipment (such as efficient Chulha) there is substantial scope for reducing burden on the resources. Availability of cooking energy can be a problem in un-irrigated areas if green cover has seriously depleted. We should reduce dependence on commercial fuels, such as LPG and Kerosene, due to cost as well as environmental concerns. Hence, special efforts are needed in the form of providing irrigation and energy plantations, to reduce the drudgery of obtaining energy for daily cooking needs[1].

1.2 Pumping Energy Needs of the Local Populations: The pumping energy needs for irrigation is a major problem today. Last year about 60% of the rural electricity consumption in MP was on account of agricultural use (MPEB 1998). As seen in chapter * on "*Alternative for Development of Water and Biomass Resources*", the need for water pumping (per Ha of irrigated area) can be substantially reduced by adopting judicial water

[1] This issue was not a major concern while the NVDP was prepared. Moreover, this issue is closely linked with water use and irrigation facilities, hence is not considered in more detail here.

application practices. Along with low external input agriculture practices and local water harvesting it is possible to bring down the need for external water (and hence the irrigation energy needs). Moreover, even when such lift irrigation is required, farmers can bear the energy costs of such lifts. Only 10 to 15% of the incremental biomass generation due to the additional water availed through such lift can meet the energy needs of such lifts. The user response has shown that farmers are willing to contribute this biomass towards cost recovery, if they are assured a reliable delivery. In other words, the agricultural sector can generate the fuel required for the biomass based power plants, in quantities sufficient for meeting its own needs. Achieving this energy self reliance is a high priority. This will substantially reduce the demands on the grid and need for the subsidy.

In short it can be said that the cooking and irrigation energy needs of the local population can be met through, changes in water use, irrigation and biomass policies.

2. Power Requirements of the Grid

The second component of the energy need is the power need of the state (i.e. of the grid). Indian Power Sector has progressed a great deal since independence. Budgetary financial support and centralised supply from large thermal and hydro projects have been the main pillars of this development. More than 20% of plan funds have been allocated for power sector for the last few decades. But still the country is facing power shortages and over a third of houses still do not have electricity connection. Most SEBs are in the red and cannot raise funds for expanding the capacity to meet the growing demand. At the same time, the social and environmental impacts of power sector development have become more pronounced. Reasons for this state of affairs are complex and vary from the state to state. But at a broad level it can be seen that the Indian power sector is trapped in a vicious circle.

2.1 Vicious Cycle

The power planning starts from demand forecasts Due to high demand forecasts, planners tend to concentrate on the large centralised projects, that are easier to manage and which appear to be the only option of bridging the large demand-supply gap. Typically these projects are bulky investments, which necessitate heavy financial support from government. This has resulted in massive public funds getting blocked in the long repayment power projects.

Large dependence on government and popular demand for subsidy from farmers led to a peculiar tariff policy that has resulted in fast growing and un-targeted subsidies. As described later, this policy of flat rate tariff or free electricity has let to highly inequitous subsidy distribution and introduced many distortions. With such tariff, farmers have no incentive for judicious use of electricity and to improve efficiency. The result is a pathetic end use efficiency in agricultural sector. Even other sectors has serious in-efficiencies of power utilisation.

This state of affairs has led to many problems. First, the demands on the grid (for power as well as for subsidy) has increased rapidly, to un-justified high levels. Second, the small decentralised generation projects and efficiency improvement measures have got neglected. Users have little or no incentive and planners saw them as insignificant and these were usually treated as a public relation activity. The result was growing energy intensity and demand for power.

For obtaining funds for growth, the power sector had a near total dependence on government budgetary support. The need of the sector (i.e. the likely shortfall) was one of the major factor deciding the budgetary allocations. As a result the demand forecasts became a bargaining tool to ensure higher budgetary allocation. This completed a vicious circle where issues of overall efficiency, rational tariff and cost recovery or commercial viability got sidelined. Every generation project became an utmost necessary as the demand was always growing and no option could be seen to meet such a fast rising demand. Fast growing agricultural energy consumption in MP is a good example of this. Nearly 70 % of the increased consumption in MP in last 4 years is from agricultural sector only.

