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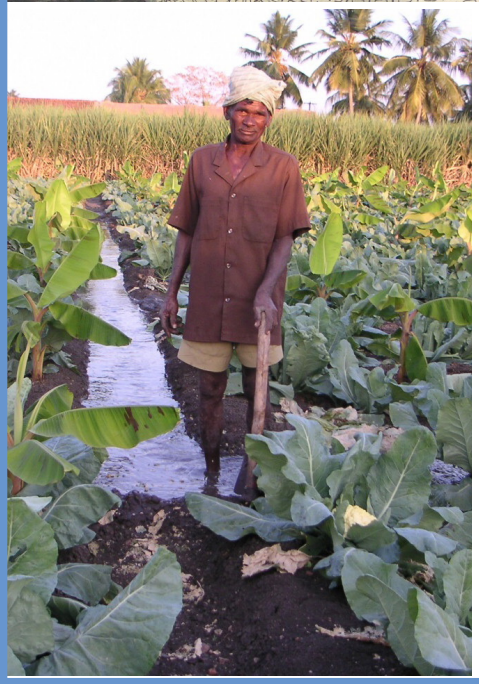

POWER TO SEGREGATE: IMPROVING ELECTRICITY ACCESS AND REDUCING DEMAND IN RURAL INDIA

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List of Abbreviations

BP	*formerly known as* British Petroleum
CDM	Clean Development Mechanism
DISCOM	Distribution company
EIA	International Energy Agency
GDP	Gross domestic product
GEB	Gujarat Electricity Board
GW	Gigawatt
HVDS	High Voltage Distribution System
IMF	International Monetary Fund
INR	Indian Rupee (INR 100 = EUR 1.25; USD 1.65, by end of August 2014)
LPG	Liquefied petroleum gas
T&D	Transmission and distribution
TWh	Terawatt-hours
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
V	Volt
WB	World Bank
WEF	Water–Energy–Food

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Executive Summary

India's energy situation is marked by deficits, coal imports, a national grid that collapsed in 2012, and efforts to develop renewable sources. Acknowledging that 400 million people lack access to electricity, the government is obliged to endeavour to provide electricity to all parts of the country. Yet missing infrastructure leaves large rural areas and many poor households behind. The conditions are aggravated by the fact that, to irrigate their fields, millions of farmers opt for pumping groundwater. Dwindling water tables and cheaper but ever more powerful pumps together with high energy subsidies contribute significantly to unsustainably rising electricity consumption. This not only adds to the fiscal burden of the state but results in load shedding that disrupts well-being and production.

In order to reverse the negative trends, several Indian states have developed programmes for rural electricity segregation whereby separate feeders provide agricultural and non-agricultural consumers. According to evaluations of this scheme by the World Bank, the experiences are mixed. The State of Gujarat, which serves as the most interesting and widely disseminated example, previously had to deal with rampant power theft and farmers refusing to comply with regulations for rationing. Eventually, the Gujarat electricity utilities decided to enforce the rules through deployment of 500 ex-military men. Gujarat's load management reforms have, all in all, attempted to reduce the demand for both electricity and groundwater among farmers, but they have resulted mainly in increased power supply to villagers and small rural industries.

1. Introduction

The world still contains large geographical areas characterised by 'energy poverty': a lack of access to modern energy services. Without a (legitimate[1]) electricity connection and clean cooking facilities – including fuels and stoves that do not cause hazardous air pollution in people's homes – well-being and development potential is at risk. Aggregated estimates by the International Energy Agency state that, globally, almost 1.3 billion people lack access to adequate electricity, 84 per cent of whom live in rural areas (International Energy Agency 2013).

In India, according to the latest census (2011), two thirds of the population of 1.2 billion live in rural areas[2] and altogether some 400 million people are still waiting to be provided with electricity services. The country's objective has for long been straightforward: to increase access to energy in general, and to electricity in particular. The Electricity Act 2003 stipulates that there is an obligation to endeavour to provide electricity to all areas, including villages.

Access to clean, adequate and affordable energy is a basic human need linked not only to improved well-being and quality of life but also to enhanced education prospects and income generating activities. Economic and social development is heavily dependent on different forms of energy, not least for the agricultural sector that is India's socio-economic and cultural backbone, and improved access to electricity is a prerequisite for cold storage capacity that can contribute to reduced food wastage. The government faces a significant challenge in other respects too: according to the 2011 census, almost 85 per cent of rural households were dependent on traditional biomass fuels for their cooking energy requirements. In its analysis of the situation, the Central Statistics Office (2013) holds that a transition to cleaner forms of energy would have positive implications for health and gender equality and bring about greater social progress in general.

It is projected that India will shortly be leading the growth in global energy and electricity demand (International Energy Agency 2013). This development cannot take place without additional energy supply. This inevitable fact will have to be reconciled with the objective of reducing greenhouse gas emissions to mitigate climate change.[3] The need for strategic development of renewable sources is therefore recognised. In its input to the Twelfth Plan for 2012-2017, a Working Group set up under the Ministry of Power stated that "[a]s a responsible nation, a two-pronged strategy has been adopted whereby on one hand, continuous efforts are being made to augment the supply of clean and green power, and on the other, emphasizing the need for demand-side management and energy efficiency measures" (2012: iii).

