11 Energy–Irrigation Nexus in South Asia: Improving Groundwater Conservation and Power Sector Viability

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Introduction

In the populous South Asian region, power utilities have been at loggerheads with the region's groundwater economy for more than 15 years. As groundwater irrigation has come to be the mainstay of irrigated agriculture in much of India, Pakistan Punjab and Sind provinces, Nepal Terai and Bangladesh, the energy sector's stakes in agriculture have risen sharply. Way back in the 1950s, when raising energy consumption was considered synonymous with economic progress, government-owned state power utilities aggressively persuaded unwilling farmers to install electric tube wells. In states like Punjab and Uttar Pradesh, chief ministers gave steep targets to district-level officials to sell electricity connections to farmers. All manner of loans and concessions were made available to popularize tube well irrigation. During the 1960s and 1970s, the World Bank supported huge investments in rural electrification infrastructure to stimulate groundwater irrigation and agricultural growth. These policies were vindicated when the Green Revolution was found to follow the tube well revolution with a lag of 3–5 years; and researchers like Robert Repetto (1994) asserted that 'the Green Revolution is more tubewell revolution than wheat revolution'. By the 1970s, the energy–irrigation nexus had already become a prominent feature of the region's agrarian boom; even in canal commands, such as in India Punjab and Pakistan Punjab, groundwater irrigation had grown rapidly.

However, the enthusiasm of state electricity boards (SEBs) towards their agricultural customers had begun to gradually wane. All of them were charging tube well owners based on metered consumption; however, as the number of tube wells increased, SEBs found it costly and difficult to manage metering and billing. The cost of meters and their maintenance was the least of the worry; but the transaction costs of farm power supply – in terms of containing rampant tampering of meters, underbilling, corruption at the level of meter readers, the cost of maintaining an army of meter readers, increasing pilferage of power – were far higher and more difficult to control. Introduction of flat tariff in state after state during the 1970s and 1980s was a response to this high and rising transaction costs of metered power supply. Flat tariff linked to the horsepower rating of the pump eliminated the hassle and cost of metering in one go; it still afforded scope for malpractices, such as underreporting the horsepower rating, but controlling this was easier than controlling pilferage under metered tariff. Flat tariffs, however, became 'sticky'. As power supply to agriculture emerged as a major driver of irrigated agriculture, chief ministers found its pricing a powerful weapon in the populist vote bank politics. Unable to raise flat tariff for years on end and under pressure to supply abundant farm power, power utilities began to find their balance sheets turning red; and the industry as well as its protagonists and multilateral donors veered around to the view that reverting to metered tariff for farm power supply is a precondition to restoring its viability. This view based on neoclassical economic theory considered only the 'transformation cost' of generating and distributing power, but overlooked the 'transaction costs' of volumetric pricing of power supply to farmers.

In this chapter, our objective is to re-evaluate the entire debate by putting it in the perspective of the New Institutional Economics, which shows how some activities we all know have high pay-offs in terms of productivity fail to get undertaken because of the presence of transaction costs, which neoclassical economics ignores (North, 1997). We begin with the premise that electricity pricing and supply policies in South Asia are closely linked with the policy goals of managing groundwater irrigation for efficiency, equity and sustainability. Analysing the energy and groundwater economies as a nexus could evolve joint strategies to help South Asia conserve its groundwater while at the same time improving the viability of its power industry.

Energy–Irrigation Nexus

Energy–irrigation nexus focuses on a class of issues that are unique to the South Asian region as well as the North China Plain. Many countries – the USA, Iran, Mexico – make intensive use of groundwater in their agriculture sectors. However, in these countries, groundwater irrigation affects a small proportion of their people; energy use by agriculture is a small proportion of their total energy use and the cost of energy use in farming is a small proportion of the total value added in farming.

India, Pakistan, Bangladesh and Nepal (but not Bhutan, Myanmar, Sri Lanka and Maldives) are the biggest groundwater users in the world. Between them, they pump around 210 km^3 of groundwater every year (Fig. 11.1). In doing so, they use approximately 21–23 million pump sets, of which about 13–14 million

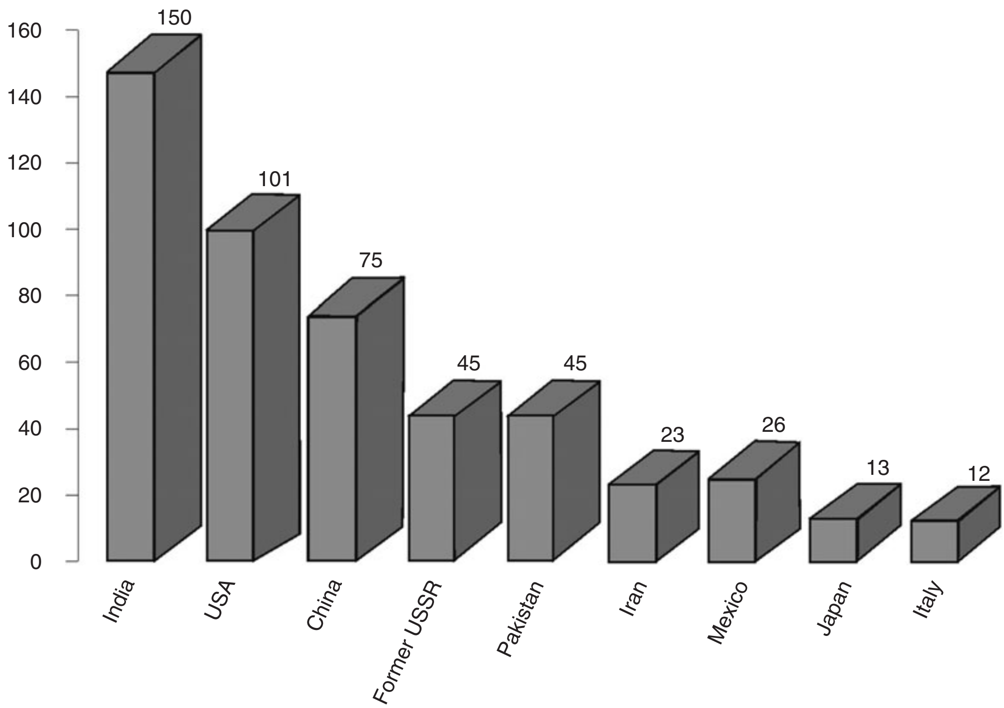


Fig. 11.1. Groundwater use in selected countries in the 1980s. (From Llamas *et al*., 1992, p. 4.)

are electric and around 8–9 million are powered by diesel engines (NSSO, 1999). If we assume that an average electric tube well (with pumping efficiency of say 25%) lifts water to an average head of 30 m, the total electricity equivalent of energy used in these countries for lifting 210 km^3 of groundwater is around 69.6 billion kilowatt-hour per year.[1] At an alternative cost of Rs 2.5 ($0.05)/kWh, supplying this energy costs the region's energy industry Rs 174 ($3.78) billion[2]; the market value of the irrigation produced is around Rs 450–550[3] ($9.8–12) billion and its contribution to agricultural output is Rs 1350–1650 ($29.3–35.9) billion.[4] In these emerging low-income economies, pump irrigation is a serious business with economy-wide impacts, positive and negative.

Unlike in other groundwater-using countries, the pump irrigation economy in South Asia also affects vast numbers of low-income households and large proportions of people. This growth in groundwater irrigation in the region is relatively recent (Fig. 11.2). In India, gravity systems dominated irrigated agriculture until the 1970s; but by the early 1990s, groundwater irrigation had far surpassed surface irrigation in terms of area served as well as proportion of agricultural output supported (Debroy and Shah, 2003; Shah *et al*., 2003). According to Government of India estimates, 60% of India's irrigated lands are served by groundwater wells (GOI Ministry of Water Resources, 1999); however, independent surveys suggest the proportion may be more like 75% (Shah *et al*., 2004a; NSS 54th round).

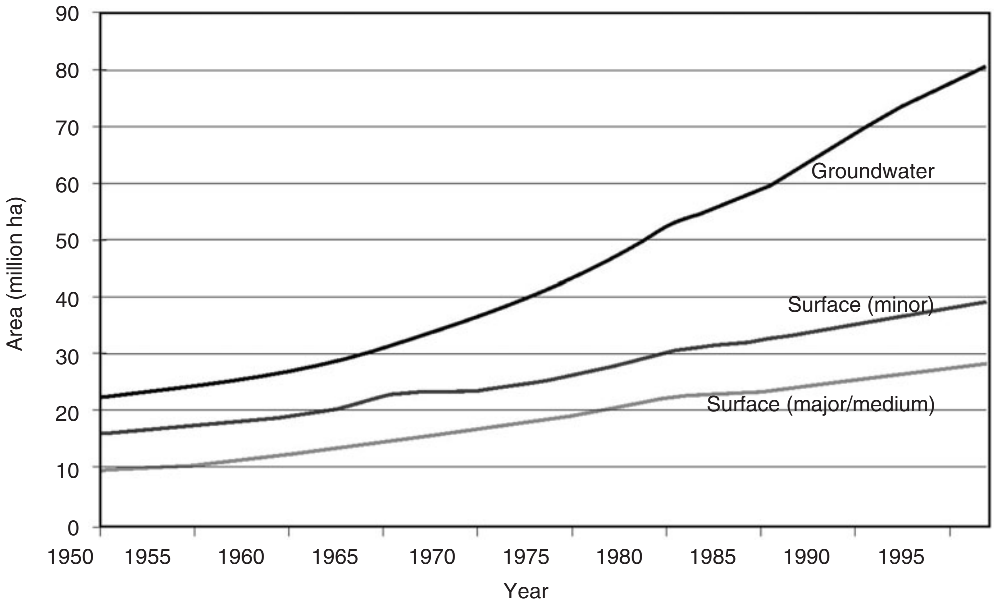


Fig. 11.2. India, irrigated area by source. (From GOI Ministry of Water Resources, 1999.)

In 1999/2000, India's 81 million landowning families (http://labourbureau.nic.in/) had more than 20 million tube wells and pump sets among them; on average, roughly every fourth landowning household has a pump set and a well; and a large proportion of non-owners depend on pump set owners for supplying pump irrigation to them through local, fragmented groundwater markets (Shah, 1993). According to a World Bank estimate, groundwater irrigation contributes around 10% of India's gross domestic product (GDP) (World Bank and Government of India, 1998), but this is made possible because groundwater irrigation uses up around 15–20% of total electricity used in the country.

