Understanding the Electricity, Water & Agriculture Linkages

Volume 2: Electricity Supply Challenges

प्रयास
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Executive Summary

Electricity distribution companies (DISCOMs) have been reeling under massive financial losses for a long time. The central government has implemented three bailout packages in the last 15 years to relieve their financial stress. Thus, it is no surprise that electricity distribution is characterised as the weakest link in the power sector. This in turn is largely seen as a result of subsidised electricity supply to certain categories, major among them being agriculture. This subsidy is covered either by consumers of other categories who are charged higher tariffs (cross-subsidy), or by grants from the state governments (direct subsidy).

Since the 1970s, agriculture in many Indian states has been receiving electricity with low tariffs. In some cases, electricity is supplied for free. Much of this supply is unmetered. Subsidised supply has played a key role in the growth of groundwater irrigation and agricultural production in the country during the green revolution and after. But in recent years, studies have emphasised the negative impacts of subsidised electricity supply not only on DISCOMs, but also on state governments and cross-subsidising consumers who also finance this subsidy. Free or subsidised electricity supply is seen as the primary cause of unsustainable groundwater extraction as well as the poor quality of electricity supply to rural consumers. Unsurprisingly, a large part of the story of power sector reforms has been the push for the reduction of this subsidy. However, such reforms have been largely ineffective, and issues related to DISCOM finances have persisted or been aggravated. This problem thus requires deeper examination.

We reiterate that electricity based ground water irrigation has a crucial role in ensuring food security and rural livelihoods. We argue that this subject needs to be analysed in an integrated manner, covering the water and agriculture or food production aspects of electricity supply, as well as its linkages with farmers' livelihoods and welfare. This is because of the inextricable linkages between agricultural electricity supply and groundwater, food production and farmer livelihoods, and the far-reaching implications of reforms in the electricity sector on these issues. Only such an integrated analysis and joint efforts by all concerned actors can address the challenges in electricity based ground water irrigation.

This discussion paper on understanding the linkages between electricity, water, and agriculture is presented in two volumes. While Volume 1 provides an overview of the subject, Volume 2 addresses the challenges in electricity supply. Together, they tackle important questions like: How does unmetered subsidised electricity supply to agriculture affect DISCOM finances? How much is the subsidy responsible for over-extraction of groundwater? What is the impact of the subsidy on agricultural growth and farmers' livelihoods? What are the likely implications of cutting back on the subsidy for agricultural growth and farmers' livelihoods? What has been the efficacy of attempts undertaken to address the challenges so far? And what are the possible methods to address them?

The key findings of the study are:

1. **Subsidy to agriculture is overestimated:** The subsidy to agriculture is overestimated as electricity consumption in agriculture is overestimated, which has been a long-standing problem. When more accurate methods to estimate agricultural consumption are used,

many states have seen a downward revision in their agricultural electricity consumption and upward revision in distribution loss, some even multiple times over the years. Thus, it would appear that state governments and cross-subsiding consumers are financing theft and DISCOM inefficiencies under the guise of agricultural consumption. Feeder separation (separating agriculture feeders from village feeders) should have helped to improve the estimation of agriculture consumption. But this has not happened, since it is not completed in all states and in some cases where it is, feeder data is not used for estimation, for example in Gujarat.

2. **Financing of total subsidy is a problem:** Agriculture is not the only consumer category that receives subsidised electricity. Subsidy to other consumer categories, especially domestic consumers, is on the rise. State governments bear a higher share of the total subsidy. At the same time, subsidy from state governments is getting delayed or is falling short of their subsidy reimbursement obligations to the DISCOMs, leading to financial problems for the latter. This issue is only going to get worse due to the current trend of reduction in share of the cross-subsidy in the total subsidy.

3. **Subsidised electricity supply has facilitated agricultural growth:** The availability of electricity at cheap rates has been one of the important factors in the sharp rise in irrigation facilities, thus helping growth in agriculture. Groundwater is now the dominant source of irrigation in the country. As groundwater (or pumped) irrigation places control of the timing and quantity in the hands of the farmers, it has been the preferred mode of irrigation, and is likely to remain so in the future. Thus, groundwater, and in turn electricity will remain crucial for agricultural growth and by implication for livelihoods and food security in the country.

4. **Rationing hours of supply and connections has limited impacts:** Rationing of power supply by limiting hours of supply or restricting number of connections to agriculture does help impose some limits on in its electricity consumption and subsidy requirements, but it has not led to the expected results. The limitations in hours of supply have often been met by farmers installing higher capacity pumps and/or more pumps. Restrictions on new connections have seen rise in unauthorised connections. Feeder separation has reduced the hours of supply to agricultural pump-sets and reportedly improved the quality of supply. But it has also adversely affected water markets in several cases. Thus, rationing hours of supply and connections alone cannot curtail electricity consumption and thereby significantly reduce subsidy. This is because electricity consumption is driven primarily by the need for pumped irrigation, which would in turn depend on the irrigation water requirement of the crops cultivated, i.e. on the cropping pattern.

5. **Raising agricultural electricity tariff is likely to have significantly impact on farmers' incomes:** Farmers' margins for their produce are already being squeezed, and a rise in electricity tariff will only make matters worse for them, even though electricity cost is a small portion of the total input cost.

6. **DISCOMs need to take the first step to address the issues of poor quality electricity supply and low levels of metering:** While low metering levels for pump-sets have been attributed to resistance from farmers to metering, poor supply and service quality to agriculture has been seen as a result of the low agricultural tariff. However, continued

issuance of unmetered connections by DISCOMs and the failure of DISCOMs to take regular meter readings has shown that DISCOMs have also been reluctant when it comes to metering. It is difficult to attribute poor supply quality to agriculture and rural areas to low tariffs, as subsidy has been largely addressing the issue of low tariff. But it is also to be noted that subsidy is not always fully covered by the state or cross-subsidy, or not covered by the state in a timely manner.

Farmers and DISCOMs have been caught in a low equilibrium because of low revenue from agriculture for DISCOMs and poor supply quality for farmers. It is a challenge to ensure quality supply and service to rural consumers thinly spread over a large area. One way suggested to break out of this low equilibrium is to raise agricultural tariff which will improve the DISCOM's ability to provide better quality supply. However, improvement in power and service quality through higher tariffs is uncertain, largely owing to the lack of accountability of the DISCOM in ensuring improvements in supply and service quality.

Further, owing to farmers' distrust of DISCOMs as well as the significant impact of higher tariffs on farmer economics, DISCOM revenue from agriculture will not improve if power quality and service is not improved prior to tariff increase. Therefore, it is the DISCOMs which should take the first step to improve the quality of service before raising tariffs. A separate regulatory process with public hearings can be initiated to monitor power supply and service quality.

7. **Electricity subsidy is an enabler, rather than driver for excessive groundwater extraction:** The link between excessive extraction of groundwater and electricity subsidy is not straightforward. Hence, whether metering and raising tariff will address groundwater over-extraction is questionable. Cropping patterns are a major driver for the demand for groundwater, with cheap electricity being an enabler. The extensive use of diesel to power pump-sets, even though expensive to run, testifies to this. Growing crops in areas that are not agro-climatically suitable leads to less efficient use of water, and the need for excessive water withdrawals from groundwater. Sugarcane in some parts of Maharashtra and rice in Punjab are examples of this phenomenon. Such skewed cropping patterns are a result of better prices and more assured procurement compared to those prevalent for less water-intensive crops or crops more suitable to the region. Thus, unless farmers get a remunerative price and assured markets for crops which consume less water and are suitable to the local agro-climatic characteristics, commercial pricing of electricity to agriculture may not lead to reduction in groundwater extraction.

8. **Reduction in electricity subsidy alone is not a solution:** All of the above show that a higher electricity tariff (even if the increase is modest and within the paying capacity of farmers) may not solve the problems, unless there are simultaneous measures in power supply, agricultural marketing and groundwater conservation and regulation. It is also doubtful that increases in tariff would reduce the financial losses of DISCOMs and agricultural electricity subsidy, unless there are reliable estimates of agricultural consumption.

9. **Existing data is inadequate, unreliable and inconsistent:** Right from agricultural electricity consumption estimates to data on the groundwater irrigated area, many data points and data-sets with respect to electricity, water and agriculture are unreliable. There

is no data for key parameters like groundwater irrigated area by crop, or for variables related to electricity supply in some states, and existing data has many gaps. There are inconsistencies in the same data published by different agencies involved in ground water, agriculture and electricity. All of these make it hard to analyse issues related to subsidised electricity supply to agriculture. However, available data has been used with care so that the broad lessons and observations drawn in this discussion paper are not undermined by the data limitations.

