RESEARCH
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Energy-Irrigation Nexus in South Asia

Improving Groundwater Conservation and Power Sector Viability

Tushaar Shah, Christopher Scott, Avinash Kishore and Abhishek Sharma

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Revised Second Edition

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Abbreviations, Acronyms and Units

GOI	Government of India
ICAR	Indian Council of Agricultural Research
IWMI	International Water Management Institute
hp	horsepower
kV	kilovolt
kVA	kilovolt-ampere
kWh	kilowatt-hour
SEB	State Electricity Board
T&D	transmission and distribution

Exchange Rates (July 2004)

US$1.00 = Indian Rs 46.00
US$1.00 = Pakistan Rs 60.20
US$1.00 = Bangladesh Taka 60.90
US$1.00 = Nepalese Rs 74.50
US$1.00 = Yuan 8.00

Units

1 acre = 0.4047 hectare (ha)
1 horsepower = 746 joules per second
1 horsepower-hour = 0.7457 kilowatt-hour
1 kilowatt-hour = 1.3410 horsepower-hour

Summary

In the populous South Asian region where pump irrigation, mostly from open wells and tubewells, predominates gravity-flow irrigation, the fortunes of groundwater and energy economies are closely tied. New paradigms in water resource management, which advocate pursuit of basin-level water productivity in favor of classical water use efficiency, tend to treat the energy costs of irrigation as insignificant relative to the social cost of water. But South Asia uses energy worth US$3.78 billion per year to pump approximately 210 km^3 of water, mostly for irrigation. Classical efficiency would be difficult to dislodge because it optimizes water use as well as energy use concurrently, whereas the notion of basin-level water productivity ensures *optimal* water-sector outcomes but *sub-optimal* energy-sector outcomes.

In this region, little can be done to improve the groundwater economy without affecting the energy economy. The struggle to make the energy economy viable is frustrated by the farming community's often-violent opposition to efforts to rationalize energy prices. As a result, the region's groundwater economy has boomed by bleeding the energy economy. This report suggests that this does not have to be so. The first step to evolving approaches to sustaining a prosperous groundwater economy with a viable power sector is for the decision makers in the two sectors to talk to each other, and jointly explore superior options for the co-management of the groundwater and energy economies, which we suggest have so far been overlooked.

In co-managing the two economies, the most important aspect is the formulation of appropriate policies for the pricing and supply of power to pump irrigators. During the past three decades, power industry managers as well as international players, especially the World Bank and the Asian Development Bank, have insisted that flat tariff charged to irrigators, based on the capacity of the pump rather than the metered consumption of power, is the key reason for power industry losses, and they have advocated a transition to a metered power supply regime. We suggest that doing so may not help unless the power industry addresses the formidable logistical problems of supplying metered power to more than 13 million scattered, small users. In India, during the 1970s, these problems forced the power industry to abandon metered power supply in favor of a flat tariff for power supplied for irrigation. On the other hand, we suggest that what has been so far passed off as a flat tariff is a *degenerate* pricing policy. Zero tariff for power, as levied in the Indian states of Punjab, Andhra Pradesh and Tamilnadu, is not a flat tariff. A flat tariff without proactive rationing of the power supply cannot achieve a balance between satisfying irrigation needs and keeping the power sector viable. Levied as a tax rather than as a price, a scientific flat tariff for the power supply to pump irrigation can be a logical and viable alternative in a situation where the transaction costs of metering and metered charge collection are exceedingly high, as the power sector in Pakistan discovered after it reverted to metering in 2000.

We explore the metered tariff and flat tariff regimes not just as alternative pricing policies but as alternate *business philosophies*. In the first, the electricity industry charges an economic price and in return offers the best service by providing quality power on demand; in the second, the power industry saves on massive transaction costs by using a flat tariff accompanied by the sophisticated management of a high quality but carefully rationed power supply. We argue that while the first represents the long term goal, the second has the potential to help improve at once the financial

sustainability of energy use in agriculture and the environmental sustainability of groundwater irrigation in a region where depletion and deterioration of this resource can spell doom for farming and livelihoods.

The report suggests that the inability to manage groundwater and energy economies as a *nexus* is a great opportunity missed in moving towards sustainable groundwater management. In South Asia, there seems to be no practical means for the direct management of groundwater. Laws are unlikely to check the chaotic race to extract groundwater because of the logistical problems of regulating a large number of small, dispersed users. Water pricing and property-right reforms also will not work for the same reasons. Appropriate policies for the supply and pricing of power offer a powerful toolkit for the *indirect* management of both groundwater and energy use.

We conclude that the metering of the farm power supply to 13-14 million electric tubewells in the South Asian region—the solution most widely espoused—poses a formidable logistical challenge as well as mass-based farmer opposition, which would make it politically difficult to implement. Even if it is accepted, the logistical problems and high transaction costs of metering and billing a large number of dispersed farm power connections continue to remain on a far larger scale today. If metering is to be introduced, its chances of working depend critically on the institutional innovations in metering and billing at the feeder level or below, as has happened in China. However, in the short run, the best course of action is to transform the existing *degenerate* system of flat tariff into a *rational* flat tariff. This involves, first, raising flat tariffs moderately and regularly rather than in big jumps, and second, implementing a proactive power supply policy for the farm sector.

The proactive power supply policy should cap the total duration of power supply over the entire year to a level viable relative to the level of flat tariff, and then schedule the power supply to fit farmers' irrigation needs as best as possible. This can be done in several ways. We outline a sample of five illustrative approaches: (i) agronomic scheduling, (ii) demand-based scheduling, (iii) canal-based scheduling, (iv) zonal roster, and (v) adjusted zonal roster. Pursuing this strategy of proactive management of a rationed power supply can reduce power industry losses from its farm operations, reduce overall technical and commercial losses of power, curtail wasteful use of an estimated 12-21 km^3 of groundwater per year, and improve farmer satisfaction with the power industry.

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

Tushaar Shah, Christopher Scott, Avinash Kishore and Abhishek Sharma

Introduction

Groundwater irrigation has come to be the mainstay of irrigated agriculture in much of India, the Punjab and Sindh provinces of Pakistan, the Terai region of Nepal, and Bangladesh. Farmers in this populous South Asian region use more than 21 million pumps, about half of them powered by heavily subsidized electricity, to irrigate their fields and the energy sector's stake in agriculture has risen sharply. Agricultural use of electricity accounts for 15-20 percent of the power consumption and the pricing of power to agriculture is a hot political issue. State power utilities have been at loggerheads with the region's groundwater economy for over 15 years.

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 tubewells. In Indian states like Punjab and Uttar Pradesh, the Chief Ministers set steep targets to district-level officials to sell electricity connections to farmers. Loans and concessions were made available to farmers to popularize tubewell irrigation. During the 1960s and the 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 tubewell revolution, lagging 3-5 years behind it, 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, for example in Indian and Pakistan Punjab, groundwater irrigation had grown rapidly.

However, soon, the enthusiasm of state power utilities towards their agricultural customers began to wane. In India, State Electricity Boards (SEBs) were charging tubewell owners based on the metered consumption, but, as the number of tubewells increased, the SEBs found it costly and difficult to manage metering and billing. The cost of meters and their maintenance was the least worry. The transaction costs of the farm power supply—in terms of the costs of containing rampant tampering of meters, under-billing and corruption at the level of meter readers, and of maintaining an army of meter readers, and increasing pilferage of power—were far bigger and difficult to control. The introduction of a flat tariff based on the horse-power rating of the pump, in state after state during the 1970s and 1980s, was a response to these high and rising transaction costs of metered power supply. While the flat tariff eliminated the hassle and cost of metering it still allowed malpractices such as under-reporting of the horse-power rating, but controlling this was easier than controlling pilferage under the metered tariff system. Flat tariffs however became "sticky." As the power supply to agriculture emerged as a major driver of irrigated agriculture, politicians found its pricing a powerful weapon in populist vote-bank politics. Unable to increase the flat tariff for years on end and under pressure to supply abundant power to farms, 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 a metered tariff for the farm power supply is a precondition to restoring the viability of the power industry. This view, based on the neo-classical economic theory, considered only the "transformation cost" of generating and distributing power and overlooked the "transaction costs" of unit pricing of the power supply to farmers.

In this report, our objective is to reevaluate the entire debate by putting it in the perspective of *the new institutional economics*, which shows how some activities that we all know have high payoffs in terms of productivity fail to get undertaken because of the presence of transaction costs that neo-classical 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. Analyzing the energy and groundwater economies as a nexus could help evolve joint strategies that can help South Asia conserve its groundwater while at the same time improving the viability of its power industry.