A dual approach to the energy situation with supply and demand management in parallel will have to be accompanied by a range of other measures in associated fields. Trade-offs will be required in order to allow for more equitable energy provision for the future while also taking wider sustainability and nexus aspects into account. One such relates to water. India's growth trajectory has become strongly dependent on its groundwater resources. The agricultural and the industrial sector both benefit from free, largely unregulated access to water from wells; pricing policies drive this development and subsidies for electricity and diesel increase groundwater extraction. Governing groundwater is simultaneously a growing challenge in large parts of the country where the water table is steadily sinking. Over-exploitation and quality deterioration is either spurred or deterred by different policy and reform choices at federal, state and local levels (Water Governance Facility 2013). In many areas marked by scarcity, groundwater depletion is directly linked to the tradition of offering subsidised electricity for agricultural purposes; the pumping is free, or a flat rate per unit of power is charged.

Groundwater over-exploitation is already threatening food production prospects in large parts of the country and thereby, in the long run, jeopardising national food security as well as exports. The price of power for irrigation pumping has a causal effect on food production: research has suggested that Indian farmers respond to electricity subsidies by expanding the area cultivated, particularly for water-intensive crops such as rice and sugarcane (Badiani and Jessoe 2013).

At least half of India's irrigation pumps – an estimated 15 to 20 million – rely on electricity.[4] In general terms, about a fifth of electricity use is for irrigation, and more than half of hydropower production goes to the pumping of groundwater (Hoff 2011). According to the 2030 Water Resources Group (2013[5]), by 2050 water demand for domestic use in India is expected to rise by 260 per cent, for irrigation by 130 per cent, and for energy generation by 370 per cent. Today the Indian Planning Commission[6] emphasises the need to restrict electricity access for competitive pumping between tubewell owners while other rural users increasingly need to be served. To achieve this goal of restricting

[1] Arguably, a large but unknown number of households tap the electricity network in illegitimate ways.

[2] It is likely that this proportion is outdated, not least as many poor migrant families refrain from registering in the city even many years after having settled there.

[3] India is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), but as an Annex II developing country it is not obliged to reduce its carbon emissions. However, India is an active participant in the Clean Development Mechanism (CDM) established by the Kyoto Protocol to the Convention and had more than 889 registered CDM projects as of 10 September 2012. The National Action Plan on Climate Change of 2008 contains a National Water Mission that set a goal of a 20 per cent improvement in water use efficiency through pricing and other mechanisms.

[4] Mukherji (2013), who also explains how the source of energy was not part of the latest census of minor irrigation structures conducted by the Ministry of Water Resources. Jain and Jolly (2012) maintain, though without reference, that there are about 21 million irrigation pump sets in India, of which about nine million are run on diesel and the rest are grid-based.

[5] The base year for the WRG's projections is not stated.

access, incentives and disincentives must be applied side by side, unconventional solutions be tried, and uncomfortable decisions made. The so-called water–energy–food (WEF) nexus approach can support a transition to sustainability by reducing trade-offs and generating additional benefits that outweigh the transaction costs associated with stronger integration of the water–energy–food sectors (Hoff, 2011).

Based on a review of the literature, this paper describes and analyses lessons learned from the segregation of power for agricultural and non-agricultural use in the context of India's quest to reduce rural demand while improving access. One such lesson from the field seems to be that communication and training is essential, not least of utility staff involved in implementation.

2. Energy Access and Demand in India

India's natural resources are under pressure from a growing population and changing consumer behaviour. The demand for energy in different forms is currently far from met by the distribution companies (DISCOMs). According to the latest census statistics, the percentage of all households with electricity connection increased from 56 in 2001 to 67 in 2011, which still leaves as many as 400 million people without authorised supply. Among rural households, 45 per cent have no electricity (Planning Commission 2013, Central Statistics Office 2013). There are no reliable figures for how many households have access to unauthorised supply.

Households with connections typically do not have assured power, even in urban areas, and access to electricity is subject to frequent interruptions and scheduled load shedding that takes place as a demand management strategy. There is a large latent demand for adequate supply. Among private companies the practice is to exit the state-run system and rely on a company's own, on-site (diesel) power generation to ensure a consistent and reliable source of electricity, something that is encouraged by the Electricity Act (Joseph 2010). An ever-increasing number of urban middle-class residents are likewise installing private diesel generators for back-up, while power-storage batteries and inverters have become essential for rural households as well, though they still remain unaffordable to large groups. Solar power panels for water heating can be seen on a growing number of roofs.

Total electricity production from all sources was 1053.9 TWh according to the latest statistics from 2012 (BP 2013). By February 2014 the installed electricity capacity was 237 GW, of which 12.4 per cent came from renewable energy sources and another 17 per cent from hydro energy.[7] Almost 60 per cent was sourced from coal (Central Electricity Authority 2014).

Large capacity additions are being planned for the coming years, as well as the utilisation of more efficient technologies to improve electricity generation from coal-based power plants. It is predicted that with improved use of capacity, a higher share of clean(er) energy can be attained. Dependence on fossil fuels in the energy mix is nonetheless high and many commentators hold that the root of India's energy challenge lies in its dependence on coal, just as in China. Domestic (public) industry has always produced less coal than the actual demand and the Ministry of Coal began encouraging imports from 2005. A parallel increase in demand from China soon led to overheated market prices and, in turn, to a continued gap between supply and demand.

The cost of imported fuels adds to the fiscal burden of the government and exposes the country to fluctuating world market prices, and it also makes India more geopolitically vulnerable. The International Energy Agency (2012) has warned that the country's patchwork of energy policies is in need of reform, and points to the potential of liberalisation of the coal and nuclear sectors. Private actors currently generate less than a third of the installed capacity. The Planning Commission sees increased private sector investments in the energy infrastructure as an important factor for energy development (Planning Commission 2011).

