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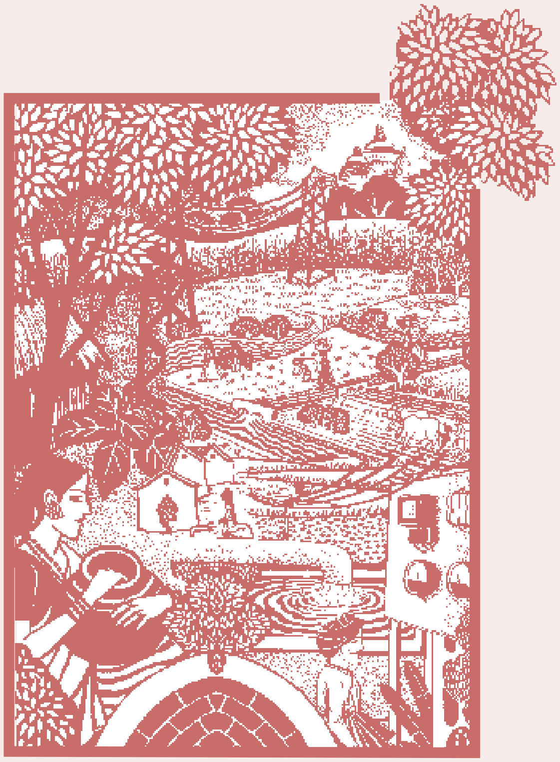


The rural Power Supply Environment (PSEn) - daily hours of power available, frequency of voltage fluctuations, frequency and length of interruptions - is a major casualty of the boom that India's western states have experienced in tube well irrigation during recent decades. Poor PSEn has been a roadblock to broad-based development of rural economies, the growth of non - farm livelihoods, the development of cottage industries and even to basic services such as health and education in villages. Free power supply to farmers and the subsidised flat tariff are at the root of the growing anarchy at the feeder, resulting in poor PSEn.

This Highlight summarises the results of a survey, undertaken by IRMA interns of some 1400 rural electricity consumers in Gujarat, Rajasthan, Madhya Pradesh, Punjab and Kerala in 2010, to explore the relationship between farm power rationing and rural PSEn. We also explore approaches used by states to improve rural PSEn. Technical fixes - such as feeder separation and High Voltage Distribution System (HVDS) - can help contain feeder-level anarchy. But the potency of these approaches increases manifold in conjunction with vigorous campaigns to control power theft and organisational reform of power utilities, to enhance customer service orientation.

IWMI-TATA
Water Policy Program

Water Policy Research

HIGHLIGHT

The Other Side of India's Electricity-Groundwater Nexus

The Disruptive Impact of Tube Well Irrigation on Rural Development in Western India

Nisha Nair and Tushaar Shah

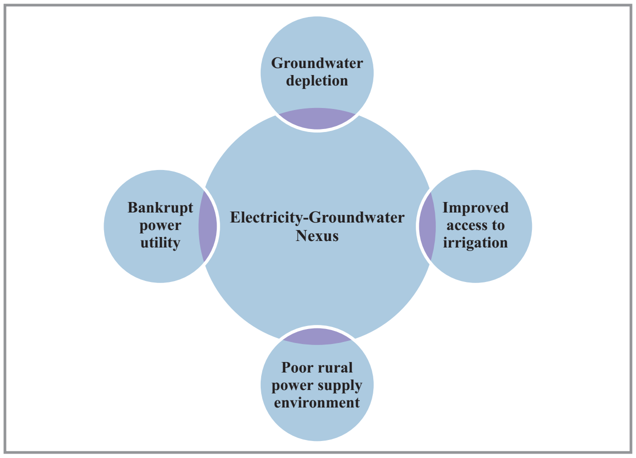
The Other Side of India's Electricity-Groundwater Nexus

The Disruptive Impact of Tube Well Irrigation on Rural Development in Western India [1,2]

Research highlight based on Srivastava and Desai (2011); Sinha and Gupta (2011); Rajput and Saharan (2011); Swami and Jain (2011); Eapen and Remya (2011); Nair (2012)[3]