Energy-Irrigation Nexus

The energy-irrigation nexus focuses attention on a class of issues that are unique to the South Asian region as well as the North China Plain. Many countries—for example, the USA, Iran and Mexico—make intensive use of groundwater in their agriculture sectors. However, in these countries, groundwater irrigation affects only 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 is the biggest groundwater user in the world (figure 1). In South Asia, in addition to India, Pakistan, Bangladesh and Nepal are the major groundwater users. Good data on the groundwater-irrigated area, groundwater draft and the number of mechanized irrigation wells in operation are hard to come by. However, our estimate is that between them these four countries pump about 210-250 km^3 of groundwater every year. In doing so, they use about 21-23 million pumps, of which about 13-14 million are electric and around 8-9 million are powered by diesel engines (NSSO 1999, for India). If we assume that an average electric tubewell (with a pumping efficiency of 25%) lifts water to an average head of 30 meters, the total energy used in these countries for lifting 210 km^3 of groundwater is about 68.6 billion kWh equivalent per year.[1] At an alternative cost of US$0.05 (Indian Rs 2.5) per kWh,[2] supplying this energy costs the region's energy industry US$3.78 billion.[3] The market value of the

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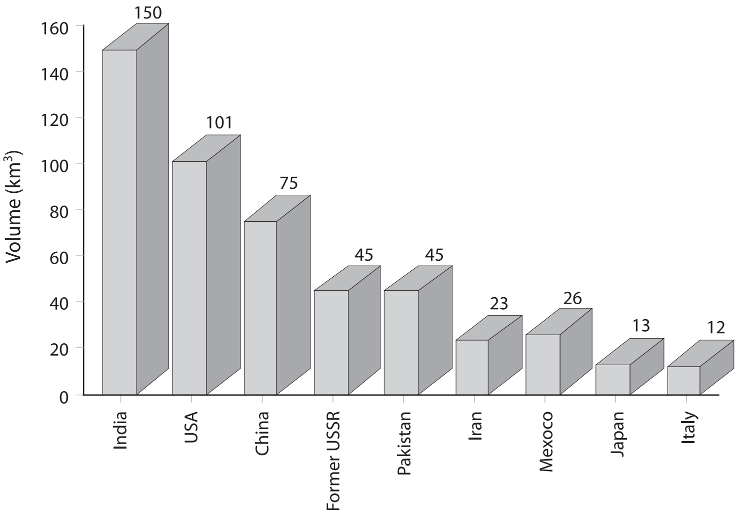
[1] According to Centre for Monitoring Indian Economy, electricity use in Indian agriculture in 2000-2001 is 84.7 billion kWh, much greater than our estimate of 68.6 billion kWh of *total* energy use (by electric and diesel pumpsets) per year by tubewells for India, Pakistan, Bangladesh and Nepal, where at least one-third of the tubewells are run by diesel pumps. However, we also know that the estimates of agricultural electricity use in India are overestimates (see footnote 7) and include a portion of transmission and distribution losses in non-farm sectors that are passed off as agricultural consumption (CMIE 2003).

[2] US$1.00 = Indian Rs 46.00 = Pakistan Rs 60.20 = Bangladeshi Taka 60.90 = Nepalese Rs 74.50 (July 2004).

[3] Gulati and Narayanan (2003) took the difference between the total cost of supplying power to all sectors and the tariff charged from the agriculture sector as a measure of the subsidy to agriculture per kWh. Multiplying this by the estimated power supply to agriculture, they place the power subsidy to agriculture in 2000-2001 at US$6.26 billion (Indian Rs 288.14 billion) and suggest that this is 78 times more than what it was in 1980-1981. But they acknowledge that their estimate is likely to be a huge overestimate because of the propensity of SEBs to pass off excessive transmission and distribution (T&D) losses in other sectors as farm consumption.

FIGURE 1.
Groundwater use per year in selected countries during the 1980s.

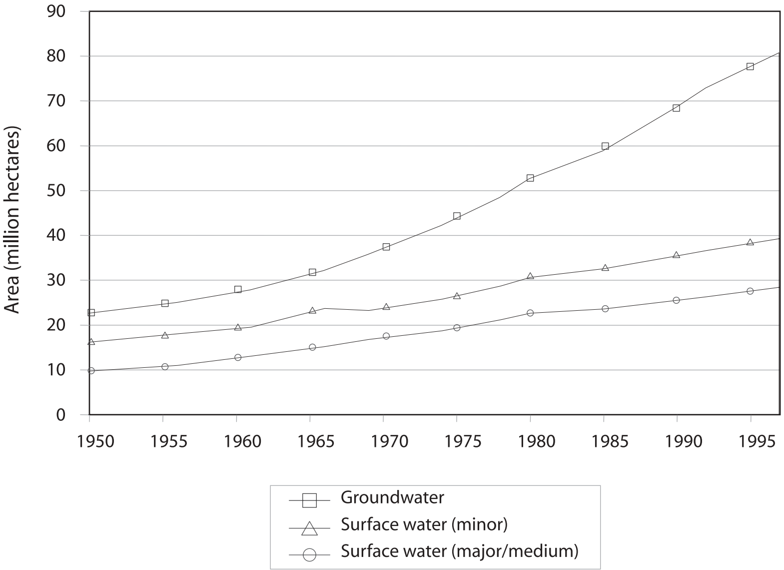


Source: Llamas et al. 1992.

irrigation produced is US$9.8-12.0 billion[4] and its contribution to agricultural output is likely of the order of US$29.3-35.9 billion.[5] In these emerging low-income economies, pump irrigation is serious business with economy-wide impacts, both positive and negative.

Unlike in other groundwater using countries, the pump irrigation economy in South Asia affects vast numbers of low-income households and large proportions of rural populations. The growth in groundwater irrigation in the region is relatively recent (figure 2). In India, gravity

FIGURE 2.
Irrigated area by source, India.



Source: GOI 1999.

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[4] We assumed that an average South Asian tubewell uses 4 kWh of energy per hour, the equivalent of the energy used in pumping for an hour, which gives us 17.15 billion hours of pumping of groundwater per year. At an average price of US$0.65 per hour, the computed market value of pump irrigation in the region is US$11.34 billion. In many parts of South Asia, water sellers providing a pump irrigation service claim a one-third crop share. Based on this, we computed the contribution to farm output as 3 times the market value of pump irrigation. Alternatively, according to our calculations, a representative South Asian tubewell produces about US$543.48 worth irrigation water per year, which helps to produce crops worth US$1,630.44. If we take the World Bank estimate, which places the groundwater contribution to India's GDP at 10%, our calculations are severe underestimates of the productive contribution of tubewell irrigation.

[5] Dhawan estimated the net value of the marginal product of power in agriculture as US$0.20 per kWh in net terms and US$0.30 per kWh in terms of gross value of output (Dhawan 1999).

systems dominated irrigated agriculture until the 1970s, but by the early 1990s groundwater irrigation had far surpassed surface irrigation in terms of the area served as well as the proportion of agricultural output supported (Debroy and Shah 2003; Shah et al. 2003). According to Government of India estimates, 60 percent of India's irrigated lands is served by groundwater wells (GOI n.d.; GOI 2001). However, independent surveys suggest that the proportion may be more like 75 percent (Shah et al. 2004b; NSSO 1999).

In 1999-2000, India's 81 million land owning families (http://labourbureau.nic.in/) had an estimated 20 million tubewells and pumpsets among them. On average, every fourth landowning household has a pumpset and a well and a large proportion of non-owners depend on pumpset owners for their irrigation water, supplied through local, fragmented groundwater markets (Shah 1993). According to a World Bank estimate, groundwater irrigation contributes to about 10 percent of India's GDP (World Bank and GOI 1998). This is possible because groundwater irrigation uses about 15-20 percent of the total electricity consumed in the country.

The large number of small pump users is a peculiarity of the South Asian region. In countries like the USA, Iran and Mexico, which have large groundwater irrigation economies, tubewells are fewer and larger and a typical tubewell irrigates an area 10-500 times larger than the area irrigated by a typical tubewell in India, Bangladesh or Nepal. In Mexico's Guanajuato province, the heartland of its intensive groundwater irrigated agriculture, a typical tubewell is run by a 100-150 horsepower pump and operates for over 4,000 hours in a year (Scott et al. 2002). In India, Bangladesh and Nepal, the modal pump size is 6.5 hp and the average duration of operation is 400-500 hours per year (Shah 1993). In Iran, only 365,000 tubewells are used to pump 29 km^3 of groundwater per year (Hekmat 2002) while India uses 38 times more wells, compared to Iran, to extract five times more groundwater.

From the viewpoint of managing groundwater as well as the transaction costs of the energy supply to irrigation, these differences are crucial. Having to deal with a relatively small number of fairly large irrigators is one of the factors that has helped countries like Iran and Mexico to manage groundwater irrigation. In Iran, when groundwater overdraft in the hinterland threatened the 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 the plains (Hekmat 2002). In Mexico, the Commission National de Aqua has endeavored to establish and enforce a system of water rights in the form of concessions and initiate a program to create groundwater user organizations to promote sustainable resource management. While this has helped to register most of its 90,000 tubewell owners, Mexico is finding it difficult to limit pumping to the quotas assigned to them (Scott et al. 2002).

An important aspect in groundwater management is the relation between groundwater irrigation and food security and livelihoods. In countries with shrinking agriculture, the proportion of people dependent on groundwater-irrigated agriculture tends to be small (see table 1, last column). 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 posture with irrigators, especially if serious environmental anomalies are 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, not for wealth creation as much as to support the livelihoods 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 percent of the value of irrigated farm output. Rapid groundwater development is at the heart of the agrarian

TABLE 1.
Groundwater usage, number of pumps used and extraction rate, and dependence on groundwater in different countries.