Large number of small pumpers is a peculiarly South Asian aspect. In countries like the USA, Mexico and Iran, which have large groundwater irrigation economies, tube wells are fewer and larger, typically irrigating 10–500 times larger areas compared to groundwater users in India, Bangladesh and Nepal. In Mexico's Guanajuato province, the heartland of its intensive groundwater-irrigated agriculture, a typical tube well is run by a 100–150 hp pump and operates for more than 4000 h/year (Scott *et al.*, 2002). In India, Bangladesh and Nepal, the modal pump size is 6.5 hp and average operation is around 400–500 h/year (Shah, 1993). In Iran, only 365,000 tube wells are pumped to produce 45 km^3 of groundwater (Hekmat, 2002); India uses 60 times more wells compared to Iran to extract three times more groundwater.

From the viewpoint of managing groundwater as well as of transaction costs of energy supply to irrigation, these differences prove crucial. In Iran, when groundwater overdraft in the hinterland threatened water supply to cities in the plains, the Ministry of Power (which also manages water resources) was able to enforce a complete ban (provided under its Water Law) on new groundwater structures coming up in two-fifths of its plains (Hekmat, 2002). In Mexico, the Commission National de Aqua (CNA) has struggled to establish and enforce a system of water rights in the form of concessions and initiate a programme to create groundwater user organizations to promote sustainable resource management; however, while this has helped register most of its 90,000 tube well owners, Mexico is finding it impossible to limit pumping to quotas assigned to them (Scott *et al*., 2002). Among the many factors that help Mexico make such direct management work, a very important one is that groundwater administrations in these countries have to deal with a relatively small number of fairly large irrigators.

A related aspect is the relation between groundwater irrigation, food security and livelihood. In countries with shrinking agriculture, the proportion of people dependent on groundwater-irrigated agriculture tends to be small (last column in Table 11.1). This, for example, is the case in the USA, Mexico and Iran. One would have normally thought that in such situations, it would be easier for governments to adopt a tough position with irrigators, especially if serious environmental anomalies were involved. However, we find that this is not so; Mexico has been unable to remove substantial energy subsidies to agriculture or rein in groundwater depletion (Scott *et al*., 2002); and the USA has found it possible to only restrict the rate of, but not quite stop, the mining of the great Ogallala aquifer. Even after imposing a ban, Iran is still struggling to eliminate its annual groundwater overdraft of 5 km^3 (Hekmat, 2002). In South Asia, the dependence on groundwater is far greater, and not for wealth creation as much as to support the livelihood of millions of rural poor households. In India, for instance, pump irrigation has emerged as the backbone of its agriculture and accounts for 70–80% of the value of irrigated farm output; rapid groundwater development is at the heart of the agrarian dynamism found in some areas in eastern India that remained stagnant for a long time (Sharma and Mehta, 2002). The greatest social value of groundwater irrigation is that it has helped make famines a matter of history: during 1963–1966, a small deficit in

Table 11.1. Extent of dependence of population on groundwater and average size of WEMs in different countries. (From Hekmat, 2002, for Iran; Mukherji and Shah, 2002, for India; Scott *et al*., 2002, for Mexico; and Shah *et al*., 2003, for China and Pakistan.)

Country	Annual groundwater use (km^3)	Number of groundwater structures (million)	Extraction per structure (m^3/year)	Population dependent on groundwater (%)
Pakistan Punjab	45	0.5	90,000	60–65
India	150	21.28	7,900	55–60
China	75	3.5	21,500	22–25
Iran	29	0.5	58,000	12–18
Mexico	29	0.07	414,285	5–6
USA	100	0.2	500,000	<1–2

rainfall left reservoirs empty and sent food production plummeting by 19%, whereas in the 1987/1988 drought, when rainfall deficit was 19%, food production fell by only 2%, thanks to widespread groundwater irrigation (Sharma and Mehta, 2002).

It is often argued that with 60 million tonnes of food stocks, India can now take a tough stand on groundwater abuse. However, this view misses an important point; groundwater contribution to farm incomes and rural livelihood is far more crucial than its contribution to food security, especially outside canal commands.[5] In South Asia, the proportion of total population that is directly or indirectly dependent on groundwater irrigation for farm-based livelihood is many times larger than in Iran and Mexico. Indeed, our surmise is that by the turn of the millennium, three-fourths of the rural population and more than half of the total populations of India, Pakistan, Bangladesh and Nepal depended for their livelihood directly or indirectly on groundwater irrigation. It is not surprising therefore that the energy–irrigation nexus has been at the centre of the vote-bank politics in the region.

Sectoral Policy Perspectives

Groundwater policymakers face conflicting challenges in managing this chaotic economy in different areas. Particularly after 1970, agrarian growth in the region has been sustained primarily by private investments in pump irrigation. However, the development of the resource has been highly uneven. In the groundwater-abundant Ganga–Brahmaputra–Meghana basin – home to 400 million of the world's rural poor in Bangladesh, Nepal Terai and eastern India – groundwater development can produce stupendous livelihood and ecological benefits (Shah, 2001). However, it is precisely here that it is slow and halting. In contrast, Pakistan Punjab as well as India Punjab, Haryana and all of peninsular India are rapidly overdeveloping their groundwater to a stage where agriculture in these parts faces serious threats from resource depletion and degradation. The priority here is to find ways of restricting groundwater use to make it socially and environmentally sustainable. In stimulating or regulating groundwater use as appropriate, the tools available to resource managers are few and inadequate. Regulating groundwater draft and protecting the resource is proving far more complex and difficult. Direct management of an economy with such a vast number of small players would be a Herculean task in most circumstances. In South Asia, it is even more so because the groundwater bureaucracies are small, ill-equipped and outmoded. For instance, India's Central Ground Water Board, which was created during the 1950s for monitoring the resource, has no field force or operational experience and capability in managing groundwater. Direct management of groundwater economy will therefore remain an impractical idea for a long time in South Asia.

This makes *indirect* management relevant and appealing; and electricity supply and pricing policies offer a potent tool kit for indirect management provided these are used as such. Regrettably, these have so far not been used with imagination and thoughtfulness. In the groundwater-abundant Ganga basin, favourable power supply environment can stimulate livelihood creation for the poor through accelerated groundwater development; but as described later in this chapter, this region has been very nearly de-electrified (Shah, 2001). Elsewhere, there is a dire need to restrict groundwater draft as abundant power supply and perverse subsidies are accelerating the depletion of the resource. All in all, power supply and pricing policies in the region have so far been an outstanding case of perverse targeting.

A major reason for this is the lack of dialogue between the two sectors and their pursuit of sectoral optima rather than managing the nexus. The groundwater economy is an anathema to the power industry in the region. Agricultural use accounts for 15–20% of total power consumption; and power pricing to agriculture is a hot political issue. In states like Tamil Nadu, power supply to farmers is free; and in all other states, the flat electricity tariff – based on horsepower rating of the pump rather than actual metered consumption – charged to farmers is heavily subsidised. Annual losses to electricity boards on account of power subsidies to agriculture are estimated at Rs 260 ($5.65) billion in India; and these are growing at a compound annual growth rate of 26% (Lim, 2001; Gulati, 2002). If these estimates are to be believed, it will not be long before power industry finances are completely in the red. These estimates have, however, been widely contested; it is found that SEBs have been showing their growing T&D losses in domestic and industrial sectors as agricultural consumption, which is unmetered and therefore unverifiable.[6] However, the fact remains that agricultural power supply under the existing regime is the prime cause of the bankruptcy of SEBs in India.

As a result, there is a growing movement now to revert to metered power supply. The power industry has been leading this movement from the front; but international agencies – particularly, the World Bank, the US Agency for International Development (USAID) and the Asian Development Bank (ADB) – have begun to insist on metered power supply to agriculture as the key condition for financing new power projects. The Central and State Electricity Regulatory Commissions have been setting deadlines for SEBs and governments to make a transition to universal metering. The Government of India has resolved (i) to provide power on demand by 2012; (ii) to meter all consumers in two phases, with phase I to cover metering of all 11 kVA (kilovolt-ampere) feeders and high tension consumers, and phase II to cover all consumers; and (iii) to install regular energy audits to assess T&D losses and eliminate all power thefts as soon as possible (Godbole, 2002). This is an ambitious agenda indeed. However, all moves towards metered power consumption have met with farmer opposition on unprecedented scale in Andhra Pradesh, Gujarat, Kerala and in other states of India. All new tube well connections now come with metered tariff; and most states have been offering major inducements to tube well owners to opt for metered connections. Until it announced free power to farmers in June 2004, Andhra Pradesh charged metered tube wells at only Rs 0.20–0.35 ($0.4–0.7)/kWh, and Gujarat and several other states charged up to only Rs 2180.50–0.70/kWh against the supply cost of Rs 2.50–3.80 ($5–8)/kWh. In a recent move, the Gujarat government has offered a drip irrigation system free to any farmer who opts for metering.

Yet, there are few takers for metered connections; instead, demand for free power to agriculture has gathered momentum in many states.[7] Farmers' opposition to metered tariff has only partly to do with the subsidy contained in flat tariff; they find flat tariff more transparent and simple to understand. It also spares them the tyranny of the meter readers. Moreover, there are fears that once under metered tariff, SEBs will start loading all manner of new charges under different names. Finally, groundwater irrigators also raise the issue of equity with canal irrigators: if the latter can be provided irrigation at subsidized flat rates by public irrigation systems, they too deserve the same terms for groundwater irrigation.

Despite this opposition, power industry persists in its belief that its fortunes would not change until agriculture is put back on metered electricity tariff. Strong additional support to this is lent by those working in the groundwater sector where it is widely, and rightly, held that zero and flat power tariff produce strong perverse incentives for farmers to indulge in profligate and wasteful use of water as well as power because it reduces the marginal cost of water extraction to nearly zero. This preoccupation of water and power sector professionals in aggressively advocating reversion to metered tariff regime – and of farmers to frustrate their design – is, in our view, detracting the region from transforming a vicious energy–irrigation nexus into a virtuous one in which a booming, and better managed, groundwater-based agrarian economy can coexist with a viable electricity industry.