This vicious circle of high demands on the grid, insufficient revenues, and difficulty in finding resources continues even today. Although now private investors are providing the funds, they are insulated from the risks of uncertain demand or of low revenues due to government guarantees for payments. The vicious cycle continues, resulting in neglect of cost effective options that have low social and environmental impacts.

2.2 Breaking the Vicious Cycle

Breaking this vicious cycle needs a fundamental change in the policy approach. We will have to transcend the constraints of present institutional, political and governance system to achieve this. Components of this approach are:

(a) maximum utilisation of cost effective options that have low (or positive) social and environmental impacts,
(b) achieving optimum efficiency in supply (generation and distribution), as well as utilisation (end-use efficiency) of electricity,
(c) creating structures and mechanisms to ensure public participation and rational decision-making that is based on the above principles.

The principle of resource development (mentioned at the beginning of the chapter) implies that flow of resources from one area to other should be considered only when the resources of that area are being utilised to the best possible extent (and in an efficient manner). Hence, as far as the needs of the grid are concerned, the first priority is to utilise the cost-effective options to increase the efficiency of existing system.

3. A Three Step Approach to Re-orient the Power Sector

A three step approach to break the vicious cycle and reorient the power sector in line with the above principle can be envisaged. This section elaborates these steps. These steps are distinct but the implementation should begin simultaneously.

3.1 Immediate Steps

It is essential that urgent actions are taken to tackle the immediate problems being faced by the sector such as growing financial losses and increasing power and energy shortages. The immediate steps to address these crisis are:

(a) Tariff rationalisation and measures to increase transparency and accountability
(b) Supply side efficiency improvement

3.1.1 Tariff Rationalisation and Measures to Increase Transparency and Accountability

Ill effects of the Agricultural Tariff Structure: Today the power supply to irrigation pumpsets is based on the flat rate, i.e. tariff based on connected load rather than actual consumption. In 1994-95, the agricultural sector paid just Rs. 0.21 / unit, while industrial sector paid Rs. 2.27 / unit. Such lop-sided tariff structure has led to sever distortions.

In-Efficient Use and Untargeted Subsidies: The un-metered electricity (flat rate tariff) is a barrier to efficiency improvement. The consumers have no incentive for preventing wasteful use of electricity and even water (in water abundant areas). Table below shows the increasing share of IPS consumption in the total consumption in MP Table also shows the average hours of pump use for last few years. The 1996-97 consumption amounts to an average pump operation for daily 10 hours for 250 days a year ! Many studies have demonstrated poor end use efficiency in agricultural sector (Sant, Dixit, 1996; Patel, Pandey 1993; Rajashekar P Mandi, et.al., 1994). It is possible to reduce the IPS consumption by 30-40% with use of good quality, properly matched pump and piping system. Further, it is easily possible to achieve 15 to 25% savings by judicious use of water. As a result of such in-efficient use the agricultural consumption is increasing very rapidly. The land quality is deteriorating due to excess water use and SEB's financial situation is deteriorating due to the subsidy.

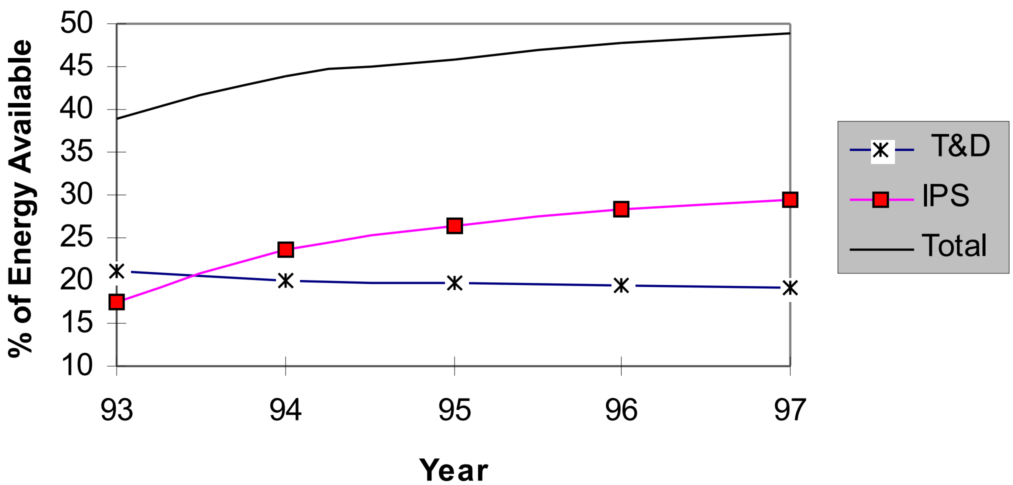
Table 1 : Increasing Power Use by Agricultural pumps.