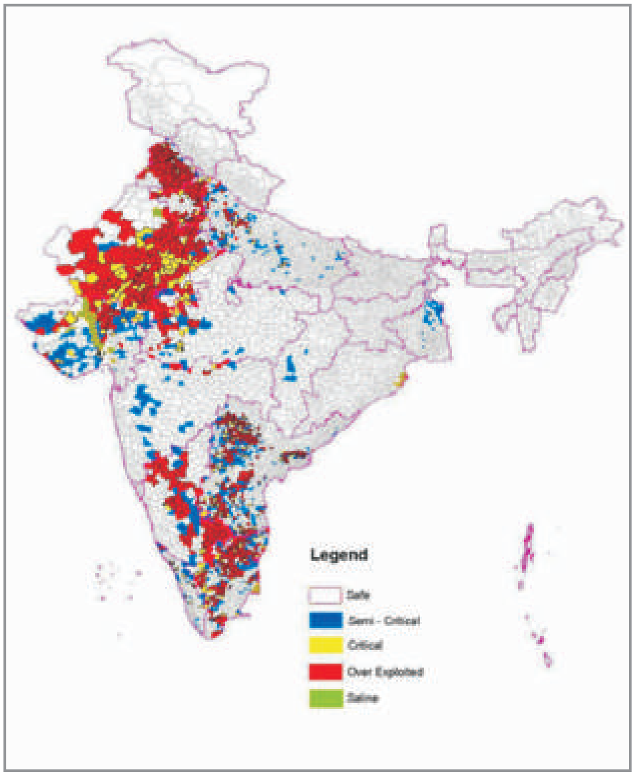
The unique nexus that has developed in India between electricity and groundwater irrigation has had myriad direct and indirect impacts. Four of these are critical (Figure 1). The first impact, largely beneficial, is in terms of expanding access to groundwater irrigation of a large number of small farmers, who would otherwise have been forced to do rainfed farming. During the 1980s and 1990s, the flat power tariff or free power also stimulated vibrant, decentralised, informal markets in groundwater irrigation service. Billions of marginal farmers, who did not have the capital to own tube wells, were able to benefit by buying groundwater for irrigation from tube well owners at an affordable price. This equity benefit of the flat power tariff has been widely documented (Shah 1993; Mukherji 2007; Shah 2009).

Figure 1 Impacts of electricity-groundwater nexus



However, these benefits of irrigation expansion were clouded by a second major impact of groundwater over-exploitation. With limited groundwater resources and without significant programs to enhance groundwater recharge, power subsidies and enhanced use of groundwater irrigation led to a proliferation of blocks designated as semi-critical, critical and over-exploited[4] by the Central Ground Water Board (see Figure 2).

Figure 2 Blocks designated as over-exploited and critical



(Source: Planning Commission 2007)

The third major impact of the nexus has been on the finances of power utilities. Most power distribution companies in western India have massive accumulated losses, which are explained, in large measure, by

[1]This IWMI-Tata Highlight is based on research carried out under the IWMI-Tata Program (ITP) with additional support from the International Water Management Institute (IWMI), Colombo. It is not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or its funding partners - IWMI, Colombo and Sir Ratan Tata Trust (SRTT), Mumbai.

[2]This study would not have been possible without active support from Dr Mihir Shah, Member, Planning Commission, Government of India. The authors also acknowledge support from the managements of various DISCOMs as well as chief secretaries of the states covered.

[3]These reports are available on request from p.reghu@cgiar.org

[4]Blocks where groundwater development in relation to known annually replenishable resource availability is 65-85 percent, 85-100 percent and more than 100 percent respectively.

agricultural power subsidies. Moreover, because the flat tariff made meters redundant, the internal accountability mechanism in distribution companies (DISCOMs) was undermined. As a result, the DISCOMs - could hide their growing inefficiency by showing high aggregate technical and commercial (AT&C) losses as agricultural consumption. The energy-irrigation nexus undermined the character of DISCOMs as business enterprises.