Making Metered Tariff Regime Work

Arguments in favour of metered tariff regime are several. First, it is considered essential for SEBs to manage their commercial losses; you cannot manage what you do not monitor, and you cannot monitor what you do not measure. Second, once farm power is metered, SEBs cannot use agricultural consumption as a carpet under which they can sweep their T&D losses in other segments. Third, metering would give farmers correct signals about the real cost of power and water, and force them to economize on their use. Fourth, for reasons that are not entirely clear, it is often suggested that compared to flat tariff regime, metered tariff would be less amenable to political manipulation and easier to raise as the cost of supplying power rises. Finally, flat tariff is widely argued to be inequitable towards small landowners and to irrigators in regions with limited availability of groundwater.

The logic in support of metered tariff is obvious and unexceptionable. The problem is how to make metered tariff work as envisaged. Two issues seem critical: (i) How to deal with the relentless opposition from farmers to metering? (ii) How will SEBs now deal with the problems that forced them to switch to flat tariff during the 1970s in the first place?

The extent of farmer resistance to metering is evident in the repeated failure of SEBs in various states to entice farmers to accept metering by offering metered power at subsidized rates ranging from Rs 0.20 to Rs 0.70 ($0.4–1.3)/kWh as against the actual cost of supply of about Rs 2.50 to Rs 3.80 ($5–8)/kWh. In late 2002, Batra and Singh (2003) interviewed 188 water extraction mechanism

(WEM) owners in Punjab, Haryana and western Uttar Pradesh to understand their WEM pumping behaviour. They noted that in Punjab and Haryana, an average electric WEM owner would spend Rs 2529.65 ($54.99) and Rs 6805.42 ($147.94)/year *less* on their total power bill if they accepted metering at prevailing rates of Rs 0.50 ($1)/kWh and Rs 0.65 ($1.4)/kWh, respectively, and yet would not accept metering. In effect, this is the price they are willing to pay to avoid the hassle and costs of metering.[8]

Besides dealing with mass farmer resistence, protagonists of metering also need to consider that the numbers of electric tube wells – and alongside, the problems associated with metering them – are now ten times larger than when flat tariff was first introduced. Before 1975, when all SEBs charged farm power on metered basis, the logistical difficulty and transaction costs of metering had become so high that flat tariff seemed the only way of containing it. A 1985 study by the Rural Electrification Corporation in Uttar Pradesh and Maharashtra had estimated that the cost of metering rural power supply was 26% and 16%, respectively, of the total revenue of the SEB from the farm sector (Shah, 1993). This estimate included only the direct costs, such as those of the meter, its maintenance, the power it consumes, its reading, billing and collecting. These costs are not insignificant[9]; however, the far bigger part of the transaction costs of metering is the cost of containing pilferage, tampering with meters, underreading and underbilling by meter readers in cohort with farmers.

All in all, the power sector's aggressive advocacy for introducing metered tariff regime in agriculture is based, in our view, on an excessively low estimation of the transaction costs of metering, meter reading, billing and collecting from several hundred thousand tube well connections scattered over a vast area[10] that each SEB serves. Most SEBs find it difficult to manage metered power supply even in industrial and domestic sectors where the transaction costs involved are bound to be lower than in the agriculture sector. Even where meters are installed, many SEBs are unable to collect based on metered consumption. In Uttar Pradesh, 40% of low tension (LT) consumers are metered but only 11% are billed on the basis of metered use; the remaining are billed based on minimum charge or an average of past months of metered use (Kishore and Sharma, 2002). In Orissa, under far-reaching power sector reforms, private distribution companies have brought all users under the metered tariff regime; however, 100% collection of amounts billed has worked only for industries, as in the domestic and farm sector – subject to a large number of scattered small users – collection as a percentage of billing declined from 90.5% in 1995/1996 to 74.6% in 1999/2000 (Panda, 2002).

In order to make metered tariff regime work reasonably well, three things are essential: (i) the metering and collection agent must have the requisite authority to deal with deviant behaviour amongst users; (ii) the agent should be subject to a tight control system so that he or she can neither behave arbitrarily with consumers[11] nor form an unholy collusion with them; and (iii) the agent must have proper incentives to enforce metered tariff regime. In agrarian conditions comparable to South Asia's, a quick assessment by Shah *et al*. (2003) suggested that all these conditions obtain in some way, and therefore metered tariff regime works reasonably well in North China (Shah *et al*., 2004b).

The Chinese electricity supply industry operates on two principles: (i) total cost recovery in generation, transmission and distribution at each level with some minor cross-subsidization across user groups and areas; and (ii) each user pays in proportion to his or her use. Unlike in much of India where farmers pay either nothing or much less than domestic and industrial consumers do for power, agricultural electricity use in many parts of North China attracts the highest charge per unit, followed by household users and then industries. Operation and maintenance of local power infrastructure is the responsibility of local units, the village committee at the village level, the Township Electricity Bureau at the township level and the County Electricity Bureau at the county level. The responsibility of collecting electricity charges is also vested in local units in ways that ensure that the power used at each level is paid for in full. At the village level, this implies that the sum of power use recorded in the meters attached to all irrigation pumps has to tally with the power supply recorded at the transformer for any given period. The unit or person charged with the fee collection responsibility has to pay the Township Electricity Bureau for power use recorded at the transformer level. In many areas, where power supply infrastructure is old and worn out, line losses below the transformer make this difficult. To allow for normal line losses, 10% allowance is given by the Township Electricity Bureau to the village unit. However, even this made it difficult for the latter to tally the two; as a result, an Electricity Network Reform programme was undertaken by the National Government to modernize and rehabilitate rural power infrastructure. Where this was done, line losses fell sharply[12]; among the nine villages Shah visited in three counties of Hanan and Hebei provinces in early 2002, none of the village electricians he interviewed had a problem tallying power consumption recorded at the transformer level with the sum of the consumption recorded by individual users, especially with the line loss allowance of 10%.

An important reason why this institutional arrangement works is the strong local authority structures in Chinese villages: the electrician is feared because he is backed by the village committee and the powerful party leader at the village level; and the new service orientation is designed partly to project the electrician as the friend of the people. The same village committee and party leader can also keep in check flagrantly arbitrary behaviour of the electrician with the users. The hypothesis that with better quality of power and support service, farmers would be willing to pay a high price for power is best exemplified in Hanan where at 0.7 yuan ($8.75; Rs 4.03)/kWh[13] farmers pay a higher electricity rate compared to most categories of users in India and Pakistan, as also compared to the diesel price at 2.1 yuan/l.

In India, there has been some discussion about the level of incentive needed to make privatization of electricity retailing attractive at the village level. The village electrician in Hanan and Hebei is able to deliver on a reward of 200 yuan/month, which is equivalent to half the value of wheat produced on a mu (or one-thirtieth of the value of output on a hectare of land). For this rather modest wage, the village electrician undertakes to make good to the Township Electricity Bureau full amount on line and commercial losses in excess of 10% of the power consumption recorded on the transformers. If he can manage to keep losses to less than 10%, he can keep 40% of the value of power saved.

All in all, the Chinese have all along had a working solution to a problem that has befuddled South Asia for nearly two decades. Following Deng

Xiaoping who famously asserted that 'it does not matter whether the cat is black or white, as long as it catches mice', the Chinese built an incentive-compatible system that delivered quickly rather than wasting time on rural electricity cooperatives and village Vidyut Sanghas (electricity user associations) being tried in India and Bangladesh. The way the Chinese collect metered electricity charges, it is well nigh impossible for the power industry to lose money in distribution since losses there are firmly passed on downstream from one level to the one below.

If South Asia is to revert to metered tariff regime, the Chinese offer a good model. But there are two problems. First, the Chinese agricultural productivity is so much higher than most regions in South Asia that even with power charged for at real cost, the cost of tube well irrigation constitutes a relatively small proportion of the gross value of output. In South Asia, irrigation cost of this order – i.e. Rs 2100–8600 ($45.65–186.96)/ha – would make groundwater irrigation unviable in all regions except parts of Punjab and Haryana where farm productivity approaches the Chinese levels.

The second problem is that while South Asian power industry can mimic – or even outdo – the Chinese incentive system, it cannot replicate the Chinese authority system at the village level. Absence of an effective local authority that can guard the farmers from arbitrary behaviour of the metering agent or protect the latter from non-compliance by the users may create unforeseen complications in adapting the Chinese model to South Asia. India has begun experiments to find new metering solutions only recently. Indian Grameen Services, a non-governmental organization (NGO), tried an experiment to organize Transformer User Associations in Hoshangabad district of Madhya Pradesh; the idea was that the SEB would set up a dedicated plant if farmers paid up unpaid past dues and agreed to metered tariff. However, before the 2004 elections, the chief minister 'waved' past dues of farmers, and the Hoshangabad association disintegrated, its members disillusioned. Orissa organized similar village Vidyut Sanghas in thousands under its reforms; while these lie defunct, Orissa has achieved modest success in improving metered charge collection by using local entrepreneurs as billing and collection agents. It is difficult to foresee if this would work elsewhere because less than 5% of rural load in Orissa is agricultural; it is equally difficult to see what kind of treatment collection agents would receive in Gujarat villages where agricultural load may be 50–80% of total rural load. Although it is early times yet to learn lessons from these, it is all too clear that the old system of metering and billing – in which SEBs employed an army of unionized meter readers – would just not work.[14] That model seems passé; in power as well as surface water, volumetric pricing can work, where needed, only by smartly designed incentive contracts.

From *Degenerate* Flat Tariff to *Rational* Flat Tariff Regime

Flat tariff for farm power is universally written off as inefficient, wasteful, irrational and distortionary, in addition to being inequitable. In the South Asian experience, it has indeed proved to be so. It was the change to flat tariff that encouraged political leaders to indulge in populist whims such as doing away with farm power tariff altogether (as Punjab and Tamil Nadu have) or to peg it at unviably low levels regardless of the true cost of power supply. Such examples have led to the general perception that the flat tariff regime has been responsible for ruining the electricity industry and for causing groundwater depletion in many parts of South Asia.

However, we would like to suggest that flat tariff regime is wrongly maligned; in fact, the flat tariff that South Asia has used in its energy–irrigation nexus so far is a completely *degenerate* version of what might otherwise be a highly rational, sophisticated and scientific pricing regime. Zero tariff, we submit, is certainly not a rational flat tariff; nor is a flat tariff without proactive rationing and supply management. To most people, the worst thing about flat tariff is that it violates the marginal cost principle that advocates parity between the price charged and marginal cost of supply. Yet, businesses commonly price their products or services in ways that violate the marginal cost principle but make overall business sense. Flat rates are often charged to stimulate use to justify the incremental cost of providing a service. In early days of rural electrification, SEBs used to charge a flat-cum-pro-rata tariff to achieve two ends: SEBs wanted each tube well to use at least the amount of power that would justify its investment in laying cable and poles; the flat component of the tariff encouraged users to achieve this level. India's telephone department still provides the first 250 calls for a flat charge even though all calls are metered; the idea here is to encourage the use of telephone service to a level that justifies the incremental cost of providing the service.

