9 The Energy–Irrigation Nexus in South Asia: Groundwater Conservation and Power Sector Viability

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Introduction

Back in the 1950s, when energy use was considered synonymous with economic progress, state power utilities in India aggressively persuaded unwilling farmers to install electric tube wells. The chief ministers set ambitious connection targets and all manner of loans and concessions were made available to popularize tube well irrigation. The World Bank supported huge investments in rural electrification to promote groundwater use and agricultural growth, policies that appeared to be vindicated when the Green Revolution was found to follow the tube well revolution with a lag of 3–5 years. Repetto (1994) even asserted that 'the Green Revolution is more a tube well revolution than a wheat revolution'.

By the 1970s, the energy–irrigation nexus was a prominent feature of South Asia's agrarian boom, and groundwater irrigation had spread rapidly even within canal commands. The enthusiasm of the State Electricity Boards (SEBs) towards their agricultural customers however soon began to wane. The SEBs invariably charged their fees based on metered consumption but – as tube well numbers increased – metering and billing became an increasing burden. The costs of provision and maintenance of meters were perhaps the least of the SEB's worries. Farm power supply required an army of meter readers, and led to rampant meter tampering and power pilferage, underbilling and pervasive corruption. These high and rising transaction costs proved insupportable and, during the 1970s/1980s, state after state adopted a flat tariff linked to the horsepower (hp) rating. This eliminated the hassle and cost of metering in one go and, though still affording scope for malpractices such as under-reporting of the hp rating, this was much easier to control than pilferage under a metered tariff regime. In turn, however, as farm power emerged as a major driver of irrigated agriculture, chief ministers found electricity pricing to be a powerful vote-winner. Flat tariffs became 'sticky' and, unable to raise flat tariffs for years on end, yet still pressured to supply abundant farm power, the SEBs found their balance sheets turning red. The argument has thus turned full circle and the industry and its protagonists (e.g. the multilateral donors) have returned to the view that metering is a precondition for restoring the SEB's financial viability.

Support for metering is based essentially on the neoclassical economic theory that typically focuses on the 'transformation costs' of generating and distributing power,

and the efficiency gains to be derived from economic pricing, while overlooking the 'transactions costs' incurred. In this chapter, our objective is to re-evaluate this debate from the perspective of the New Institutional Economics (North, 1997). We begin by assessing the scale of the energy–irrigation nexus in South Asia. The estimates quoted matter less than the broad conclusion that – by any measure – the nexus is far more important in South Asia than elsewhere in the world with the exception perhaps of North China. This is followed by a section describing what it would take to make a metered tariff regime work, the main comparison being with North China where such a regime does seem to work. Concluding that South Asia differs in too many ways to duplicate China's success, the rest of the chapter explores the potential for indirect management of the groundwater economy through the specific mechanism of electricity pricing and supply policies.

The central premise is that electricity pricing and supply in South Asia are closely linked with the policy goals of managing groundwater irrigation for efficiency, equity and sustainability. The chapter makes no claim that the solutions proposed would resolve all problems of aquifer management though it does suggest that they would complement measures in other subject areas. Nor does the chapter address broader environmental issues associated with sustainability. It takes as given the generally accepted view that rapidly falling groundwater tables can have deleterious effects on the rural economy and on the environment, and that pragmatic measures that moderate such declines are generally beneficial. A further premise is that the financial viability of the power utilities has been undermined by their farm power operations and that this can be attributed at least in part to the failure of the power and irrigation sectors to interact in an intelligent manner. Again, the problems of the utilities and their operations go well beyond the issues addressed in the chapter. But even if the solutions proposed are, in some sense, partial and second best, the chapter concludes that analysing the energy and groundwater economies as a nexus can help evolve joint strategies that would contribute significantly to the preservation of South Asia's groundwater resources while at the same time improving the viability of its power industry.

The Scale of the Energy–Irrigation Nexus in South Asia

South Asia in a world context

The energy–irrigation nexus focuses attention on a class of issues that is largely confined to South Asia and, to a lesser extent, North China (see below). Many other countries – e.g. the USA, Iran, Mexico – make intensive use of groundwater in agriculture (Fig. 9.1). However, in these countries this involves only a small proportion of their people; energy use by agriculture is a small proportion of total energy use; and the cost of energy use is only a small proportion of the total value added in farming. The opposite is the case over much of South Asia and North China (Table 9.1).

According to a World Bank estimate, groundwater irrigation contributes about 10% of India's GDP (World Bank and GOI, 1998) using 15–20% of the electricity generated. In contrast, in Mexico's Guanajuato province, heartland of its intensive groundwater-irrigated agriculture, a typical tube well is run by a 100–150 hp pump and operates for over 4000 h/year (Scott *et al.,* 2002). In India, Bangladesh and Nepal, the modal pump size is 6.5 hp and average hours of operation are around 400–500 h/year (Shah, 1993). In Iran, 365,000 tube wells lift 45 km^3 of groundwater/year (Hekmat, 2002); India uses 60 times more wells than Iran to extract three times as much groundwater.

Despite these differences, other countries can still find it difficult to enforce groundwater controls. In Mexico, the Commission National de Aqua (CNA) has struggled to establish and enforce a system of water rights. While this has helped to register most of its 90,000 tube well owners, Mexico still finds it impossible to limit

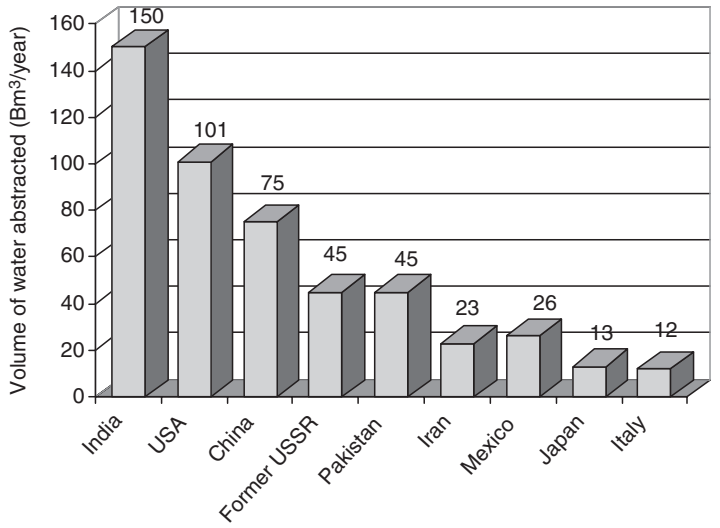


Fig. 9.1. Groundwater use in selected countries in the 1980s (MCM). (From Llamas *et al.,* 1992, p. 4.)

pumping to assigned quotas. Mexico has similarly been politically unable to remove substantial energy subsidies to agriculture or rein in groundwater depletion (Scott *et al.,* 2002). In Iran, when groundwater overdraft in the hinterland threatened water supply to cities, the government enforced a ban on many new groundwater structures, yet it is struggling to eliminate its annual groundwater overdraft of 5 km^3 (Hekmat, 2002). Even the USA has only found it possible to slow rather than stop the mining of the great Ogallala aquifer. If richer countries where groundwater irrigation is far less important cannot manage irrigators even in the face of serious environmental anomalies, how much less can it be expected of countries in South Asia where groundwater is relatively far more important and where it supports the livelihoods of millions of poor rural households?

Groundwater in South Asia

South Asia constitutes the largest user of groundwater in the world. Between them, India, Pakistan, Bangladesh and Nepal pump around 210 km^3/year, using some 21–23 million pump sets (13–14 million electric pumps and 8–9 million diesel pumps) (NSSO, 1999). If an average electric tube well (with pumping efficiency of, say, 25%)

Table 9.1. Dependence on groundwater in different countries. (From Hekmat, 2002, Iran; Mukherji and Shah, 2002, India; Scott *et al.*, 2002, Mexico; Shah *et al.*, 2003, China and Pakistan.)