The fourth, and by far the least emphasised, however, is the role of agricultural power subsidies in creating anarchy on rural feeders, which has translated into poor rural PSEn, and a roadblock to rural development itself. Free power as well as flat power tariff made it imperative for DISCOMs to ration power supply to farmers to a few hours daily. This also meant shutting off power supply to all the four categories of users - domestic, commercial, micro, small and medium enterprises (MSMEs), and farmers - who were served by the same distribution network for much of the day and night. Moreover, during peak irrigation seasons, farmers secure electricity for irrigating their land, by fair means or foul. This results in a cat-and-mouse game between the DISCOM and the farmers. When rationed power supply falls short of farmers' demand under the flat tariff regime, several consequences follow: farmers use auto switches so that pumps run whenever the power is available, leading to wastage of power and water. To pump more and deeper during limited power hours, they replace the small pumps with larger ones, which is illegal. Many farmers just hook cables on to the power lines and steal electricity. All these lead to increase in the load on transformers and distribution systems, causing low voltage, heavy voltage fluctuations, frequent power outages, damage to lines, transformers and equipment, high maintenance and repair costs, low energy efficiency and, in general, poor PSEn for the entire village. Even as the power - connectivity of Indian villages improves, the quality of rural PSEn in many parts of India is deteriorating, thanks mainly to 'anarchy-at-the-feeder' that punishes everyone including its perpetrators.

The standard solution suggested is: go back to the basics. Treat the farmer as any other customer, meter the tube well, provide 24 x 7 power, and charge for the metered consumption. Agricultural power subsidy should be provided as a direct discount per kWh consumed on the metered power supply rather than in an indirect form through either free power or under a regime of flat power tariff. Alternatively, provide a fixed quota of free power beyond which a farmer will pay pro-rata tariff on the metered consumption. However, any move in this direction has been thwarted by strident opposition from farmer bodies as well as DISCOMs in several states. As a result, political leaders at the state level have been reluctant to initiate the metering of tube wells and power supply.

As a second best solution, many states, starting with Gujarat, have invested in separating agricultural feeders from non-agricultural rural feeders, to insulate non-agricultural consumers from feeder-level anarchy, for which mostly farmers are responsible. After implementing its Jyotigram scheme of feeder separation, Gujarat claims to be the first state to provide 24 x 7 uninterrupted, three-phase power supply to village homes, institutions, shops, schools and MSMEs (Shah and Verma 2008). In order to understand the possible impact of direct subsidy as well as feeder separation on rural power supply environment, IWMI-Tata Program (ITP) deployed ten IRMA interns in Gujarat, Rajasthan, Madhya Pradesh, Punjab, and Kerala for a ten-week field study from October to December 2010. The objectives of the research were to: [a] undertake a market survey of electricity consumers in agricultural, domestic, commercial and industrial sectors; and [b] understand the efforts of electricity utilities to improve consumer satisfaction.

Rural PSEn survey in five states

Each pair of student researchers deployed in a state was mandated to identify and survey 100 domestic consumers, 100 electric tube well owners, 30 commercial/institutional consumers and 30 owners of MSMEs randomly. Using a short-survey instrument, they sought consumer feedback about the quality of PSEn, henceforth referred to as ITP survey 2010. The sample was to be distributed over at least ten villages, such that they were representative of the head, the middle and the tail of a distribution line from the sub-station. Two of the ten villages also had to be from a tribal and/or a backward area. Perceptions about PSEn were elicited through several questions; the most important to the respondents from all categories were the hours of power available daily, the frequency of interruptions and voltage fluctuations, the damage to appliances and the swift response of the DISCOMs to local breakdowns. Questions about the level of consumer satisfaction with their PSEn were also included.

Table 1 presents the profile of the field study host DISCOMs, locations in five chosen states, the actual sample size and the number of villages covered by different pairs of interns. Figures 3 to 9 summarise the key results of the survey of some 1400 rural power users contacted in over 55 villages in 5 states. Figure 3 shows that Gujarat, Kerala and Punjab offered 22-24 hours of power daily to non-farm customers. The Gujarat government's claim of 24 x 7 power supply to 18000 villages was endorsed by the sample customers. When it comes to agricultural consumers, the Kerala utility emerges as the best performer because it treats agricultural users at par with other consumers. Punjab and Rajasthan utilities limit power supply to farmers between 3 and 6 hours. Gujarat, on the other hand, provides a constant 8 hours of power during *kharif, rabi* as well as summer.