	Agricultural use (% of total)1	**Hours per year 2**
1992-93	22.3	1,296
1993-94	29.7	1,923
1994-95	32.8	2,217
1995-96	35.1	2,456
1996-97	36.6	2,476

Notes :
1. The percentage of agricultural use to the total power use in the state,
2. Average hours of pump usage (calculated as electricity use per kW connected load)

This tariff structure is also leading to un-targeted subsidies. A study for Maharashtra (also having flat rate tariff), indicated that only 2% farmers corner 20% of subsidy while 80% farmers get nothing (Sant, Dixit as quoted in Rajadhakshaya Committee 1997). It also found that, inspite of low tariffs (i.e. Rs 400/- per Hp/yr.) farmers in water scares area are effectively paying up to Rs 1/- per kWh, if they do not opt for metered tariff. Where as, farmers in water rich areas (growing water intensive crops) pay as little as Rs. 0.15 per kWh.. In the absence of specific data / study for MP, precise distribution pattern of IPS subsidy cannot be worked out. But it is clear that with a flat rate tariff, farmers with abundant water, growing water intensive cash crops will benefit the most. Implying that higher the consumption higher the subsidy.
On the other hand consumers who do not have access to irrigation are prepared to pay for it to the extent of contributing a quarter of crop production ("*Chauthayee*"). Farmers using diesel pumps effectively pay equivalent to Rs 3/- per kWh, while the IPS users are not willing to pay even Rs 0.5 per kWh. Such subsidy policy further aggravates in-equity and is regressive in nature.

Increasing Un-Accounted Electricity: Another lacuna of this tariff structure is the lack of accounting for electricity generated, distributed and consumed. Since the agricultural consumption is not metered, it cannot be estimated accurately. This along with technical and commercial losses (T&D losses), implies that a high proportion of electricity generated remains un-metered and hence not accurately accounted. Following figure shows the increasing proportion of un-metered energy in total energy generation. In 1996-97, nearly half of electricity available in MP was not metered.



To avoid such ill effects, it is essential to rationalise the tariff structure and meter all consumers, including agricultural consumers. Metering has multiple advantages. First, since farmers will have to pay for what they consume (which can be a subsidised rate), they will be more conscious of water and electricity use. One study has estimated that IPS consumption would reduce by 5 % due to just metering (Nadel et.al. 1991). Such savings

would accrue mainly due to reduction in wasteful water consumption and due to compromising productivity. In fact, the survey by people of '*Sulgaon*' (a water rich area) has estimated this saving at 25%. Such saving will reduce the subsidy burden on MPEB. Metering will also help in better targeting subsidies to those who need them the most. Secondly, this would help in accurately accounting for all the energy generated.
This applies even to single point connections. It is known that over 22 lakh houses having single point connection use more electricity than expected. Some houses have been found to have even electric heating plates for cooking. This amounts to theft of power. These houses should be asked to opt for metered supply or accept a load limiter that allows use of efficient light bulbs.

Another drawback of such lop-sided tariff structure is the declining revenue from industrial sector. The industrial tariffs are often set so as to cover subsidies to IPS. This has resulted in industrial tariff being too high. At MPEB tariff of Rs. 3.5 /unit, the industries can afford to opt for DG set captive plants. High tariff coupled with un-reliable, poor quality supply; increasing number of industries are resorting to captive power. MPEB data shows that captive power plant capacity in the state is rapidly increasing in the recent years. With strained financial situation MPEB can ill afford to loose it's revenue generating industrial customers. Hence, there is an urgent need to rationalise tariff structure.