Country	Annual groundwater use (km^3)	Groundwater structures (million)	Extraction/ structure (m^3/year)	Population dependent on groundwater (%)
Pakistan Punjab	45	0.5	90,000	60–65
India	150	21.3	7,900	55–60
China	75	3.5	21,500	22–25
Iran	29	0.5	58,000	12–18
Mexico	29	0.1	414,285	5–6
USA	100	0.2	500,000	<1–2

lifts water on average 30 m,[1] the electricity equivalent of energy used is around 69.6 billion kWh/year. At an assumed cost of Rs 2.5 ($0.05)/kWh, this implies a total cost of Rs 174 billion ($3.8 billion). We estimate the market value of the irrigation water produced is around Rs 450–550 billion ($9.8–12 billion) and its contribution to agricultural output at about Rs 1350–1650 billion ($29.3–35.9 billion).[2]

Growth in groundwater irrigation is relatively recent (Fig. 9.2). In India, gravity systems dominated until the 1970s but by the early 1990s groundwater had far surpassed surface irrigation in terms of area served and proportion of agricultural output (Debroy and Shah, 2003; Shah *et al.*, 2003). According to estimates of the Government of India (GOI), 60% of India's irrigated lands are now served by groundwater wells (GOI, 2001). Independent surveys suggest that the proportion may be as much as 75% if conjunctive use in command areas is included (Shah *et al.*, 2004b; NSSO 54th round). By now, pump irrigation in India accounts for 70–80% of the value of irrigated farm output; and rapid groundwater development is at the heart of the agrarian dynamism found in areas in Eastern India that had been stagnant for a long time. Furthermore, groundwater irrigation has helped make famines a matter of history: during 1963–1966, a small rainfall deficit left reservoirs empty and food production plummeted by 19%; during the 1987–1988 drought, the rainfall deficit was 19% but food production fell by only 2% thanks in large part to widespread groundwater irrigation (Sharma and Mehta, 2002).

In contrast to other countries, pump irrigation in South Asia also involves vast numbers of low-income households and a large proportion of the population. 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 one for every fourth landowning household. Moreover, a large proportion of non-owners are supplied through local fragmented groundwater markets (Shah, 1993). It is often argued that with 60 million tonnes of food stocks, India can now take a tough posture on groundwater abuse but this misses an important point. Quite apart from the practical difficulties of implementing such a policy, the contribution of groundwater to farm incomes and rural livelihoods is far more crucial than its contribution to food security, especially outside canal commands.[3] At the turn of the millennium, perhaps three-quarters of the rural population and over half of the total population of India, Pakistan, Bangladesh and Nepal depended for their livelihoods, directly or indirectly, on groundwater irrigation, many times larger than in Iran and Mexico. It is not surprising therefore that the energy–irrigation nexus has been at the centre of vote-bank politics in the region.

[1]Most groundwater irrigation in South Asia is based on open dug wells and shallow tube wells. Deep tube wells are less than 1% of all groundwater structures.

[2]The Centre for Monitoring Indian Economy estimates that 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 the *total* energy use in agriculture for the four countries. However, these estimates for India include transmission and distribution (T&D) losses in non-farm sectors that are passed off as agricultural consumption (CMIE, 2003). Dhawan puts the value of the marginal product of power in agriculture at Rs 9.00/kWh ($0.20/kWh) in net terms and Rs 14/kWh ($0.30/kWh) in gross terms (Dhawan, 1999). We assume an average South Asian tube well uses 4 kWh/h, implying 17.5 billion h of pumping/year. At an average price of Rs 30/h (USc65/h), the market value of pump irrigation is Rs 522 billion ($11.34 billion). Those selling pump services typically claim a third of the crop. Based on this, we estimate the contribution to farm output as three times the market value of pump irrigation. An alternative approach assumes that a South Asian tube well produces Rs 25,000 ($543.48) worth of irrigation water/year contributing to Rs 75,000 ($1630) worth of crops. The World Bank asserts that groundwater contributes 10% of Indian GDP (World Bank and GOI, 1998). If so, our estimates are greatly understated.

[3]Dhawan (cited in Samra 2002), for instance, has asserted that in low rainfall regions of India, '[A] wholly [*groundwater*] irrigated acre of land becomes equivalent to 8 to 10 acres of dryland in terms of production and income.' (italics added).

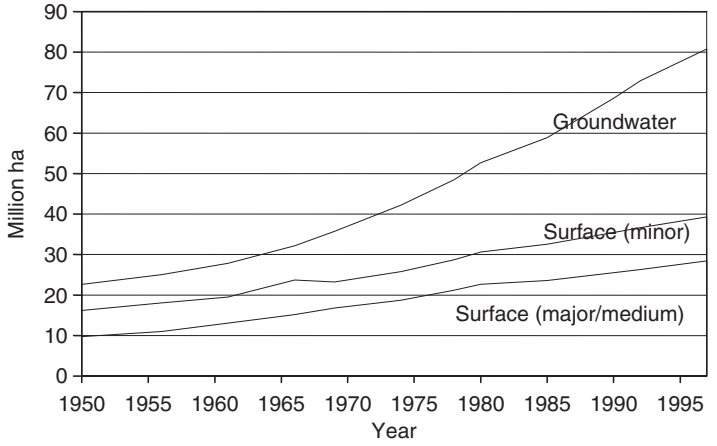


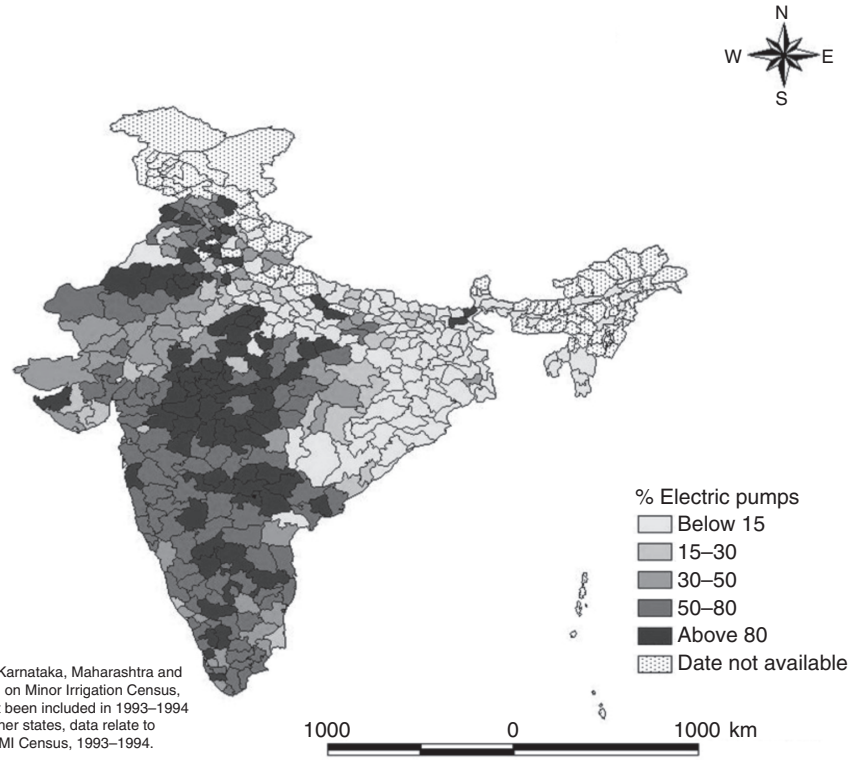
Fig. 9.2. India, irrigated area by source. (From Ministry of Water Resources, Government of India, 1999.)