Country/province	Annual groundwater usage (km^3)	No. of pumps (million)	Extraction per pump (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

Sources: Hekmat 2002 for Iran; Mukherji and Shah 2002 for India; Scott et al. 2002 for Mexico; and Shah et al. 2002 for China and Pakistan.

dynamism found in some areas in eastern India where agriculture remained stagnant for a long time (Sharma and Mehta 2002). The greatest social value of groundwater irrigation is that it has helped to make famines a thing of the past. During 1963-66, a small deficit in rainfall left reservoirs empty and sent food production plummeting by 19 percent; but during the 1987-88 drought, when the rainfall deficit was 19 percent, food production fell by only 2 percent, thanks to widespread groundwater irrigation (Sharma and Mehta 2002).

It is often argued that with 60 million tons of food stocks, India can now assume a tough posture on groundwater abuse. However, this view misses an important point; contribution of groundwater to farm incomes and rural livelihoods is far more crucial than its contribution to food security, especially outside canal commands.[6] In South Asia, the proportion of the total population that is directly or indirectly dependent on groundwater irrigation for farm-based livelihoods is many times larger than that of Iran and Mexico. Indeed, our surmise is that at least three-fourths of the rural population and over half of the total population of India, Pakistan, Bangladesh and Nepal depend, directly or indirectly, on groundwater irrigation for their livelihoods. It is not surprising, therefore, that the energy-irrigation nexus has been at the center of vote-bank politics in the region.

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[6] 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 dry land in terms of production and income” (emphasis added).

Sectoral Policy Perspectives

Management of the Groundwater Economy

Groundwater policymakers face conflicting challenges in managing this chaotic economy in different areas of South Asia. Agrarian growth in the region, particularly after 1970, 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, the Nepal Terai and eastern India—groundwater development can produce stupendous livelihood and ecological benefits (Shah 2001). However, it is precisely here that development is slow and halting. In contrast, Pakistan Punjab, Indian Punjab, Haryana and all of peninsular India are rapidly overdeveloping their groundwater resources and it has reached a stage where agriculture in these areas faces a serious threat 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 to monitor groundwater resources, has no field force nor operational experience and capability in managing groundwater. Direct management of the 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, the favorable power supply environment can stimulate livelihood creation for the poor through accelerated groundwater development. But, as described later in this report, 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, energy and groundwater irrigation, and their pursuit of sectoral optima rather than managing the *nexus.*

Charging for Power to Agriculture: Flat Tariff or Metered Tariff?

The groundwater economy is an anathema to the power industry in the region. Agricultural use of power accounts for 15-20 percent of the total power consumption and power pricing to agriculture is a hot political issue. In India, the power supply to agriculture is free in states like Tamilnadu, Andhra Pradesh and Maharashtra while in other states, farmers pay a *heavily subsidized* flat electricity tariff, which is based on the horse-power rating of the pump rather than the actual consumption. Annual losses to Indian State Electricity Boards (SEBs) on account of power subsidies to agriculture are estimated at US$5.65 billion (Indian Rs 260 billion) and these losses are growing at a compound annual growth rate of 26 percent per year (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. However, these estimates have been widely contested. It has been shown that SEBs have been misassigning their growing transmission and distribution (T&D) losses in the domestic and industrial sectors as agricultural consumption, which is unmetered and so unverifiable.[7] However, the fact remains that the 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 favoring a reversion to the metered power supply and pricing system. The power industry has been leading this movement, and international agencies—particularly, the World Bank, the United States Agency for International Development and the Asian Development Bank—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 of India have been setting deadlines for SEBs and state governments to make a transition to universal metering. The Government of India has resolved to:

- provide power on demand by 2012,
- 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
- carry out regular energy audits to assess T&D losses and eliminate all power thefts within 2 years (Godbole 2002).

This is an ambitious agenda indeed. However, all moves towards metered power consumption have met with farmer opposition on an unprecedented scale in Andhra Pradesh, Gujarat, Kerala and other states of India. Most Indian states have been offering major inducements to tubewell owners to opt for metered connections. Until it announced free power to farmers in June 2004, Andhra Pradesh charged metered tubewells at only US cents 0.4-0.7 per kWh, and Gujarat and several other states only US cents 1.1-1.5 per kWh, compared to the supply cost of US cents 5-8 per kWh. In a recent move, the state government of Gujarat has offered a drip irrigation system free to any farmer who opts for metering.

Yet, there are few takers for metered electricity connections. Instead, the demand for free power to agriculture has gathered momentum in many Indian states.[8] 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 a metered tariff system, SEBs will start imposing all manner of new charges under different names. In addition, groundwater irrigators raise the issue of equity with canal irrigators, arguing that if the latter can be provided irrigation at subsidized flat rates by public irrigation systems, they too deserve the same terms for groundwater irrigation.

In South Asia, the power industry persists in the belief that its fortunes would not change until agriculture is put back on a metered electricity tariff regime. Strong support to this view 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. 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 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.

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[7] Shah (2001) has analyzed this aspect for the SEB of the Uttar Pradesh state of India and found that agricultural power use is 35 percent lower than that claimed. Similarly, based on a World Bank study in Haryana state, Kishore and Sharma (2002) report that the actual agricultural power consumption is 27 percent less than that reported, and the overall T&D loss is 47 percent while the official claim is that it is 36.8 percent, making the SEB more efficient than it actually is. The power subsidy ostensibly meant for the agricultural sector but actually accruing to other sectors is estimated at US$0.12 billion per year (Indian Rs.5.50 billion per year) for Haryana alone.

[8] And farmers are getting away with it in many states. The electricity supply to agriculture became a major issue in India's 2004 parliamentary and state elections. Chief Ministers of some states (Andhra Pradesh, Gujarat and Tamilnadu) suffered major electoral reverses, arguably, on account of the farmer opposition to their stand on the pricing of the electricity supply to agriculture. The new Chief Minister of Andhra Pradesh announced free power to farmers the day after he assumed office. The Chief Minister of Tamilnadu, who had abolished free power in the state, restored it soon after the election. Gujarat's Chief Minister softened his hard stand on farm power supply and in Maharashtra, the ruling party has promised to provide free power to farmers if it comes to power.

Making a Metered Tariff Regime Work

Arguments in favor of a metered tariff regime are several. One is that it allows state power utilities to manage their commercial losses; you cannot manage what you do not monitor and you cannot monitor what you do not measure. Another is that once farm power is metered, power utilities cannot use agricultural consumption as a carpet under which they can sweep their T&D losses in other sectors. It is also argued that metering would give farmers correct signals about the real cost of power and water, and force them to economize on their use. For reasons that are not entirely clear, it is often suggested that compared to a flat tariff regime, metered tariff would be less amenable to political manipulation and easier to raise when 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 groundwater availability.

The logic in support of metered tariff is obvious and unexceptionable. The problem is how to make a metered tariff regime work as envisaged. Two issues seem critical. First is how to deal with the relentless farmer opposition to metering. The second issue is how will power utilities now deal with the problems that forced them to switch to a flat tariff during the 1970s in the first place.

The extent of the farmer resistance to metering is evident in the repeated failure of State Electricity Boards (SEBs) in various states of India to entice farmers to accept metering by offering metered power at subsidized rates. The subsidized rates range from US cents 0.4 to 1.3 per kWh as against the actual cost of supply of US cent 5 to 8 per kWh. In late 2002, Batra and Singh (2003) interviewed 188 pump owners in Indian Punjab, Haryana and western Uttar Pradesh to understand their pumping behavior. They noted that in Indian Punjab as well as Haryana, an average electric pump owner would spend US$54.99 and US$147.94 *less* per year on their total power bill if they accepted metering at the prevailing rates of US cents 1.0 per kWh and US cents 1.4 per kWh, respectively. Yet they would not accept metering. In effect, this is the price they are willing to pay to avoid the hassle and costs of metering.[9]

Transaction Costs of Metering

Besides dealing with mass farmer resistance, protagonists of metering need also to consider the numbers of electric tubewells and the problems associated with metering them, which are now 10 times larger than when a flat tariff was first introduced. Before 1975, when all SEBs charged for farm power on a metered basis, logistical difficulties and transaction costs of metering had become so high that a flat tariff seemed to be the only way of containing it. A 1985 study by the Rural Electrification Corporation estimated that the cost of metering the rural power supply in Uttar Pradesh and Maharashtra was 26 percent and 16 percent, respectively, of the total revenue of the SEB from the farm sector (Shah 1993). And this estimate included only the direct costs, such as cost of meter, cost of maintaining it, cost of the power consumed by the meter, and the costs of meter reading, billing and collection of payments. These costs are not insignificant.[10] However, the far bigger part of the transaction cost of metering is the cost of containing pilferage, tampering with meters, and undercharging by meter readers in connivance with farmers.

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[9] According to Batra and Singh (2003), farmers resist metering because of the prevalence of irregularities in the SEBs. Frequent meter burn-outs, which cost the farmer US$21.74 (Indian Rs 1,000) per meter, false billing, uncertainty about the accuracy of bills, etc. make farmers reject metering. 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 rental charge, the “minimum bill,” which they have to pay even if they do not use electricity in a given month.