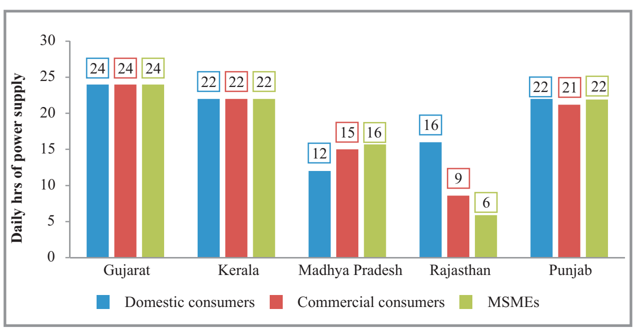
Figure 4 shows that the Gujarat and Punjab seem to be doing better than Kerala, Madhya Pradesh and Rajasthan in terms of interruptions in power supply. Similarly, on the criterion of voltage fluctuations, Figure 5 confirms that Gujarat is by far the best because non-agricultural consumers faced little or no voltage fluctuations whereas in the other four states this segment complained significantly about voltage fluctuations. When it comes to the farmers, even Gujarat farmers complained of voltage fluctuations and pump burnouts due to overloading of the lines.

Against these perceptions, the real test of quality PSEn is in terms of actual expenditure that consumers have to incur on power quality related repairs. We had two questions:

Table 1 Profile of the field study host DISCOMs and locations in the chosen states

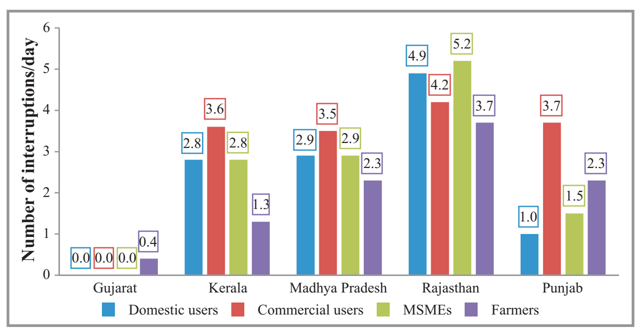
Sl. No.	State	Name of the DISCOM	Districts covered by the study	Number of villages covered by the interns	Sample Size
1	Gujarat	Uttar Gujarat Vij Company Ltd.	Sabarkanta, Mehsana, Banaskanta, Ahmedabad	11	266
2	Madhya Pradesh	Madhya Pradesh Poorva Kshetra Vidyut Vitran Company Ltd.	Ujjain, Ratlam, Jhabua, Dhar, Khandwa, Khargone	19	261
3	Rajasthan	Ajmer Vidyut Vitran Nigam Ltd.	Ajmer, Bhilwara, Udaipur, Banswara	10	263
4	Punjab	Punjab State Power Corporation Ltd.	Patiala, Barnala, Fatehgarh Sahib, Mohali	12	216
5	Kerala	Kerala State Electricity Board	Kannur	10	256

Figure 3a Daily hours of power supply to rural non- farm consumers



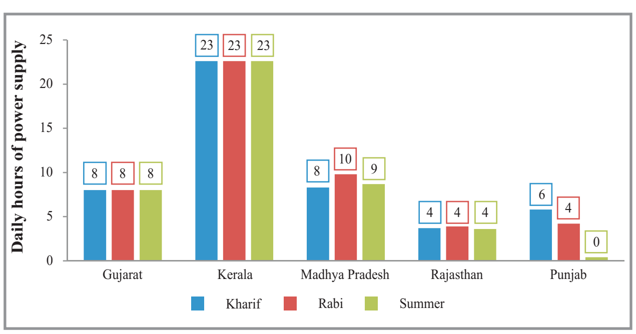
(Source: ITP survey 2010)