Subregional patterns

Though groundwater is critical over much of South Asia, policy makers face conflicting challenges in different subregions. Particularly since 1970, agrarian growth has been sustained primarily by private pump investments. However, this has been highly uneven. In the groundwater-abundant Ganga–Brahmaputra–Meghna basin – home to 400 million of the world's rural poor – groundwater can have major livelihood and ecological benefits (Shah, 2001) but it is precisely here that economic development has been slow and halting. Eastern India is a classic example. After the eastern Indian states switched to a flat power tariff, the utilities found it difficult to maintain viability in the face of organized opposition to the raising of the flat tariff. As a result, the power utilities began to neglect the maintenance and repair of power infrastructure resulting, in turn, in a feeble rural power supply. Unable to irrigate their crops, farmers began en masse to replace their electric pumps by diesel pumps. Over a decade, the groundwater economy became more or less completely dieselized in large areas, including Bihar, eastern Uttar Pradesh and north Bengal. Figure 9.3 shows the electrical and diesel halves of India; in the western parts, groundwater irrigation is dominated by electric pumps but as we move east, diesel pumps become preponderant. The saving grace was that in these groundwater-abundant regions, small diesel pumps, though dirtier and costlier to operate, kept the economy going.

The issues in regions like north Gujarat, where groundwater is lifted from 200 to 300 m, are very different since such de-electrification could completely destroy the agricultural economy. In much of Pakistan, in the Indian Punjab, Haryana and neighbouring states, and in peninsular India, groundwater is being seriously overdeveloped to a stage that agriculture faces serious threats from resource depletion and degradation. The priority in these areas is to promote a constructive re-engagement of the power sector with agriculture and to find ways of managing groundwater use so as to make it socially and environmentally sustainable. It is in regard to these areas that this chapter is largely concerned.

In regulating groundwater use, the tools available to resource managers are few and inadequate, though the protection of the resource is proving far more complex and difficult than stimulating its initial development. The alternatives fall into two broad categories: (i) *direct management* through a system of metered tariffs and/or quotas; and (ii) *indirect management*, e.g. through the operations of the power market. These options are now considered in turn.



* Figures for Gujarat, Karnataka, Maharashtra and Tamil Nadu are based on Minor Irrigation Census, 1986 as they have not been included in 1993–1994 MI Census. For the other states, data relate to 1993–1994 based on MI Census, 1993–1994.

Fig. 9.3. Percentage of electricity operated groundwater structures to total mechanized groundwater structures.

Making a Metered Tariff Regime Work

Introduction

In India and elsewhere in South Asia there is a growing movement to revert to metered power supply. Despite widespread farmer opposition, the power industry believes that its fortunes will not change until agriculture is put back on a metered electricity tariff. Strong additional support 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 and power because it reduces the marginal cost of water extraction to nearly zero. Annual losses to electricity boards on account of power subsidies to agriculture have been estimated at Rs 260 billion ($5.65 billion) in India, growing at an annual rate of 26%/year (Lim, 2001; Gulati, 2002). These estimates have, however, been widely contested, for instance it has been shown that SEBs have been classifying rising Transmission and Distribution (T&D) losses in domestic and industrial sectors as agricultural consumption since it is unmetered and so unverifiable.[4] But the fact

[4]Shah (2001) has analysed this aspect for Uttar Pradesh State Electricity Board and found agricultural power use to be 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 official claims made it 36.8%, making the SEB more efficient than it actually was. Power subsidy ostensibly meant for the agriculture sector but actually accruing to other sectors was estimated at Rs 5.50 billion/year ($0.12 billion/year) for Haryana alone.

remains that agricultural power supply under the existing regime is the prime cause of bankruptcy of SEBs in India.

Reflecting pressure from the power industry, GOI has prescribed that: (i) power on demand will be provided by 2012; (ii) all consumers will be metered in two phases, with phase I to cover metering of all 11 kVA feeders and High Tension consumers, and phase II to cover all consumers; and (iii) regular energy audits will be undertaken to assess T&D losses and eliminate power thefts within 2 years (Godbole, 2002). This is an ambitious agenda. Consistent with these policies, Central and State Electricity Regulatory Commissions have set deadlines for SEBs and state governments to make the transition to universal metering, and all new tube well connections now come with the option of a metered tariff with most states offering inducements to opt for metered connections. Support has also come from international agencies – notably the World Bank, USAID and ADB – which have begun to insist on metered power supply to agriculture as a key condition for financing new power projects.

Arguments for a metered tariff regime are several. First, metering 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 markets. Third, metering provides farmers with the correct signals concerning the real cost of power and water, and encourages them to economize on their use. Fourth, for reasons that are not entirely clear, it is often suggested that a metered tariff would be less amenable to political manipulation than a flat tariff regime and easier to raise as the cost of supplying power rises. Finally, it is widely argued that a flat tariff is inequitable towards small landowners and to irrigators in regions with limited availability of groundwater. The logic in support of a metered tariff is thus obvious and unexceptionable. The problem is to make a metered tariff regime work as broadly envisaged. For this, three things seem essential:

- The metering and collection agent must have the requisite authority to deal with deviant behaviour among users.
- The agent should be subject to a tight control system so that he can neither behave arbitrarily with consumers nor form an unholy collusion with them.
- The agent must have proper incentives to enforce a metered tariff regime.

Under agrarian conditions that in many ways are comparable with those in South Asia, these three conditions appear to obtain in North China where a metered tariff regime works reasonably well (Shah, 2003; Shah *et al.*, 2004a). How is this possible? And if it works in North China why not in South Asia?

Why is metering effective in North China?

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 use. In contrast to much of India, tariffs thus reflect relative costs and agricultural use, which often attract the highest charge per unit, followed by household users and then industries. The operation and maintenance (O&M) of local power infrastructure is the responsibility of local units – the Village Committee at village level, the Township Electricity Bureau at township level and the County Electricity Bureau at county level. Responsibilities for collecting electricity charges are assigned to ensure that the power used at each level is paid in full at that level. At village level, the sum of power use for any given period recorded at individual meters has to tally with the power supply recorded at the transformer. The unit or person charged with fee collection pays the Township Electricity Bureau for power use at the transformer after allowing for

10% to account for normal losses. If the power supply infrastructure is old and worn out, line losses below the transformer make this difficult. With this supposition turning out to be true, an Electricity Network Reform program was undertaken by the National Government to modernize and rehabilitate rural power infrastructure. Where this was done, line losses fell sharply[5] and among the nine villages Shah visited in three counties of Henan and Hebei in early 2002, none of the Village Electricians interviewed had a problem tallying transformer records with the sum of the consumption recorded by individual users given the line-loss allowance of 10%.

An important reason why this institutional arrangement works is the strong local authority structures: the electrician is feared because he is backed by the Village Committee and powerful Party Leader; and the new service orientation is designed partly to project the electrician as the friend of the people. The Committee and Leader can also keep flagrantly arbitrary behaviour in check. The hypothesis that with better quality power and support service, farmers will be willing to pay a high price for power is exemplified in Henan where farmers pay a higher electricity rate compared not only to most categories of users in India and Pakistan (Yuan 0.7/kWh or US$0.0875/kWh, Rs 4.03/kWh) but also to the diesel price at Yuan 2.1/l. The village electrician in Henan and Hebei receives a fairly modest reward of Yuan 200/month, equivalent to half the value of wheat produced on a mu (or 1/30th of the value of output on 1 ha of land). For this modest wage, he undertakes to make good to the Township Electricity Bureau 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 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 have built an incentive-compatible system that delivers quickly rather than wasting time on rural electricity cooperatives and Village *Vidyut Sangha*s (Electricity Associations) being tried in India and Bangladesh (see below). Given the Chinese method of collecting metered electricity charges, it is well-nigh impossible for the power industry to lose money in distribution since losses are firmly passed on downstream from one level to the level below.