We need to immediately improve the transparency and accountability of the power sector. We have to create accountability procedures for the power sector staff (in terms of accounting for power generated and sold). Results of energy audit (metering from EHV to LT feeders) showing energy loss in each segment should be made public. And person in-charge of that segment / area should be responsible for reducing these losses. This will help us reduce power theft, which is a serious problem.

In short, tariff rationalisation, coupled with metering, transparency in energy audit and accountability measures can bring substantial benefits to MPEB. These measures are required irrespective of the development paradigm we adopt. And its benefits need to be articulated in the future plans.

3.1.2 Supply-Side Efficiency Improvements

The supply side efficiency measures (R&M of power plants and T&D improvements) have a large potential. These measures are known to be highly economical. The R&M measures effectively increase power plant capacity at one forth the cost of new generation. Same holds true for T&D improvement. Actions on these front are already initiated, with impressive results. In 1996-97, a demand of 680 MW higher than in 1994-95 could be met without significant addition in capacity, largely due to improved plant performance. But these measures are still not fully integrated in capacity addition planning. As a result, their benefits are not clearly articulated in (future) plans. Hence, these measures should be explicitly made a part of demand-supply planning. This will give a boost to the ongoing action on this front, leading to significant additional benefits, especially through T&D improvements.

3.2 Intermediate Step

Apart from the supply side efficiency mentioned above there are many avenues for efficiency at the user end. Similarly, there are several decentralised generation sources that are already cheaper than large power plants. These options usually have a low negative or at times a positive social and environmental impact. To tap these cost effective sources, a comprehensive Integrated Resource Plan (IRP) should be worked out. Such IRP will ensure that most economical investments are made. IRP should be prepared and implemented in the intermediate period of next 3 to 5 years. This envisages :

(a) Listing of all technologies and resources (for generation and efficiency improvement; centralised and de-centralised sources), working out their cost and potential;
(b) Work-out the required management structure essential to utilise these resources;
(c) Transparency and public participation in the process so as to be able to receive the suggestions from people and remain accountable to people, and
(d) Making investment decisions to implement the plan.

Tariff rationalisation, awareness campaigns, metered tariff and incentive for renewable sources are essential but these do not replace need for an IRP. The IRP is essential to identify, plan and implement the least cost options. The major steps involved are briefly described below.

3.2.1 Widening of Candidate Options

To begin with we must widen our choice of candidate options, to include efficiency improvement and decentralised generation options in addition to the large thermal and hydro options. Such options are identified in a host of research papers and similar plans prepared by agencies in India and abroad. For example a USAID study analysed 27 conservation and load management options (Nadel et. al. 1991). Annexture VI shows the list of these options, which range from efficiency improvements in refrigerator to motors to industrial arc furnaces. Similarly an IRP carried out for Maharashtra considered 4 de-centralised generation options and 9 demand side management options. Table below shows the potential of these options considered in this IRP. (Sant, Dixit, 1996,3). Similarly, a study by Indira Gandhi Institute of Development Research, Bombay, identified 12 DSM options for HT industries, such as energy efficiency motors, variable speed drives, vapour absorption refrigeration systems, time of day tariff and efficient pumps and fans. (Parikh et. al. 1994)

Table 2 : Potential of Decentralised Generation and DSM Options

Option	Potential (MW)
Sugar Co-generation	500
Co-generation in other industries	500
Small Hydel Plants	712
Producer Gas	100

DSM Options	Savings		Implementation cost (Rs million)
	Peak Power (MW#)	**Energy (MU#)**	
Household lighting	680	1670	1,274
Solar Water Heaters	150	950	2,153
Refrigerator Efficiency	46	400	245
Commercial Sector	110	540	658
Irrigation pumpset rectification	200	2655	1,219
LT industry	164	900	458
HT industry & Misc.	400	3600	1,151
T&D Loss reduction	175	1400	637
Industrial Load Shifting	250	Nil	539
Total Cost Rs. Million / Yr.			**8,333**

Note : The cost for implementation in 1991 Rs.