Figure 4 Number of interruptions/day in power supply



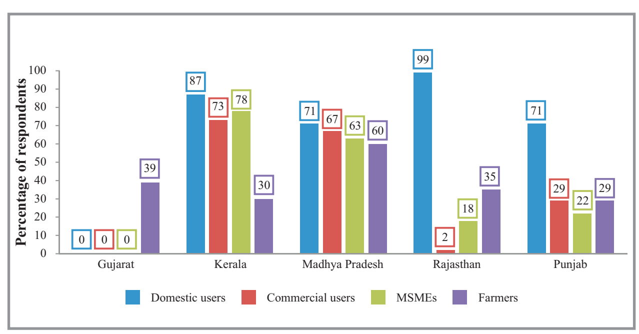
(Source: ITP survey 2010)

Figure 3b Daily hours of power supply to farmers during different seasons



(Source: ITP survey 2010)

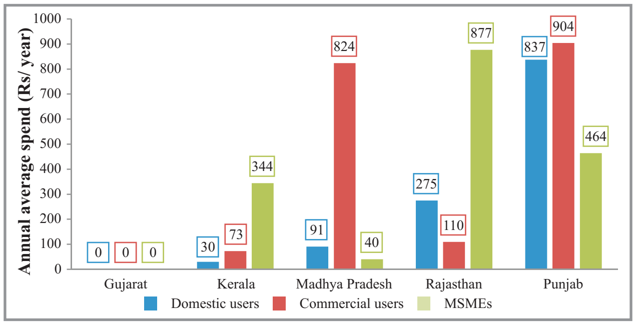
Figure 5 Percentage of respondents who complained about heavy voltage fluctuations



(Source: ITP survey 2010)

The first question was about the annual spend per sample household on power quality related repairs; and the second was on the consumer investment in coping devices such as stabilizers, invertors and gen-sets. In these two, the Gujarat DISCOM has emerged as better than all the other states (Figure 6). The Kerala utility comes next but the respondents in Kerala from all four market segments reported significant annual spend on power quality related repairs. These numbers need to be interpreted carefully. It is likely that Kerala consumers, having enjoyed quality power supply over a long period, have invested much more in electrical appliances compared, to say, rural consumers in Rajasthan; as a result, their annual spend on repair and maintenance of electrical appliances may be higher than for Rajasthan consumers even if their PSEn is better. Gujarat farmers also reported the highest incidence of pump burnouts and pump repair expenditure. This did not tally with their responses on power quality. When interrogated, farmers gave several explanations for the high pump burnouts. Most of them seldom got their pumps serviced; often, when water levels suddenly fell below the submersible pumps, sand and clay entered the strainers and caused a breakdown; many farmers used larger motors than their registered load, leading to overloading. According to many, high pump breakdowns in the Gujarat sample were despite a good PSEn; this experience suggests that feeder separation by itself has been unable to fully control the overloading of the distribution system.

Figure 6 Annual average spend on power-quality related repairs by non-farm consumers



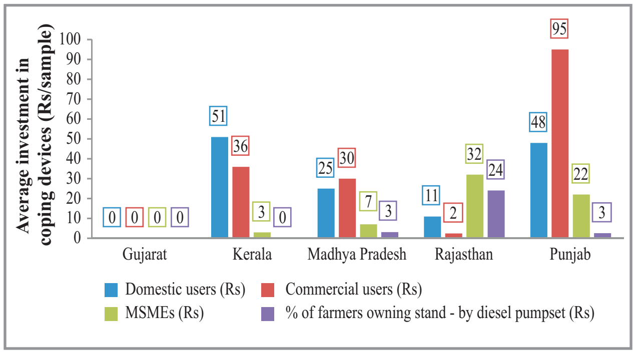
(Source: ITP survey 2010)

In rural Gujarat, the PSEn is so good that none of the 260 respondents across market segments reported any investment in coping devices such as stabilizers, invertors and generator sets. In all the other states, these investments were significant (Figure 7). In the case of farmers, a major coping investment was in a standby diesel engine. In the Rajasthan DISCOM, one-quarter of the farmers interviewed kept a diesel pump as a standby. In Madhya Pradesh as well as in Punjab, a small number of farmers kept standby diesel pumps. However, in both these states, there is more widespread use of tractors to operate irrigation pumps during peak irrigation season - something that the survey failed to capture.