Why cannot a metering regime work in South Asia?

If South Asia is to revert to a metered tariff, the Chinese offer a good model. But there are two initial problems. First, agricultural productivity in China is much higher than in most of South Asia and even with power charged at full cost, pumping constitutes a relatively small proportion of the gross value of output. In South Asia, irrigation costs of this order (Rs 2100–8600/ha or $46–197) would make groundwater irrigation unviable except in parts of Punjab and Haryana. Second, while the South Asian power industry can perhaps approximate to the Chinese incentive system, it cannot repli-

[5]The village electrician's reward system encourages him to exert pressures to cut line losses. In the Dong Wang Nu village in the 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, he pressurized the Village Committee to sell the old transformer to the Township Electricity Bureau and raise Y10,000 (partly by collecting a levy of Y25 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.*, 2004a).

cate the Chinese authority system at village level. The 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 users may create unforeseen complications in adapting the Chinese model by South Asia. These costs soar in a 'soft state' in which an average user expects to get away even if caught.[6,7] An important reason why metering works reasonably well in China is that it is a 'hard state': an average user fears the village electrician whose informal power and authority border on the absolute in his domain. Two issues in South Asia are thus critical:

- The relentless opposition from farmers to metering;
- The problems that forced the SEBs to switch to a flat tariff during the 1970s in the first place.

Moves towards metered power consumption have met with unprecedented farmer opposition and there are few takers for metered connections; instead, the demand for free power has gathered momentum.[8] Opposition to a metered tariff is in part due to an assumed threat to the subsidy contained in the existing flat tariff. In addition, farmers find the flat tariff transparent and simple to understand; it spares them the tyranny of the meter readers; they fear that, once metered, all manner of new charges will be added under different names; and they raise the issue of equity – if canal irrigators receive irrigation at subsidized flat rates in public schemes, why not provide the same terms to groundwater irrigators?

The extent of farmer resistance is evident in the repeated failure of SEBs to entice farmers to accept metering even at subsidized rates ranging from Rs 0.20/kWh to Rs 0.70/kWh (US$0.004–0.013/kWh) compared to an actual cost from Rs 2.50/kWh to Rs 3.80/kWh (US$0.05–0.08/kWh). In 2002, Batra and Singh (2003) interviewed well owners in Punjab, Haryana and western Uttar Pradesh. They noted that an average well owner would spend Rs 2530 ($55) and Rs 6805/year ($148/year) *less* on their total power bill in Punjab and Haryana, respectively if they accepted metering at prevailing rates of Rs 0.50/kWh (US$0.011/kWh) and Rs 0.65/kWh (US$0.014/kWh). Even so, they would not accept metering. In effect, this

[6]Transaction costs of charge collection will be high even under a flat tariff regime if farmers think they can get away with non-payment. Throughout India and Pakistan, replacing nameplates of electric motors on tube wells has emerged as a growth industry under the flat tariff. In Haryana, a World Bank study has recently estimated that the actual connected agricultural load was 74% higher than that shown by the official utility records (Kishore and Sharma, 2002).

[7]There are exceptions in South Asia, notably in the urban sector. Private electricity companies that supply power in cities like Ahmedabad and Surat also instill the fear of God in 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 pay the fine because going to courts would take years to redress their grievances while they stay without power. Although these stories paint a sordid picture, the company would find it difficult to keep its commercial losses to acceptable levels if its customers were not repeatedly reminded of their obligation to pay.

[8]And 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 Tamilnadu 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 Tamilnadu, restored it soon after the results of election. Gujarat's Narendra Modi softened his hard stand on farm power supply; and in Maharashtra, Shiv Sena chief Bal Thakre announced his promise to provide free power to farmers should his party come to power.

is the price they are willing to pay to avoid the hassle and costs of metering.[9]

India has a long history of electricity cooperatives in an attempt to improve accountability and improve performance in the sector, originally under a metered regime (Gulati and Narayanan, 2003, p. 129). However, despite 50 years of effort to make these work, including with donor support, they have not succeeded.[10] The 50-year-old Pravara electricity cooperative in Maharashtra survives but only by owing the SEB several billions of rupees in unpaid past dues (Godbole, 2002). Recent experiments with new metering solutions include that of Indian Grameen Services, an NGO which organized Transformer User Associations in Hoshangabad district of Madhya Pradesh; the idea was that the SEB would set up a dedicated plant if farmers paid unpaid dues and agreed to a metered tariff. However, before the 2004 elections, the chief minister 'waived' past dues and the Hoshangabad association disintegrated, its members disillusioned. Orissa organized similar Village *Vidyut Sangha*'s (Electricity User Associations); while these are now defunct, Orissa has achieved modest success in improving metered charge collection by using local entrepreneurs as billing and collection agents. However, less than 5% of rural load in Orissa is agricultural, and this approach may be much more difficult in, for instance, Gujarat where agriculture may account for 50–80% of the total rural load.

It is too early to learn lessons from these experiments though there is a prima facie case that a direct approach to incentives on the Chinese model might be preferable. What is clear is that the old system of metering and billing – under which the SEBs employed an army of unionized meter readers – just will not work.[11] If the logistical difficulty and transaction costs of metering prior to 1975 were so high that a flat tariff seemed the only way of containing them, how much more so is this now that there are ten times as many electric tube wells? Even with far fewer connections, a 1985 study in Uttar Pradesh and Maharashtra by the Rural Electrification Corporation estimated that the cost of metering rural power was 26% and 16%, respectively, of the total revenue of the SEB from the farm sector (Shah, 1993). And this estimate included only direct costs, e.g. the cost of the meter and maintaining it, of the power consumed by the meter, of reading the meter, and of billing and collecting. These costs are not insignificant[12]; but of much greater relevance is the cost of contain-

[9]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 per meter burnt or $22), false billing, uncertainty in the bill amount etc. were quoted. They suggest 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. In Gujarat which had metered tariff until 1987, an important source of opposition to metering is the arbitrariness of meter readers and the power they had come 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 the villages except in fairly large groups, and often with police escort.

[10]Thus, Madhav Godbole 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' (Godbole, 2002, p. 2197).

[11]A 1997 consumer survey revealed that 53% of power consumers had to bribe electricity staff for services supposed to be free; 68% said that grievance redressal was poor or worse than poor; 76% found staff attitudes poor or worse; 53% found repair and 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).

[12]A recent World Bank Study estimated that the cost of metering all farm power connections in the small State of Haryana would amount to $30 million (Rs 1380 million) in capital investment and $2.2 million/year (Rs 101.2/year) in operating costs (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).

ing pilferage, of tampering with meters, of under-reading and underbilling by meter readers in cohort with farmers over vast areas.[13]

Most SEBs find it difficult to manage a metered power supply even in the industrial and domestic sectors. In Uttar Pradesh, 40% of low tension (LT) consumers are metered but only 11% are billed on metered use; the rest are billed based on a 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 a metered tariff regime. However, 100% collection of amounts billed has worked only for industry; in the domestic and farm sectors collection as a proportion of billing declined from 90.5% in 1995/1996 to 74.6% in 1999/2000 (Panda, 2002). All in all, the power sector's aggressive advocacy of a metered tariff regime in agriculture is based, in our view, on an excessively low estimation of the transaction costs involved.

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

Introduction

The preoccupation of water and power sector professionals in aggressively advocating reversion to a metered tariff regime – and of farmers to frustrate their design – is, in our view, detracting from the discussion of pragmatic approaches that have the potential for promoting a better-managed, groundwater-based agrarian economy in coexistence with a viable electricity sector. In other words, if direct management is impractical in South Asia what are the options for *indirect* management? One option is indirect management based on carefully designed electricity supply and pricing policies and the adoption of an 'intelligent' flat tariff regime.