Following are the suggestions that follow from these observations:

1. **Integrated approach to electricity supply and subsidy is needed:**

   Agricultural supply, metering, and tariff revision should not be seen only from an electricity/ DISCOM perspective. These issues need to be seen from a larger social perspective, which includes the needs and situation of farmers, and incorporates an understanding of the agriculture as well as water sectors, as shown in the figure. The determination of subsidy should also be done in such an integrated manner at the state level (or lower levels like district, block or panchayat), and can be coordinated by state governments. The quantum of subsidy should be backed by a clear rationale arrived through research, studies and planning that addresses suitable cropping patterns, farmers' economics and groundwater regulation.

2. **Framework for estimation of agricultural electricity consumption is needed:**

   Past experience has shown that universal pump-set metering is difficult due to various reasons. Thus, feeder and distribution transformer (DT) metering, regular energy audits, third party audits, publication of data in the public domain, and a periodic census of pump-sets will be needed for more reliable estimates of agricultural electricity consumption.

3. **Ideas need to be tested through pilot projects:**

   Since tariff reform alone is not a solution for the problem, other ideas need to be tried out in the form of pilot projects after consultation with farmers. Pre and post implementation studies should be conducted to evaluate their effectiveness. Solar plants of 1-2 MW capacity at the feeder level catering exclusively to agriculture feeder is an excellent alternate supply option. Metering of a group of pump-sets where farmers have shown interest, DT metering, automatic feeder metering, census of pumps and third party energy audits will help to improve consumption estimation. Setting up distributor transformer associations on the line of water users associations, community driven regulation of ground water extraction and recharge, and improved power and service quality and grievance redressal are some other possible pilots. Ideas to improve efficiency include extending capital subsidy for new and efficient pumps in areas without groundwater stress, block level hours of supply or electricity tariff depending on the cropping pattern and groundwater status of the block and a procurement and price regime to encourage a shift towards an appropriate cropping pattern.

It is apparent that the mainstream discourse around the role of electricity supply to agriculture in the financial loss of DISCOMs and groundwater over extraction has severe limitations. It only addresses issues like low electricity tariffs and lacks the emphasis on many key systemic problems of the electricity distribution, water and agriculture sectors, and the interlinkages between these sectors. Given low incomes and high risks in agriculture, levying higher charges on farmers should not be the immediate priority. Before that, the system needs to be made more accountable, inefficiencies in the system need to be weeded out, and supply and service quality has to be improved. Without these measures, agriculture will continue to be an easy scapegoat for issues surrounding the electricity-groundwater-agriculture 'nexus', and effective solutions for these problems will continue to remain elusive.

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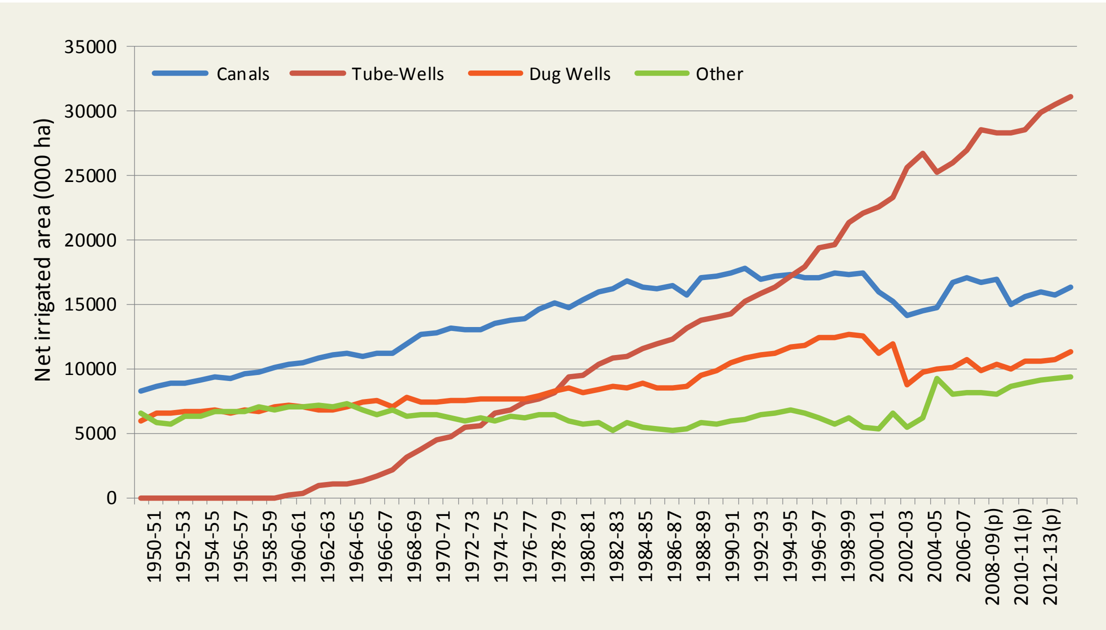
1. Introduction

The energy, water, agriculture sectors interact with each other in many ways. These inter-linkages between the three have far-reaching implications not only for sustainable development but also for the future resource security of the country. Known as the 'water-energy-food nexus' in relevant literature, use of electricity for pumped irrigation in agriculture forms an important part of these inter-linkages. The Green Revolution, which saw the advent of high-yielding varieties of seeds, increased use of chemical fertilizers and procurement and price support for crops, necessitated more, reliable and timely irrigation. With stagnation in the irrigation coverage of surface water schemes, uncertainty in the supply of surface irrigation water for farmers at the tail end of distribution networks, and easy accessibility of irrigation pumps in the market, more and more farmers started using pumped groundwater for irrigation.

Groundwater-based irrigation afforded farmers better control over water and enabled them to supply water to crops at crucial stages of the agricultural cycle. As electricity networks extended to rural areas, irrigation pumps started running on electricity, along with diesel. Flat tariff for electricity to agriculture was introduced in the 1970s in Karnataka and Andhra Pradesh, and subsequently implemented by many state electricity boards (SEBs) in the 1980s, which dismantled the metered tariff regime in agriculture. There are many reasons for this development. Chief among these are the elimination of metering and billing costs for the electricity distribution companies (DISCOMs), the rising political influence of large farmers, and agitations by farmers demanding parity between pump-set irrigation and surface irrigation costs (Dubash & Rajan, 2001; PEG, 2017a; Sankar, 2009, pp. 258-287). Irrigation pump-sets were operated on highly subsidised tariffs, and in a few states, were provided with free power. What followed was a manifold increase in groundwater-based irrigation as seen in Figure 1, thus making it the largest source of irrigation.

Figure 1: Rise in Area Irrigated by Groundwater (Dug-Wells and Tube-Wells)



Source: (MoACFW, 2016)

Rise in groundwater irrigation also led to a rise in agricultural productivity and substantial increases in production. Total production of food grains increased by close to five times from 1950-51 to 2010-11 as shown in Table 1. The main contributors to this growth were rice and wheat production, which together constituted about 75% of total food grain production in 2010-11 as against 53% in 1950-51, especially from northern states like Punjab and Haryana. Groundwater irrigation brought water to the fields of many farmers, boosted their yields and production, increased their incomes, and improved rural livelihoods. In all of these, along with other input subsidies, electricity subsidies played a significant role (Swain & Mehta, 2014).

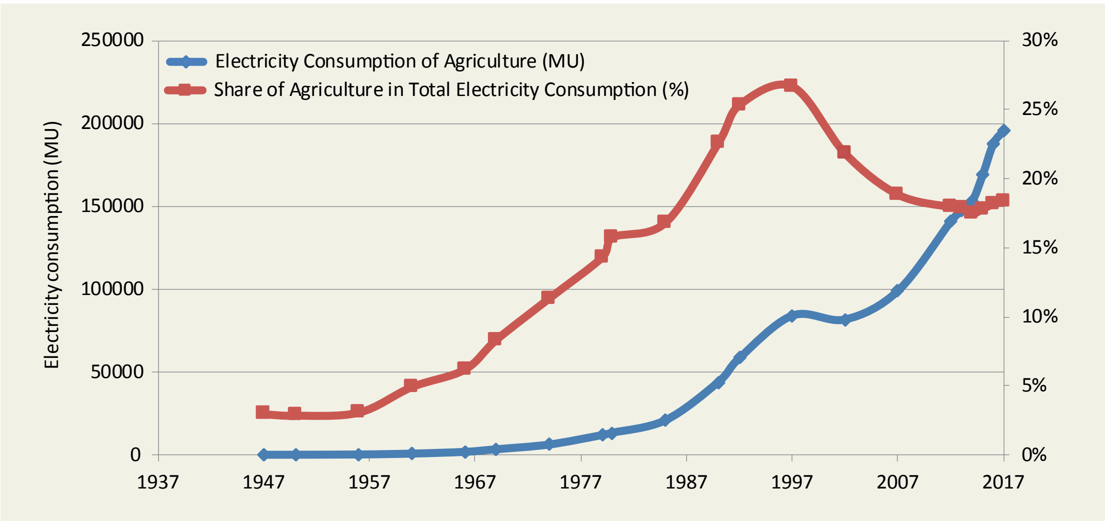
Table 1: Growth of Food Grain Production since Independence

Year	Food grain production in Million Tonnes (MT)
1950-51	50.82
1980-81	129.59
2010-11	244.49

Source: (MoA, 2013, p. 27)

Since the 1990s, the electricity sector has seen many changes such as the entry of private players (especially in generation), unbundling of State Electricity Boards (into generation, transmission and distribution companies), corporatisation of electricity companies and the establishment of electricity regulatory commissions. The policy discourse during the years leading to and following these changes has emphasised the negative impacts of the subsidy. Electricity distribution companies (DISCOMs) have been reeling under massive financial losses for a long time. In 2014-15 the accumulated losses of DISCOMs were more than Rs 58,000 Cr[1], constituting 15% of their total revenue in that year, while the aggregate technical and commercial losses stood at 24.6% (PFC, 2016). Three bailout packages have been implemented by the government so far to relieve them of their financial stress (PEG, 2017a). The latest, the Ujwal DISCOM Assurance Yojana (UDAY) introduced in 2015, has issued bonds worth more than 2 lakh crores as of January 2017 (PIB, 2017).