In general, however, flat tariff regime is commonly resorted to when saving on the transaction costs of doing business is an important business objective. Organizations hire employees on piece rate when their work is easy to measure; but flat rate compensation is popular worldwide because it is not easy to measure the marginal value product of an employee on a daily basis. Urban public transport systems offer passes to commuters at an attractive flat rate in part because commuters offer a stable business but equally because it reduces queues at ticket windows, the cost of ticketing and collecting fares daily. Cable operators in India still charge a flat tariff for a bunch of television channels rather than charging for each channel separately because the latter would substantially increase their transaction costs. The Indian Income Tax Department a few years ago offered all businesses in the informal sector to pay a flat income tax of Rs 1400 ($30.44)/year instead of launching a nationwide campaign to bring these millions of small businesses within its tax net because the transaction costs of doing so would have been far greater than the revenue realized. A major reason municipal taxes are levied on a flat rate is the transaction costs of charging citizens based on the value they place on the margin of the municipal services.

Are all these businesses that charge for their products or services on a flat rate destined to make losses? No; often they make money because they charge a flat rate. Many private goods share this one feature with public goods like municipal services and defence: the high transaction costs of charging a differential price to different customers based on their use as well as the value they place on the product or service. So they recover their costs through a flat rate and then remain viable through deft supply management. Canal irrigation is a classic example. For ages we have been hearing about the exhortations to charge irrigators on volumetric basis; however, nowhere in South Asia can we find volumetric water pricing practised in canal irrigation. In our view, transaction costs of collecting volumetric charge for canal irrigation become prohibitively high (Perry, 1996, 2001) because: (i) in a typical South Asian system, the number of customers involved per 1000 ha command is quite large; so the cost of monitoring and measuring water use by each user would be high; (ii) once a gravity flow system is commissioned, it becomes extremely difficult in practice for the system managers to exclude defaulting customers from the command area from availing of irrigation when others are; (iii) the customer propensity to frustrate sellers' effort to collect a charge based on use would depend in some ways on the proportion the charge constitutes to the overall scale of his or her income. On all these counts, one can surmise that volumetric pricing of canal irrigation would be far easier in South African irrigation systems serving white commercial farmers; here, a branch canal serving 5000 ha might have 10–50 customers, and charging them based on actual use would be easier than in an Indian system where the same command area would contain 6000–8000 customers (Shah *et al*., 2002). The only way of making canal irrigation systems viable in the Indian situation is to raise the flat rate per hectare to a level that ensures overall viability.

Supply restriction is inherent to rational flat rate pricing; by the same token, flat rate pricing and on-demand service are incompatible in most situations. In that sense, consumption-linked pricing and flat rate pricing represent two different business philosophies: in the first, the supplier will strive to 'delight the customer' as it were, by providing on-demand service without quantity or quality restrictions of any kind; in the second, the customer has to adapt to the supplier's constraints in terms of the overall quantum available and the manner in which it is supplied. In the case of buffet meals, restaurants give customers a good deal but save on waiting costs, which are a substantial element in the economics of a restaurant. In the Indian *thali* system, where one gets a buffet-type meal served on one's table, the downside is that one cannot have a leisurely meal since the restaurant aims to maximize the number of customers served during a fixed working period and in limited space. Thus, there is always a price for the value businesses offer their customers through products and services offered on flat tariff; but that does not mean that the seller or the buyer is any the worse for flat rate pricing.

The reason why flat rate tariff for power supply to WEMs as currently practised in South Asia is degenerate – and power industry is in the red – is because the power utilities have failed to invest more intelligence in managing rationed power supply. Under flat tariff systems until now, most SEBs have tried to maintain farm power supply at 8–15 h/day right through the year. Raising flat tariff to a level that covers the cost of present levels of supply would be so high that it will send state governments tumbling in the face of farmer wrath.[15] However, we believe that it is possible for the SEBs to satisfy farmer needs while reducing total power supply to farmers during a year by fine-tuning the scheduling of power supply to irrigation needs of farmers. Ideally, the business objective of a power utility charging flat tariff should be to supply the best quality service it can offer its customers consistent with the flat tariff pegged at a given level. The big opportunity for 'value improvement' in the energy–irrigation nexus – and by 'value improvement' we mean 'the ability to meet or exceed customer expectations while removing unnecessary cost' (Berk and Berk, 1995, p. 11) – arises from the fact that the pattern of power demand of the farming sector differs in significant ways from the demand pattern of domestic and industrial customers. The domestic consumers' idea of good-quality service is power of uniform voltage and frequency supplied 24 h/day, 365 days of the year. But the irrigators' idea of good-quality service from power utilities is power of uniform voltage and frequency when their crops face critical moisture stress. With intelligent management of power supply, we argue that it is possible to satisfy irrigation power demand by ensuring a supply of 18–20 h/day for 40–50 key moisture-stress days in *kharif* and *rabi* seasons of the year, with some power available on the rest of the days. Against this, Tamil Nadu supplies power to farmers 14 h/day for 365 days of the year! This is like being in the command area of an irrigation system with all branches and the distribution network operating at full supply level every day of the year.

Groundwater irrigators are always envious of farmers in the command areas of canal irrigation projects. But in some of the best irrigation projects in South Asia, a typical canal irrigator gets surface water for no more than 10–15 times a year. In most irrigation systems, in fact, the irrigator would be happy if he or she got water 6 times a year. In the new Sardar Sarovar project in Gujarat, the policy is to provide farmers a total of 53 cm depth of water in 5–6 installments during a full year. For an irrigation well with a modest output of 25 m^3/h, this would mean the ability to pump for 212 h/ha. In terms of water availability, a WEM owner with 3 ha of irrigable land would be at par with a farmer with 3 ha in the Narmada command if he or she got 636 h of power in a year. The WEM owner would be better off if the 636 h of power came when he or she needed water the most. When the Gujarat government commits to year-round supply of 8 h/day of farm power, it in effect offers tube well owners water entitlements 14 times larger than those that the Sardar Sarovar project offers to farmers in its command area.[16] Under metered tariff, this may not matter all that much since tube well owners would use power and groundwater only when their value exceeded the marginal cost of pumping; but under flat tariff, they would have a strong incentive to use some of these 'excess water entitlements' for low marginal value uses just because it costs them nothing on the margin to pump groundwater. This is why the present flat tariff in South Asia is degenerate.

Rational flat tariff, if well managed, can confer two larger benefits. First, it may curtail wasteful use of groundwater. If farm power supply outside main irrigation seasons is restricted to 2–3 h/day, it will encourage farmers to build small on-farm storage tanks for meeting multiple uses of water. Using progressive flat tariff – by charging higher rates per connected horsepower as the pump size increases – will produce additional incentive for farmers to purchase and use smaller-capacity pumps to irrigate less areas, and thereby reduce overdraft in regions where resource depletion is rampant. Above all, restricted but predictable water supply will encourage water-saving irrigation methods more effectively than raising the marginal cost of irrigation. Second, given the quality of power transmission and distribution infrastructure in rural India, restricting the period of time when the farm power system is 'on' may by itself result in significant reduction in technical and commercial losses of power. The parallel with water supply systems is clear here. In a 1999 paper, for example, Briscoe (1999) wrote that throughout the Indian subcontinent, unaccounted-for water as a proportion of supply is so high 'that losses are "controlled" by having water in the distribution system only a couple of hours a day, and by keeping pressures very low. In Madras, for example, it is estimated that if the supply was to increase from current levels (of about 2 hours supply a day at 2 m of pressure) to a reasonable level (say 12 hours a day at 10 m of pressure) leaks would account for about 900 MLD, which is about three times the current supply in the city.' Much the same logic works in farm power, with the additional caveat that the T&D system for farm connections is far more widespread than the urban water supply system.

Five preconditions for successful rationing

We believe that transforming the present degenerate flat power tariff into rational tariff regime will be easier, and more feasible and beneficial in the short run in many parts of South Asia than trying to overcome farmer resistance to metering. We also believe that doing so can significantly cut the losses of power utilities from their agricultural operation. Five points seem important and feasible.

Separating agricultural and non-agricultural power supply

The first precondition for successful rationing is infrastructural changes needed to separate agricultural power supply from non-agricultural power supply to rural settlements. The most common way this is done now is to keep two-phase power on for 24 h so that domestic and (most) non-agricultural uses are not affected and ration three-phase power necessary to run irrigation pump sets. This is working, but only partially. Farmers' response in states like Gujarat is a rampant use of phase-splitting capacitors with which they can run pumps on even two-phase power. There are technological ways to get around this. It is possible to use gadgets that ensure that the 11 kV line shuts off as soon as the load increases beyond a predetermined level. However, many SEBs have begun separating the feeders supplying farm and non-farm rural consumers. The government of Gujarat has now embarked on an ambitious programme called Jyotirgram Yojana to lay parallel power supply lines for agricultural users in 16,000 villages of the state over the next 3 years at an estimated cost of Rs 9 billion ($195.7 million). In Andhra Pradesh, the process of separation of domestic and agricultural feeders is already 70% complete (Raghu, 2004). This would ensure that industrial users in the rural areas who need uninterrupted three-phase power supply as well as domestic users remain unaffected from rationing of power supplies for agricultural consumers. Another infrastructural change needed would be to install meters to monitor power use so that proper power budgeting can be implemented. For this, meters at transformer level, or even feeder levels, might be appropriate. Many states have already installed meters at the feeder level.

Gradual and regular increase in flat power tariff

Flat tariffs have tended to remain 'sticky'; in most states, they have not been changed for more than 10–15 years while the cost of generating and distributing power has soared. We surmise that raising flat tariff at one go to close this gap between revenue and cost per kWh would be too drastic an increase. However, we believe that farmers would be able to cope with a regular 10–15% annual increase in flat tariff far more easily than a 350% increase at one go as has been proposed by the Electricity Regulatory Commission in Gujarat.