3.2.2 Evaluation of Options

The next step in planning is to evaluate these options for cost effectiveness and potential. While doing this, care must be taken to adopt a methodology that can account for peculiar characteristics of each option, without a bias. For example, conservation options typically have high up-front costs and negligible running costs but limited life. While some generation technologies have high running (or investment) costs and longer life. In this situation, comparing only the investment costs or simple average annual cost would lead to incorrect conclusion. Similarly, care needs to be taken to account for factors such as difference in location of generation / saving and cost of associated T&D system etc. A methodology to account for such differences and evaluation of different options on equal basis is well established. This method compares the life cycle costs (annualized cost over the entire life) at a common point (either at the bus-bar or at the user-end). Research paper on life-cycle costing methodology by Amulya Kumar N Reddy et. al is enclosed as Annex I. Further, it needs to be emphasised that social and environmental costs of different options needs to be considered. For example, cost of proper resettlement and rehabilitation (not just the cost required for legally mandated R&R), cost of lost energy / resources due to submergence and mining etc. for hydro and coal thermal projects also need to be considered.

Several doubts are expressed about the reliability, cost and potential of energy efficiency options. It is not possible to deal with all of these here. But as an example, details of one such option of improving lighting efficiency through use of CFLs in place of high usage and high wattage Incandescent Bulbs (IBs) is illustrated at some detail in the box below.

3.2.3 Estimating Potential of Candidate Options

The achievable potential of any option in a given time span is largely a function of good program design. In addition to utility supported efficiency programs, other approaches also need to be considered. These include options such as efficiency standards and mandatory labeling. A study of irrigation pump sets showed that improved BIS standards can result in nationwide reduced demand equivalent to 60 MW thermal plant each year, considering only 50% implementation of BIS standards (Sant, Dixit 1996,2). Similarly the utilities or government can create a "Market Pull" towards efficiency. A program in USA called "Golden Carrot" is an excellent example of how "market pull" strategy achieved improved refrigerator efficiency. Under this program, few utilities joined hand and announced a competition for development of most efficient refrigerators. Along with a cash price, the utilities assured the winning company a huge sale of the new refrigerator. Utilities offered a rebate on this new model. The result was spectacular. A leading company developed a refrigerator model with 30% less power consumption than the existing efficiency standard in the USA. This model was priced competitively compared to the other models in the market. (John Feist et. al., "Super Efficient Refrigerators - Golden Carrot Approach - From Concept to Reality" 1994). Such innovative strategies to expand the potential and reduce cost of efficiency resources need to be considered.

Community participation in planning can also reveal large opportunities for energy conservation. The presentation by villagers of '*Sulgaon'* is a good example of this. The villagers carried out a survey of their village to identify the energy consumption and resources available in the village The survey found that resources such as crop residue of Cotton and *Tur,* cattle dung which are not used efficiently today can be used for energy generation. The villagers also identified opportunities for energy saving, such as metering of pumps, rationlisation of water consumption through efficient irrigation practices, metering of single point connections (for houses), and increased use of biogas for cooking. The survey demonstrated that it is possible to save over 1.5 Million units electricity p.a. and a local generation of over 1.5 million units from agro-residues and dung. Thus, by providing technical and financial resources it is possible to reduce demands on the grid by as much as 3.5 million units (equivalent to nearly 0.7 MW plant) from each villages like *'Sulgaon'.*

3.2.4 Developing Least Cost Integrated Resource Plan

After an estimation of cost and potential of different options the next step is to develop a least cost integrated plan. Maximum possible exploitation of the least cost options followed by the next costly source is planned until the expected demand is met. A more sophisticated approach of "Screening curves" can be used to evaluate the cost effectiveness of different options. "Screening curve" is a tool to compare the varying cost of generation projects (with the varying PLF) and the fixed cost of conservation and load management options along with fixed operating / saving period (i.e fixed PLF). An example of such screening curve used to evaluate least cost options is attached as Annex II. Advance utility planning software programs on the lines of A/S Plan and WASP are capable of calculating effect on LoLP with and without IRP, given the constraint of investible funds.

Such an IRP can identify a set of options that can meet the power demand at a least cost. Actions to implement such plan should be and can be taken simultaneously. Unfortunately, no utility in India has officially prepared such an IRP. But plans developed by researchers for Karnataka and Maharashtra show that nearly 60 to 80% of the incremental demand can be met through efficiency improvement, electricity substitution and de-centralised generation. Moreover, such plan is expected to be 30 to 40% cheaper than the conventional plans. (Reddy et. al., 1991, Sant Dixit, 1996,3).