Petroleum products such as LPG and kerosene gas as well as electricity are heavily subsidised – for the agricultural sector, tariffs on electricity amount to less than ten per cent of the cost of supply (World Bank 2013). Domestic fuel subsidies reached nearly two per cent of GDP in 2011/12 (IMF 2013) but are coming down with the recent step-by-step phasing out of the diesel subsidy begun in early 2013. The cost of the subsidies is incurred in the first instance by the predominantly state-owned oil marketing companies, and financed in a variety of ways – a large part off-budget, with transfers from state-owned enterprises involved in the upstream production of crude oil, and the oil marketing companies self-financing some of the subsidies (IMF 2013).

The prices are set by state-level Regulatory Commissions (see below) who have shown a tendency to hold back tariff adjustments, typically under political pressure from various interest groups. The DISCOMs may also be discouraged from seeking tariff revisions, which in combination with high transmission and distribution losses jeopardises their financial viability (Planning Commission 2011, International Energy Agency 2012, World Bank 2013, Planning Commission 2013).

[7] Hydropower is presented separately from the renewable sources in the statistics.

3. Sector Regulation

'Electricity' is listed on the Concurrent List of the Indian Constitution, meaning that the legislative responsibility is divided between the federal level and the states (and union territories). Residual power remains with the central government but its influence on law-making, implementation and reforms at the state level is limited. 'Water' is listed as a state subject and the central government can therefore only seek to encourage management of what is deemed a common property resource through non-binding policies (Water Governance Facility 2013).

After Independence in 1947, State Electricity Boards were formed in all states. The Industrial Policy Resolution of 1956 envisaged generation, transmission and distribution of power as a task to be developed almost exclusively by the public sector. Only as a result of the general reforms of the Indian economy at the beginning of the 1990s and the Electricity Laws Act of 1991 was a certain degree of private investment into power generation and distribution encouraged.

The central government promulgated the Electricity Regulatory Commission Act in 1998 for the setting-up of independent regulatory bodies both at the central and at the state level. The Central Electricity Regulatory Commission regulates the tariffs of power-generating companies. State Electricity Regulatory Commissions are in place in almost all states, primarily to look into all aspects of tariff setting and related matters. The state level Commissions set power tariffs for wholesale, bulk, grid or retail use. They also fix tariffs for transmission facilities and regulate the purchase and procurement process of transmission and distribution (T&D) utilities.

In 2003 the Electricity Act (amended in 2007) replaced three previous laws enacted in 1910, 1948, and 1998. Among the objectives of the Act are to better coordinate development of the country's power sector within a competitive and liberal framework to attract investments, while protecting consumers. It also seeks to promote efficient and environmentally benign policies. The Act opened up for unbundling of the Electricity Boards and their services – including the separation of electricity generation, T&D functions, and universal metering of all consumers – and in consequence new market players emerged in the power sector. The reform was triggered by the poor financial status of most Electricity Boards.

Currently, the Electricity Act applies in parallel with the Energy Conservation Act of 2001, as well as numerous Rules, Regulations and Orders. The federal level also formulates policies for the entire nation. In 2006, in compliance with and to steer progress within the ambit of the Electricity Act, the central government notified the Tariff Policy in continuation of the National Electricity Policy of 2005. The aim of the former is to achieve a consistent regulatory approach to power tariffs across the country's Electricity Regulatory Commissions.

In addition to national legislation, several states, including Gujarat, Orissa, Haryana, Karnataka, Uttar Pradesh, Andhra Pradesh, and Punjab, have more recently passed Acts aimed at reforming and unbundling electricity services delivery.

Experts at the Ministry of Power and the Planning Commission have recently observed that the regulatory structure in the states has been quite poor, as has the governance in particular of the DISCOMs. There have therefore been calls for significant improvement in their functioning. Further, it has been noted that the power sector cannot deliver on its social commitments unless it is commercially and financially viable. To keep the reform process on track would necessitate legislative and policy changes, and rationalised tariffs and optimisation of the procurement costs of power (Planning Commission 2011, Ministry of Power 2012a).

India has long sought to deal with its unequal electricity provision through policies on supply management. Besides favourable pricing mechanisms, measures taken include the Rural Electrification Policy of 2006, which acknowledges the large proportion of the population still unserved and recognises that electricity is a basic human need. It applies alongside both the 2005 Rajiv Gandhi Grameen Vidhyutikaran Yojana Policy, which has the goal of electrifying all un-electrified villages and providing access to electricity to all households, and also the National Electricity Policy (see above), which states that the key development objective of the power sector is the supply of electricity to all areas, including rural areas. The policies are formulated in accordance with the Electricity Act's provision (Sec 6) that the government is obliged to endeavour to provide electricity to all areas, including villages.

The energy sector is split among five ministries and several government commissions, authorities, departments and agencies at federal level. The federal government contains the Ministry of Power (charged with overseeing electricity production and infrastructure development, including generation, transmission, and delivery, as well as maintenance projects), and the Ministry of Energy and Renewable Sources (responsible for research and development, intellectual property protection, and international cooperation, promotion, and coordination in renewable energy sources). The Central Electricity Authority is a statutory organisation under the Power Ministry that advises on matters relating to the National Electricity Policy and formulates short-term and perspective plans for the development of electricity systems. The Authority plays a lead role in promoting the integrated operations of the regional power grids and the evolution of a national grid. The five regional grids were integrated step by step, with the southern grid as the last to be connected to the national grid in 2014. Under the notion One Nation, One Grid, One Frequency, they are synchronised to help in optimal utilisation by transfer of power between regions as needed.