Figure 8 sums up the overall level of consumer satisfaction with their PSEn for all the four categories. Expectedly, rural power consumers in Gujarat and Kerala have little to complain about. In contrast, in rural Rajasthan and Madhya Pradesh, consumer satisfaction levels are significantly lower. In Punjab, farmers are unhappy; but other consumer categories are less so. At the time of the survey, Punjab had completed rural feeder separation in most areas; and its impact on quality of power supply to non-farm customers is evident.

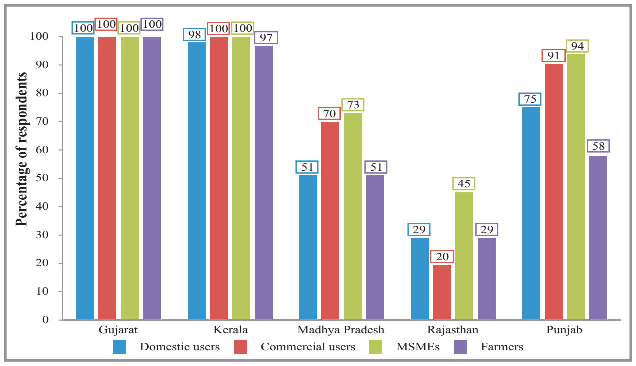
Figure 9 depicts the service orientation of DISCOMs. The respondents were asked whether local breakdowns in power were repaired within 24 hours. In Gujarat, 100 percent of the respondents answered in the affirmative; in Kerala too, an overwhelming majority of consumers agreed that local breakdowns were repaired within 24 hours. However, only a small proportion of our sample respondents in Madhya Pradesh, Rajasthan and Punjab reported that local breakdowns were repaired within 24 hours. This suggests that, in addition to many other factors, power utilities in Gujarat and Kerala have a higher level of customer orientation.

Figure 7 Average investments in 'coping devices'



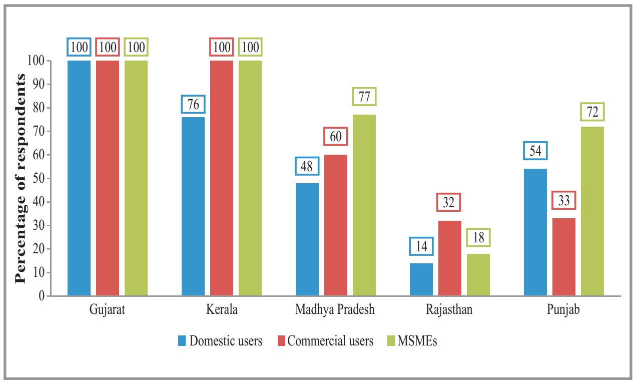
(Source: ITP survey 2010)

Figure 8 Percentage of respondents who said they were satisfied with their PSEn



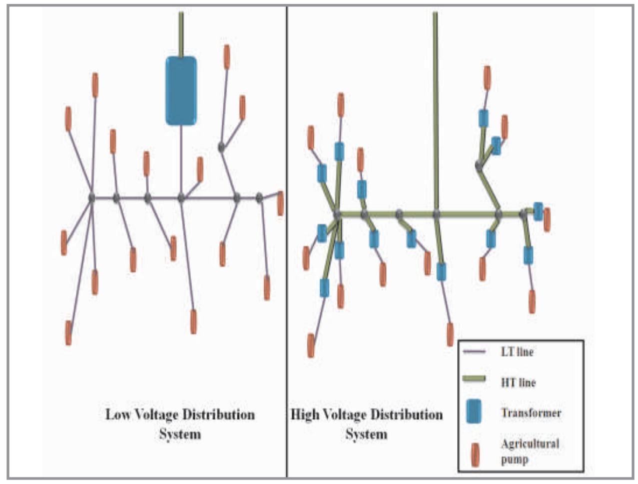
(Source: ITP survey 2010)

Figure 9 Percentage of respondents who agreed that local breakdowns are repaired within 24 hours



(Source: ITP survey 2010)

Figure 10 High Voltage Distribution System



(Source: Nair 2012)

Can HVDS tame feeder-level anarchy?