[10] A recent World Bank study in the small Indian state of Haryana estimated that the cost of metering all farm power connections in the state would amount to US$30 million (Indian Rs 1,380 million) in capital investment and US$2.2 million (Indian Rs 101.2 million) per 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 US$0.25 billion (Indian Rs 11.50 billion) (Godbole 2002).

All in all, the power sector's aggressive advocacy of a metered tariff regime in agriculture is based, in our view, on excessively low estimates of the transaction costs of metering, meter reading, billing and payment collection from several hundred thousand electric tubewell users scattered over a vast area[11] that each power utility serves. Most Indian SEBs find it difficult to manage a metered power supply even in industrial and domestic sectors where the transaction costs involved are bound to be lower than those in the agriculture sector. Even where meters are installed, many SEBs are unable to collect charges based on metered consumption. In Uttar Pradesh, 40 percent of the low-tension power consumers has metered connections, but only 11 percent is billed on the basis of metered use; the remainder is billed based on a minimum charge or an average of the 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 percent collection of amounts billed has worked only for industries. In the domestic and farm sectors—with a large number of scattered small users—collection as a percentage of billing declined from 90.5 percent in 1995/96 to 74.6 percent in 1999/2000 (Panda 2002).

Achieving Success: An Example from North China

In order to make a metered tariff regime work reasonably well, three things seem essential: (i) the metering and collection agent must have the requisite authority to deal with deviant behavior among users; (ii) the agent should be subject to a tight control system so that he can neither behave arbitrarily with consumers[12] nor work in collusion with them; and (iii) he must have proper incentives to enforce the metered tariff regime. A quick assessment by Shah (2003) of a metered tariff regime in north China, where the agrarian conditions are in some ways comparable to South Asia, suggests that all the above conditions are found there in some way, and therefore, the metered tariff regime works reasonably well in this area of north China (Shah et al. 2004a).

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 usage. Unlike in much of India, where farmers pay for power either nothing or much less than domestic and industrial consumers, 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 also is vested in local units in ways that ensures 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 the power usage recorded at the transformer level. In many areas, where power supply infrastructure is old and worn out, line losses below the transformer made this difficult. To allow for normal line losses, a 10 percent allowance is given by the Township Electricity Bureau to the village unit. However, even this must have made it difficult for the latter to tally the payments collected with the units recorded at transformer level. As a result,

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[11] Rao and Govindarajan (2003) lay particular emphasis on the geographic dispersion and remoteness of farm consumers in increasing the transaction costs of metering and billing. For example, a rural area of the size of Bhubaneshwar, the capital of Orissa state, has approximately 4,000 consumers with an electricity charge collection potential of US$15,217 (Indian Rs 0.7 million) a month. Bhubaneshwar has 96,000 consumer with a collection potential of US$0.48 million (Indian Rs 22.0 million) a month.

[12] In states like Gujarat, which had a metered tariff regime until 1987, an important source of opposition to metering was the arbitrariness of meter readers and the power they had come to wield over the farmers. In many villages, farmers organized themselves with 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.

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.[13] 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 total consumption recorded by individual users, especially with the line-loss allowance of 10 percent (Shah et al. 2004a).

An important reason why this institutional arrangement works is the strong local authority structure in Chinese villages. The electrician is respected because the Village Committee and the powerful Party Leader at the village level back him, and the new service orientation is designed partly to project the electrician as a friend of the people. The same Village Committee and Party Leader can also check any flagrantly arbitrary behavior of the electrician with the users. The hypothesis that with better quality power and support service, farmers would be willing to pay a high price for power is best exemplified in Hanan where at US cents 8.75 per kWh,[14] farmers pay a higher electricity rate compared to most categories of users in India and Pakistan.

In India, there has been some discussion about the level of incentive needed to make privatization of electricity retailing attractive at the village level. A village electrician in Hanan or Hebei is able to deliver on a fairly modest reward of US$25.00 per month (Yuan 200 per month, which is equivalent to half the value of wheat produced on 1.0 mu or 0.067 hectare of land). For this rather modest reward, the village electrician undertakes to make good to the Township Electricity Bureau the full value of line and commercial losses in excess of 10 percent of the power consumption recorded at the transformers. If he can manage to keep losses to less than 10 percent, he can keep 40 percent 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 have built an incentive-compatible system that delivers quickly. They did not waste time on rural electricity cooperatives and Village Electricity Associations (*Vidyut Sangha*s) that are being tried in India and Bangladesh. In 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 down from one level to the level below.

Can South Asia Emulate the Chinese Model?

If South Asia is to change to a metered tariff regime, the Chinese offer a good model. But there are two problems. First is the low gross value of agricultural output in most of South Asia. Chinese agricultural productivity is so much higher than that in most regions of South Asia that even with power charged for at real cost, the cost of tubewell irrigation constitutes a relatively small proportion of the gross value of output. In South Asia, irrigation costs in the range of US$45.65 to 186.96 per hectare would make groundwater irrigation unviable in all regions except parts of Indian and Pakistan Punjab and Haryana where farm productivity approaches 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 system of authority at the village level. Absence of an effective local authority that can ensure compliance to rules and regulations and proper behavior by both farmers and metering agents may create unforeseen complications in adapting the Chinese model to South Asia.

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[13] A reward system for the village electrician encourages him to take action to achieve greater efficiency by cutting line losses. In Dong Wang nu village in Ci county, the Village Committee’s single large transformer that served both domestic and agricultural power connections caused heavy line losses of 22-25 percent. Once the Network Reform Program began, the village electrician pressurized the Village Committee to sell the old transformer to the Township Electricity Bureau and raise US$1,250 (Yuan 10,000), partly by collecting a levy of US$3.12 (Yuan 25) per family and with a contribution from the Village Development Fund, to buy two new transformers, one for domestic connections and the other for pumps. Since then, power losses have fallen to a permissible level of 12 percent here (Shah et al. 2004a).

[14] US$1.00 = Yuan 8.00 = Indian Rs 46.00 = Pakistan Rs 60.20 = Bangladeshi Taka 60.90 = Nepalese Rs 74.50 (July 2004).

In India, pilot projects to find new metering solutions have been started recently. Indian Grameen Services, a nongovernmental organization (NGO), organized Transformer User Associations in the Hoshangabad district of Madhya Pradesh state to implement a plan under which the SEB will set up a dedicated power plant if farmers paid unpaid dues and agreed to a metered tariff system. However, before the 2004 elections, the Chief Minister waived the unpaid dues of farmers and the Hoshangabad associations disintegrated, its members disillusioned. The state of Orissa organized similar Village Electricity User Associations (*Vidyut Sangha*s), in thousands, under its reforms but these lie defunct now. 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 percent of the rural power load in Orissa is used for agriculture. In Gujarat, where the agricultural power consumption is 50 to 80 percent of the total rural power consumption, it is difficult to envisage what kind of treatment collection agents would receive from farmers. Though it is too early 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.[15] That model seems passé; for electric power as well as surface water, unit or volumetric pricing can work, where needed, only through smartly designed incentive contracts.

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

A flat tariff system for pricing farm power is generally written off as inefficient, wasteful, irrational and distortionary, besides being inequitable. In the South Asian experience, it has indeed proved to be so. It was the change to a flat tariff system that encouraged political leaders to indulge in populist whims such as doing away with the farm power tariff altogether (as Andhra Pradesh, Tamilnadu and more recently, Maharashtra have done) or pegging it at unviably low levels, regardless of the true cost of the power supply. Such actions have led to the general perception that the flat tariff regime has been responsible for ruining the electricity industry and causing groundwater depletion in many parts of South Asia.

However, we would like to suggest that the flat tariff regime is wrongly maligned. In fact, the flat tariff system that South Asia has used in its energy-irrigation nexus so far is a completely *degenerate* version of what could have been 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.

Pros and Cons of Flat Tariff

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 the marginal cost of supply. Yet, businesses commonly price their products or services in ways that violate the marginal cost principle but makes overall business sense. Flat rates are often charged to stimulate use to justify the incremental cost of providing a service. In the early days of rural electrification, power utilities used to charge a flat-cum-pro-rata tariff to induce each tubewell owner to use at least the amount of power that would justify its investment in laying the power lines; the flat component of

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[15] A 1997 consumer survey of the power sector in India revealed that: 53 percent of consumers had to pay bribes to electricity staff for services supposed to be free; 68 percent suggested that grievance redress is poor or worse than poor; 76 percent found staff attitudes to be poor or worse; 53 percent found repair of fault services to be poor or worse; 42 percent said they had to make 6 to 12 calls just to register a complaint; 57 percent knew of power thefts in their neighborhoods; 35 percent complained of excess billing; and 76 percent complained of inconvenience in paying their bills (Rao 2002).

the tariff encouraged users to achieve this level. India's telephone department still charges the first 250 calls in every billing cycle at a flat rate even though all calls are metered; the idea here is to encourage the use of the telephone service to a level that justifies the incremental cost of providing the service.