The major advantage of the rational flat tariff would be 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 a 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, the evidence suggests that farmers respond more strongly to scarcity of these resources than to their price. Pockets of India where drip irrigation is spreading rapidly – such as Aurangabad in Maharashtra, Maikaal in Madhya Pradesh, Kolar in Karnataka and Coimbatore in Tamilnadu – are all regions where water and/or power is scarce rather than costly. A rational flat tariff with intelligent power supply rationing to the farm sector holds the promise of minimizing wasteful use of both resources and of encouraging technical change towards water and power saving. Such a strategy might reduce annual groundwater extraction in western and peninsular India by as much as 12–21 km^3/year and reduce power use by 4–6 billion kWh, valued at Rs 10–15 billion/year ($0.22–0.33 billion/year).

A flat tariff is often written-off as inefficient, wasteful, irrational and distortionary besides being inequitable. In South Asia, this has indeed proved to be the case. It was the change to a flat tariff that encouraged political leaders to indulge in populist whims such as doing away with the farm power tariff altogether (as in Punjab and Tamil Nadu) or pegging it at low levels regardless of the true cost of power supply. Such examples have led to the general perception that flat tariffs have been responsible for ruining the electricity industry and for causing groundwater depletion in many parts of South Asia. But, in our view, the flat tariff regime has been wrongly maligned since, as applied in South Asia, it is a *degenerate* version of what

[13]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 96,000. *The former* will have a collection potential of Rs 0.7 million/month ($15,217/month); for Bhubaneshwar, it is Rs 22.0 million/month ($0.48 million/month).'

might otherwise be a rational pricing regime. A zero tariff is not rational; nor is a flat tariff without proactive rationing and supply management.

Marginal cost pricing is far from universal in other sectors

To most analysts, a flat tariff violates the marginal cost principle that advocates parity between the price charged and the 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. For instance, flat rates may be charged to stimulate use so as to justify the incremental cost of providing a service. In the early days of rural electrification, SEBs charged a flat-cum-pro-rata tariff to achieve two ends: to ensure that each tube well used at least the power to justify its investment in laying cable and poles; and 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 being to encourage telephone use to a level that justifies the incremental cost of providing the service.

But the most important justification for a flat tariff regime is to save on the transaction costs of doing business. Organizations hire employees on a piece rate when their work is easy to measure; but flat rate compensation is prevalent worldwide since it is not easy to measure the marginal value of an employee's output on a daily basis. Urban public transport systems offer passes to commuters at attractive flat rates in part because commuters offer a stable business and equally because it reduces queues at ticket windows, and 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. A few years ago, the Indian Income Tax Department offered businesses in the informal sector to pay a flat income tax of Rs 1400/year ($30.4/year) rather than launching a nationwide campaign to bring millions of small businesses within its tax net because the transaction costs of doing that would have been far higher than the revenue realized. A major reason municipal taxes are levied on a flat rate is the transaction cost of charging citizens based on the value they place at the margin on the municipal services.

Are all these businesses that charge for their products or services on a flat rate destined to make losses? No. They often 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 cost 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 remain viable through deft supply management. Canal irrigation is a classic example. Volumetric supply has long been advocated but nowhere in South Asia is volumetric water pricing practised in canal irrigation given the prohibitive costs of collecting volumetric charges (Perry, 1996, 2001). This is due to such factors as: (i) the large number of potential small farmers; (ii) the difficulty of excluding defaulting farmers; and (iii) the propensity for farmers to frustrate sellers' effort. While volumetric pricing of canal irrigation may be possible in, say, South African irrigation systems where a branch canal serving some 5000 ha might have 10–50 white commercial farmers, an Indian system serving the same area might contain 6000–8000 farmers (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 busi-

ness 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[14]; in the latter, 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 a limited space. Thus, there is always a price for the value businesses offer their customers through products and services offered on a flat tariff; but that does not mean that the seller or the buyer is any the worse for flat rate pricing.

The flat tariff in irrigation

The reason that the flat rate tariff, as currently practised for pump irrigation in South Asia, is degenerate – and the power industry is in the red – is that the power utilities have failed to manage a rationed power supply. Under the flat tariff system as practised, most SEBs try to maintain farm power supply at 8–15 h/day throughout the year. This is comparable to maintaining a surface canal at full supply every day of the year. Raising a flat tariff to a level that covers the cost of this service is politically untenable.[15] A domestic consumer may assess a good quality service as power of uniform voltage and frequency supplied 24 h a day, 365 days a year. But the irrigators' idea of good quality service is power of uniform voltage and frequency when their crops face critical moisture stress. Ideally, the business objective of a power utility should be to supply the best-quality service consistent with the flat tariff pegged at a given level. With intelligent management of power supply, it should be possible to satisfy irrigation power demand by ensuring a supply of 18–20 h a day for 40–50 key moisture-stress days, with some power available at other times.[16] The pattern of farming demand differs in significant ways from that of domestic and industrial customers. It is this that provides the main opportunities for 'value improvement,' that is, 'meeting or

[14]On-demand power supply is the norm in most developed electricity systems and on-demand irrigation also typifies most groundwater systems worldwide. In contrast, fully on-demand surface irrigation is only found in a very few fully reticulated systems backed by adequate water supplies. Under the vast majority of conditions, balancing water supply and demand in surface irrigation requires quota limitations of some sort.

[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 within the ruling party, and cabinet ministers began clamouring for a leadership change. Subhash Yadav, the Deputy Chief Minister, lamented in an interview with India Today: 'A farmer who produces 10 t of wheat earns Rs 60,000 ($1304.35) and he is expected to pay Rs 55,000 ($1195.65) 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 and just before the May 2004 assembly elections, the Chief Minister waived all past electricity dues. Even so, 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* and *Sadak* (electricity, irrigation and roads).

[16]No doubt there will always be a few farmers who might demand a very different schedule to that of the predominant farming pattern in a specific area. These will typically be entrepreneurial farmers growing high-return, specialized crops. Options for these farmers include on-farm storage, duplicate diesel pumps, market solutions, etc. Even so, some activities at the margin may be precluded. But in a country as vast as India, conditions somewhere will be suitable for meeting such specialized demands and, given the other advantages associated with the proposed 'rational flat tariff' system, this is likely to be a minor issue.

exceeding customer expectations while removing unnecessary cost' (Berk and Berk, 1995).

Groundwater irrigators are envious of farmers in canal irrigation projects since they pay so little for their water. But a typical canal irrigator may get surface water no more than 10–15 times in a year and often he would be happy to get water six times in 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 instalments. 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, an electric pump owner with 3 ha of irrigable land would be at par with a farmer with 3 ha in the Narmada command if he gets 636 h of power in a year and would be considerably better off if the 636 h of power comes when he needs the water most. When Gujarat commits to year-round supply of 8 h/day of farm power, in effect it offers tube well owners water entitlements that are, in theory, 14 times larger than the water entitlements that the Sardar Sarovar project offers to farmers in its command area.[17] Under a metered tariff, this may not matter since tube well owners would use power only when the value generated exceeds the marginal cost of pumping. But under a 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.

A rational flat tariff, if well managed, can confer two main benefits. *First*, it may curtail wasteful use of groundwater. If farm power supply outside the 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 a progressive flat tariff – by charging higher rates per connected hp as the pump size increases – would provide an additional incentive to purchase and use smaller-capacity pumps to irrigate smaller areas, e.g. in regions where resource depletion is rampant. Above all, a restricted but predictable water supply would encourage water-saving irrigation techniques more effectively than raising the marginal cost of irrigation. *Second*, given the quality of power T&D 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. 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 low. In Madras, for example, if the supply was to increase from current levels (about 2 h of supply a day at 2 m of pressure) to a reasonable level (say, 12 h a day at 10 m of pressure) leaks would account for about 900 million litres per day, 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 extensive than the urban water supply system.