In comparison to feeder separation, experts believe a more potent medicine to tame feeder-level anarchy is HVDS (Figure 10). HVDS involves conveying power in high tension lines to a pump through a small step-down transformer. The many benefits of HVDS are well demonstrated worldwide and in several places in India (Agrawal and Patra, 2011; APSPDCL, n.d.; NPCL, n.d.). For the user, it means better and more stable voltage, and fewer interruptions. For the power company, it means lower line losses and pilferage. High tension (HT) lines are much harder to hook on to, compared to low tension (LT) lines. HVDS is, thus, expected to reduce AT&C losses. Even after the Jyotigram Yojana, the AT&C losses of DISCOMs in Gujarat are still higher than 20 percent - over twice that in China and the developed world. Therefore, HVDS is an option many power utilities in India are considering.

The nub is the cost. If a new permanent connection costs Rs. 1.5 lakhs[5], a new HVDS connection can cost 2-3 times as much. Gujarat is planning to convert all farm connections into HVDS connections under Kisan Heet Urja Shakti Yojana (KHUSHY), using the state government's Energy Conservation Grant. To explore the costs and benefits of HVDS, Nisha Nair (2012) interviewed 150 farmers in five Gujarat districts, namely, Anand, Banaskanta, Bhavnagar, Mehsana and Sabarkanta. Half of her respondents were KHUSHY beneficiaries, linked to HT lines and with small transformers of their own. The other half were on low tension LT lines, with a large transformer being shared by 8-20 irrigation pumps.

Nair's survey confirmed the benefits of HVDS. KHUSHY farmers enjoyed better voltage profiles, caused by reduced line losses. Compared to LT connections, there were fewer interruptions, pump burnouts, and lower pump repair and maintenance costs. The major gain was a 6-8 percent reduction in AT&C losses. Nair's survey results are summarised in Table 3. Note that the average number of pumps per transformer has declined from 7.6 to 1.7. When two farmers share a transformer, there is lesser chance of chicanery below the transformer than when 15 share one. Nair also undertook a preliminary economic cost-benefit analysis of HVDS conversion on a 36 km long feeder in Gujarat. When 56 large transformers were replaced by 220 smaller ones shared by one or two pumps, the connected load reduced from 3361 to 2744 kVA and the total cost of conversion was nearly Rs. 3 crores[6]. Nair estimated the total annual benefit to be Rs. 1.02 crores, 83 percent from reduced line losses and the balance on account of reduced pump burnouts and fewer interruptions. She estimated the net present value (NPV) to be positive and internal rate of return (IRR) an impressive 23 percent.

The real benefit to the DISCOM, however, may be the reduced commercial losses from hooking. That KHUSHY is exclusively offered to farmers suggests that even after feeder separation, anarchy at the agricultural feeder is not fully controlled. By improving the voltage and reducing interruption, HVDS will also augment effective power ration because farmers are able to work their pumps more during the 8 hours of daily supply.

From Nair's sensitivity analysis, it appears that the techno-economics of HVDS becomes favourable when AT&C losses are high, agricultural load per kilometre of line is high and connected load per customer is high, as in Mehsana and Patan districts of north Gujarat. As values of

[5] One lakh = 0.1 million
[6] One crore = 10 million

Table 3 Comparison of survey findings in HVDS (before and after scenario) and non HVDS feeders

	Before HVDS	After HVDS	Non HVDS
Total no. of pumps owned by the farmers surveyed	81	93	80
Average HP of pumps	9.77	9.68	10.48
Average kVA of transformer connected	80.21	18.42	84.69
No. of pumps connected to the transformer	7.60	1.73	8.40
Voltage (V)	357.15	408.33	368.64
Percentage of farmers who faced voltage fluctuation	72	11	59
Frequency of voltage fluctuation (per day)	1.48	0.35	1.09
Percentage of farmers who did not have adequate voltage	76	15	73
Percentage of farmers who faced power interruptions	82	38	63
Frequency of power interruptions (per day)	1.52	0.64	0.82
Percentage of farmers who had pump burnouts	65	30	56
Percentage of pump burnouts per year	104	37	84

(Source: Nair 2012)

all these decline, HVDS costs soar and gains shrink. However, where power theft is high and hard to control, HVDS can pay off even on domestic lines, as evidenced by the power utility in some parts of Saurashtra.