4. The Electricity–Groundwater–Food Nexus

The domestic experiences from coordinated implementation of supply and demand management of energy are so far limited and mixed. They take into account, to a varying degree, the nexus between water, energy and food and also build on different components of 'good governance'. The supply and demand interconnections between water and energy for food production are often painfully felt in India. At the end of July 2012, a sweltering hot nation was suffering from delayed monsoon rains. Farmers in the north feared for the summer crops and utilised their irrigation pump sets. The resulting excessive electricity consumption contributed to a power disruption that caused first the northern grid and subsequently the northern, eastern and north-eastern region grids to collapse.[8] The blackout affected over 600 million people in 22 states during two days (Ministry of Power 2012b).

The pumping of groundwater for irrigation has been key to India's realisation of the green revolution, and in most regions water and energy thus worked together in making the country self-sufficient in food production half a century back. Access to groundwater via submersible pumps has enabled farmers to change cropping patterns and intensify their output regardless of season and monsoon rain predictability; compared to canal irrigation by surface water that is fraught with a range of hydro-political difficulties and risks, they are also more in control of the water resource. By the end of the 1970s, groundwater had become the main source of irrigation.[9] Dug wells, shallow tubewells and deep tubewells now account for more than 90 per cent of all minor irrigation structures used by small and marginal farmers (with less than 2,000 ha) (Mukherji 2013), while large landholders are more often connected to surface water irrigation schemes. The socio-economic dimensions of groundwater access are clear.

The development was made possible through accessible loans and a subsidised supply of electricity to the agricultural sector. Bhattacharyya (2005) even holds that in India rural electricity supply is often considered synonymous with the energising of agricultural pump sets and hence official definitions and statistics focus on the number of villages connected to the grid, without paying attention to actual access at household level. Introduced in the 1960s as part of the first rural electrification programme, the aim of the subsidies was to promote agricultural productivity through development of the power infrastructure. In several respects electric pump sets for irrigation were seen as advantageous over diesel-powered sets, but already twenty years ago the state subsidies were subject to calls for reform (cf. Rajagopalan and Demaine 1994). In 2008-09, state electricity utilities booked a total subsidy of INR 29,665 crore[10] (equalling more than EUR 3.7 billion in August 2014) against which they received a payment of INR 18,388 crore (equalling more than EUR 2.3 billion) (Power Finance Corporation 2010 in Mukherji 2013).

For decades the pressure has increased to abolish or at least reform the system while ensuring that poor and marginalised farmers still benefit from better-targeted assistance. Distorted prices can never send the necessary signals when electricity usage as well as groundwater pumping for irrigation must be reduced. The build-up in subsidies is also contributing to India's fiscal deficit. This is now seen as a burden of particular concern because a substantial part of the subsidy is not reflected in the budget of the central government, as the real losses of the power sector are not reflected in the budgets of the state governments (Planning Commission 2013).

[8] The Ministry of Power's Enquiry Committee into the collapse refrained from singling out factors contributing to the disturbances.

[9] However, according to Mukherji (2013) the statistics show that the growth of the groundwater irrigation sector has slowed down since 2000-01, with an absolute decline in groundwater structures in eastern India (which is underlain by alluvial strata and therefore experiences no discernible lowering of the groundwater table). The reason for contraction in this region is the lack of access to affordable energy.

[10] One crore is ten millions.

5. Demand-Side Management Through Rural Feeder Segregation

To decouple electricity use from groundwater extraction, numerous instruments have been tried and tested, some with promising results. Tariffs, technology, quotas and customer education are common methods for demand management. With India simultaneously suffering from energy poverty and implementing supply side management in several areas, information campaigns to encourage conservation and efficiency can be seen as a hard target, but may have untapped development potential. But, as the case of Gujarat shows (see below), communication with and the training of utility staff is essential for successful reform.

With pricing being a most delicate matter, and regulation seen by many as practically impossible due to endemic corruption, bureaucracy, and a culture of non-compliance (cf. Water Governance Facility 2013), rationing has become the demand-side management tool of choice to restrict power usage for irrigation. In many regions, DISCOMs supply electricity for a limited number of hours only, and often during the night. However, where such policies are in place they also affect rural households and non-agricultural income-generating activities, as well as education, health services and general well-being.

In the northern State of Punjab, researchers found that the 6-8 hours of electricity supplied per day was considered insufficient for paddy (rice) farmers (Mukherji, 2012). The restriction gave the farmers an incentive to supplement their electric pumps with diesel-run generators. Because the opportunity cost of the last litres of groundwater equalled the (high) price of diesel, this induced the farmers to minimise their pumping, thereby reducing the groundwater depletion. Most of India is, however, characterised by sedimentary and crystalline (hard-rock) aquifers where the water table has now declined so much that diesel-generators cannot aid in pumping the groundwater.[11] When the effect of rationing schemes is access to less groundwater than before, the rational response of farmers is therefore often to try and circumvent them (ibid).

In theory it is clear that efforts must be stepped up to achieve better resource use and productivity through 'system efficiency' that includes technological innovation, recycling and general reduction of wastage (Hoff 2011). Authorities and stakeholders need to collaborate when investigating interconnected WEF strategies and plans (Bach, Bird *et al.* 2012). But to be appropriate and feasible in their social context, arrangements must likewise nurture inclusive development and ensure that the country's rural population – the majority of Indians – are progressively provided with adequate electricity. Given that the vicious cycle between free energy and excessive use of groundwater has developed into vote-bank politics,[12] researchers, policy-makers, the Planning Commission, and others involved must inevitably also address a sensitive political and socio-economic reality.