In general, however, a 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 a piece rate when their work output is easy to measure. But flat rate compensation is popular worldwide because it is not easy to measure the marginal value of the output of an employee on a daily basis. Urban public transport systems offer passes to commuters at attractive flat rates in part because commuters offer a stable business but equally because it reduces queues at ticket windows and the cost of ticketing and collecting fares daily. Cable television operators in India still charge a flat tariff for a group 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 a flat income tax of US$30.44 per year, instead of launching a nationwide campaign to bring these millions of small businesses within its tax net, because the transaction costs of doing that would have been far greater than the revenue realized. A major reason municipal taxes are levied on a flat rate is the high transaction cost of charging citizens according to the marginal value they place on municipal services.

Flat Tariff with Supply Management

Are all the 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 with public goods, like municipal services and defense, the feature of 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 flat rate charges 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 a volumetric basis. However, nowhere in South Asia can we find volumetric water pricing practiced in canal irrigation. In our view, the transaction costs of collecting volumetric charges for canal irrigation become prohibitively high (Perry 1996; Perry 2001) because:

- In a typical South Asian system, the number of customers involved per 1,000 ha of command is quite large; so the cost of monitoring and measuring water use by each user would be high.
- Once a gravity flow system is commissioned, it becomes extremely difficult in practice for the system managers to exclude defaulting customers of the command area from availing themselves of irrigation when others are.
- The customer propensity to frustrate the seller's effort to collect a charge based on use would depend in some ways on the magnitude of the charge as a proportion the customer's overall income.

Volumetric pricing of canal irrigation would be far easier in irrigation systems serving a small number of farmers. An example is South African irrigation systems where a branch canal may serve some 5,000 ha owned by 10 to 50 white commercial farmers. Charging them for irrigation based on actual use would be easier than in an Indian system where the same command area would have 6 to 8 thousand 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 irrigated to a level that ensures the overall viability of the systems.

Supply restriction is inherent to *rational* flat rate pricing; by the same token, flat rate pricing is incompatible with on-demand service 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 satisfy the customer by providing an on-demand service without quantity or quality restrictions of any kind. 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.

Intelligent Management of Rationed Power

The reason why the flat rate tariff for power supply to agriculture, as currently practiced in South Asia, is degenerate—and the power industry is in the red—is because the power utilities have failed to invest more intelligence in managing a rationed power supply. In India, under the flat tariff system until now, most SEBs have tried to maintain the duration of the farm power supply at 8-15 hours per day right through the year. Raising the flat tariff to a level that covers the cost of present levels of supply would make it so high that it will send state governments tumbling in the face of farmer wrath.[16]

However, we believe that it is possible for power utilities to satisfy farmer needs while reducing the total power supply to farmers during a year by fine-tuning the scheduling of power supply to the irrigation needs of farmers. Ideally, the business objective of a power utility charging a flat tariff should be to supply the best quality service it can offer to 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)—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 sectors. For the domestic consumer, a good quality service is power of uniform voltage and frequency supplied 24 hours per day, 365 days of the year. But for the irrigators a good quality service from power utilities is power of uniform voltage and frequency when their crops face critical moisture stress. We argue that, with intelligent management of the power supply, it is possible to satisfy the irrigation power demand by ensuring a supply of 18-20 hours a day for 40-50 key moisture-stress days in the kharif and rabi seasons of the year, with some power available on other days. Against this, Tamilnadu supplies power to farmers 14 hours per day for 365 days of the year! This is equivalent to supplying 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 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 in a year. In most irrigation systems, in fact, he would be happy if he gets water 6 times in a year. An example is the new Sardar Sarovar project in Gujarat, India. The Sardar Sarovar dam is built on the Narmada river. In this project, the policy is to provide farmers a total of 53 cm water in 5-6 installments during a full year. To supply this depth of water, an irrigation well with a modest output of 25 m^3 per hour would pump for 212 hours for each hectare. In terms of water availability, a 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 hours of power in a year. He would be better off if the 636 hours of power comes when he needs the water most. When the Gujarat government commits to a year-round farm power supply of 8 hours per day, it in effect offers tubewell owners water entitlements 14 times larger than the water entitlements that the

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[16] In Madhya Pradesh, the Chief Minister announced a six-fold hike in the flat tariff in 2002. No sooner was the announcement made, there was a realignment of forces within the ruling party and the most senior cabinet ministers began clamoring for a leadership change. Subhash Yadav, the Deputy Chief Minister, lamented in an interview with India Today, "A farmer who produces 10 tons of wheat earns Rs 60,000 (US$1,304.35) and he is expected to pay Rs 55,000 (US$1,195.65) to the electricity board. What will he feed his children with and why should he vote for the Congress?" (India Today 2002.32). The farmers stopped paying the revised flat rate 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).

Sardar Sarovar project offers to farmers in its command area.[17] Under a metered tariff system, this may not matter all that much since tubewell owners would use power and groundwater only when their value exceeds the marginal cost of pumping. But under a flat tariff system, they would have a strong incentive to use some of these "excess water entitlements" for low marginal value uses just because it costs them little on the margin to pump groundwater. This is why the present flat tariff in South Asia is *degenerate.*

A rational flat tariff regime, if well managed, can confer two large benefits. First, it may curtail wasteful use of groundwater. If the farm power supply outside main irrigation seasons is restricted to 2-3 hours per day, it will encourage farmers to build small on-farm storage tanks to store water for multiple uses. Using a progressive flat tariff—charging higher rates for increasing horse power of pumps—will produce additional incentives 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, a 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 reductions in technical and commercial losses of power. The parallel with water supply systems is clear here. For example, Briscoe (1999) wrote that throughout the Indian subcontinent, the proportion of unaccounted-for water in the 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 the water pressure very low. In Madras, for example, it is estimated that if the water supply to the city was to increase from current levels (of about 2 hours of supply a day at 2-meter pressure) to a reasonable level (say 12 hours a day at 10-meter pressure) leaks would account for a loss of about 900 million liters per day, which is about three times the current supply to the city! Much the same logic works in farm power, with the additional caveat that the T&D system of farm power 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 system into a 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. There are five preconditions, which seem important and feasible, for achieving these objectives.

1. Separation of agricultural and nonagricultural power supplies

The first precondition for successful rationing is infrastructural changes needed to separate the agricultural power supply from the nonagricultural power supply to rural settlements. The most common way this is done now is to keep 2-phase power on for 24 hours so that domestic and (most) nonagricultural uses are not affected and ration the 3-phase power necessary to run irrigation pumps. This is working, but only partially.

In India, the farmer response to rationed 3-phase power in states like Gujarat is rampant use of phase-splitting capacitors with which they can run pumps on even 2-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 program (called *Jyotirgram Yojana)* to lay parallel power supply lines for agricultural users in 16,000 villages of the state over the next three years at an

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[17] At a rate of 25 m^3 per hour, a tubewell can pump 73,000 m^3 of water if it is operated whenever the power supply is on. At the water entitlement of 5,300 m^3 per hectare prescribed in the Sardar Sarovar project, this volume of water can irrigate 13.77 ha of land.

estimated cost of US$195.7 million. In Andhra Pradesh, the process of separation of domestic and agricultural feeders is already 70 percent complete (Raghu 2004). This would ensure that industrial users in the rural areas who need an uninterrupted 3-phase power supply as well as domestic users remain unaffected by the rationing of power supplies to 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 feeder level.

2. *Gradual and regular increases in flat tariff for power*

Flat tariffs have a tendency to be unchangeable. In most Indian states, flat tariffs for power have not changed for over 10-15 years while the cost of generating and distributing power has soared. Raising the flat tariff at once 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 percent annual increase in flat tariff far more easily than a 350 percent increase as has been proposed by the Electricity Regulatory Commission in Gujarat.

3. *An explicit subsidy*

If we are to judge the value of a subsidy to a large mass of people by the scale of popular opposition in India to curtailing it, there is little doubt that, among the plethora of subsidies that state governments in India provide, the power subsidy is one of the most valued. Indeed, any decision by a ruling party to curtail the power subsidy is the biggest weapon that opposition parties will use to bring down the 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 and recommend. However, the problem with the power subsidy in the current, degenerate flat tariff system is its indeterminacy. Chief Ministers of Indian states keep issuing 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, the 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 energy the flat tariff and the government subsidy can buy for agricultural use.

4. *Use of off-peak power*

In estimating losses from the 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 supplying power to agriculture under a flat tariff system. 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.[18] Over half of the power supply to the farm sector is in the night, and this proportion can increase further. But in computing the amount of power the prevailing flat tariff and pre-specified subsidy can buy, the power utilities must use the lower opportunity cost of the off-peak supply.