Annex. III shows one such plan prepared for implementation by the North West Council of Power Utilities in the USA. It found it economical (and practical) to meet 65% of incremental needs through energy efficiency, another 28% through industrial co-generation. It found that it was not economical to complete the partially built nuclear plant (that was already 78% completed).

Box 1 : Lighting efficiency improvements : Can it work in India and How ?

Many experts have time and again suggested lighting improvements as an economical means of reducing peak load in India. Replacement of incandescent bulbs (IBs) by Compact Fluorescent lamps (CFLs) in rural and low income houses is suggested as one of the measure. Such suggestions often invoke objections from some engineers. These objections can be grouped as below :

<u>Common Objections to the Suggestion of Replacement of IBs by CFLs :</u>

a. Cost Effectiveness: It is said that CFLs costing Rs. 700 per piece are too costly and no consumer would invest such a large sum when IBs are available for Rs 10/- a piece. At another level questions are raised about the cost effectiveness of CFLs even from SEB's point of view.

b. Implementation Problems of Such Retrofit Measures: In the present institutional set up (that is geared to addressing demands of centralised structures) it is difficult to envisage retrofitting huge number of lamps. It is also feared that poor consumers would sell CFLs and again revert back to the cheap inefficient bulbs.

c. Technical Concerns: Critiques also draw attention to the poor quality, (low PF, high harmonics) and lower than expected life of CFLs, difficulty in starting CFLs at low voltage conditions of the CFLs available in the Indian market.

<u>How to Overcome These Difficulties</u>

Cost of CFLs : Thought the retail price of some models of CFL (with ballast) is around Rs. 700/-, this is the street price for one piece. While estimating cost of a dam, we do not base our calculation on the market price of one 100 Kg cement bag. Similar is the case here. It is certainly possible to get CFLs at much less cost if we are negotiating purchases in millions of lamps. Issues such as economies of scale apply, reduction in costs of

Box continues on next page

Box 1 : Lighting efficiency improvements : Can it work in India and How ?

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advertisement, packing, transportation and dealer commission all add up in our favor. Utilities usually obtain CFLs at one third to one quarter of the market prices (*Mills, 1991 "Efficient Lighting Programs in Europe .."*)

Quality of the CFLs : It is true that many CFL brands in the market today are of inferior quality. But good quality equipment is available and more over CFLs (and ballast) can be designed to suit out needs of voltage, PF etc. The WB funded program in Mexico installed 2 million lamps, only after the CFL manufacturers delivered the CFLs of the quality that was demanded by the WB.

Ballast is the key to life and performance of the CFL. Lab measurements of the technical parameters of electronic ballasts made by different manufacturers are shown in Annex IV. It can be seen that some manufactures do produce high quality ballasts capable of offering Power Factor of 99.5%, low harmonics (below 5%), and high performance at extremely varying voltage conditions (from 170 to 270 V). The volumes for one program in MP would be comparable to the annual sales of CFLs (of all manufacturers) all over India. With such a large order, it is possible to dictate the quality (technical parameters) of CFL / ballasts.

For such a program, it is possible to get good quality CFLs (with electronic ballasts) at Rs. 500 per piece. By proper specification of technical parameters in the tender, it is possible to overcome problems related to the quality of CFLs.

With proper program design, involving use of techniques such as bar coding of lamps, distribution against coupons attached to the electricity bills, training of un-employed rural youths for installation; the program can be implemented efficiently. Some researchers have already designed scheme for pilot program, suitable for Indian conditions. Along with this and the international experience, a refined schemes can be developed in a short while.

Cost-Effectiveness of CFLs : Attached worksheet (Annex V) shows the calculation of cost of conserved energy when IBs are replaced by CFLs. Some points that need to be remembered are listed below :

- When a good quality ballast is used, CFL life is over 7,000 hrs. Life of ballast is more than 14,000 hrs. Replacement of the tube would cost about Rs. 100 per lamp.
- CFLs save energy at the peak time, at the consumer end and hence benefits of reduced T&D losses need to be calculated.
- A study in US found that cost of program administration, campaign etc. (program cost) is usually between 10 to 30% of the cost of equipment.("Program Experience and its Regulatory Implications - A Case Study of Utility Lighting Efficiency Programs", Krause et al, 1989). A program cost of 15-20% should be sufficient for Indian situation (due to low cost of manpower).