Until the early 1970s, all State Electricity Boards charged tubewell owners based on their metered consumption but, because of various administrative issues, this was changed to a flat tariff in the early 1980s (Mukherji, Shah and Verma 2010). Today, the vast majority of states still charge prices much below the marginal cost of supply. Land-owning farmers have become used to insulating policies, and in many parts of the country they make up an important lobby group whose power and groundwater dependence, it is widely believed, cannot be effectively regulated. Entrenched in path dependency,[13] it has for long been seen as politically impossible to introduce or raise tariffs. This is mirrored by groundwater regulation in villages, where Phansalkar and Kher (2006) found that nominated leaders who fear not being re-elected as much as they fear for their social standing refrain from invoking enacted rules that restrict the digging or drilling of new wells. Ultimately, as Lundqvist and Falkenmark (2010) argue, the political will to do 'the right thing' – and the skill to do so in a proper and effective manner – is conditioned by the political will to stay in power, which presumes social acceptance.

The financial consequences of decades of artificially low prices, together with the perceived administrative and logistical problems connected with the enforcement of laws relating to a very large number of dispersed irrigation wells, eventually spurred researchers to develop alternative instruments to regulate demand. The need for rural electrification set the frame for the *Jyotigram* (also known as Jyotirgram and Jyoti Gram Yojana, meaning 'lighted village') programme for segregation (or separation) of electricity feeders[14]. In effect, this prioritises power provision to villagers at the expense of agricultural purposes. Starting in the State of Andhra Pradesh in 2001, eight states now have experience of attempting to separate their electricity supply systems for agricultural and other consumers: Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab and Rajasthan (World Bank 2013). Of these, Gujarat serves as the most interesting and widely disseminated example.

[11] Similarly, solar-powered pumps are very promising for drip irrigation in north-eastern, alluvial India with its generally shallow water table. They are less suitable for farmers needing 5 or 10 hp pumps for deep tubewells.

[12] 'Vote-banks' build on a patron-client relationship where a core of supporters – based on religion, caste, community or trade – vote en masse in exchange for favourable treatment and by their number have the power to exert influence over the decisions of aspiring and elected politicians.

[13] The term is used especially by scholars within the economics and social sciences to explain how decisions and actions for the future are shaped by the present and the past.

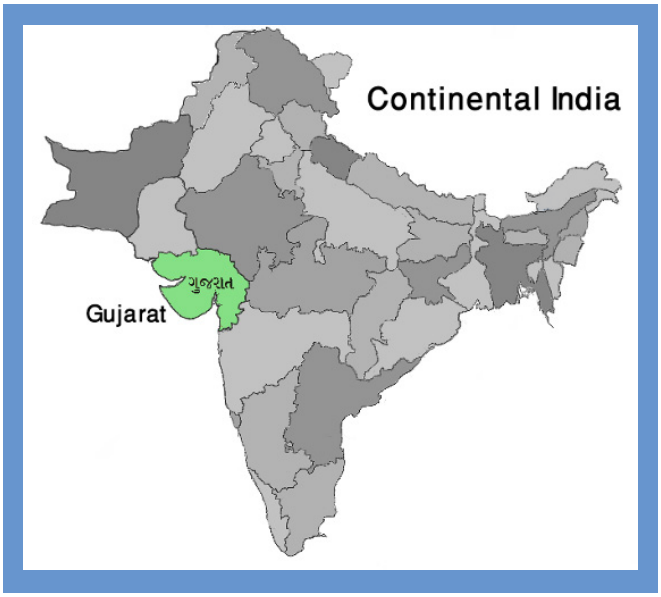
[14] A feeder is an electrical cable or group of electrical conductors that supplies power from a larger central source (a primary distribution centre) to one or more secondary distribution centres, branch-circuit distribution centres, or a combination of these (www.dictionaryofconstruction.com).

5.1. Implementation of Jyotigram in Gujarat

Rationing has long been used for demand management in Gujarat, which lies on the north-west coast of India and has a population of 60 million people. Power used to be supplied from one and the same source in the villages and provided in three-phase (400-440 V) for eight hours for agriculture, whereas domestic and other users received single-phase (230-240 V) electricity around the clock. Farmers, however, easily evaded the rationing by illegally converting the domestic single-phase power into three-phase so as to render themselves continuous power to drive their pump set motors. Doing so they were able to produce more irrigated crops, but also consume large volumes of water – and paralyse the rural electricity supply system completely.

By the year 2000 the Gujarat State Electricity Board (GEB) was unable to meet the rapidly growing demand of its other customers due to the large agricultural demand and its inability to increase its purchasing power on the market. It was also on the verge of bankruptcy due to the irrigation subsidies. Additionally, groundwater depletion had been considered serious since the mid-1980s; by 2000, the benefit many farmers derived from pumping had stagnated or even declined as the amount of groundwater available decreased. It was also felt that the transaction costs for a traditional command and control system, most notably the manual reading of hundreds of thousands of electricity meters, were insupportable. Meters, tariffs and meter reading staff were all components of a system riddled by endemic corruption (Narula, Fishman *et al.* 2011, Shah, Mehta *et al.* 2012).