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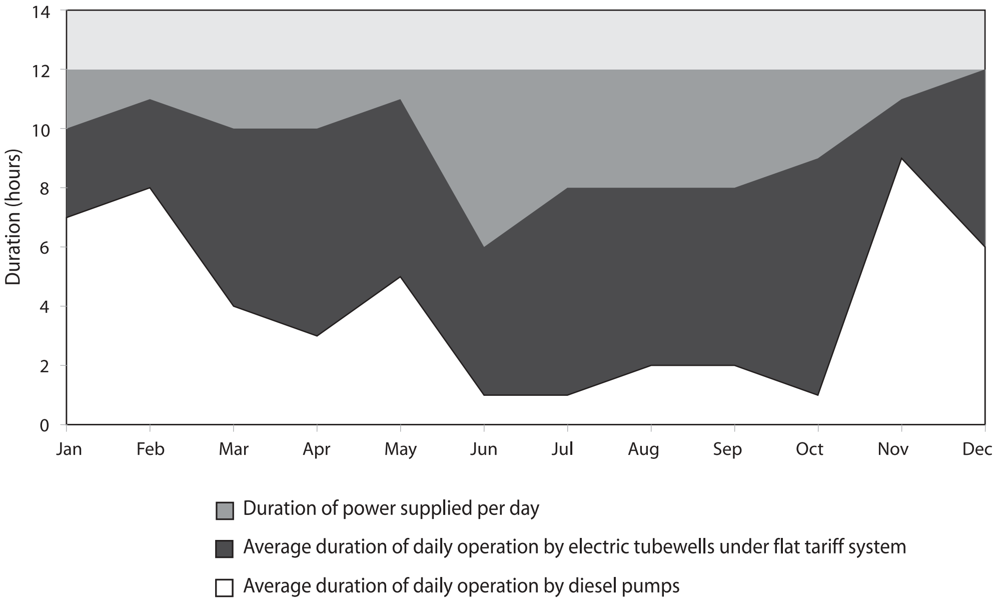
[18] The cost of the power supply has three components: energy cost, fixed generation cost and T&D cost. The first two account for about 60-80 percent of the total cost of supplying power. The energy cost, which is variable, depends on the length of time of power consumption but the fixed generation cost depends on how much a consumer consumes at peak load. The T&D cost depends 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 the power supply to agriculture is lower than the overall average cost of the supply. Moreover, agricultural consumption, most of it off-peak, helps smoothen the load curve for the whole system and saves on the back-up cost, which is high for coal-based plants and insignificant for hydropower plants.

FIGURE 3.
Duration of power supply and duration of operation of electric and diesel pumps.



Note: This is a schematic diagram. The numbers shown are indicative and not based on actual field data.

5. Intelligent supply management

There is tremendous scope for cutting costs and improving the service through supply management (figure 3). In India, the existing policy in many states of maintaining a constant power supply to the farm sector during pre-specified hours, according to a roster, is irrational and is the prime reason for the wasteful use of power and water.[19] Ideally, the power supply to the farm sector should be so scheduled as to reflect the pumping behavior of a modal group of farmers in a given region where they would be subject to metered power tariff at full cost. However, it is difficult to simulate this behavior because farmers everywhere are charged under a flat tariff system under which they would have a propensity to use power whenever it is available, regardless of its marginal product. In many Indian states, there is a small number of new tubewells 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. By comparing the electricity use before and after flat tariff, the extent of overutilization of power and water attributable to flat tariff could be gauged.[20]

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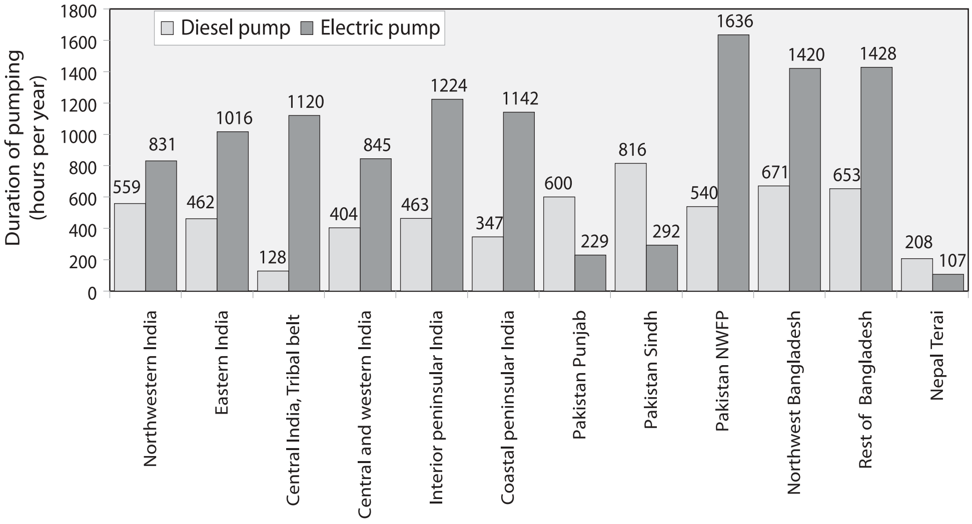
[19] In Tamilnadu, where the farm power supply is free, 14 hours of 3-phase power, 6 hours during day and 8 hours during night, is supplied throughout the year. In Andhra Pradesh, 9 hours of 3-phase power supply is guaranteed, 6 hours during the day and 3 hours during the night (Palanisami and Kumar 2002); this was recently reduced to 7 hours when the new government began providing power free. This implies that in theory, a tubewell in Tamilnadu can run for over 5,000 hours in a year; and in Andhra Pradesh, it can run for 3,200 hours. If the real cost of power is taken as US cents 5.4 per kWh, depending upon how conscientious he is, a Tamilnadu farmer operating a 10 hp tubewell can avail himself of a power subsidy as high as US$2,038 (Indian Rs 93,750) per year, and an Andhra farmer, US$1,304 (Indian Rs 60,000) per year. Reports that farmers use automatic switches to turn on the tubewells whenever the power supply starts suggest that many farmers are going to extremes in using power and water. Palanisami and Kumar (2002) mention the use of such automatic switches by farmers who own bore-wells, to lift water during the night to fill an open well; during the day, they pump the water from the open well to irrigate their fields! They would not indulge in such waste if they had to pay a metered charge of US cents 5.4 per kWh and they would also not do this if they got only 3-4 hours of good quality power during convenient hours on a pre-announced schedule.

[20] An extreme case is Tamilnadu, where electricity consumption per tubewell shot up from 2,583 kWh per year under a metered tariff system in the early 1980s to 4,546 kWh per year during 1997-98. However, this jump represents 3 components: (a) increased consumption due to the degenerate flat tariff; (b) increased consumption because of the increased average lift caused by resource depletion; and (c) T&D losses in other segments that are wrongly assigned to agriculture. Palanisami (2001) estimated that 32 percent of the increased power use was explained by additional pumping, and 68 percent by increased lift. However, he made no effort to estimate the T&D losses, which we suspect are quite large.

However, our surmise is that the pumping behavior of diesel pump owners, who are subject to the full marginal cost of energy comparable to what electric tubewell owners would pay under an unsubsidized metered tariff regime, would provide a good indicator of the temporal pattern of power use by electric tubewells under a metered tariff regime. Several studies have shown that the annual duration of operation of diesel tubewells is often half or less compared to electric tubewells using flat-tariff power (Mukherji and Shah 2002).[21] Batra and Singh (2003) interviewed some 188 farmers in Indian Punjab, Haryana and Central Uttar Pradesh to explore whether the pumping behavior of diesel and electric pump owners differed significantly. They did not find significant differences in Indian Punjab and Haryana[22] but their results for central Uttar Pradesh suggest that diesel pumps are used when irrigation is needed and electric pumps 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 4 and 5 present the central premise of our case: a large part of the excess of pumping by electric tubewells over diesel tubewells is indicative of the waste of

FIGURE 4.
Duration of operation (hours per year) of electric (flat tariff) and diesel pumps: India and Bangladesh, 2002.



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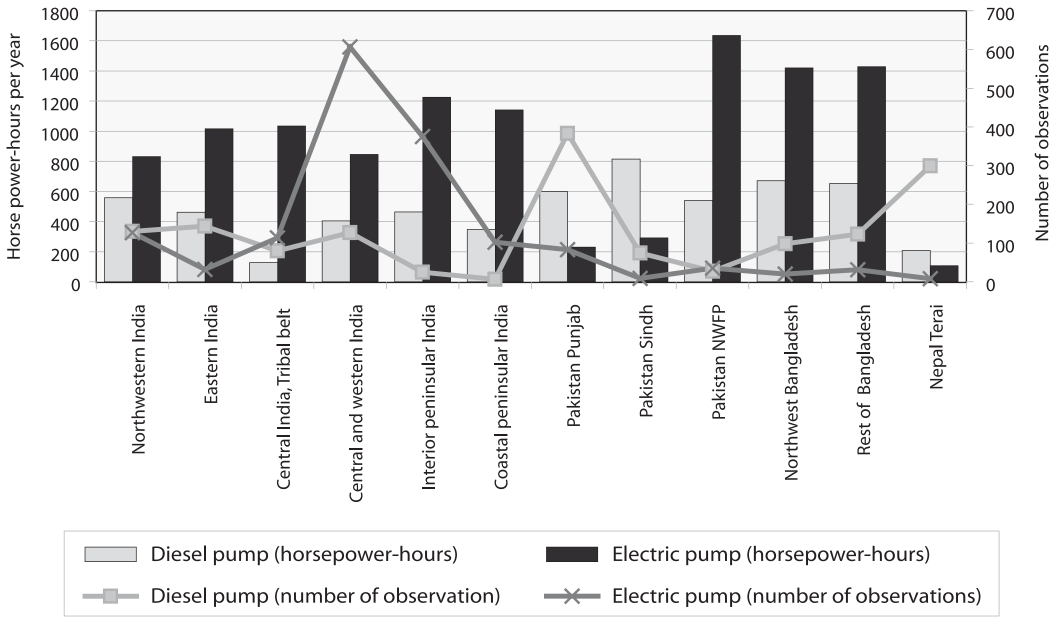
[21] We recognize that comparing the duration of operation of diesel and electric tubewells is not the same as comparing the quantity of water extracted. However, in understanding the economic behavior of tubewell owners, we believe that comparing the duration of operation is more meaningful than comparing the quantity of water extracted. In any case, for the same duration of pumping, an electric pump would produce more water per horsepower compared to a diesel pump *ceteris paribus* due to the higher efficiency of the electric pump.