As shown in the worksheet the cost of conserved energy (at the bus-bar) works out to be Rs. 1.8 / kWh. This is much less than conventional peaking plant options. Hence it can be seen that replacement of IBs by CFLs in rural, poor houses is highly cost effective and implementable option.

Other Options for Lighting Efficiency Improvement : CFLs is just one of many options for lighting efficiency improvements. There are more than a dozen other options, such as use of 36 W fluorescent tube instead of 40 W tube, electronic ballast instead of electromagnetic ballast, use of circular fluorescent, use of 2 feet (20 W) tube instead of IBs etc. Annex VI shows six economical lighting improvements considered in an USAID study titled "*Opportunities for Improving End-use Electricity Efficiency in India*". The cost and potential of each options is indicated in the table. We need to select the most suitable option from a vast array of options available.

Post-Facto Evaluation of Lighting Efficiency Programs: Research papers evaluating the success of lighting efficiency improvement programs by US utilities are attached in annex VII. In most cases, the programs saved power at less than half the cost of new generation capacity. These reviews show that lighting efficiency programs are cost effective and can be successful.

3.2.5 Moving Beyond Conventional IRP

Systemic and Inter-sectoral Issues: Some IRP studies also have limitations, they concentrate only on the technical efficiency improvement options. These studies fail to identify the efficiency improvement possibilities that involve more than one sector. For example, a presentation to the TF by villagers in the valley was unique as it identified an area for energy conservation that most IRP would miss out. A minor dam has a defective gate, that closes only after all the water has flown out. This coupled with the incomplete canals of that dam is rendering it un-usable. Farmers in the command of this dam have installed pumpsets of over 1,500 Hp. These pumps are consuming 4million units per year. When repaired, this completed irrigation project will eliminate the need for this consumption. This should be investigated. Prima-facie it appears that the required investment is small and it must have been budgeted in irrigation department plans. If this is implemented MPEB would save about Rs 1 crore per year[2]. There are several such instances where with little effort electricity consumption can be reduced or eliminated without causing any hardship for consumers.

Identification of these cost effective options needs public participation. To achieve this, procedure followed during the IRP done by US utilities (mentioned above) needs to be adopted. The cost and other utility data was made accessible to public. Comments from people to identify low cost energy saving and generation options were invited and analysed. *The North West Council conducted public hearings and read through a 3 feet high stack of public comments*. Based on this and other studies a draft IRP was prepared and it was made public. Public comments on the draft IRP were invited. *More than 1,300*

[2] Connected load of pumps, million units savings and financial savings are approximate figures, given to get an idea of order of magnitude.

individuals and groups submitted their opinion in writing and 16 public hearings were conducted. Suggestions were analysed and many were incorporated in the final IRP. A IRP prepared in such a manner is sure to save a lot of money and lot of social and environmental ill effects associated with the power development.

Market-Based Options: In some countries, the power sector regulators require that utilities consider energy saving on par with power generation. While floating tender for competitive bidding, along with energy generators, even offers to save power are allowed to compete. Then in evaluation, the least cost offer (of generation or saving) is declared as successful bidder. By this logic, if MPEB is going to pay Rs 0.8 crore / MW per year for the SMHPP power, the same (or similar payment) should be offered to any party that guarantees peak power generation or peak demand reduction.

4. Long-Term Steps

As described earlier, the IRP based planning can reduce the dependence on large centralised fossil fuel and hydro projects by as much as 60%. But it can be argued that over time the potential for cost effective efficiency improvements would be exploited and be over. Then in the next period the centralised projects may again become prominent, and we would again need all these large projects. But this does not have to be necessarily true. We can take concrete actions now to avoid this situation.