Figure 2: Growth of Electricity Sales to Agriculture



Source: (CEA, 2017, p. 43)

1. After accounting for subsidy received from the state government

Between 1973-74 and 2015-16 electricity sales to agriculture grew by an average of 8% per annum, reaching 173 billion units in 2015-16. Their share in the total electricity sales in the country, which was 11% in 1974, went on rising until it reached a peak of 27% in 1997, and steadily fell thereafter reaching 17% in 2015-16 (CEA, 2017).[2] This can be seen in Figure 2. With electricity sales to agriculture, the electricity subsidy required also increased. Electricity to agriculture is subsidised not only by the state governments, but also through cross-subsidy by commercial and industrial consumers who pay tariffs higher than the cost of supply. While the entire subsidy to agriculture is supposed to be met by the government and cross-subsidies, often some part of it is not covered by either and accrues as a loss to the DISCOM (as described in Section 3). At the same time, groundwater extraction, mainly driven by irrigation, exceeded replenishable groundwater availability in certain areas. As a result, blocks in such areas became over-exploited and critical. Electricity subsidies have thus drawn a lot of flak for causing many problems. They are blamed for the deteriorating finances of the electricity distribution companies (DISCOMs) (AF-Mercados, 2014), burdening cross-subsidising consumers (PWC, 2015), the poor quality of electricity supply to agricultural as well as other rural users (World Bank, 2001; Nair & Shah, 2012), the drain of state government coffers, the rapid rise in groundwater abstraction (Kumar & Singh, 2007; Kumar, Scott, & Singh, 2013) (MoP, 2007), and the inefficient use of electricity and groundwater. Crucially, the long term sustainability of groundwater irrigation itself has been brought into question.

The impact of electricity subsidies on the financial health of DISCOMs, and the electricity distribution sector as a whole, has been the subject of several government committees and industry reports. Rationalisation of agricultural tariff (which means reducing the subsidy component, and raising the tariff for agricultural consumers) was recommended by a central government committee as far back as 1980[3] (V G Rajadhyaksha Committee, 1980). Another committee constituted by the Planning Commission quantified the cumulative financial losses of the SEBs due to agriculture and pegged them at more than 5000 Cr in the early 1990s[4] (Planning Commission, 1994). A large body of literature has highlighted agriculture's role in eroding the financial viability of DISCOMs (AF-Mercados, 2014). According to a report published by the World Bank, which cited data from the Power Finance Corporation, "The share of agriculture in total electricity sales was 23% in 2011, while revenues from agriculture were only 7% of the total (Pargal & Ghosh Banerjee, 2014). Even the subsidised tariff revenue expected from agriculture may not be fully realised, because the bill payment rate of farmers is lower than that of other electricity consumers (MSEDCL, 2016). This is evidenced by government schemes to write off penalties and interest on dues from farmers like the Krishi Sanjivani Yojana in Maharashtra (MERC, 2004b) . Thus agriculture is cited as a key factor responsible for the losses in electricity distribution.

Is Agriculture the Trouble Maker for the Electricity Distribution Sector?

There is some truth in the idea that electricity supply to agriculture is a financial burden for the electricity distribution sector. However, our analysis shows that the losses attributed to

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2. The decline in the share of agricultural sales in the total electricity sales after 1997 can be attributed mainly to the faster growth in agricultural as opposed to non-agricultural sales. Some of it can also be attributed to a restatement of agricultural sales, which is likely to be responsible for the dip in agricultural sales before 2000. Refer Section 2.2 for details.

3. The committee also cited power intensive industries as a major beneficiary of subsidies.

4. Losses are in early 1990s prices.

agriculture cannot be laid solely at its door. Despite the focus on tariff subsidies to agriculture, not much attention has been paid to its nature, trends, financing, and whether the entire subsidy goes to agriculture in reality. Being largely unmetered, the quantum of electricity consumption to agriculture is as good as unknown. Not much is known about electricity consumption patterns across crops, seasons, metered and unmetered consumers. Evidence from literature, our analysis and the current incentive structure for DISCOMs suggest that electricity consumption in agriculture is over-stated. This is covered in detail in Section 2. Low electricity bill payments in agriculture are as much a DISCOM issue as a farmers' issue, because farmers do not trust DISCOMs. This aspect is discussed in Section 4. Other factors that have contributed to DISCOM losses like non-receipt of the full state government subsidy required by DISCOMs have often flown under the radar. As a result, the extent of the sector's losses attributable to agriculture but due to factors other than agriculture has not been duly assessed. This would include factors outside the power sector as well, which are discussed in Section 5. It is imperative to ascertain this to know if measures to reduce the subsidy are indeed effective.

On the other hand, the financial problems of DISCOMs also affect farmers, who have to make do with poor power supply and service quality. While this is acknowledged as a problem, it is projected as a result of the low agricultural tariffs alone (World Bank, 2001). However, poor quality of supply to agriculture is the result of a combination of factors, which include neglect by DISCOMs, lack of adequate regulatory mechanisms, along with low tariffs. This is discussed in Section 4.

Proposed Solutions and Their Limitations

The issues surrounding the inter-linkages between electricity, water and agriculture have been analysed and discussed by academic researchers, policy makers, government committees and international organisations like the World Bank. These individuals and organisations have also offered suggestions to resolve these issues. Many of these suggestions include metering of pump-sets, charging electricity according to its use, and rationalising tariffs, which will set a cost for using groundwater (Kumar, Scott, & Singh, 2013; World Bank, 2001; MoP, 2007). Multiple government committees have suggested a minimum tariff for agriculture at 50 paise/kWh in the 1990s (GoI, 1993; Planning Commission, 1994). However, tariffs continue to be low. Since raising agricultural tariffs is seen as politically difficult, some other measures to limit the subsidy burden and groundwater extraction have been implemented. Efforts by the DISCOMs include limiting hours of supply to restrict agricultural electricity consumption, provision of agricultural supply at off-peak hours[5], rationing new connections, promoting efficient pump-sets to reduce consumption and encouraging solar pump-sets. Efforts made in the water sector include attempts to promote groundwater conservation through drip irrigation as well as farm ponds, rainwater harvesting and ground water regulations. On the agriculture side, there has been some discussion on the lines of shifting cropping patterns to less water-intensive crops, but there has been little effective implementation. Also, these efforts are handicapped by a lack of coordination. Due to the complex and multi-faceted nature of the issue as well as inertia on the part of stakeholders to work towards consensus, their impact has been limited.

Most importantly, farmers, especially small and marginal farmers (who need affordable, timely, adequate and sustainable access to irrigation), are not at the centre of any initiative to address the

5. This also makes agriculture an effective load management tool for the DISCOM, which is discussed in detail in Section 4.5.

linkage challenges. These farmers dig their own wells, install pump-sets, and cannot circumvent poor service and supply through multiple electricity connections or diesel pump-sets. As a result, they continue to be affected adversely. The role of state electricity regulatory commissions (SERCs) in effectively tackling these challenges has not been adequately explored.

We felt it important to examine this issue more closely, and in a more comprehensive manner against the background of persisting financial problems of the DISCOMs, the onus that is placed on the agricultural supply for this, and the far-reaching implications of any measures in agricultural electricity supply. There are two key motivations behind this study: First is to question the role of electricity supply to agriculture in the financial losses of DISCOMs. Secondly, we make a fresh comprehensive analysis of electricity supply to agriculture keeping in mind its linkages to the water and agriculture sectors.