[22] Indian Punjab and Haryana have a much more productive agriculture compared to other parts of India with the cost of irrigation being just 8-10 percent 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 examined.

FIGURE 5.
Duration of pump operation weighted by horsepower rating of electric (flat tariff) and diesel pumps: India and Bangladesh, 2002.



water and power that is encouraged by the zero marginal cost of pumping under the present degenerate flat tariff regime. Figure 4 presents results of a survey of 2,234 tubewell irrigators across India and Bangladesh in late 2002. It shows that electric tubewell owners subject to flat tariff everywhere in the survey area invariably operate their pumps for a much longer duration compared to diesel pump owners who face a steep marginal energy cost of pumping (Mukherji and Shah 2002). It might be argued that the duration is less because diesel pumps, on average, might be bigger in capacity compared to electric pumps. So we also compared the duration of pumping weighted by the horsepower rating of the pump, and figure 5 shows that the number of horsepower-hours of use of electric pumps under flat tariff too are significantly higher than that for diesel pumps everywhere in the area of survey by 40 to 150 percent. 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

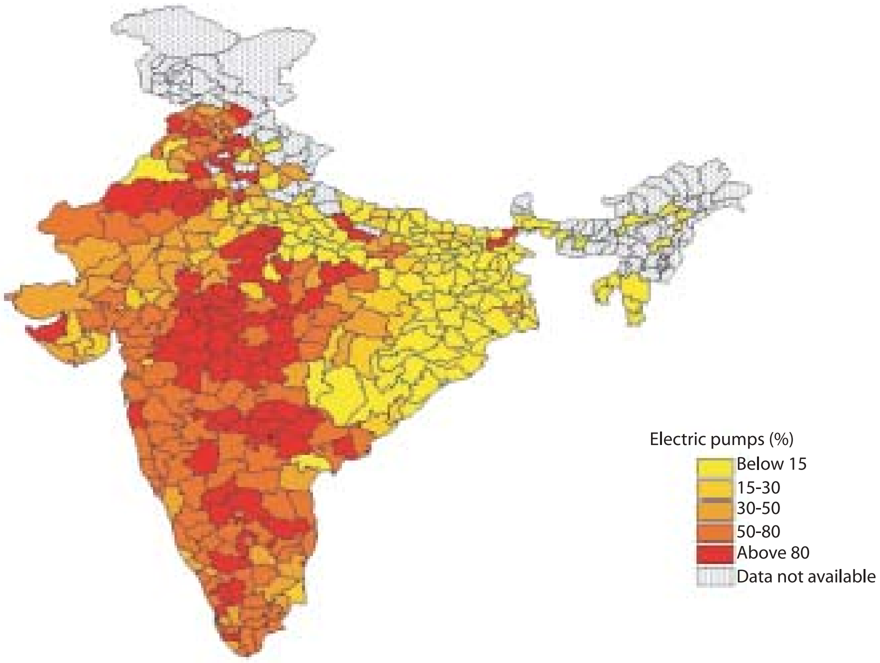
If power utilities undertake a refined analysis of the level and pattern of pumping by diesel pump owners in a region, and shave off the potential excess pumping by flat-tariff paying electric tubewell owners (as shown in figure 3) by fine-tuning the power supply schedule around the year, flat tariff can not only become viable but also socially optimal by eliminating "waste."

In India, the average number of hours for which diesel pumps operate is between 500 and 600 per year. At 600 hours of annual operation, an electric tubewell would use about 450 kWh of power per horsepower of the pump. If all the power used is off-peak load, discounted at 25 percent of a generation cost of US cents 5.43 per kWh, the power utility supplying farm power would break even at a flat tariff of US$18.34 per horsepower per year. The flat tariff rate in force in Gujarat since 1989 is US$10.87 (Indian Rs 500) per horsepower per year. The Gujarat state government is committed to raise the flat tariff eventually to around US$45.65 (Indian Rs 2,100) per horsepower per year at the instance 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 the flat tariff in stages to about US$26.00 (Indian Rs 1,200) and restrict the annual supply of farm power to 1,000 to 1,200 hours against the 3,000 to 3,500 hours of power per year provided now. A 5-hp pump lifting 25 m^3 of water per hour over a head of 15 meters can extract 30,000 m^3 of water per year in 1,200 hours of tubewell operation, sufficient to meet the needs of most small farmers in the region.

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

1. Enhancing the *predictability* and *certainty of the supply:* More than the total quantum of power delivered, in our assessment, the power supplier can help farmers by announcing an annual schedule of power supply finely tuned to match the demand pattern of farmers. Once announced, the utility must stick to the schedule so that farmers can be certain about power availability.
2. Improving the *quality of the power supply*: Whenever power is supplied, it should be at the specified, standard voltage and frequency, minimizing damage to motors and downtime of transformers due to voltage fluctuation and unstable frequency.
3. Better *matching of supply to peak periods of moisture stress*: Most canal irrigators in South Asia manage with only 3 to 4 canal water releases in a season. There are probably 2 weeks during kharif and 5 weeks during rabi in a normal year when the average South Asian irrigation farmer experiences great nervousness about moisture stress to his crops. If the power utility can take care of these periods, 80-90 percent of the farmers' power and water needs would be met. This will, however, not help sugarcane growers of the Indian states of Maharashtra, Gujarat and Tamilnadu who are a big part of the power utility's problems in these Indian states.
4. Better *upkeep of the farm power supply infrastructure*: Intelligent power supply management to agriculture is a tricky business. If power rationing is done through arbitrary power cuts and the rural power infrastructure is neglected, there could be disastrous consequences. Eastern India is a classic example. After the eastern Indian states switched to a flat power tariff, they found it difficult to maintain the viability of power utilities in the face of organized opposition to raising the flat tariff from militant farmer leaders like Mahendra Singh Tikait. As a result, the power utilities began to neglect the maintenance and repair of the power infrastructure and the rural power supply was reduced to a trickle. Unable to irrigate their crops, farmers began en masse to replace electric pumps with 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. As figure 6 shows, electric

FIGURE 6.
Distribution of electric pumps, as percentage of total pumps used for groundwater extraction, in India, 1993-94.



Note: Data for Gujarat, Karnataka and Tamilnadu are based on the Minor Irrigation Census of 1986, as these states were not included in the 1993-94 Minor Irrigation Census, which is the basis of the data for the other states.

pumps dominate groundwater irrigation in the western parts of India while diesel pumps are preponderant in the east. In these groundwater abundant eastern regions of India, small diesel pumps, though dirtier and costlier to operate, kept the agricultural economy going. But in regions like north Gujarat, where groundwater is lifted from depths of 200-300 meters, such de-electrification can completely destroy the agricultural economy.

A 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 the water demand in agriculture is inelastic, within a large range, to the cost of pumping water. While a metered charge system without subsidy can make power utilities viable, it may not help much to cut water use and encourage water saving in agriculture. If anything, a growing body of evidence suggests that water and power saving methods respond more strongly to the scarcity of these resources than to their price. Pockets of India where drip irrigation is spreading rapidly—such as the Aurangabad region in Maharashtra, Maikaal region in Madhya Pradesh, Kolar in Karnataka, and Coimbatore in Tamilnadu—are all areas where water or power is scarce rather than costly. A rational flat tariff system with intelligent power supply rationing to the farm sector holds out the promise of minimizing wasteful use of water and power and encouraging technical change towards water and power saving. Our surmise is that such a strategy could easily reduce the annual groundwater extraction in western and peninsular India by 12-21 km^3 per year and reduce energy use in groundwater extraction by 4-6 billion kWh per year, valued at US$220-330 million.

Approaches to Rationing

Improving the Current System

The strongest piece of evidence in support of our argument for "*intelligent*" rationing of the farm power supply as the way to improve groundwater conservation and power sector viability is the experience of State Electricity Boards (SEBs) in India. Most SEBs have followed some kind of rationing of the farm power supply for over a decade. Andhra Pradesh, where the new state government announced free power to farmers in June 2004, has now decided that the farm power supply would henceforth be restricted to 7 hours per day. Nobody, including farmers, consider a 24-hour, 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 state governments almost everywhere in India are carried out in terms of the minimum hours of daily power supply the government can guarantee.

A power supply of constant duration per day to farmers, which is the current norm, is the least intelligent way of rationing power 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 and, on many other days when the need for irrigation is not high, it leads to wasteful use of power and groundwater. From where the present power rationing practices of SEBs stand today, they only have to improve by achieving a better fit between power supply schedules and farmers' irrigation schedules. Farmers keep demanding that the "constant hours per day" must be increased because the present system does not provide enough power when they need it most.