To reverse the negative trends and implement the Jyotigram programme in almost all of the state's 18,000 villages, socio-technocratic and political realities had to be taken into account. Concerted efforts were put into a complete overhaul of the energy sector, including the very management and work culture within the DISCOMs. As part of this unbundling and re-structuring, the Gujarat Electricity Industry (Re-organisation and Regulation) Act, 2003, was passed. Under the provisions of the Act, the government framed the Gujarat Electricity Industry Re-organisation and Comprehensive Transfer Scheme, 2003, for the transfer of assets, liabilities etc. of the GEB to the successor entities. Subsequently, in 2005, the GEB was split into seven companies: the Gujarat Urja Vikas Nigam Ltd. as the umbrella services company and four DISCOMs that were not, like most counterparts in other states, privatised. In addition, a Transmission Company and a Generation Company was set up (Shah, Mehta *et al.* 2012, World Bank 2013).



This is an adapted version of a map found on: http://commons.wikimedia.org/wiki/File:South_asia_local.png It is used under the Creative Commons Attribution-Share Alike 3.0 Unported license.

The Jyotigram scheme involved an investment of around USD 260 million to build a new transmission network, re-wire the vast rural part of Gujarat, and separate the supply feeders for agricultural and non-agricultural users. The end result was that non-agricultural customers could continue to enjoy power supply 24/7, but now instead from metered, three-phase current connections (Shah, Bhatt *et al.* 2008, Shah, Mehta *et al.* 2012, World Bank 2013). This benefits modern households, but also commercial and small industrial establishments who can now invest in electrical motors thanks to the smoother and more consistent higher voltage power.

Meanwhile, farmers now receive their rationed eight hours of electricity but from a high voltage distribution system (HVDS). A HVDS enhances system performance because of the more efficient transformation of the energy before it reaches the consumer, and results in a higher quality of supply as it has less problems with fluctuations in voltage, power outages, fuse blowouts and motor burns than the Low Voltage system. It promises improved load management and together with other elements, it results in lower technical energy losses. It should also curb commercial losses, as the technique prevents power theft (Spandana *et al.* 2013).

A major change was that the farmers were provided with power in accordance with a predictable rotation schedule with alternate weeks of day or night supply on village-basis. While better controlling the farmers' power access and demand, the ambition was thus to simultaneously ensure a high-quality supply (Shah, Bhatt *et al.* 2008, Shah, Mehta *et al.* 2012, World Bank 2013).

The new system was nevertheless neither popular nor sufficiently tamper-proof. For a long time, the dependence on electricity for pumping groundwater had increased in Gujarat just as in other states, and farmers had organised themselves into powerful lobbies to maintain the beneficial power tariff policy (Mukherji, Shah *et al.* 2012). The decision to limit their electricity access met with violent opposition from the farmers, backed by local politicians – if not by the top among state-level politicians. There was admittedly high-level political support for Jyotigram, though this was later described as "necessary but not sufficient to control the anarchy" among farmers disinclined to accept the changes (Shah, Mehta *et al.* 2012: 6).

An entire battery of additional measures therefore had to be designed and implemented. From the outset, concerted efforts were made to transform the DISCOMs' organisation and internal work culture through capacity building that involved morale boosting and attitude changes, involving the employee unions

and assurances against privatisation and retrenchment. These efforts have been described as part of the recipe for success, but they were not enough in themselves without a decade's worth of parallel determination to also transform the pervasive culture of non-compliance that was based on theft, vandalism, political brinkmanship and hooliganism directed at the companies' staff. This in particular had made staff members reluctant to venture into villages for fear of violence from irate mobs; they were reportedly often taken hostage and kept in bondage (Shah, Mehta *et al*. 2012). The World Bank (2013) has also concluded that it was essential that the DISCOMs communicated the programme's objective and process to the members of staff involved and added training to improve monitoring capacity and a feeling of accountability.

One practical solution that became a necessary complement was to set up dedicated police stations and employ 500 retired army personnel to keep violence in check in the villages. Researchers have described the reaction as 'uproar' when the electricity police filed cases against more than 100,000 farmers (Shah, Mehta *et al.*, 2012: 4). Gujarat, like several other states, had made power theft a criminal offence.[15] The Urja Vikas Nigam has a Vigilance Department headed by an officer seconded from the police. The Department coordinates with the DISCOMs to keep electricity pilfering in check. Mass checking drives performed by a number of special squads are carried out as and when required, and there is a cash reward for those who wish to anonymously report a neighbour's power theft.[16]

Despite their sustained campaign to control this culture of rampant power theft, the DISCOMs also had to develop various new technologies to outsmart farmers, preventing them from stealing power by, for instance, installing phase-splitting capacitors. Engineers eventually came up with Special Design Transformers that supply continuous single-phase electricity to farmers residing in farmhouses, through feeders that trip whenever the load exceeds a limit. Over 3,000 such transformers were installed throughout Gujarat. In addition, the HVDS makes it harder for farmers to hook lines onto the insulated above-ground cables in order to steal power from them (Shah, Mehta *et al.,* 2012, World Bank 2013, Spandana *et al*., 2013).

5.2 Lessons Learned

More than anything, the Jyotigram scheme has generally been seen as contextually successful in terms of a load management strategy and as a way to curb transmission and distribution losses: The energy supply during day or night in alternate weeks flattens the peak demand. Farmers still pay a subsidised flat-rate tariff, but according to the official story the demand is reduced and the total volume of energy consumed has come down compared to the situation before the implementation of Jyotigram began, and so the total subsidy amount has also been lowered. As a result, Gujarat is presently one of very few states in India with surplus power and with its energy-related finances in order. The Energy and Petrochemicals Department of the Gujarat Government, under which the Jyotigram programme falls, even maintains on its web page that Jyotigram has led to "buoyant revenue through prevention of power theft".[17] Among other results claimed are local employment generation; improved standards of living in rural areas; improved health services and sanitation facilities, and quality of education; and a reduction in migration from rural areas to urban. Not least, it is stressed that "regulated but improved quality power supply to agriculture enabled efficient and optimum use of water, which in turn contributes to conservation of ground water resources" (ibid).