This discussion paper, on the issue elaborated above and called 'Understanding the Electricity, Water, Agriculture Linkages' is presented in two volumes. Volume 1 provides an overview of the linkages between electricity, water and agriculture, 'and Volume 2 (which is this document) discusses the challenges in electricity supply. Volume 2 provides a detailed analysis of issues related to the electricity-water-agriculture linkages specifically pertaining to the electricity sector. It also includes a brief overview of the relationship of the electricity sector with water and agriculture in Section 5. It critically examines the current power sector approach to agriculture with respect to consumption estimation, subsidy, power supply and service, load management, connections and metering. To begin with, we look at the estimation of electricity consumption in agriculture and the impact of its overestimation. Next, we assess the distribution of the subsidy among consumers and subsidy financing. Following this, we examine the issues surrounding power supply and the quality of service to agriculture. Finally, we summarise our observations and offer suggestions towards a way forward. This volume has an Annexure which discusses certain sections of the volume in detail and can be downloaded from the Prayas (Energy Group) website (http://www.prayaspune.org/peg/publications.html).

Before we begin, we would like to mention some important disclaimers about this volume. There are many gaps in the data on electricity end use, especially agricultural consumption, connected load, subsidy, metering, revenue, and power quality. For many states no data is available. These gaps have been highlighted by Prayas (Energy Group) before (PEG, 1996). Also, there are inconsistencies in the data published by different agencies like the Power Finance Corporation (PFC), Planning Commission, State Electricity Regulatory Commissions (SERC), Central Electricity Authority (CEA), Ministry of Water Resources, River Development and Ganga Rejuvenation and Ministry of Agriculture and Farmers' Welfare (MoAFW). Since SERC data is subjected to some third party oversight, we have largely depended on it for our observations. We suggest that the quality of data available should be improved on priority.

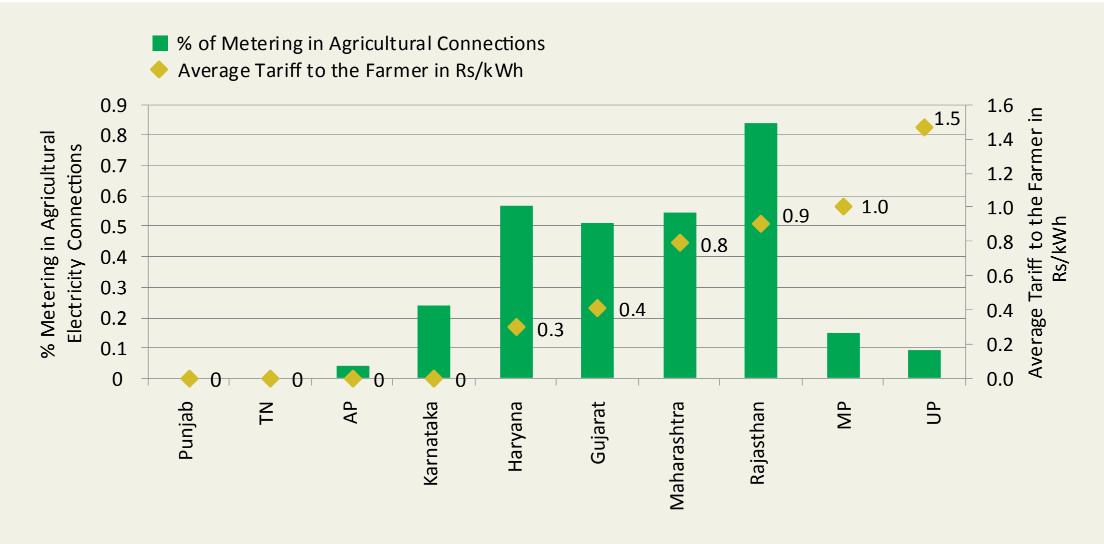
In addition to this, some reference years for the analysis may seem dated. This is because common reference years for different data points required for analysis were limited, and this report has relied on true-d up financial and physical parameters of DISCOMs (i.e. the actual figures rather than projected ones) which were available at the time of writing. Care has been taken that the lessons and observations drawn are not undermined by the limitations of data.

2. Estimation of Electricity Consumption in Agriculture

Ever since electricity to agriculture became unmetered, its actual consumption is unknown[6]. Only 27% of electricity connections for agriculture were metered in 2012-13 in the major agricultural electricity consuming states: erstwhile undivided Andhra Pradesh (AP), Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh (MP), Punjab, Rajasthan, Tamil Nadu (TN) and Uttar Pradesh (UP).[7] Among these, almost all agricultural connections in Punjab, Andhra Pradesh and Tamil Nadu are unmetered. This is despite the fact that since the last two decades, many official agencies have suggested 100% metering of all electricity consumers, including agricultural consumers (Planning Commission, 1994) (GoI, 1993). 100% metering has also been stipulated in the Electricity Act 2003, is a pre-requisite for the bailout schemes for DISCOMs, and has repeatedly been directed by the SERCs.

The second important feature of agricultural electricity consumption is that it is free in many states, or has very low tariffs. Figure 3 shows the metering levels of agricultural connections[8] and average tariffs to the farmer (after subsidy) in different states in the 2012-2014 period[9]. As a comparison, many of the states had an average cost of supply to consumers of more than Rs 6/kWh during this period.

Figure 3: Average Electricity Tariff after Subsidy to the Farmer, and Metering % in 2012-2014 period



Source: Prayas (Energy Group) analysis from data in various state tariff orders and petitions.

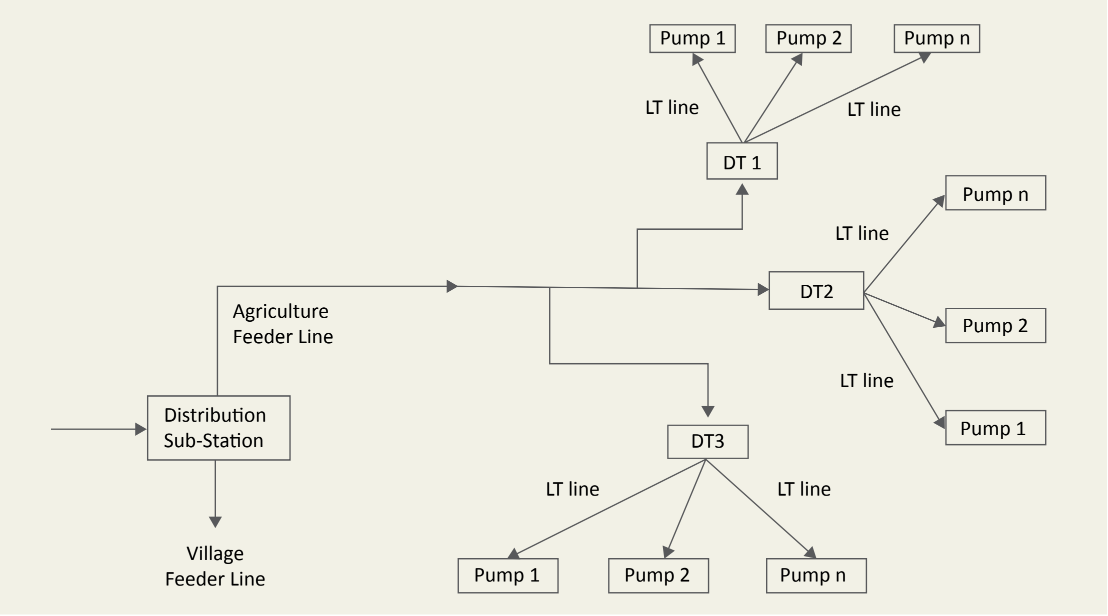
6. Here the term 'electricity consumption in agriculture' is used for electricity consumption by irrigation-related pumping, as DISCOMs categorise irrigation pumps in the 'agriculture' category.
7. Analysis by Prayas (Energy Group) based on various regulatory petitions and orders.
8. This is an approximation of the metering level of pump-sets.
9. Average electricity tariffs are for the year 2013-14, whereas pump-set metering data is for the year 2012-13, except for Andhra Pradesh for which it is for the year 2013-14.

The figure shows that metering is close to zero in states where power to agriculture is free, i.e. Andhra Pradesh[10], Punjab and Tamil Nadu[11]. This shows that free power reduces the incentive for DISCOMS to meter pump-sets. Rajasthan shows high levels of metering, but it employs a different metering arrangement where meters are not always installed on pump-sets, but on electricity poles and transformers (Rajasthan Electricity Regulatory Commission, 2012). Given the large share of unmetered connections in agricultural connections, there is a need to study how unmetered electricity consumption in agriculture is estimated. We use the term 'electricity consumption in agriculture' in this volume as that is the term used by DISCOMs. This electricity consumption is essentially electricity consumption by irrigation pump-sets.