Explicit subsidy

If we are to judge the value of a subsidy to a large mass of people by the scale of popular opposition to curtailing it, there is little doubt that, amongst the plethora of subsidies that governments in India provide, power subsidy is one of the most valued. Indeed, a decision by a ruling party to curtail power subsidy is the biggest weapon that opposition parties use to bring down a government. So it is unlikely that political leaders will want to do away with power subsidies completely, no matter what the power industry and international donors would like. However, the problem with the power subsidy in the current degenerate flat tariff is its indeterminacy. Chief ministers keep issuing diktats to the SEBs about the number of hours of power to be supplied per day to farmers; that done, the actual subsidy availed of by the farmers is in effect left to them to usurp. Instead, the governments should tell the power utility the amount of power subsidy it can make available at the start of each year; the power utility should then decide the amount of farm power the flat tariff and the government subsidy can buy.

Use of off-peak power

In estimating losses from farm power supply, protagonists of power sector reform, including international agencies, systematically overestimate the real opportunity cost of power supplied to the farmers. For instance, the cost of supplying power to the domestic sector – including generation, transmission and distribution – is often taken as the opportunity cost of power to agriculture, which is clearly wrong, since a large part of the high transaction costs of distributing power to the domestic sector is saved in power supply to agriculture under flat tariff. Moreover, a large part of the power supplied to the farm sector is off-peak load power. In fact, but for the agriculture sector, power utilities would be hard-pressed to dispose of this power.[17] More than half of the power supply to farm sector is in the night, and this proportion can increase further. But in computing the amount of power the prevailing flat tariff and prespecified subsidy can buy, the power utilities must use the lower opportunity cost of the off-peak supply.

Intelligent supply management

There is tremendous scope for cutting costs and improving service here. The existing rostering policy in many states of maintaining power supply to the farm sector at a constant rate during prespecified hours is irrational and the prime reason for wasteful use of power and water.[18] Ideally, power supply to the farm sector should be so scheduled as to reflect the pumping behaviour of a modal group of farmers in a given region when they would be subject to metered power tariff at full cost. However, it is difficult to simulate this behaviour because farmers everywhere are subject to flat tariff under which they would have a propensity to use power whenever it is available, regardless of its marginal product. In many states, there is a small number of new tube wells whose owners pay for power on a metered basis; however, they are charged so low a rate that they behave pretty much like flat tariff–paying farmers. Another method is to compare electricity use before and after flat tariff to gauge the extent of over-utilization of power and water attributable to flat tariff.[19] However, our surmise is that the pumping behaviour of diesel pump owners, who are subject to full marginal costs of energy, comparable to what electric tube well owners would pay under unsubsidized metered tariff regime, would be a good indicator of the temporal pattern of power use by electric tube wells under metered tariff. Several studies have shown that annual hours of operation of diesel tube wells is often half or less than half compared to flat tariff–paying electric tube wells (Mukherji and Shah, 2002) (Fig. 11.3).[20] Batra and Singh (2003) interviewed approximately 188 farmers in Punjab, Haryana and central Uttar Pradesh to explore if pumping behaviour of diesel and electric WEM owners differed significantly. They did not find significant differences in Punjab and Haryana[21] but their results for central Uttar Pradesh suggested that diesel WEMs are pumped

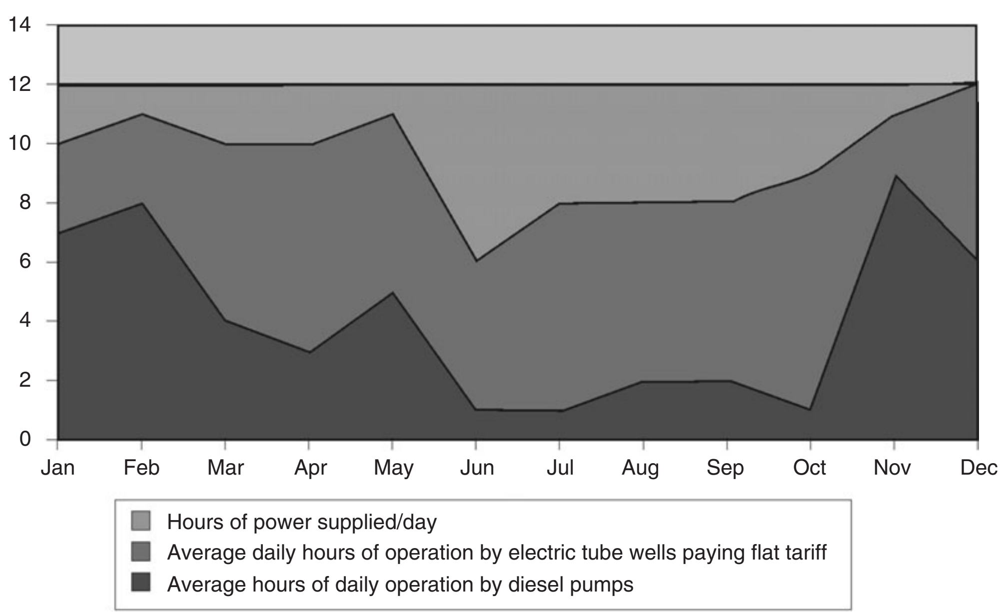


Fig. 11.3. Minimizing waste of power and water through supply management. The numbers shown in this schematic diagram are indicative and not based on actual field data.

when irrigation is needed and electric WEMs are operated whenever electricity is available. Very likely, a good deal of the excess water pumped by farmers owning both electric and diesel pumps is wasted in the sense that its marginal value product falls short of the scarcity value of water and power together.

Figures 11.4 and 11.5 present the central premise of our case: a large part of the excess of pumping by electric tube wells over diesel tube wells is indicative of the waste of water and power that is encouraged by the zero marginal cost of pumping under the present degenerate flat tariff regime. Figure 11.4 presents results of a survey of 2234 tube well irrigators across India and Bangladesh in late 2002, which shows that electric tube well owners subjected to flat tariff everywhere invariably operate their pumps for much longer hours compared to diesel pump owners who face a steep marginal energy cost of pumping (Mukherji and Shah, 2002). It might be argued that diesel pumps on average might be bigger in capacity compared with electric pumps; so we also compared pumping hours weighted by horsepower ratings; and Fig. 11.5 shows that horsepower-hours pumped by flat tariff–paying electric WEMs too are significantly higher than for diesel WEMs everywhere. The survey showed the difference in annual pumpage to be of the order of 40–150%; some of this excess pumping no doubt results in additional output; however, a good deal of it very likely does not, and is a social waste that needs to be eliminated.

Making 'Rational Flat Tariff and Intelligent Power Supply Management' Work

If power utilities undertake a refined analysis of the level and pattern of pumping by diesel pump owners in a region and shave off the potential excess pumping by

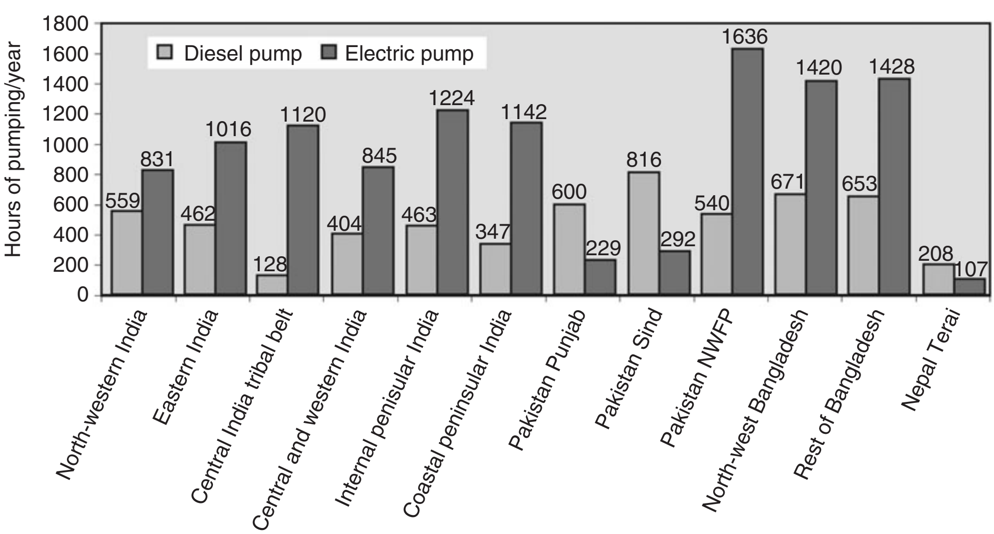


Fig. 11.4. Flat electricity tariff induces farmers to pump more.

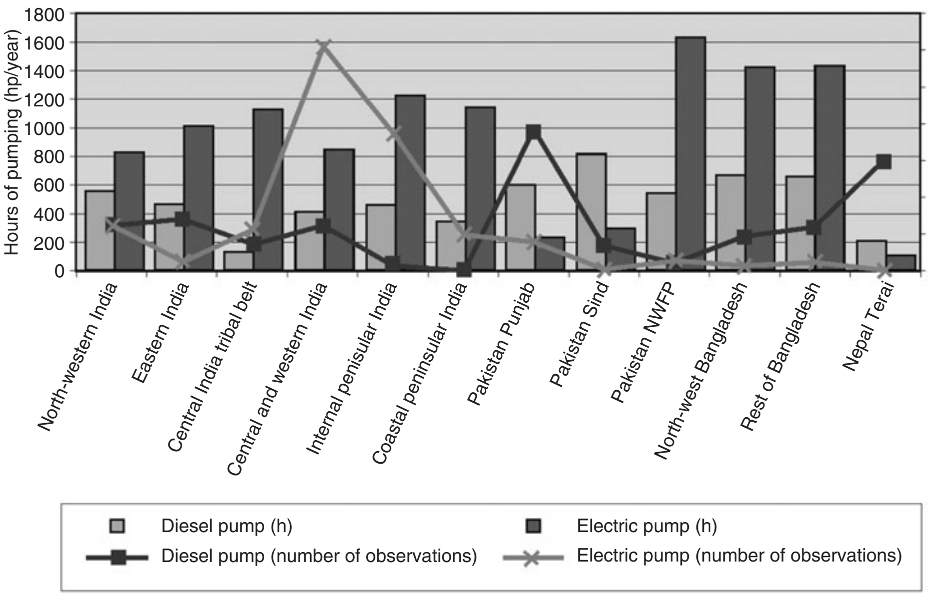


Fig. 11.5. Impact of flat tariff on average annual hours of pumping weighted by pump horsepower.

flat tariff–paying electric tube wells (as shown in Fig. 11.3) by fine-tuning power supply schedule around the year, flat tariff can become not only viable but also socially optimal by eliminating the 'waste'. The average number of hours for which diesel pumps operate is around 500–600/year. At 600 h of annual operation, an electric tube well would use 450 kWh of power per horsepower; if all the power used is off-peak load, commanding, say, 25% discount on a generation cost of Rs 2.5 ($5)/kWh, then farm power supply by the power utility would break even at a flat tariff of Rs 843.75 ($18.34)/hp/year as against Rs 500 ($10.87)/hp/year in force in Gujarat since 1989. The government of Gujarat is committed to raise the flat tariff eventually to around Rs 2100($45.65)/hp/year at the insistance of the Gujarat Electricity Regulatory Commission; however, chances are that if it does so, farmers will unseat the government. A more viable and practical course would be to raise flat tariff to perhaps Rs 900 ($19.57) first and then to Rs 1200 ($26.09), and restrict annual supply of farm power to around 1000–1200 h against the existing regime of supplying farm power for 3000–3500 h/year. A 5 hp pump lifting 25 m^3 of water per hour over a head of 15 m can produce 30,000 m^3 of water per year in 1200 h of tube well operation, sufficient to meet the needs of most small farmers in the region.