Illustrative Approaches

The rationing of the power supply to agriculture, while raising farmer satisfaction and controlling power subsidies, can be carried out in ways that reduce farmers' uncertainty about the timing of power availability or achieve a better fit between power supply schedules and irrigation schedules, or both. We suggest a few illustrative approaches that need to be considered and tried out.

Agronomic Scheduling

Ideally, power utilities should aim to achieve the "best fit" by matching power supply schedules with irrigation needs of farmers. In this approach to rationing, the power utility: (i) constantly studies the irrigation behavior 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 (figure 7). The advantages of such a system are: (i) farmers are happier; (ii) the total power supplied to agriculture can be reduced; (iii) power and water waste is minimized; and (iv) the level of subsidy to farmers is within the control of the power utility. The key disadvantage of this approach is that it is highly management intensive and, therefore, difficult to operationalize.

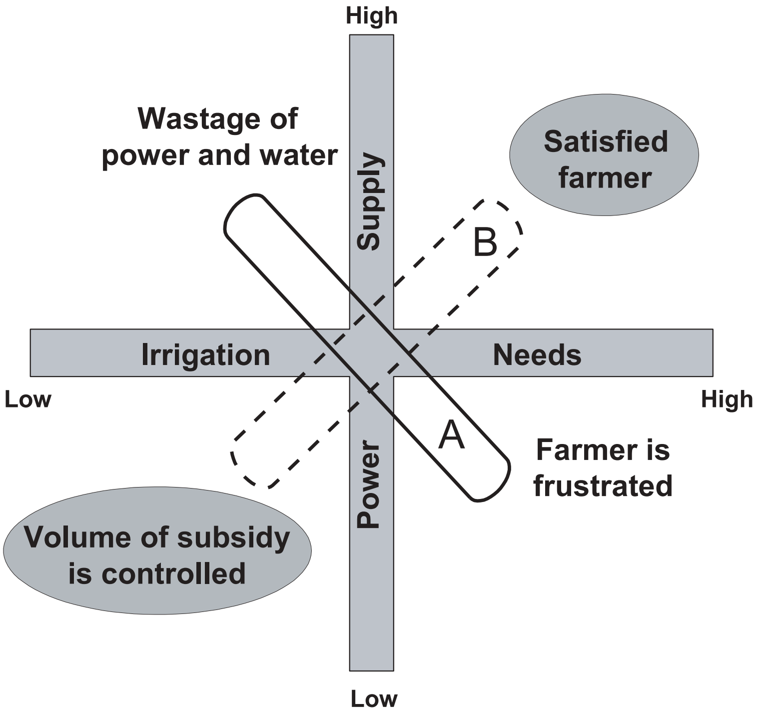
Demand-based Scheduling

In this approach, feeder-level farmer committees or other representational bodies of farmers assume the responsibility of ascertaining member 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 may make it more difficult to serve the power according to the schedules. Moreover, the organizational challenge this approach poses is formidable.

Canal-based Scheduling

Tubewell irrigators outside canal commands justify their demands for power subsidies by comparing their lot with canal irrigators who get cheap canal irrigation without any capital

FIGURE 7.
Improving farmer satisfaction and controlling subsidies for electricity through intelligent management of the farm power 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).

investments of their own. However, under the present, degenerate flat tariff system, tubewell irrigators often have the best of both the worlds. For example, in the Indian state of Andhra Pradesh, at 10 hours of power supply per day, a tubewell 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 only for 10-15 times in an entire year. In this approach, power rationing aims to remove the inequity between tubewell and canal irrigators by scheduling the power supply to mimic the irrigation schedule of a benchmark public irrigation system. This can drastically reduce power subsidies from current levels, but for that very same reason, will face stiff resistance from tubewell irrigators.

Zonal Roster

An approach to rationing that is simpler to administer is to divide the area covered by a power utility into zones, say 7 zones, each zone assigned a fixed day of the week when it gets 20 hours of uninterrupted, quality power throughout the year. On the rest of the days, each zone gets 2 hours of power. This is somewhat like a weekly turn in the *warabandi* system of canal irrigation systems in Indian Punjab and Pakistan Punjab. The advantages of this approach are: (i) it is easy to administer; (ii) the agricultural power load for the area as a whole remains constant, and becomes easier to manage for the power utility; (iii) the level of subsidies is controlled; and (iv) the power supply to each zone is predictable and so the farmers can plan their irrigation easily. The disadvantages are: (i) farmers in deep water-table areas or areas with poor aquifers (for example, Saurashtra in the Indian state of 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 Roster

The zonal roster can help farmers plan their cropping patterns and irrigation schedules by reducing uncertainty in the 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 roster for the kharif and rabi seasons makes little sense. Modifying the zonal roster system so that the power supply offered is higher in winter and summer than in the monsoon season would improve the seasonal fit as well as reduce uncertainty.

Conclusion

We have reevaluated the entire debate on the supply of power for groundwater irrigation in South Asia. In examining the energy-irrigation nexus, issues that are unique to South Asia and the North China Plain came into focus. In India, the biggest groundwater user in the world, either a switch to a metered tariff regime at this juncture or increasing the flat tariff fourfold, as proposed in Gujarat, will very likely backfire in most of the states. Metering is highly unlikely to improve the fortunes of the power utilities, which have found no smarter way of dealing with the exceedingly high transaction costs of a metered farm power supply that led them 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 the higher cost of a 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, to meter individual power consumption and collect revenue rather than experiment with wooly ideas of electricity cooperatives, which continue to be promoted (Gulati and Narayanan 2003:129). Despite 50 years of effort to make these cooperatives work, including provision of donor support, they have not succeeded in India. The 50-year old Pravara electricity cooperative in Maharashtra survives but owes the SEB several billions of Indian rupees in unpaid dues (Godbole 2002).[23]

In promoting the metering of the farm power supply, it should be borne in mind that the largest component of the transaction costs of metering, which is the most difficult to manage, arises from measures taken to contain user efforts to frustrate the metered tariff regime, by pilfering power, making 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 malpractice.[24] One reason why metering works reasonably well in China is

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[23] 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: 2197).

[24] The transaction costs of charge collection will be high even under a flat tariff regime if farmers think they can get away with cheating. Throughout India and Pakistan, replacing nameplates of electric motors of tubewells has emerged as a "growth industry" under flat tariff. In the Indian state of Haryana, a World Bank study had recently estimated that the actual connected agricultural load was 74 percent higher than what the official utility records showed (Kishore and Sharma 2002).

because it is a “hard state;” an average user fears the village electrician whose informal power and authority border on the absolute in his domain.[25] In the Indian state of Orissa, ongoing experiments on the privatization of electricity retailing will soon produce useful lessons on whether metering-cum-billing agents can drastically and sustainably reduce the cost of metered power in a situation where tubewell owners account for a significant proportion of the electricity used.

However, with tight and intelligent supply management, in the particular context of South Asia, a rational flat tariff and intelligent power supply management can achieve all that a 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. The total duration 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 most. The power supply to agriculture should 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 a metered tariff regime will turn groundwater markets into sellers’ markets, hitting the resource-poor water buyers, a 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 (for the detailed argument, see Shah 1993). Rational flat tariff—under which power rationing is far more defensible than under a metered tariff regime—will make it possible to put an effective check on the total use of power and water and make their use more sustainable than under the present regime or under a metered tariff regime. Moreover, restricting the total duration of operation of the farm power supply would help greatly curtail technical and commercial losses experienced by power utilities. Above all, a rational flat tariff can significantly curtail groundwater depletion by minimizing wasteful resource use. Based on an IWMI survey of 2,234 owners of diesel and electric tubewells in India, Pakistan, the Terai region of Nepal and Bangladesh, it was concluded that electric tubewell owners subject to a flat tariff regime with an unrestricted, poor-quality power supply worked their pumps 40-150 percent more horsepower-hours compared to diesel tubewell owners with greater control over their irrigation schedules. A rational flat tariff with planned irrigation schedules can easily curtail groundwater draft by 13-14 million electric tubewells at least by 10-14 percent, that is, by 12-21 km^3 every year, assuming that they pump a total of 120-150 km^3 of groundwater every year.

Contrary to popular understanding, a rational flat tariff is an elegant and sophisticated regime, managing 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 power utilities employ only engineers (Rao 2002). In the power sector reforms under way in many Indian states, this important aspect has been overlooked in the institutional architecture of unbundling. In this region, distributing power to agriculture is a different ball game from selling it to town people and industry; and private

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[25] Private electricity companies that supply power in Indian cities like Ahmedabad and Surat instill fear in their users by regularly meting out exemplary penalties for misuse, often in an arbitrary manner. The Ahmedabad Electricity Company’s inspection squads, for example, are set steep targets of 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 are repeatedly reminded about their obligation to pay for the power they use.

distribution companies will most likely exclude the agricultural market segment in a hurry as being "too difficult and costly to serve," as the experience of the Indian state of Orissa is already showing.[26] Perhaps, the most appropriate course would be to promote a separate distribution company to serve the agriculture sector with specialized competence and a skill base. Predetermined government subsidies to the farming sector should be directed to the agricultural power distribution companies.[27]

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[26] The Orissa Electricity Regulatory Commission opened the gates for power utilities 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).

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

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