2.1 Methodologies of Estimation of Electricity Consumption in Agriculture

Figure 4 depicts the distribution system[12] and how electricity is supplied to agricultural pump-sets. From a 33 kV substation, there would typically be 3-4 agricultural feeders[13], on each feeder there would be some 20 DTs and on each DT, around 20 pump-sets[14]. This is the common layout in cases where physical feeder separation has been done, i.e agricultural load is separated from non-agricultural load. Alternatively, there are mixed feeders supplying to a common load of agricultural pumps and non-agricultural village load.

Figure 4: Agriculture Supply in the Electricity Distribution System



Source: (PEG, 2015)

10. For pump-sets meeting certain efficiency criteria and farmers having less than 2.5 acres of land and 3 connections. Most agricultural connections in Andhra Pradesh fall under this category.
11. Karnataka also has free power for pumps less than 10 hp (which constitute most of the agricultural connections), but the metering % given is not very low. However the figure is from a secondary source (AF-Mercados, 2014) and could not be verified from regulatory data. Anecdotal evidence suggests that the metering level is lower.
12. In a distribution system with separate feeders for agriculture and other rural consumers
13. There can be a few non-agricultural consumers connected to agricultural feeders, but agriculture pump-sets typically consume nearly 90% of the total electricity consumed under these feeders.
14. Substation = 33 kV substation; Feeder = 11 kV feeder; DT = distribution transformer; LT = Low Tension.

Unmetered electricity consumption is estimated using norms for benchmark consumption of pump-sets and distribution transformers (DTs). The benchmark is the average number of units consumed by a pump per hp or by a DT of a particular capacity in one year. In the case of pump-sets, one benchmark value is used for all unmetered pump-sets in a DISCOM in many states. While estimating the benchmark consumption of DTs, those supplying exclusively or predominantly to pump-sets are considered. The benchmarks are arrived at by monitoring sample pump-sets, DTs. Consumption is also estimated using quantum of energy input into agricultural feeders.

As shown in Table 2, unmetered agricultural consumption can be estimated by using one of the three methods—based on the pump-set benchmark, DT benchmark or feeder energy input. Different states, sometimes even DISCOMs within a state, use different estimation methodologies.

Table 2: Main Approaches to Unmetered Agricultural Power Estimation

Approach	Description	States using the approach
Based on benchmark consumption norm for agricultural pump-sets	Meters are fixed on sample pump-sets or sample DTs to measure the benchmark consumption of a pump-set (per pump-set, per hp or per kW of pump capacity) in a year. In case of DTs, loss in the LT line is subtracted to arrive at the pump-set consumption. Benchmark value is multiplied by the total connected load of the pump-sets. In some cases, instead of fixing meters on sample pump-sets, readings of metered connections are used to estimate consumption.	Maharashtra, MP, Gujarat, Rajasthan, TN, UP, Karnataka (MESCOM, HESCOM, BESCOM, GESCOM)
Based on benchmark consumption norm of DTs	DTs supplying power predominantly to agricultural pumps are considered. Meters are fixed on sample DTs of different capacities to measure the benchmark consumption of a DT of that capacity. The benchmark value is multiplied by the number of DTs of that capacity to arrive at the consumption by all DTs of that capacity. Consumption of DTs of a capacity is aggregated across capacities to arrive at total consumption by DTs. Line losses below the DT are subtracted to arrive at the consumption by pump-sets. This method was devised by the Indian Statistical Institute, Hyderabad. (Telangana State Electricity Regulatory Commission, 2015)	Telangana, AP
Based on Energy Input into Agricultural Feeders	Here meters are fixed on feeders to measure energy supplied by them. Agricultural feeders or those predominantly supplying to agriculture are chosen. Ideally this requires segregation of pump-set load from that of other rural consumers. The line losses below the feeder are subtracted to arrive at the consumption by pump-sets.	Punjab, Haryana, Karnataka (CESC)

Estimation methodologies are also used to project future consumption using compound growth rates of past consumption, or past growth in pump-set consumption per HP and anticipated growth in the connected load of pump-sets, based on proposed release of connections. State level estimation methodologies are described in detail in Section 1 of the Annexure, while the key shortcomings are described in Section 2.4.

2.2 History of (Over) Estimation of Electricity Consumption in Agriculture

Some electricity is lost in the distribution system during transit before it reaches the end consumer, which is termed the distribution loss.[15] This loss consists of a technical loss (loss in the electricity lines and transformers) and a commercial loss (that due to unaccounted consumption or theft). Thus, the distribution loss is the difference between the total electricity input to the DISCOM and the total electricity sold by the DISCOM. When electricity consumption is unmetered, one cannot determine how much electricity is reaching the consumer and how much is getting lost as a distribution loss. As agriculture accounts for most of the unmetered consumption[16], estimation of distribution loss is highly dependent on the estimation of unmetered agricultural consumption. Thus, an overestimation of the agricultural electricity consumption leads to an underestimation of the distribution loss.

Many have argued that agricultural electricity consumption is overestimated by the DISCOMs to project low distribution losses and claim higher subsidy. A 2011 committee on distribution utility finances constituted by the Planning Commission and headed by V K Shunglu pointed out that, while an average pump-set was reportedly consuming 28,000 kWh/annum in Jammu & Kashmir, its consumption was 5,300 kWh/annum in Tamil Nadu.[17] It remarked that, *"It would be apparent that agricultural consumption estimates are overstated and some of the losses otherwise attributable to Aggregate Technical and Commercial (AT&C) losses are classified as agricultural consumption"*[18] (Planning Commission, 2011, p. 88). An earlier World Bank survey of agricultural pump-sets in Andhra Pradesh and Haryana also made the same observation (World Bank, 2001). But nowadays, this phenomenon often does not find a place in discussions around DISCOM financial losses due to agriculture as it did during the reform period in the 2000s.

Before the SERCs were set up, State Electricity Boards (SEBs) had a relatively free reign over the estimation of electricity consumption in agriculture, which was often done in an ad-hoc and non-transparent manner (Honnihal, 2004). During this time, there were also some blatant errors in calculation, like in the case of the Karnataka Electricity Board (KEB)[19]. An independent survey of pump-sets was carried out in the KEB around 1994, which put agricultural consumption for 1994-95 in Karnataka at 26% of energy input instead of 36% (as claimed by the KEB), and T&D losses at 30% instead of 19% (as claimed by the KEB)[20]. After the SERC's were established in

15. Some states like Tamil Nadu and Punjab don't report the distribution loss separately, but include it with the losses in the transmission lines (lines from generating stations up to distribution sub stations). This is reported as a transmission and distribution loss (T&D).

16. Except in UP and Bihar which also have many unmetered domestic connections.

17. The distribution loss at the time in J&K was 69.05% and in Tamil Nadu was 14.39%.

18. AT&C loss is the difference between the electricity units input into the system and the units for which payment is collected. Hence it includes both distribution loss, as well as the loss on account of bills not being issued by the DISCOM and the billed amounts not being collected from consumers (PEG, 2006).

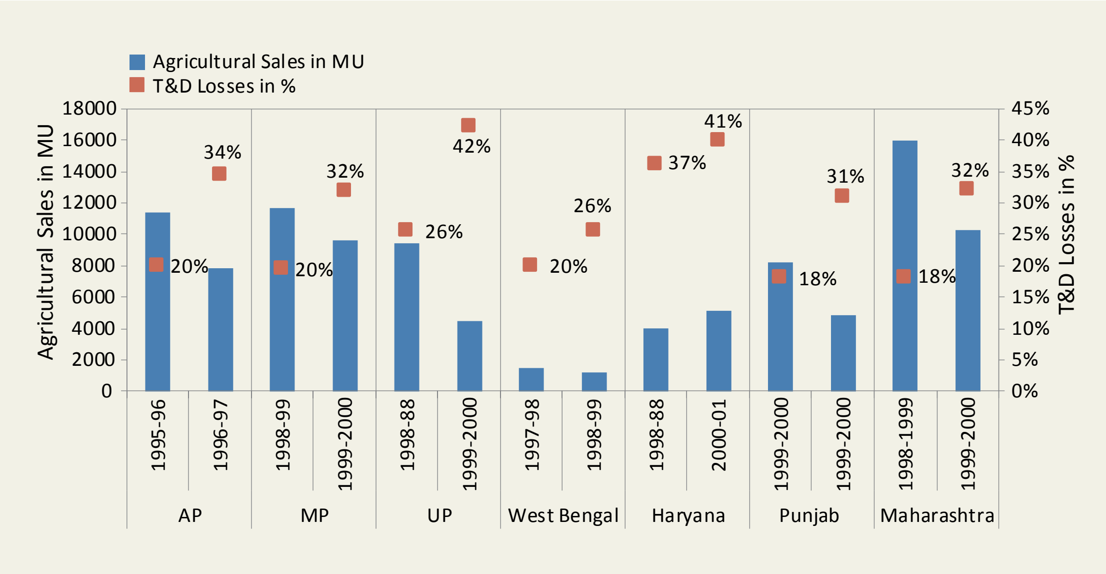
19. For estimating agricultural consumption for 1994-95, the KEB had used the normative consumption by pump-sets on dug-wells, tube-wells and river beds from an independent sample survey of metered pump-sets to estimate total agricultural consumption. However, the weights used for these different types of pump-sets were based on the distribution of new pump-sets installed in 1991-96, instead of being based on the distribution of total pump-sets in that year.