Farmers will no doubt resist such rationing of power supply; however, their resistance can be reduced through proactive and intelligent supply management by the following methods:

1. Enhancing the *predictability* and *certainty*: More than the total quantum of power delivered, in our assessment, power suppliers can help the farmers by announcing an annual schedule of power supply fine-tuned to match the demand pattern of farmers. Once announced, the utility must then stick to the schedule so that farmers can be certain about power availability.

2. Improving the quality: Whenever power is supplied, it should be at full voltage and frequency, minimizing the damage to motors and downtime of transformers due to voltage fluctuations.

3. Better matching of supply with peak periods of moisture stress: Most canal irrigators in South Asia manage with only 3–4 canal water releases in a season; there are probably 2 weeks during *kharif* in a normal year and 5 weeks during *rabi* when the average South Asian irrigation farmer experiences great nervousness about moisture stress to the crops. If the power utility can take care of these periods, 80–90% of farmers' power and water needs would be met. This will, however, not help sugarcane growers of Maharashtra, Gujarat and Tamil Nadu, but then they constitute the big part of the power utility's problems.

4. Better upkeep of farm power supply infrastructure: Intelligent power supply management to agriculture is a tricky business. If rationing of power supply is done by arbitrary increase in power cuts and neglect of rural power infrastructure, it can result in disastrous consequences. Eastern India is a classic example. After the eastern Indian states switched to flat power tariff, they found it difficult to maintain the viability of power utilities in the face of organized opposition to raising flat tariff from militant farmer leaders like Mahendra Singh Tikait. As a result, the power utilities began to neglect the maintenance and repair of power infrastructure; and rural power supply was reduced to a trickle. Unable to irrigate their crops, farmers began en masse to replace their electric pumps by diesel pumps. Over a decade, the groundwater economy got more or less completely dieselized in large regions including Bihar, eastern Uttar Pradesh and North Bengal. Figure 11.6 shows the electrical and diesel halves of India; in the western parts, groundwater irrigation is dominated by electric pumps; as we move east, diesel pumps become more preponderant. The saving grace was that in these groundwater-abundant regions, small diesel pumps, though dirtier and costlier to operate, kept the economy going. But in regions like north Gujarat, where groundwater is lifted from 200 to 300 m, such de-electrification can completely destroy the agricultural economy.

Against this danger, the major advantage the rational flat tariff regime offers is in putting a brake on groundwater depletion in western and peninsular India. Growing evidence suggests that water demand in agriculture is inelastic to pumping costs within a large range. While metered charge without subsidy can make power utilities viable, it may not help much to cut water use and encourage water-saving agriculture. If anything, a growing body of evidence suggests that adoption of water- and power-saving methods respond more strongly to scarcity of these resources than their price. Pockets of India where drip irrigation is spreading rapidly – Aurangabad region in Maharashtra, Maikaal region in Madhya Pradesh, Kolar in Karnataka, Coimbatore in Tamil Nadu – are all regions where water and/or power is scarce rather than costly. Rational flat tariff with intelligent power supply rationing to the farm sector holds out the promise of minimizing wasteful use of both the resources and of encouraging technical change towards water and power saving. Our surmise is that such a strategy can easily reduce annual

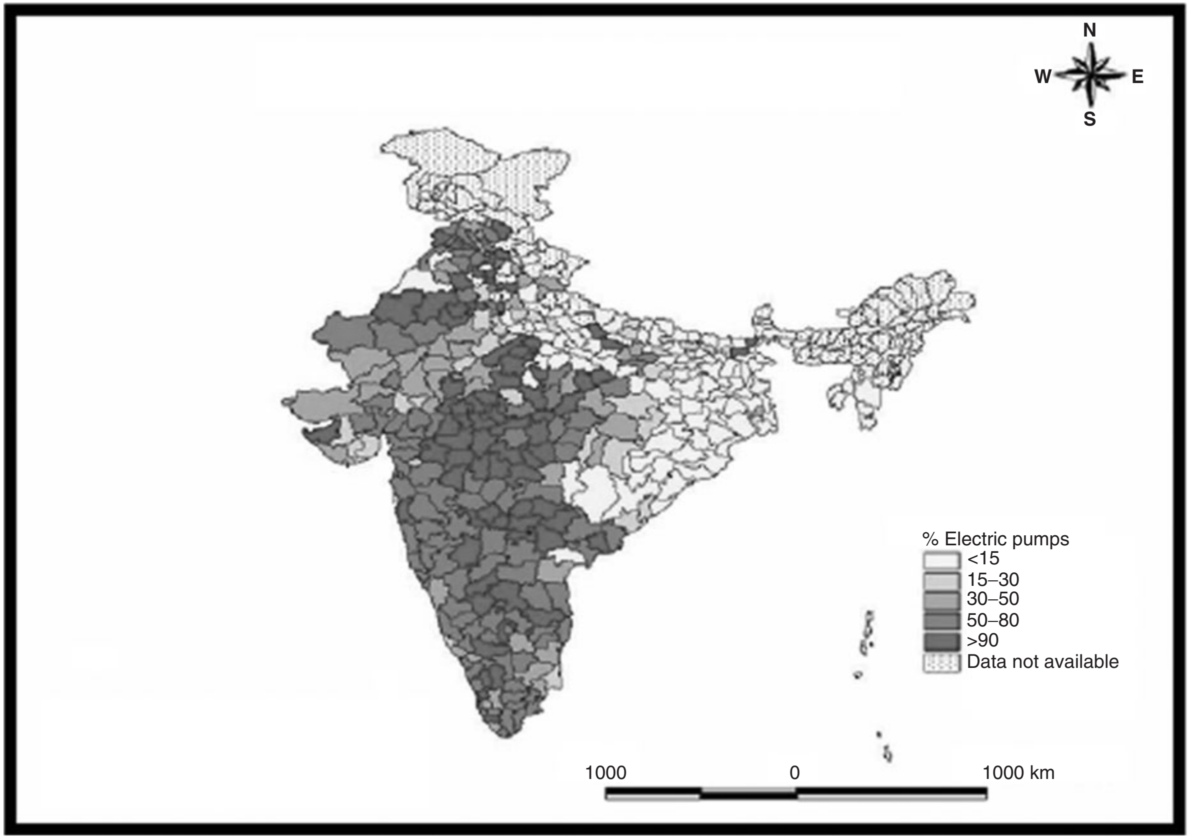


Fig. 11.6. Percentage of electricity-operated groundwater structures to totally mechanized groundwater structures.

groundwater extraction in western and peninsular India by 12–21 km^3/year and reduce power use in groundwater extraction by about 4–6 billion kilowatt-hour of power, valued at Rs 10–15 ($0.22–0.33) billion per year.

Approaches for Rationing

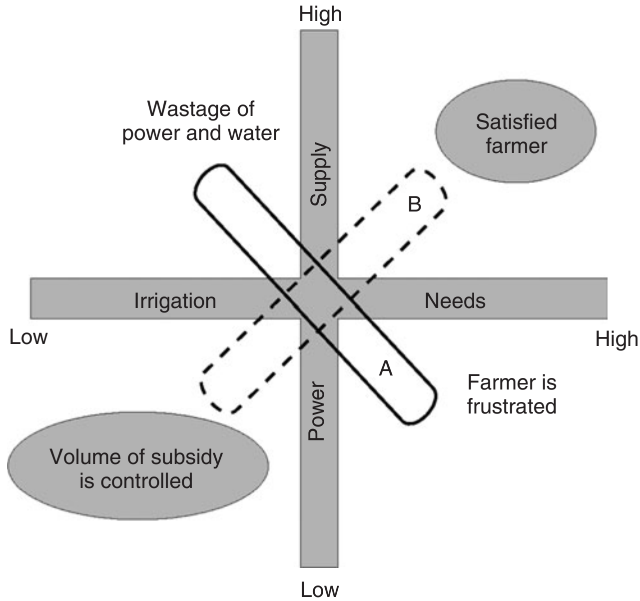
The strongest piece of evidence in support of our argument for intelligent rationing of power supply as the way to go is that intuitively most SEBs in India have already been doing some kind of rationing of farm power supply now for more than a decade. Andhra Pradesh, where the new government announced free power, also announced that farm power supply would henceforth be restricted to 7 h/day. Nobody – farmers included – considers 24 h, uninterrupted power supply to agriculture to be either a feasible proposition or a defensible demand under the flat tariff regime in force. Negotiations between farmer groups and governments almost everywhere in India are carried out in terms of the minimum hours of daily power supply the government can guarantee.

Default system of rationing

Constant hours/day of power supply to farmers, which is the current default, is the least intelligent way of rationing power supply to agriculture because it fails to achieve a good 'fit' between the schedule of power supply and farmers' desired irrigation schedule. It leaves farmers frustrated on days when their crops need to be watered the most; on the other hand, on many other days when the need for irrigation is not high, it leads to wasteful use of power and groundwater. From where the SEBs' present power-rationing practices stand today, they only have to gain by achieving a better fit between power supply schedules and farmers' irrigation schedules. Farmers keep demanding that the 'constant hours/day' must be raised because the default system does not provide enough power when they need it the most. There are a number of ways rationing of power supply in agriculture can be carried out to raise farmer satisfaction and control power subsidies provided (i) it reduces farmers' uncertainty about the timing of power availability; (ii) it achieves a better fit between power supply schedules and irrigation schedules; or (iii) both. We suggest a few illustrative approaches that need to be considered and tried out.