Conclusion

For a long time, our rural electrification benchmark depended on whether a village was connected, regardless of the number of households, shops or cottage industries connected. Now, the benchmark is revised to include certain minimum user coverage before a village can be called 'electrified'. The real impact of electricity on development, however, requires not only notional 'connectedness' of users but access to a quality PSEn; that is, having round-the-clock power supply without interruptions, at full and stable voltage.

The significant impact of electricity on rural development has been highlighted by many scholars in India and elsewhere (Bhatt 2007; Zomers 2001). The experience of rural Gujarat during recent years puts in bold relief how by liberating the village society from the stranglehold of feeder-level tube well anarchy, powerful forces of all-round socio-economic transformation of villages can be unleashed. If rural communities in Madhya Pradesh, Rajasthan and elsewhere in India are not up against the

political class for their poor PSEn, it could only be for two reasons: first, most of their members are participants in the anarchy themselves; and second, having never enjoyed quality PSEn, rural people cannot appreciate the positive medium and the longer-term impacts of quality PSEn in the socio-economic development and quality of rural life.

The advantage of including Kerala in our study was that it follows a text-book approach to power pricing, as does West Bengal in recent years. It treats all the four segments of rural electricity customers on par. Every farmer is charged, based on his actual use or consumption of electricity though at a subsidised price (unlike West Bengal, where it is not). As a result Kerala and West Bengal have bypassed all the problems that many other states of India are facing. Notably, however, neither Kerala nor West Bengal faces the electricity-groundwater nexus that bedevils power utilities as well as agricultural economies in the western corridor of India. Kerala, where irrigation pumps are mostly of 1-1.5 HP and connected with domestic power lines, has a very low agricultural load (of 1.5 HP per connection as against 10.2 HP in Gujarat, 12.5 HP in Punjab). Kerala farmers, irrigating high value crops, are thus able to take their modest energy costs of irrigation in their stride. In West Bengal, agricultural load/ha may be higher than in Kerala but thanks to a hyper-cautious approach of its groundwater hydro-cracy, just one-tenths of its shallow tube wells run on electricity (Mukherji et al. 2012). Consumers of agricultural power in West Bengal are neither as numerous nor as organised nor as dependent on subsidies - as in Punjab, Karnataka or Andhra Pradesh - to become an 'intense minority' that undermines the lives of an 'apathetic majority'.

Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu - all offering poor PSEn to their rural communities - can benefit from the experience of Gujarat, Punjab and Kerala in improving rural power supply environment. It is doubtful if these states can follow the Kerala (and West Bengal) model at this stage. Metering all the tube wells and charging farmers for power consumption at near commercial rate would invite farmer opposition on a scale that may not be acceptable to the state governments. The practical option, therefore, may be to follow the path that Gujarat and Punjab have taken. Madhya Pradesh (along with Karnataka and Andhra Pradesh) is already planning to separate its rural feeders as Gujarat and Punjab have done. Rajasthan follows virtual feeder segregation, the impact of which is far from clear, if our survey results are any guide.

One common mistake that needs to be avoided is to assume that feeder separation or HVDS can work as a technical fix to rein in feeder-level anarchy. It is highly doubtful if feeder separation under the Jyotigram scheme by itself would have improved rural PSEn in Gujarat much. Gujarat success rests on a tripod: feeder separation under Jyotigram Yojana; a ruthless non-stop vigilance campaign to book power theft; and an intensive program of organisational reform and revitalisation of power utilities, with emphasis on commercial viability and customer service (Shah and Mehta 2012).

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About the IWMI-Tata Program and Water Policy Highlights

The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trust (SRTT), Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations. Through this program, IWMI collaborates with a range of partners across India to identify, analyze and document relevant water-management approaches and current practices. These practices are assessed and synthesized for maximum policy impact in the series on Water Policy Highlights and IWMI-Tata Comments.

Water Policy Highlights are pre-publication discussion papers developed primarily as the basis for discussion during ITP's Annual Partners' Meet. The research underlying these Highlights was funded with support from IWMI, Colombo and SRTT, Mumbai. However, the Highlights are not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or either of its funding partners.

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