20. The agricultural sales and losses of KEB were not actually restated. These are (Reddy & Gladys, 1997)'s estimates using the correct weights for different types of pump-sets.

the period of 1998 to 2001, successive studies on agricultural consumption using a sample of pumps/DTs/feeders were conducted in different states such as Maharashtra, Haryana, Karnataka, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh and Punjab, and better estimation methodologies were adopted (Honnihal, 2004; PSERC, 2002). This revealed that agricultural consumption was overestimated in many states.

In fact, after the establishment of many SERC's, electricity consumption in agriculture across the country actually declined from 84,000 MU in 1996-97 to 81,700 MU in 2001-02 (See Figure 2). During the same period, the number of pump-sets increased from 1.16 Cr to 1.30 Cr, and electricity consumption by all other consumers increased from 320 BU to 370 BU. T&D losses increased from 22.8% to 34% (CEA, 2015; Planning Commission, 2002; Planning Commission, 2001). Figure 5 gives information for some states whose SEBs saw a decrease in agricultural sales and increase in T&D losses in the period 1996-2001.[21]

Figure 5: Revision in Agricultural Sales and T&D Losses



Source: (Sankar, 2003) (Planning Commission, 2002)

The advent of the SERC's brought in greater oversight of agricultural estimation. Obvious mistakes, as the one committed by the KEB in Karnataka described earlier, were more likely to be corrected. This was a welcome sign, but unfortunately, these improvements in the estimation processes are not enough and more needs to be done. Estimation processes continue to be plagued by problems of unwarranted assumptions, lack of transparency and data gaps as described in Section 2.4. This has resulted in agricultural consumption and loss being restated again in a few states in recent times, as described in the next section. Some DISCOMs have seen multiple restatements of agricultural consumption and distribution loss. Table 3 shows details of these in Maharashtra and Punjab.

21. The data for Andhra Pradesh is from (Sankar, Power Sector: Rise, Fall and Reform, 2003). The revision was a result of an internal taskforce set up by the Andhra Pradesh State Electricity Board to conduct a survey of agricultural consumption. The rest of the data is from the Planning Commission.

Table 3: Agricultural Sales and Distribution Loss Before and After Restatement

State (DISCOM)	Year of Restatement	Agricultural Sales (Before) in MU	Agricultural Sales (After) in MU	Distribution Loss (Before)	Distribution Loss (After)	Agricultural Sales Overreported by %
Punjab (PSPCL)	1999-2000	8233	4888	18%*	31%*	68%
	2010-11	10,152	9656	18%*	19%*	5%
Maharashtra (MSEDCL)	1999-2000	15,968 (1998-99)	8,471 (2000-01)	18%	31.8%	68%**
	2006-07	14,968	9702	27%	35%	54%
	2014-15	25,685	23,271	14%	16%	10%

Source: PEG compilation from various regulatory orders and petitions (PSERC, 2002; MERC, 2002; PSERC, 2014; MERC, 2006; MERC, 2016; MERC, 2000).

Notes: *The loss for PSPCL is T&D loss. **The annual hours of pump operation were restated from 2120 in 1998-99 to 1260 in 2000-01. The connected load of agriculture under MSEDCL also dropped from 7533 MW to 6726 MW in the same period. 68% is the overreporting in hours of pump operation.

Some other states like Madhya Pradesh, Rajasthan and Gujarat are yet to see a validation of the agricultural consumption estimates that are accessible to the public. For example, in Madhya Pradesh, electricity sales to agriculture grew at an average rate of 13% pa, which is quite a high rate, from 12,600 MU in 2013-14 to 20,800 MU in 2017-18. It is now the state with the third highest electricity consumption in agriculture in the country. As a comparison, the electricity sales to agriculture in all other states together where electricity to agriculture is significant, grew by only 5% pa on average in the same period.[22] This could be attributed to the high growth in groundwater irrigation and electrification of pump-sets in Madhya Pradesh, but there is no publically available substantiation of the consumption estimates beyond the present methodology.

2.3 Impact of Restatement

Table 4 summarises the instances in DISCOMs where consumption and loss have been restated in recent times.[23]

Table 4: Restatement of Agricultural Electricity Sales and Distribution Loss

Particulars	Maharashtra (2014-15)		TN (2010-11)		Punjab (2010-11)		Haryana-UHBVNL (2010-11)	
	Before	After	Before	After	Before	After	Before	After
Agricultural Sales	23%	21%	16%	14%	25%	24%	33%	24%
Distribution Loss	14.2%	16.4%	17.6%	21.8%	18%	19.1%	24%	33%
Agricultural Sales in MU	25,685	23,271	11,206	9619	10,152	9656	5029	3606
Sales overreported by	10%		16%		5%		39%	

Source: PEG compilation from various regulatory orders and petitions

Note: For Punjab and Tamil Nadu, the distribution loss refers to the T&D loss. Both agricultural sales and distribution loss are expressed as a % of the total energy input to the DISCOM.

22. Compilation and analysis by Prayas from state regulatory orders and petitions and (PFC, 2016). 'Other states' here are Andhra Pradesh, Telangana, Gujarat, Haryana, Punjab, Karnataka, Maharashtra, Rajasthan and Tamil Nadu.

23. Though HERC did not officially restate the agricultural sales and losses of UHBVNL and DHBVNL (not included here), the agricultural sales for 2010-11 as reported by the UHBVNL using the old agricultural estimation methodology were markedly lower than those estimated by the commission using the new methodology.

In all instances, more robust methodologies of agricultural estimation were adopted by the SERC as part of the change in methodology. In Maharashtra and Punjab, feeder separation and availability of feeder meter readings led to the discovery of negative feeder losses, which led to the adoption of a different methodology for agricultural consumption estimation. Negative feeder losses are the curious phenomenon where electricity consumption, as determined by the agricultural estimation methodology, is greater than the energy input into the feeder. In the Maharashtra State Electricity Distribution Company Limited (MSEDCL), negative feeder losses were found on almost 40% of its agricultural feeders (MERC, 2016). Evidence of hours of pump operation being significantly higher in drought-prone areas compared to areas where water-intensive sugarcane is cultivated was also brought forward by Prayas (PEG, 2016). In Punjab, negative losses on agricultural feeders were seen in more than 40% of the Punjab State Power Corporation Limited (PSPCL)'s divisions (PSERC, 2016). It is also important to note here that the presence of negative feeder loss even after a decade of agricultural sales restatement in many states indicates the dismal state of metering at the feeder level. Haryana, too, adopted the feeder-based methodology at around the same time, leading to restatement. On the other hand, the Tamil Nadu DISCOM, the Tamil Nadu Generation and Distribution Corporation (TANGEDCO) conducted a larger survey of pump-sets at the circle level with better sampling, which changed the benchmark pump-set consumption norm.

Restatement of agricultural consumption has multiple financial impacts on the electricity distribution sector. First, subsidy required for agriculture is lower because electricity consumption in agriculture is shown to be lower.[24] Second, DISCOMS have to bear a higher share of the financial loss. Since distribution loss is electricity for which the DISCOM has incurred power purchase and related expenses, but has received no revenue, a higher distribution loss results in higher financial loss. SERCs set targets for reduction in distribution loss, and when these are not met, a higher financial loss is incurred than anticipated. According to tariff regulations in states, this higher financial loss is either fully or predominantly borne by the DISCOMs. Three out of the four states considered here—Maharashtra, Tamil Nadu and Punjab—have regulations stipulating that the distribution loss that is higher than the targets set by the SERC has to be partially or fully borne by the DISCOM[25]. On the other hand, a DISCOM's loss in revenue because of other uncontrollable factors, like subsidised power to agriculture, can be partly recovered from non-agricultural consumers in the form of higher tariffs.[26] Thus, when the distribution loss is revealed to be higher, the DISCOM cannot fully pass the resultant financial loss onto others. Third, DISCOM gets a better image with lenders, the government, etc by showing low distribution loss. This shows that hiding distribution loss as agricultural sales helps DISCOMs.