Agronomic scheduling

Ideally, SEBs should aim to achieve the 'best fit' by matching power supply schedules with irrigation needs of farmers. In this approach, the power utility constantly (i) studies irrigation behaviour of farmers in regions and subregions by monitoring cropping patterns, cropping cycles, rainfall events; (ii) matches power supply schedules to meet irrigation needs; and (iii) minimizes supply



A Mismatch between power supply and irrigation needs; existing system in which the farmer is frustrated.

B A win-win scenario; power supply is good and reliable when the irrigation needs are high (satisfied farmer), and power supply is low when irrigation needs are low (volume of subsidy is controlled).

Fig. 11.7. Improving farmer satisfaction and controlling electricity subsidies through intelligent management of farm power supply.

in off-peak irrigation periods (see Fig. 11.7). The advantages of such a system are that (i) farmers are happier; (ii) total power supply to agriculture can be reduced; (iii) power and water waste is minimized; and (iv) level of subsidy availed is within SEB control. The key disadvantage of this approach is that it is highly management-intensive, and therefore difficult to operationalize.

Demand-based scheduling

In the demand-based approach, feeder-level farmer committees or other representational bodies of farmers assume the responsibility of ascertaining members' requirements of power, and provide a power supply schedule to the utility for a fixed number of allowable hours for each season. This is a modified version of agronomic scheduling in which the power utility's research and monitoring task is assumed by feeder committees. This may make it easier to generate demand schedules but more difficult to serve it. Moreover, the organizational challenge this approach poses is formidable.

Canal-based scheduling

Tube well irrigators outside canal commands justify demands for power subsidies by comparing their lot with canal irrigators who get cheap canal irrigation without any capital investment of their own. However, under the present degenerate flat tariff, tube well irrigators often have the best of both worlds. At 10 h/day of power supply, an Andhra Pradesh tube well irrigator could in theory use 300–500 m^3 of water every day of the year. In contrast, under some of the best canal commands, farmers get irrigation for 10–15 times in an entire year. In this approach, power rationing aims to remove the inequity between tube well and canal irrigators by scheduling power supply to mimic the irrigation schedule of a benchmarked public irrigation system. This can drastically reduce power subsidies from current levels, but for that very reason, will face stiff resistance from tube well–irrigating farmers.

Zonal roster

An approach to rationing that is simpler to administer is to divide the state into, say, seven zones, each assigned a fixed day of the week when it gets 20 h of uninterrupted, quality power throughout the year; on the rest of the days, it gets 2 h. This is somewhat like a weekly turn in the *wara-bandi* system in canal irrigation systems in India Punjab and Pakistan Punjab. The advantages of this approach are: (i) it is easy to administer; (ii) agricultural load for the state as a whole remains constant, so it becomes easy to manage for SEB also; (iii) level of subsidies are controlled; and (iv) power supply to each zone is predictable, so farmers can plan their irrigation easily. Disadvantages are: (i) farmers in deep water table areas or areas with poor aquifers (as Saurashtra in Gujarat) would be unhappy; and (ii) zonal rostering will not mimic seasonal fluctuations in irrigation demand as well as agronomic rationing would do.

Adjusted zonal roaster

The zonal roaster can help farmers plan their cropping pattern and irrigation schedules by reducing uncertainty in power supply but it does not do much to improve the 'fit' between irrigation need and power supply across seasons. In most of India, for instance, following the same zonal roaster for *kharif* and *rabi* seasons makes little sense. Modifying the zonal roaster system so that power supply offered is higher in winter and summer than in monsoon season would improve the seasonal fit as well as reduce uncertainty.

Conclusion

We have argued in this chapter that either a switch to metered tariff regime at this juncture or raising flat tariff fourfold as proposed in Gujarat will very likely backfire in most of the states of India. Metering is highly unlikely to improve the fortunes of the power utilities that have found no smarter ways – than in the 1970s – of dealing with the exceedingly high transaction costs of metered farm power supply, which led them to flat tariff regime in the first place. However, if agriculturally dynamic states like Punjab and Haryana – where non-farm uses of three-phase power supply are extensive and growing in the villages and where productive farmers can afford higher costs of better-quality power supply in their stride – want to experiment with metered power supply, they would be well advised to create micro-entrepreneurs to retail power, meter individual power consumption and collect revenue rather than experiment with wooly ideas of electricity co-operatives that continue to be promoted (Gulati and Narayanan, 2003, p. 129). Despite 50 years of effort to make these work, including with donor support, they have not succeeded in India.[22] The 50-year-old Pravara electricity co-operative in Maharashtra survives but only by owing the SEB several billions of rupees in unpaid past dues (Godbole, 2002). While promoting metering it should also be borne in mind that the component of the transaction costs of metering, which is by far the largest and the most difficult to manage, arises from containing user efforts to frustrate metered tariff regime, by pilfering power, illegal connections, tampering with meters and so on. These costs soar in a 'soft state' in which an average user expects to get away easily even if caught indulging in these.[23] One reason why metering works reasonably well in China is because it is a 'hard state': an average user fears the village electrician whose informal power and authority border on the absolute in his or her domain.[24] The ongoing experiments on privatization of electricity retailing in Orissa will soon produce useful lessons on whether metering-cum-billing agents can drastically and sustainably reduce the cost of metered power supply in a situation in which tube well owners account for a significant proportion of electricity use.

However, with tight and intelligent supply management, in the particular context of South Asia, rational flat tariff (and intelligent power supply management) can achieve all that metered tariff regime can, and more. Flat tariff will have to be raised, but the schema we have set out can cut power utility losses from farm power supply substantially. Total hours of power supplied to farmers during a year will have to be reduced but farmers would get good-quality power aplenty at times of moisture stress when they need irrigation the most. Power supply to agriculture should still be metered at the feeder level so as to be able to measure and monitor the use of power in irrigation in order to manage it well. In this way, the huge transaction costs of metered charge collection would be saved; and if power utilities were to begin viewing farmers as customers, the adversarial relationship between them could even be turned into a benign one. While metered tariff regime will turn groundwater markets into sellers' markets hitting the resource-poor water buyers, rational flat tariff would help keep water markets as buyers' markets, albeit far less so than would be the case under the present degenerate flat tariffs (see Shah, 1993 for a detailed argument). Rational flat tariff – under which power rationing is far more defensible than under metered tariff regime – will make it possible to put an effective check on total use of power and water, and make their use more sustainable than under the present regime or under metered tariff. Moreover, restricting the total hours of operation of farm supply would help greatly curtail technical and commercial losses experienced by SEBs. Above all, rational flat tariff can significantly curtail groundwater depletion by minimizing wasteful resource use. On the basis of an International Water Management Institute (IWMI) survey of 2234 owners of diesel and electric tube wells in India, Pakistan, Nepal Terai and Bangladesh, it was concluded that electric tube well owners subject to flat tariff but unrestricted, poor-quality power supply were worked 40–150% more horsepower-hours compared to diesel tube well owners with greater control over their irrigation schedules. It can easily curtail groundwater draft by 13–14 million electric tube wells at least by 10–14%, i.e. approximately 12–21 km^3/year, assuming electric WEMs pump a total of some 120–150 km^3 of groundwater every year.

Contrary to popular understanding, rational flat tariff is an elegant and sophisticated regime management, which requires a complex set of skills and deep understanding of agriculture and irrigation in different regions. Power utilities in South Asia have never had these skills or the understanding, which is a major reason for the constant hiatus between them and the agriculture sector. One reason is that SEBs employ only engineers (Rao, 2002). In the power sector reforms underway in many Indian states, this important aspect has been overlooked in the institutional architecture of unbundling. Distributing power to agriculture is a different ball game in this region from selling it to townspeople and industry; and private distribution companies will most likely exclude the agricultural market segment in a hurry as being 'too difficult and costly to serve', as Orissa's experience is already showing.[25] Perhaps the most appropriate course would be to promote a separate distribution company for serving the agriculture sector with specialized competence and skill base; and predetermined government subsidies to the farming sector should be directed to the agricultural distribution companies.[26]

Notes

1 According to the Centre for Monitoring Indian Economy, electricity use in Indian agriculture in 2000–2001 was 84.7 billion kWh, much greater than our combined estimate of 69.6 billion kWh equivalent of total energy use for India, Pakistan and Bangladesh where at least one-third of the tube wells are run by diesel pumps. However, we also know that the estimates of agricultural electricity use in India are overestimates (see footnote 5) and include a portion of transmission and distribution losses in non-farm sectors that are passed off as agricultural consumption (CMIE, 2003).

2 Gulati and Narayanan (2003, p. 99) took the difference between the combined cost of supplying power to all sectors and the tariff charged from agriculture sector as a measure of subsidy to agriculture per kWh. Multiplying this with estimated power supply to agriculture, they place power subsidy to agriculture in 2000/01 at Rs 288.14 ($6.26) billion and suggest that these are 78 times more than what they were in 1980/81 but acknowledge that their estimate is likely to be a huge overestimate because of SEB propensity to pass off excessive transmission and distribution (T&D) losses in other sectors as farm consumption.

3 We assumed that an average South Asian tube well uses 4 kWh of electricity equivalent to pump for an hour, which gives us 17.5 billion hours of pumping of groundwater per year. At an average price of Rs 30 ($65)/h, the market value of pump irrigation in the region can be computed at Rs 522($11.34) billion. In many parts of South Asia, water sellers providing pump irrigation service claim one-third crop share; based on this, we computed contribution to farm output as three times the market value of pump irrigation. Alternatively, according to our calculations, a representative South Asian tube well produces around Rs 25,000 ($543.48) worth of irrigation water per year, which helps produce Rs 75,000 ($1,630.44) worth of crops. If we take the World Bank estimate, which places groundwater contribution to India's GDP at 10%, our calculations are severe underestimates of productive contribution of tube well irrigation.

4 Dhawan estimated the net value of marginal product of power in agriculture as Rs 9 ($0.20)/kWh in net terms and Rs 14 ($0.30)/kWh in terms of gross value of output (Dhawan, 1999).