Available research (Shah, Bhatt *et al*. 2008) has suggested that less groundwater was drawn for irrigation as a consequence of the Jyotigram scheme, but the absence of before-and-after as well as with-and-without data makes the estimates inconclusive. The areas under irrigation seemed to decline in number – at least initially – which was attributed mainly to two factors: farmers could choose to convert to alternative incomes when radically improved access to electricity in the villages so allowed, and access to groundwater via electrified tubewells decreased when power rationing was enforced through new and more effective means. The latter was mainly an effect in the high-yielding alluvial aquifers of northern Gujarat, where farmers who could previously pump groundwater continuously from their deep tubewells became adversely affected by power rationing (ibid).

It has been highlighted that the Jyotigram scheme also impacted negatively on marginal farmers without land rights (and so groundwater extraction rights) who had previously relied on there being a market where they could purchase groundwater. Researchers and analysts therefore stressed the need to introduce special programmes for this group to mitigate the effects of feeder separation on them (ibid).

Farmers also increasingly moved away from cereal crops to high-value crops such as (genetically modified) Bt cotton, tobacco, orchard and commercial crops, and dairy products, so as to maximise value per drop of water (Mukherji, Shah *et al*. 2010).

However, it is unclear whether the specially designed transformers marked the end of the development of new technocratic means to keep offenders in check, or whether this work has had to continue. On the transaction costs of and need to use ex-army personnel and dedicated police to enforce changes on the ground, the case also raises questions of what 'good governance' entails in practice. The political will or sheer power to execute feeder segregation may not be equally strong tomorrow, or elsewhere. The strength of the farmers' lobbying and resistance may, on the other hand, be less in other states, all depending on climate, aquifer conditions, and socio-economic context In such cases it should be a more straightforward process to implement and enforce reforms. Nonetheless, political will is insufficient as long as it is not combined with skill in judging and balancing the outcome of policy decisions in a complex reality marked by resource deficits, unpredictability and power struggles (cf. Lundqvist and Falkenmark 2010).

[15] The Electricity Act was amended in 2007 to encompass a definition of theft that covers use of tempered meters and use for unauthorised purposes.
[16] www.gseb.com/guvnl/Content.aspx?ContentId=12, retrieved May 2014.
[17] http://guj-epd.gov.in/epd_jyotiyojna.htm, retrieved May 2014.

Legislation on groundwater conservation had for a long time been regarded as impractical to implement among such a large number of dispersed well-owners, and the law-makers in Gujarat chose instead to strengthen the energy legislation and attach forceful means of coercion. Accordingly, the State Electricity Board was instructed not to energise new irrigation tubewells without permission (No Objection Certificate) issued by the State Groundwater Authority. Even so, almost half a million new power connections for small and marginal farmers were granted during the past decade (T. Shah, pers. comm. 2013). The Gujarat utilities had a total consumer base of approximately ten million in 2008-09, of which agricultural consumers amounted to eight per cent. Sales to agricultural consumers amounted to 32 per cent during the same period. The latest available statistics from the Directorate of Agriculture (2006) show that almost a third of Gujarat's net sown area was irrigated. For this, more than 85 per cent of the irrigation water was pumped from wells.

In addition, recent research has reported that farmers have found new ways around the rationing: technological and economic advances have made it possible to invest in drilling deeper wells and installing more powerful pumps, and so abstracting water from more than 300 metres down in the hard-rock southern regions. Though far from sustainable, even in the short run, this has reportedly contributed to energy use increasing over the last two decades without a matching increase in irrigated area, and as a result it has been argued that the 'drop per unit of energy consumed' ratio has continued to deteriorate (Narula, Fishman *et al*. 2011: 6, Fishman, Modi *et al*. 2011).

5.3 Jyotigram in Other States

Leaving aside the latter analysis of the present situation in Gujarat, the World Bank (2013) has evaluated the initiatives in the eight states with experience of feeder segregation over the past ten years or more. Among its conclusions are that a 'one-size-fits-all' approach will not work across states, given the wide variety in local conditions and challenges. Each state was found to have its own contextual impetus to introduce reform, with solutions tailored accordingly. All aimed at socio-economic development through assured supply to both agricultural and non-agricultural users but, for instance, the State of Haryana sought to deal also with high distribution losses whereas in Rajasthan load management was part of a feeder renovation programme. Integration of groundwater conservation was an express objective in Gujarat, and later also in Madhya Pradesh. Only in Gujarat was the state government the project owner – elsewhere the DISCOMs were in charge.

Gujarat introduced physical load segregation and re-wiring at an early stage whereas for the remaining states virtual segregation was (deemed) sufficient. Only later (the evaluation is not yet published) did Andhra Pradesh begin a similar pilot study to come to terms with power theft.

The World Bank's conclusion was that separation of feeders led to improved power supply to rural households and small industries, but it suggested that metering on a wider scale should be introduced. It recommended that infrastructural changes should always be made part of larger strategic rural power supply improvement programmes. A suitable initial step would be to first convert all agricultural feeder lines to HVDS to reduce distribution losses. The Bank also pointed to institutional reforms and improved governance as contributing to Gujarat's success, compared with Rajasthan which had not managed to contain or reduce the agricultural electricity demand and instead ended up with increasing financial losses as a result of escalating subsidies. Components of successful management and organisational changes comprise communication of the programme's objective and steps to staff, and proper training of those involved to improve monitoring and accountability. Early consultations with stakeholders such as state regulators, elected village councils and consumers are also vital.