If efforts are made to reduce the restated distribution loss to the level reported before the restatement, the extra electricity can be sold to paying consumers.[27] We use this difference between

24. Although tariff to agriculture is based on pump-set capacity, determination of the agricultural subsidy and tariff requires some assumption about the average consumption by a pump-set, which is the benchmark consumption norm. If this norm is over-estimated, agricultural subsidy is over-estimated. In states which use feeder based methodology for agricultural consumption estimation, agricultural subsidy is estimated using estimate of agricultural sales.

25. In Maharashtra, the DISCOMs have to bear two thirds of the loss, Tamil Nadu DISCOMs have to bear half of the loss, and PSPCL in Punjab has to bear the entire loss (MERC, 2016, p. 154; TNERC, 2012, p. 286; PSERC, 2014).

26. If agricultural tariff is subsidised by the government, then the financial loss is also recovered from the government.

27. Loss reduction will require investments in the distribution infrastructure, but this will be an investment yielding long-term dividend in the form of reduced financial losses.

the distribution loss before and after restatement and the average billing rate (average per unit sales revenue of the DISCOM after subsidy) to quantify the financial benefit to the DISCOM through additional revenue. The revenue from the extra sale of electricity would be around Rs 1,140 Cr for MSEDCL, around 870 Cr for TANGEDCO, around 140 Cr for PSPCL, and around 370 Cr for Haryana's DISCOM, the Uttar Haryana Bijli Vitran Nigam Limited (UHBVNL)[28]. This additional revenue would raise existing revenues by 3% in MSEDCL, 5% in TANGEDCO, 1% in PSPCL and 12% in UHBVNL. The details of the calculation are provided in Section 2 of the Annexure. The restatement in MSEDCL and TANGEDCO is conservative, as described in Sections 1.1 and 1.5 of the Annexure respectively. The Punjab SERC, the Punjab State Electricity Regulatory Commission (PSERC) had already been revising agricultural sales estimates submitted by PSPCL to reflect a truer picture of consumption, and thus the restatement for PSPCL is not as significant as the others.

2.4 Consumption Estimation: Issues

As we have seen earlier, the estimation process is ridden with many short comings and data gaps, and assumptions about the missing data lead to overestimation of agricultural consumption. This is made worse by the fact that DISCOMs are reluctant to put out all relevant data in the public domain. With around 2.1 crore pump-sets in the country and most of them unmetered, estimating agricultural consumption is no doubt a herculean task. However, there are many lacunae on part of the DISCOMs in collecting important data, as well as in the use of the available data. Efforts of some SERCs towards making DISCOMs conduct studies on electricity consumption in agriculture, metering the distribution system, and ensuring compliance to directives have not been adequately successful. There is scope for SERCs to do more in this direction, as elaborated in the following sections.

i. Key data not reliable

One of the most fundamental data points, the total number of operational pump-sets and their total connected load, cannot be stated by anyone with confidence. The agricultural connections as recorded by DISCOMs are widely different from the number of pump-sets in other data sources. The total number of electricity powered wells and tube-wells as per the Minor Irrigation Census across the country in 2013-14 is less than 15 million (MoWR, 2017), whereas the number of irrigation pump-sets according to the CEA's data[29] as on March 2014 is more than 19 million (CEA, 2015).[30] Some of the difference may be explained by time lags and definitional differences between the sources, but the quantum of difference is too large to be explained by these factors alone (Rawat & Mukherjee, 2012).[31]

The number of agricultural connections reported by DISCOMs is the number of cumulative connections, and can include permanently disconnected agricultural connections and exclude illegal connections. The connected load data may also be outdated as actual pump capacities

28. Revenues for MSEDCL and TANGEDCO are likely to be higher as restatement is conservative.

29. CEA data is collected from DISCOMs.

30. Similarly, the total electricity powered wells and tube-wells as per the Minor Irrigation Census in 2006-07 across the country was 11 million (Minor Irrigation Census 2006-07), whereas the number of irrigation pump-sets in CEA's data as on March 2007 was 15.3 million (CEA, 2009).

31. At the state level, the discrepancies between different data sources are larger. For example, in Bihar there were more than 2 lakh electric powered wells and tube-wells in 2010-11 according to the Agricultural Census. On the other hand, there were no electricity powered wells and tube-wells according to the Minor Irrigation Census in 2006-07.

may be higher on the field than that reported to the DISCOM (World Bank, 2001). This is also corroborated by load disclosure schemes, like the one in Punjab described in Section 1.8 of the Annexure.[32] Attempts to revise records of pump-set capacity with the DISCOM to reflect the true capacity on the field may not be based on actual field surveys or energy audits. On the other hand, there can be multiple pump-sets on an irrigation scheme or a single pump-set on multiple schemes in the Minor Irrigation Census.

ii. Many unsubstantiated assumptions, limited efforts to collect important data and available data not put to use

Pump-set consumption norms should be calibrated every few years, but this is not always done. In fact, after a one-time exercise, these benchmark consumption norms are used for many years, as in the cases of DISCOMs in Gujarat and Rajasthan. These DISCOMs have been using the same benchmark consumption values since 2004 and 2006 respectively. The details are provided in Sections 1.2 and 1.3 of the Annexure.

In the absence of actual field measurements, very often unsubstantiated assumptions are employed. The official hours of supply to agriculture are used as a proxy for the hours of operation of pump-sets, like in Madhya Pradesh. However, actual hours of pump operation can be lower due to frequent outages, or higher due to manipulations like converting single/two-phase supply to three-phase. In Madhya Pradesh, pumps are assumed to be operational on all days throughout the year, excepting one day a week. This can be a problematic assumption, because the hours of operation depend on the irrigation needs of crops grown. As the irrigation requirement is seasonal in nature, and irrigation water is needed only at certain stages of the crop cycle, the hours of operation in a year can be lower than the actual hours of supply in that year.

Most of these unsubstantiated assumptions push estimates of agricultural consumption upwards. Barring certain sample surveys covering limited areas, there is no reliable disaggregated data on actual hours of pump operation, pumping efficiency and irrigation efficiency in the country. Representativeness of existing samples (be it pump-set or DT/feeder) with respect to cropping pattern and groundwater levels cannot be verified.

The importance of metering DTs has been recognised by the state commissions and policy makers. However, progress on this front has been slow in most states. The Madhya Pradesh Electricity Regulatory Commission (MPERC) had directed all DISCOMs to install meters on DTs, including agricultural DTs as far back as 2003 (MPERC, 2004, p. 43), but only 25% of agricultural DTs had meters in 2016 (MPERC, 2016, p. 10). The Maharashtra Electricity Regulatory Commission (MERC) has also been directing MSEDCL to meter all its agricultural DTs since 2003 (MERC, 2004a), but this has not been achieved so far. The UDAY website shows that in 25 states, only 53% DTs are metered in rural areas as of June 2018 (MoP, 2018b).

32. Agricultural consumption can be overestimated due to inclusion of permanently disconnected agricultural load and overestimation of hours of pump operation in a year. As opposed to this, the exclusion of unauthorised load can lead to an underestimation of agricultural consumption. However, even exclusion of unauthorised agricultural consumption is not enough to cancel out the overestimation of agricultural consumption. The external agency studying the voluntary load disclosure scheme in Punjab found that in spite of underreporting of connected load, agricultural consumption was overestimated. In Punjab, Haryana and Maharashtra, agricultural consumption estimates computed using legal agricultural load were higher than consumption estimates from agricultural feeders. In fact, negative feeder losses were reported in Maharashtra and Punjab.

In cases where alternative data is available, it is not put to use for estimation. In spite of being the first state to complete feeder separation, DISCOMs in Gujarat do not use feeder meter data to estimate agricultural consumption.[33] In Rajasthan, the DISCOMs or the regulatory commission do not use the reported meter data from 88% agricultural consumers for informing the estimation process, which also raises questions over the reliability of this data. The situation is similar with the Mangalore Electricity Supply Company Limited (MESCOM) in Karnataka, where substantial metering of pump-sets is carried out. The Karnataka Electricity Regulatory Commission (KERC) has directed MESCOM to furnish this meter data (KERC, 2016, p. 29). Pump-set metering carried out in the Udupi district of Karnataka in early 2000s covered more than 90% of pump-sets in the Udupi division of MESCOM. According to MESCOM's calculations, the benchmark consumption from DT meters in the division came to 1340 units per pump-set per annum in the year 2009-10, whereas pump meters showed the average consumption to be 631 units.[34]

DT and feeder metering based estimation also involve certain issues. Consumption by non-agricultural consumers on predominantly agricultural DTs has to be isolated accurately, but poor metering and billing systems in rural areas can skew calculations.[35] Reliable estimates of loss levels below the feeder/DT through energy audits are often not available, like in Punjab where this loss is derived from the target T&D loss (PSERC, 2016), or in Maharashtra where this loss was not accounted for. (MERC, 2016; MERC, 2006, p. 92).