Firstly, as the time progresses, technologies currently in experimental stage would mature and new opportunities would emerge. Annex VIII shows the decreasing consumption of refrigerators in the US markets over a 20 years. As mentioned earlier, through Golden Carrot Program further 30% drop in consumption was made possible. There are many such possibilities at the level of appliance as well as at the systemic level. (Nelson Lars, 1993).

Even power generation technologies based on renewable sources is showing promising results. The GEF-WB demonstration project in Brazil will field test 25-30 MW combustion turbines based on biomass gasification. This technology would more than double the efficiency of biomass utilisation for power. (Elliot and Booth, 1993). This would also offer advantages of gas turbines. Such technologies would mature in next few years, opening new opportunities and further reducing our dependence on fossil fuel and large hydro.

Inter-sectoral and institutional reforms necessary for improved irrigation and water use efficiency also have many implications for the biomass based power generation. For example, institutional structure that allows farmers to pay for electricity cost in terms of biomass would substantially increase the power potential and also reduce the need on the grid (for power and subsidy) as mentioned above. Or the potential of small hydro would increase substantially when we start implementing water and land management in the upper reaches of the valley.

New developments such as hybridization of generation sources would remove some of the critical shortcomings of the RE systems and can multiply the cost effective utilisable potential. The small hydro can also be used as dispersed pumped storage for better load management. Small storages / pumps used for irrigation can be used for this. This will further improve the economics of such schemes. Hybrid systems of solar thermal, pumped hydro and biomass power can be operationalised at a mass-scale in less than a decade. Such hybrid systems alongwith the institutional mechanisms suggested by K R Datye, can address issues of sustainable agriculture and increased irrigation. He has demonstrated that by using above techniques, it is possible to nearly double the power availability in rural areas. As per this scheme the existing power capacity will be used only in the off-peak period and techniques such as small hydro (pump back) and biomass power generation will be used in conjunction to provide nearly twice the electricity to rural areas. This can be achieved without increasing the demand on the grid power. In fact, the peak power requirement of the grid will reduce.

But this technological and institutional innovations can not occur in vacuum. An enabling environment in the form of financing, R&D facilities, and appropriate policies needs to be developed. If this work is done today we can get the benefits in coming 10 to 15 years. At present, the most of the research on these technologies is being carried out in the developed countries. Many multinational companies view these technologies as the key technologies for the future. These technologies have a large potential in the developing countries. But if we do not invest in these then we will have to continue importing equipment from the same countries (or even same companies) from which we import the power equipment today.

To achieve these long term goals planned actions need to be taken today. A beginning can be made on many fronts. We should start with pilot projects for relatively mature technologies such as Gasifier and CFLs. As a starting point, we can aim for say one gasifier of around 1 MW capacity in each taluka. We can utilise private initiatives or co-operative / community based institutions to look after aspects such as operation and maintenance, fuel collection, educating farmers to grow and conserve biomass, managing distribution of electricity, billing etc. Even this moderate transition step will have enormous impact on rural MP. For example, even if just 50 such projects become operational, it would add more than 10 cr. p.a. to rural economy. Experience gained from such pilot projects will help optimise the technology and institutional structure. As explained earlier our technical and financial resources being limited, they should be used for such projects rather than for projects that involve huge social and environmental costs.

5. Conclusions :

For considerations of equity and sustainability (economic as well as environmental), a fundamental change in the policy approach is needed. Such a change should start with improving the supply-side efficiency (of the power sector) and removing the policy barriers to efficiency. Another step should be to plan for increasing potential and use of cost-effective renewable and efficiency sources. This can be achieved by immediately planning and implementing an IRP (integrated resource plan). This can dramatically reduce our dependence on the socially and environmentally un-viable projects. As a long term strategy resources such as biomass, small hydro and solar (thermal) can be developed. Hybridization of such resources, improved institutional structures to enhance public participation and efficient use can further reduce our dependence on such projects.

The cost and resource implications of such strategy are very positive. It can meet our growing needs. For this we need to urgently prioratise use of our limited financial and managerial resources. These need to be used for achieving the above mentioned transition. This can minimise the financial and social costs of transition in the next decade or so. Moreover, though the above mentioned steps may appear time consuming, it needs to be recognised that inspite of huge efforts and resources, the conventional approach has been able to generate only 90 MW power from the Narmada Valley in last 40 years.

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