The Council on Energy, Environment and Water (2011) has pointed out that infrastructural changes, such as separation of feeders and HVDS conversion, are institutionally owned by the utilities. In addition, farmers are also required to take some action at their end to improve the overall efficiency of power utilisation. The Council lists the adoption of frictionless foot valves and pipes, fixing of power factor correcting capacitors, use of energy efficient pump sets and of appropriate capacity pumps. Farmers should also be involved in discussions around peak load management and rostering. Additionally all the poorest and most inefficient agricultural pump sets should be replaced after HVDS conversion, to save up to 30 per cent of present power consumption; most of them are operating far below their achievable efficiencies. Willingness and ability to pay for such actions at individual farms is not discussed but must inevitably be brought up in continued deliberations.

6. Discussion

The 'lighted village' approach – to improve rural access to electricity through feeder segregation while simultaneously achieve demand-side management – is highlighted in the Planning Commission's Twelfth Five Year Plan, with reference mainly to the experience from Gujarat. Additionally, the National Water Policy of 2012 recommends that the over-withdrawal of groundwater should be minimised by regulating the use of electricity for its extraction. With Narendra Modi elected India's Prime Minister in 2014 after governing Gujarat for more than ten years, it would be natural to expect that several lessons from seeking to govern the WEF nexus in that state would be implemented at a larger scale, for the benefit of others embarking on feeder segregation or extending their pilot programmes. But the federal Union Minister for Coal, Power and Renewable Energy announced in June 2014 that he had studied the 'Gujarat model' and intended to calibrate it, rather than replicate it, to apply in other states where power sector reforms were called for. Much as the World Bank concluded, there is no 'one-size-fits-all' standard.

A range of aspects should be taken into account in future adaptations of the Gujarat version of Jyotigram. A multitude of ingenious measures needed to be designed and implemented along the way, comprising new legislation, political will, rationing, metering, re-wiring, separation of feeders, rotation schemes, special transformers, HVDS organisational and internal work culture transformation, neither of which should be seen in isolation. It further seems clear that not only commitment at the top level, and hundreds of ex-military men and devoted police stations, but also adaptive learning and willingness to progressively adjust the programme were essential components.

Together, these ingredients reformed Gujarat's energy access and load management situation in a generally laudable way. But the attempts to modify and reduce farmers' demand for power and groundwater cannot be deemed entirely successful. Most of all, there are still parts that need to be improved for the sake of the increasingly vital groundwater conservation objectives.

Good governance – generally defined in terms of transparency, accountability and participation – entails a firmly-rooted system among the end-users. Inspiration may be taken from empirical experience of 'participatory groundwater management' in Andhra Pradesh. Based on this, Govardhan Das and Burke (2013) have suggested that farmers and other villagers should be actively engaged in data collection and educated about basic hydrology, rainfall patterns, crop–water budgeting and choice of water-efficient crops and irrigation methods. Over the course of a decade, and through the improved knowledge of causal relationships they gained, villagers became risk-averse and understood how demand management and prudent decisions worked to their advantage. This suggests that investments in raised awareness and involvement – not least with illiterate or poorly educated rural residents – can pay off in many ways, but also that time and concerted efforts are required for this to happen. However, it is not clear from the Andhra Pradesh experience whether farmers are willing and able to spend time and money participating in monitoring fluctuating groundwater levels, or what scale of intervention would be needed to achieve the necessary level of understanding of complex WEF interconnections. Nonetheless, the approach is promising in the way it took departure from farmers and fellow villagers' desire and need to form an improved understanding of the physical environment and ecosystem they depend on.

In Gujarat it is unclear at what scale assured, albeit rationed, electricity supply has enabled farmers with ever-more powerful pumps to draw groundwater from greater depths. The energy rationing was again outsmarted by irrigating farmers with a seemingly insatiable thirst. Smart metering and commercial tariffs may be needed as complements, together with closer cooperation between the authorities involved to evaluate trade-offs and coordinate decision-making. Those very authorities should also count stakeholders among the farmers they seek to regulate and collaborate with the elected village councils (panchayats) and other local institutions, including banks and credit lenders.

If replication elsewhere of Gujarat's recipe for intelligent rationing is attempted, the outcome may be that more farmers – marginal and others – opt for or feel forced to choose other income activities for which electricity access is secured, when at the same time water markets have collapsed. If more farmers simultaneously convert to non-cereal crops such as tobacco and cotton, the end result may be an unintended threat to food security.

Climate change and variability is predicted to have a range of negative impacts on India. Agricultural yields and profits are expected to be reduced as an effect of, among many other things, higher temperatures that cause the atmosphere to hold more water vapour, and intensified but more unpredictable precipitation patterns. Inherent modelling complexities make it difficult to reach any closer estimates with regards to aquifer recharge, and thereby gain good predictions for future groundwater availability, but the big picture is evident and must be internalised among all agricultural practitioners. Available knowledge tells us that India must decisively develop all renewable energy sources while implementing both conventional and unconventional demand and supply-side management alongside each other, for energy as well as water. Gujarat's version of Jyotigram is currently the best starting point for the country's villages, but it necessitates tweaking and complimentary measures. Inclusive governance and information à la Andhra Pradesh may be a cheap and more efficient substitute for some of today's transaction costs for enforcement, including police and military.

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