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

The preconditions for successful rationing

We believe that transforming the present *degenerate* flat power tariff into a rational tariff regime will be easier and more 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 operations.

[17] 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.

Four preconditions seem both important and feasible:

- *Separating agricultural and non-agricultural power supply*. The first precondition for successful rationing is to separate agricultural from non-agricultural power supply to rural settlements. The most common way this is done now is to keep 2-phase power on for 24 h so that domestic and (most) non-agricultural uses are not affected and ration the 3-phase power necessary to run irrigation pump sets. This is working but only partially. Farmer response in states like Gujarat is rampant use of phase-splitting capacitors with which they can run pumps even on 2-phase power. There are technological ways to avoid this. For instance, the 11 kV line could be adapted to shut off as soon as the load increases beyond a predetermined level. The costs of such infrastructural modifications could be significant and their feasibility varies. A pragmatic approach is therefore essential. Nevertheless, many SEBs have already begun separating the feeders supplying farm and non-farm rural consumers. For instance, Gujarat has embarked on an ambitious program (*Jyotirgram Yojana)* to lay parallel power supply lines for agricultural users in 16,000 villages at an estimated cost of Rs 9 billion ($196 million). In Andhra Pradesh, the separation of domestic and agricultural feeders is 70% complete (Raghu, 2004). This would ensure that industrial users in the rural areas who need uninterrupted 3-phase power supply and domestic users remain unaffected from rationing of power supplies for agricultural consumers. Another complementary infrastructural investment is to install meters to monitor power use so that power budgeting can be implemented effectively. For this, meters at transformer and feeder levels will be required. Many states have already installed meters at 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 10–15 years while the cost of generating and distributing power has soared. We surmise that raising the flat tariff at one go to close this gap between revenue and cost per kWh would be too drastic an increase. However, as has been proposed by the Electricity Regulatory Commission in Gujarat, farmers would be able to cope with a regular 10–15% annual increase in the flat tariff far more easily than a 350% increase at one go.
- *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, among the plethora of subsidies that governments in India provide, the power subsidy is one of the most valued. Indeed, a decision by a ruling party to curtail the 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 donors would like. However, the problem with the power subsidy in the current degenerate flat tariff is its indeterminacy. Chief ministers issue diktats to SEBs about the number of hours of power per day to be supplied to farmers; that done, the actual subsidy availed of by the farmers is in effect left to them to usurp. Instead, governments should tell the power utility the amount of power subsidy it can make available at the start of each year; and the power utility should then decide the amount of farm power the flat tariff and the government subsidy can buy.
- *Off-peak power*. In estimating losses from farm power supply, protagonists of power sector reform 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 a flat tariff. Moreover, under current conditions, a large part of the power supplied to the farm sector is off-peak load power. Indeed, but for agriculture, the power utilities would be hard-pressed to dispose of this power.[18] It is true that irrigation demands are also seasonal, and that this will become more transparent under an 'intelligent' tariff regime. However, more than half of the power supplied to the farm sector is at night and – despite probable farmer reluctance to accept – this proportion could increase further. The important point here is that, in computing the power the prevailing flat tariff and pre-specified subsidy can buy, the utilities should use a lower opportunity cost of the off-peak supply to the extent it is applicable.

In summary, there is substantial scope for cutting costs and improving service. The existing policy in many states of maintaining power supply to the farm sector at a constant rate during pre-specified hours is irrational and the prime reason for wasteful use of power and water.[19] Figure 9.4 provides a notional indication of the extent of this waste. 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 subject to a metered power tariff at full cost. While this might not meet the needs of *all* farmers, it would be good enough. Of course, it may be difficult to simulate behaviour for farmers subject to a flat tariff. In many states there are a few new tube wells whose owners pay for power on a metered basis but they are charged so low a rate that they behave much like farmers who pay a flat tariff. Another method would be to compare electricity use before and after a flat tariff to gauge the extent of overutilization of

[18]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. The energy cost, which is variable, depends on the length of time of power consumption but fixed generation costs depend on how much a farmer consumes 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 is high for coal-based plants and insignificant for hydropower plants.

[19]In Tamilnadu, where farm power supply is free, 14 h of 3-phase power – 6 h during day and 8 h during night – is supplied throughout the year. In Andhra Pradesh, 9 h of 3-phase power supply is guaranteed, 6 h during the day and 3 h during the night (Palanisami and Kumar, 2002); this was recently reduced to 7 h when the new government announced free power. This implies that, in theory, a tube well in Tamilnadu can run for over 5000 h/year and in Andhra Pradesh for 3200 h. If the real cost of power is taken to be Rs 2.5/kWh (USc5.4/kWh), depending on how conscientious he is, a Tamilnadu farmer operating a 10 hp tube well can avail of a power subsidy ranging from Rs 0–93,750/($0–2038)/year; and an Andhra Pradesh farmer, Rs 0–60,000)/year ($0–1304/year). 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 overusing in using power and water. Palanisami and Kumar (2002) mention that many borewell owners 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 (USc5.4)/kWh; but they would also not do this if they got only 3–4 h of good quality power at convenient hours on a pre-announced schedule.

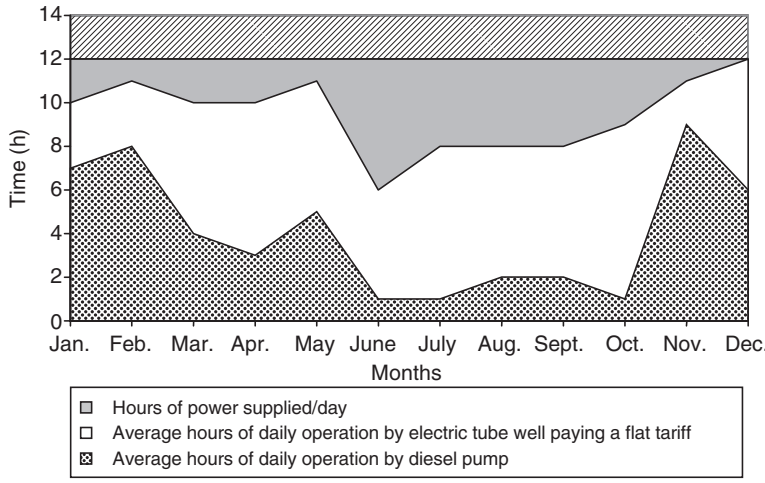


Fig. 9.4. Minimizing waste of power and water through supply management.
Note: This is a schematic diagram. The numbers are indicative and not based on actual field data.

power and water attributable to a flat tariff.[20]

However, it is the pumping behaviour of diesel pump owners, subject to the full marginal cost of energy, that might provide the best indicator. Several studies have shown that diesel tube wells are operated for half or less the time of electric tube wells that pay a flat tariff (Mukherji and Shah, 2002).[21] Batra and Singh (2003) interviewed 188 farmers in Punjab, Haryana and central Uttar Pradesh to explore if pumping behaviour of diesel and electric owners of water extraction mechanisms (WEM) differed significantly. They found no significant differences in Punjab and Haryana[22] but their results for Central UP suggested that diesel pumps are used when irrigation is needed and electric pumps when 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 9.5 and 9.6 present the central premise: the excess of pumping by electric over diesel tube wells is indicative of the waste of water and power encouraged by the zero marginal cost of pumping under the present degenerate flat tariff regime. Mukherji and Shah (2002) present results from a survey of 2234 tube well irrigators across India and Bangladesh in late 2002.