5 Dhawan (cited in Samra, 2002) has asserted that in low rainfall regions of India, 'a wholly [groundwater] irrigated acre of land becomes equivalent to 8 to 10 acres of dry land in terms of production and income'.

6 Shah (2001) analysed this aspect for the Uttar Pradesh SEB and found agricultural power use 35% lower than claimed. Similarly, based on a World Bank study in Haryana, Kishore and Sharma (2002) report that actual agricultural power consumption was 27% less than reported, and the overall T&D losses were 47% while the official claim was 36.8%, making the SEB more efficient than it actually was. Power subsidy ostensibly meant for agricultural sector but actually accruing to other sectors was estimated at Rs 5.50 billion ($0.12 billion) per year for Haryana alone.

7 Farmers are getting away with it in many states. Electricity supply to agriculture became a major issue in India's 2004 parliamentary and state elections. Chief ministers like Chandrababu Naidu of Andhra Pradesh, Narendra Modi of Gujarat and Jayalalitha of Tamil Nadu suffered major electoral reverses arguably on account of farmer opposition to their stand on electricity supply to agriculture. The new chief minister of Andhra Pradesh announced free power to farmers the day after he assumed office; and Jayalalitha, who had abolished free power in Tamil Nadu, restored it soon after the results of election. Gujarat's Narendra Modi softened his hard stand on farm power supply; in Maharashtra, Shiv Sena chief Bal Thakre announced his promise to provide free power to farmers should his party come to power.

8 According to Batra and Singh (2003), farmers resist metering 'because of the prevalence of irregularities in the SEBs'. Complaints of frequent meter burning, which costs the farmer Rs 1000 ($21.74) per meter burnt, false billing, uncertainty in the bill amount, etc., repel farmers from accepting metering. They suggest that farmers also resist metering because of the two-part tariff (energy charge and rental for meter) system offered as an alternative to flat tariff. They are reluctant to pay the minimum bill (rental charge) which they have to pay even if they do not use the pump in a given month.

9 A recent World Bank study for the small state of Haryana estimated that the cost of metering all farm power connections in Haryana would amount to $30 (Rs 1380) million in capital investment and $2.2 (Rs 101.2) million/year in operating them (Kishore and Sharma, 2002). The Maharashtra Electricity Tariff Commission estimated the capital cost of metering the state's farm connections at Rs 11.50 ($0.25) billion (Godbole, 2002).

10 Rao and Govindarajan (2003) lay particular emphasis on geographic dispersion and remoteness of farm consumers in raising transaction costs of metering and billing:

'To illustrate, a rural area of the size of Bhubaneshwar, *the capital of Orissa state*, will have approximately 4000 consumers. Bhubaneshwar has 96000. *The* former will have a collection potential of Rs 0.7 million ($15217) a month; for Bhubaneshwar, it is Rs 22.0 million ($0.48 million) a month.'

11 In states like Gujarat, which had metered tariff until 1987, an important source of opposition to metering is the arbitrariness of meter readers and the power they came to wield over them; in many villages, farmers had organized for the sole purpose of resisting the tyranny of the meter reader. In some areas, this became so serious that meter readers were declared *persona non grata*; even today, electricity board field staff seldom go to villages except in fairly large groups, and often with police escort.

12 The village electrician's reward system encourages him or her to exert pressures to achieve greater efficiency by cutting line losses. In Dong Wang Nu village in Ci county, the village committee's single large transformer, which served both domestic and agricultural connections, caused heavy line losses at 22–25%. Once the Network Reform Program began, the electrician pressurized the village committee to sell the old transformer to the Township Electricity Bureau and raise 10,000 yuan (partly by collecting a levy of 25 yuan per family and partly by a contribution from the Village Development Fund) to get two new transformers, one for domestic connections and the other for pumps. Since then, power losses have fallen to a permissible level of 12% here (Shah *et al*., 2004b).

13 1$ = 8 yuan = Rs 46 (July 2004).

14 A 1997 consumer survey of the power sector revealed that 53% of consumers had to pay bribes to electricity staff for services which were supposed to be free; 68% suggested grievance redressal to be poor or worse than poor; 76% found staff attitudes poor or worse; 53% found repair fault services poor or worse; 42% said they had to make 6–12 calls just to register a complaint; 57% knew of power thefts in their neighbourhoods; 35% complained of excess billing; 76% complained of inconvenience in paying their bills (Rao, 2002).

15 In Madhya Pradesh, the latest state to announce power pricing reforms, the chief minister announced a sixfold hike in flat tariff. No sooner was the announcement made than there was a realignment of forces within the ruling party and senior-most cabinet ministers began clamouring for leadership change. Subhash Yadav, the Deputy Chief Minister, lamented in an interview with India Today: 'A farmer who produces 10 tonNEs of wheat earns Rs 60,000 ($1,304.35) and he is expected to pay Rs 55,000 ($1,195.65) to the electricity board. What will he feed his children with and why should he vote for the Congress?' (India Today, 2002, p. 32). The farmers stopped paying even the revised flat charges in protest; and just before the May 2004 assembly elections, the chief minister announced a waiver of all past electricity dues; yet, he could not save his seat. His Congress government, until now eulogized for a progressive development-oriented stance, was trounced at the polls. Analysts attributed his defeat to the government's failure on three fronts: *bijli*, *pani*, *sadak* (electricity, irrigation, roads).

16 At a rate of 25 m^3/h, a tube well can pump 73,000 m^3 of water if it is operated whenever power supply is on. At the water entitlement of 5300 m^3/ha prescribed in the Narmada project, this amount of water can irrigate 13.77 ha of land.

17 The cost of power supply has three components: energy costs, fixed generation costs and T&D costs. The first two account for about 60–80% of the total cost to serve. Energy costs, which is variable, depend on the length of time of power consumption but fixed generation costs depend on how much a consumer uses at peak load. T&D costs depend on where the consumer is connected in the system. Since the

contribution of agricultural power consumption to peak load is often very little, the opportunity cost of power supply to agriculture is lower than the overall average cost of supply. Moreover, agricultural consumption, most of it off-peak, helps smoothen the load curve for the whole system and saves the back-up cost, which are high for coal-based plants and insignificant for hydropower plants.

18 In Tamil Nadu where farm power supply is free, 14 h of three-phase power – 6 h during the day and 8 h during the night – is supplied throughout the year. In Andhra Pradesh, 9 h of three-phase power supply is guaranteed, 6 h during the day and 3 h during the night (Palanisami and Suresh Kumar, 2002); however, it was recently reduced to 7 h when the new government announced free power. This implies that in theory, a tube well in Tamil Nadu can run for more than 5000 h in a year; and in Andhra Pradesh, it can run for 3200 h. If the real cost of power is taken to be Rs 2.5 ($5.4)/kWh, depending upon how conscientious a Tamil Nadu farmer operating a 10 hp tube well is, he or she can avail of a power subsidy in the range of Rs 0–93,750 ($0–2038)/year; and an Andhra farmer, Rs 0–60,000 ($0–1304)/year. Moreover, the stories one hears of farmers installing automatic switches that turn on the tube wells whenever power supply starts suggest that a large proportion of farmers are choosing to go overboard in using power and water. Palanisami and Suresh Kumar (2002) mention that many bore well–owning farmers lift water during the night to fill an open well using an automatic switch and then lift water during the day from the open well to irrigate their fields. True, they would not indulge in such waste if they had to pay a metered rate at Rs 2.5 ($5.4)/kWh; but they would not do this either if they got only 3–4 h of good-quality power at convenient hours on a pre-announced schedule.

19 An extreme case is Tamil Nadu, where electricity consumption per tube well shot up from 2583 kWh/year under metered tariff in the early 1980s to 4546 kWh in 1997/98. However, this jump represents three components: (i) increased consumption due to degenerate flat tariff; (ii) increased consumption because of the increased average lift caused by resource depletion; and (iii) T&D losses in other segments that are wrongly assigned to agriculture. Palanisami (2001) estimated that 32% of the increased power use was explained by additional pumping and 68% by increased lift. However, he made no effort to estimate the third point, which we suspect is quite large.

20 We recognize that comparing hours of operation of diesel and electric tube wells is not the same as comparing the quantity of water extracted. However, in understanding the economic behaviour of tube well owners, we believe that comparing hours is more meaningful than comparing water produced. In any case, for the same hours of pumping, an electric pump would produce more water per horsepower compared with a diesel pump *ceteris paribus* due to the former's higher efficiency.

21 Punjab and Haryana have much more productive agriculture compared with other parts of India, with the cost of irrigation being just 8–10% of the gross value of produce. That might explain why the pumping pattern is inelastic to the energy cost. However, this is just a hypothesis and needs to be further confirmed.

22 Thus, Godbole (2002, p. 2197) notes: 'But if co-operatives are to be a serious and viable option (for power distribution), our present thinking on the subject will have to be seriously reassessed. As compared to the success stories of electricity co-operatives (in USA, Thailand and Bangladesh), ours have been dismal failures'.

23 Transaction costs of charge collection will be high even under flat tariff regime if farmers think they can get away. Throughout India and Pakistan, replacing nameplates of electric motors on tube wells has emerged as a growth industry under flat tariff. A World Bank study had recently estimated that in Haryana the actual connected

agricultural load was 74% higher than the official utility records showed (Kishore and Sharma, 2002).

24 Private electricity companies that supply power in cities like Ahmedabad and Surat instill fear of God in their users by regularly meting out exemplary penalties often in an arbitrary manner. The Ahmedabad Electricity Company's inspection squads, for example, are set steep targets for penalty collection for pilferage. To meet these targets, they have to catch real or imagined power thieves; their victims cough up the fine because going to courts would take years to redress their grievances while they stay without power. Although these horror stories paint a sordid picture, the Company would find it difficult to keep its commercial losses to acceptable levels unless its customers were repeatedly reminded about their obligation to pay for the power they use.

25 The Orissa Electricity Regulatory Commission has already opened the gate for the power utility to ask agriculture to fend for itself, when it decided that 'any expansion of the grid which is not commercially viable, would not be taken into account in calculating the capital base of the company. In future unless government gives grants for rural electrification, the projects will not be taken up through tariff route' (Panda, 2002).

26 T.L. Sankar, for instance, has already argued for the need to set up separate supply companies for farmers and rural poor that will access cheap power from hydroelectric and depreciated thermal plants and be subsidized as necessary directly by governments (Rao, 2002, p. 3435).

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