[20]An extreme case is Tamilnadu where electricity consumption per tube well shot up from 2583 kWh/year under metered tariff in the early 1980s to 4546 kWh in 1997–1998. However, this jump would represent 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 (iii), which we suspect is quite large.

[21]We recognize that comparing hours of operation is not the same as comparing the quantity of water extracted. But, in understanding the economic behaviour of tube well owners, comparing hours is more meaningful than comparing water produced. In any case, ceteris paribus for the same hours of pumping, an electric pump produces more water due to its higher efficiency.

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

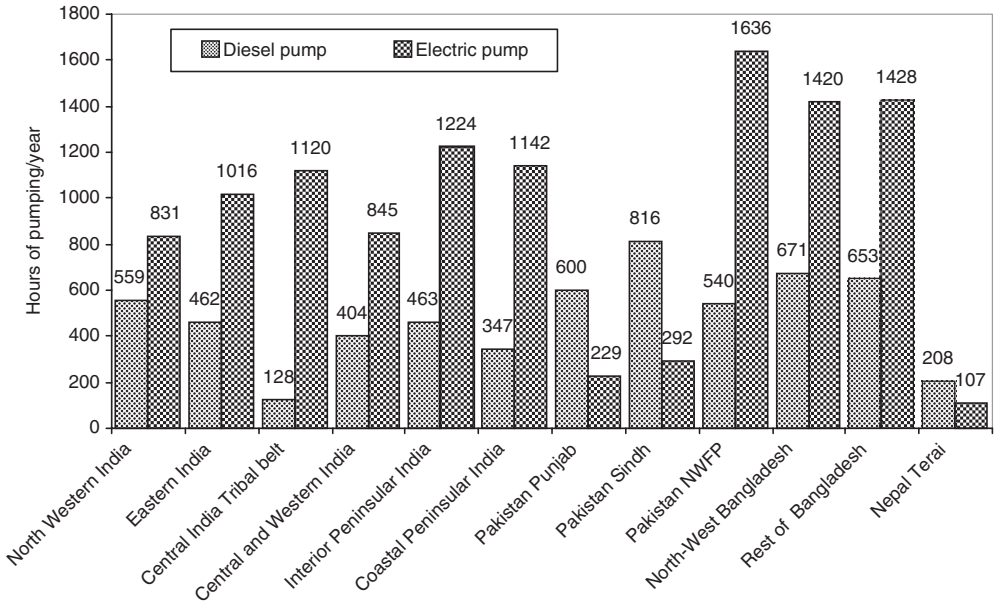


Fig. 9.5. Flat electricity tariff induce farmers to pump more.

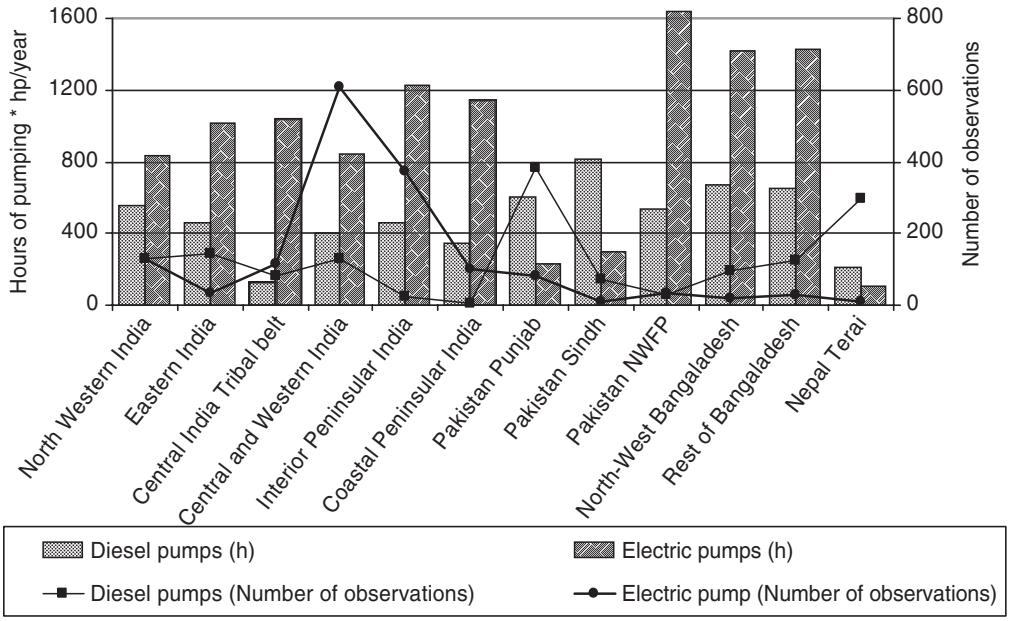


Fig. 9.6. Impact of flat tariff on average annual hours of pumping weighted by pump horsepower.

Figure 9.5 shows that electric tube well owners subject to a flat tariff invariably operate their pumps for much longer time compared to diesel pump owners who face a steep marginal energy cost. Since it can be argued that diesel pumps, on average, have a larger capacity than electric pumps we also compare pumping hours weighted by hp ratings. Figure 9.6 shows that hp-hours pumped by flat-tariff paying electric pumps are also significantly higher than those pumped by diesel pumps everywhere. The survey suggests that the difference in annual pumpage is some 40–150%; some of this excess pumping no doubt results in additional output but much of it very likely does not and, to this extent, is a social waste that needs to be eliminated.[23]

If, based on an analysis of the level and pattern of pumping by diesel pump owners, a power utility can shave off potential excess pumping by fine-tuning power supply schedule around the year, a flat tariff can become both viable and help eliminate 'waste.' The average number of hours for which diesel pumps operate is 500–600/year. At 600 h of annual operation, an electric tube well would use 450 kWh of power/hp; if all the power used is off-peak load commanding, say, 25% discount on a generation cost of Rs 2.5/kWh (US$0.05/kWh), then farm power supply by the power utility would break-even at a flat tariff at Rs 844/hp/year ($18.3/hp/year) as against Rs 500/hp/year ($10.9/hp/year) in force in Gujarat since 1989. Gujarat is committed to raising the flat tariff eventually to Rs 2100/hp/year ($45.65/hp/year) at the instance of the Gujarat Electricity Regulatory Commission. If it does so, farmers might well topple the government. A more viable and practical course would be to raise the flat tariff in steps to, say, Rs 900 ($19.6) at first and then to Rs 1200 ($26.09), and to restrict annual supply of farm power to 1000–1200 h compared to 3000–3500 h/year as at present. A 5 hp pump lifting 25 m^3 of water/h over a head of 15 m can produce 30,000 m^3 of water/year in 1200 h of tube well operation, sufficient to meet the needs of most small farmers in the region.

Alternative Approaches to Rationing

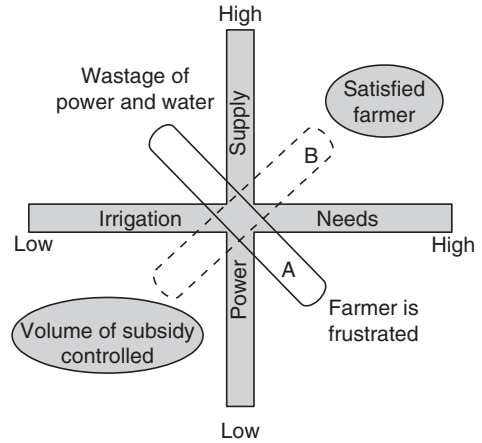
The strongest evidence in support of our argument for *intelligent* rationing of farm power is that, for more than a decade, most SEBs in India have *already* rationed power to farmers in some way. For instance, Andhra Pradesh, where the new government announced free power, also announced that farm power supply would henceforth be restricted to 7 h daily. Nobody – farmers included – considers 24 h uninterrupted power supply to agriculture to be feasible or defensible 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; and this can be termed the current default.

The current default is perhaps 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 schedules. It leaves farmers frustrated on days when their crops need to be watered most and leads to wasteful use of power and groundwater when the need is least. 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' be raised because the default system does not provide enough power when they need it most. There are a number of ways of rationing that would raise farmer satisfaction and control power subsidies so that (i) it reduces farmers' uncertainty about the timing of power; (ii) it achieves a better fit between power supply schedules and irrigation schedules; or (iii) both. We suggest below a few

[23] It is probable that the real savings in power are proportionately greater than the real savings in water since a part of the excess water pumped returns to the aquifer. This can be a significant factor, especially where irrigation depends on shallow groundwater circulation.

illustrative alternative approaches that need to be considered and tried out with a view to increasing farmer acceptance and containing the subsidies provided as well as the wastage of power and water (Fig. 9.7).

- *Agronomic scheduling*. Ideally, SEBs should aim to achieve the 'best fit' by matching power supply schedules with irrigation needs of farmers to the extent this is feasible within the context of their overall operations. Under this approach, the power utility would constantly study: (i) irrigation behaviour of farmers in regions and subregions by monitoring cropping patterns, cropping cycles and rainfall events; (ii) matches power supply schedules to meet irrigation needs; and (iii) minimizes supply in off-peak irrigation periods. The advantages of such a system are that farmers would be happier, the total power supply to agriculture can be reduced, power and water waste would be minimized, and the 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 this 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 also 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



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 low power supply when irrigation needs are low (volume of subsidy is controlled)

Fig. 9.7. Improving farmer satisfaction and controlling electricity subsidies through intelligent management of farm power supply.

any capital investment of their own. However, under the present degenerate flat tariff, tube well irrigators often have the best of both the worlds. At 10 h of power supply/day, 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. Under 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 bench-marked public irrigation system. And although this will impose constraints on tube well irrigators, it can drastically reduce power subsidies from current levels. For that very same reason, it 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 zone 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 *warabandi* system in canal irrigation systems in Indian and Pakistan Punjab. The advantages of this approach are that: (i) it is easy to administer; (ii) the agricultural load for the state as a whole remains constant, so it becomes easy to manage for SEB; also (iii) level of subsidies is controlled; and (iv) power supply to each zone is predictable so that farmers can plan their irrigation easily. Disadvantages are that: (i) farmers in deep water table areas or areas with poor aquifers (as Saurashtra in Gujarat) would be unhappy since they must pump for longer to obtain the same supply; and (ii) zonal rostering would not mimic seasonal fluctuations in irrigation demand as well as in agronomic rationing.
- *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 in different seasons makes little sense. Modifying the zonal roaster system so that power supply offered is higher in winter and summer than in the monsoon season would improve the seasonal fit as well as reduce uncertainty.

Any approach must necessarily be consistent with the characteristics of the power operations in the particular subregion concerned. Systems analysis of power operations will thus be a critical step in evaluating feasible alternatives. The issues concerned go beyond the scope of this chapter but, clearly, choices will need to be flexible in the light of ongoing experience.

It will not always be possible to meet the precise needs of all farmers and a period of adjustment and experimentation may be necessary before the final arrangements are implemented. Power utilities in South Asia have never had the necessary understanding of irrigation requirements that this implies, 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). This important aspect has been overlooked in the power sector reforms under way in many Indian states, which focus on the institutional architecture of unbundling power operations. Distributing power to agriculture in South Asia is a very different activity to supplying urban and industrial demands and there is a real danger that private distribution companies will exclude agriculture as being 'too difficult and costly to serve,' as Orissa's experience is already showing.[24] Perhaps, the most appropriate course would be to promote a separate distribution com-

[24]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).

pany 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.[25]

Supporting intelligent management

Which of the above approaches should be adopted is thus a pragmatic decision in the light of local conditions. Farmers will no doubt resist rationing of power supply and any reforms will need to be introduced sensitively in association with farmer and political representatives and flexibly in response to ongoing experience and results. Moreover, farmer resistance can be reduced if reforms are accompanied by such measures as:

- *Enhancing 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 adapted broadly to match the demand pattern of the majority of farmers. Once announced, the utility must then stick to the schedule so that farmers can be certain about power availability.
- *Improving supply 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.
- *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 the monsoonal season in a normal year and perhaps 5–6 weeks during winter when the average farmer experiences great nervousness about moisture stress to his crops. If the power utility can take care of these periods, 80–90% of farmers' power and water needs would be met. This might not, for instance, help sugarcane growers in Maharashtra, Gujarat and Tamilnadu; but then they are the large part of the power utilities' problems.
- *Better upkeep of farm power supply infrastructure*. Intelligent power supply management to agriculture will inevitably be a tricky business. If rationing is done by an arbitrary increase in power cuts and the neglect of rural power infrastructure, it might result in disastrous consequences as it did in East India. As described above, the saving grace was that in these groundwater-abundant regions, small diesel pumps, though dirtier and costlier to operate, kept the economy going. Where groundwater is lifted from 200 to 300 m, such de-electrification could destroy the agricultural economy.

Conclusions

We have argued in this report that neither a switch to a metered tariff regime at this juncture nor the raising of the flat tariff fourfold as, for instance proposed in Gujarat, is likely to be successful in South Asia and would in all probability backfire. Metering is highly unlikely to improve the fortunes of power utilities that have found no smarter ways than in the 1970s of dealing with the high transaction costs of metered farm power supply, which led to a flat tariff regime in the first place. However, if agriculturally dynamic states like Punjab and Haryana – where non-farm uses of 3-phase power supply are extensive and growing in the villages and where productive farmers can afford higher costs of better quality power supply – want to experiment with metered power supply, they would be well advised to create microentrepreneurs to retail power, to meter individual power consumption and collect revenue as in China rather than experiment with electricity cooperatives. It should, however, be borne in mind

[25] T.L. Sankar argues 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).

that the largest and most difficult problem lies in containing user efforts to frustrate the metered tariff regime, by pilfering power, illegal connections, tampering with meters and so on. While abuse remains possible in respect of a flat rate tariff, the opportunities are quite fewer. The ongoing experiments on privatization of electricity retailing in Orissa may produce useful lessons on whether metering-cum-billing agents can drastically and sustainably reduce the cost of metered power supply in a situation where tube well owners account for a significant proportion of electricity use.

Contrary to popular understanding, a rational flat tariff can be an elegant and efficient regime, which requires a complex set of skills and an understanding of agriculture and irrigation in different regions. A rational flat tariff and intelligent power supply management in fact could achieve much that a metered tariff regime is designed to achieve at much lower real cost and a much greater likelihood of success. The flat tariff will undoubtedly have to be raised, but the schema we have set out could 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 the aim would be to provide farmers with good quality power at times of moisture stress when they need irrigation most. Power supply to agriculture will need to be metered at feeder and transformer levels as a basis for power scheduling and 'intelligent' management but the transaction costs of a metered charge at farm level would be saved. If concurrently the utilities begin treating farmers as customers, the adversarial relationship between them could in time turn benign. Moreover, a rational flat tariff would tend to maintain water markets as buyers' markets albeit less than under the present degenerate flat tariffs (for detailed arguments see Shah, 1993). A rational flat tariff – under which power rationing is more defensible than under a metered tariff – would allow an effective check on total use of power and water. Restricting the total hours of operation supply would curtail technical and commercial losses by SEBs and reduce power subsidies while a rational flat tariff has the potential for significantly curtailing groundwater depletion by minimizing wasteful resource use. In most instances, proportionately more power is likely to be saved than water due to the prevalence of return flows, but which of these two benefits is more valuable will depend critically on the context. Together, however, they have the potential for making a very substantial contribution to improving economic performance and strengthening resource sustainability.

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