iii. Faulty meters and meter readings

Even though the methodology adopted by an SERC itself may be robust and reliable, measurement of data and meter readings may not be accurate. All the meters may not be in working condition and there can be errors in reading the meters on pump-sets, agricultural feeders or DTs. It is essential that meter readings used for estimation are available throughout the year. If they are not, or the meters are defective, readings are invalid. In such cases, there are limited efforts to correct the situation, except where Automatic Meter Reading (AMR) meters are used. In Andhra Pradesh, Telangana and Punjab, a sizeable proportion of meter readings in the sample have been found to be invalid by the commissions so as to bias the consumption estimates, with the proportion being as high as 94% in Andhra Pradesh's DISCOM, the Southern Power Distribution Company of AP Limited (APSPDCL) (APSPDCL, 2014). Faulty readings of agricultural feeders in Punjab resulted in readings being in excess of actual consumption in these feeders by 34.6% (PSERC, 2016, pp. 72-73).

iv. Non-compliance of SERC directives

Directives of SERCs to DISCOMs on studies of agricultural consumption, metering consumers, DTs and feeders, and regular energy audits have not been heeded. The PSPCL continued to submit agricultural consumption figures derived from the old methodology, despite PSERC directives to use the more robust feeder methodology. In Karnataka, with progress made under the feeder separation programme, only the Chamundeshwari Electricity Supply Corporation Limited (CESC) had been measuring the agricultural consumption through feeders, while the rest of the DISCOMs had continued with the old methodology as of 2016.

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33. This data was studied by the UGVCL internally, but its findings had some limitations. Another state-wide study has been commissioned by the GERC. However, its findings and report are not available in the public domain. Both are discussed in Section 1.2 of the Annexure.

34. Reply from MESCOM to RTI filed by farmer leader Shri Udupa.

35. This is an even greater problem when some of the non-agricultural consumption below the DT is unmetered, like in U.P and M.P who also have unmetered domestic consumers.

v. DISCOMs still issuing unmetered connections

If current evidence in consumer metering is considered, DISCOMs have failed to meter all pump-sets despite repeated directives from SERCs. For this, DISCOMs have cited resistance from farmers to convert unmetered connections to metered ones. However, DISCOMs in Madhya Pradesh, Punjab, Tamil Nadu, Andhra Pradesh and Uttar Pradesh are still issuing new unmetered connections.[36] The MSEDCL has been doing this in violation of an MERC directive in 2001 to issue only metered connections. In one instance, it cited non-availability of meters as a reason for issuing unmetered connections. The number of unmetered agricultural connections in MSEDCL rose from 14 lakh to 16 lakh between 2009-10 and 2014-15. In Madhya Pradesh, the rise has been sharper and more significant. The number of unmetered agricultural connections rose from over 12 lakh to 20 lakh between 2007-08 and 2014-15, bringing the share of metered in the total agricultural connections for this state down to almost zero (MP Central, Western and Eastern DISCOMs, 2017). The metered tariff should be lower than the unmetered tariff to incentivise metering, but it is either equal to unmetered tariff or higher, like in Gujarat, Madhya Pradesh and Haryana (HERC, 2017; CAG, 2016; MPERC, 2017, p. 166). In fact, in Madhya Pradesh and Gujarat, it is the unmetered agricultural connections that receive most of the state government subsidy for electricity to agriculture[37].

2.5 Consumption Estimation: Opportunities

Regulators and civil society groups have crucial roles to play in improving the estimation of agricultural consumption. Role of regulators should not be limited only to issuing directives to DISCOMs. They can also proactively undertake studies to inform better estimates of agricultural consumption or verify DISCOM estimates. One example of what a proactive and vigilant regulator can achieve in this regard is provided in Box 1.

Box 1 : Proactive Agricultural Consumption Estimation by SERC

The Punjab State Electricity Regulatory Commission (PSERC) has made significant efforts to make agricultural consumption estimates as accurate as possible. It has been helped by the Punjab Agricultural University to study electricity consumption and cropping patterns to determine benchmark consumption, employ independent agencies to verify meter readings, and establish a protocol to monitor the estimation process. It is because of the proactive steps taken by the commission that agricultural and village feeders were separated, automatic feeder meters deployed, and data from them used for estimation. This resulted in restatement of agricultural consumption and T&D losses in 2014 (PSERC, 2014). The restatement itself was not large, because of the constant scrutiny of agricultural sales estimates by the PSERC, details of which are provided in Section 1.8 of the Annexure. In 2017, the Telangana SERC (TSERC) commissioned the Administrative Staff College of India (ASCI), Hyderabad to study a new methodology for estimation of agricultural consumption (TSERC, 2018, pp. 8-9).

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36. In some states like Karnataka, metering status of new connections cannot be verified because of lack of data in the public domain.

37. In Gujarat and Madhya Pradesh, the SERCs differentiate agricultural tariff in such a way that unmetered consumers have to pay more than or equal to the metered ones, but government subsidizes unmetered consumers so that they have to pay less than metered ones.

Since decisions in the electricity regulatory space are designed as public processes, civil society organisations and consumer representatives can add a lot of value to improving the estimation process. Their efforts as a part of regulatory and public forums can help to hold the DISCOM accountable through independent research and analysis. This is demonstrated in Maharashtra where civil society engagement has resulted in more reliable estimates for agricultural consumption, as illustrated in Box 2.

Box 2: Maharashtra: Strong Civil Society Participation in Regulatory Process

The history of estimation of agricultural consumption in Maharashtra after the establishment of the MERC in 1999 is long and eventful. With strong public and civil society participation, the methodology for agricultural electricity consumption estimation and data on agricultural electricity provided by MSEDCL has been under constant scrutiny and a subject of analysis by consumer groups and the regulator. It was only through prolonged public pressure and relentless questioning of agricultural consumption data that agricultural consumption and distribution losses have been restated thrice—in 1999, 2006 and 2016. Please see Table 4 for figures on the re-statements and section 1.1 in the Annexure for further details.

Subsidised flat tariffs are seen as one of the factors enabling inefficient energy use through inefficient pump-sets (Sagebiel, Kimmich, Müller, Hanisch, & Gilani, 2016, p. 13). But proper implementation of energy efficient pump-set programmes can reduce the electricity consumption and improve the measurement of consumption. Many states have been implementing projects to replace pump-sets with efficient ones. It has been reported that the current efficiency of pump-sets is in the range of 20-25%, whereas it is felt that efficiency levels of 40-45% can be achieved (Bureau of Energy Efficiency, p. 19). Thus there is a potential and a strong case for efficiency in electricity-based agriculture pumping. Programmes to achieve agriculture pumping efficiency include the Standards and Labelling programme of the Bureau of Energy Efficiency (BEE), pilot pump replacement programmes implemented by the BEE from 2009 for 5 years (Energy Efficiency Services Limited), and the ongoing large-scale agriculture pump replacement programme of the Energy Efficiency Services Limited (EESL).

Progress on these efforts has been slow, since electricity supply to agriculture is caught in an inefficiency trap, with no takers for efficiency. The main concerns of the farmer are poor availability of water, motor burnouts, and accidents. For the DISCOMs, agriculture supply is more like a compulsion, with low revenue and high operational expenses. It may be interested in reducing the electricity consumption of farmers, but does not know much of how to implement the necessary efficiency measures. As for the pump supplier, the main concern is not efficiency, but ensuring continued business from the sale of pumps. The pump industry is highly fragmented with a significant presence of the unorganised sector, and hence market transformation similar to the experience with LED bulbs will not easily work. The field efficiency of a pump-set is largely dependent on the operational conditions (water level, piping, voltage, etc), unlike appliances like an LED or a ceiling fan. With the larger social interest in mind, the facilitators including organisations like the EESL, the government, standardisation agencies, funders, and researchers are interested in energy efficiency and could take up steps to break out of the inefficiency trap.

24 x7 Power For All programmes of most states have a component for replacing significant numbers of pump-sets with efficient ones (for example, about half the total in Andhra Pradesh,

and nearly all of the units in Rajasthan). The EESL has plans to replace 70 lakh old inefficient agricultural pumps and its Agriculture-DSM programmes are at varying stages of approval in states like Andhra Pradesh, Maharashtra, Rajasthan and Karnataka (MoP, n.d.; Financial Express, 2017).These are welcome, but the design, implementation and review needs to be strengthened significantly.

It is important to conduct base line studies before starting replacement of pumps. This should include the current efficiency levels and feedback on pump usage. The types of pumps to be replaced and the area covered should be selected based on such studies. The experiences of pump-set replacement should be collected from farmers, DISCOMs and pump suppliers. It is important to verify actual installation of efficient pump-sets and actual energy savings through field checks and measurements by third party audits. Repair or replacement of the new efficient pump-sets can offset the projected efficiency gain. Such measures are especially important during these initial stages, before taking on large-scale replacement (PEG, 2017b; International Energy Initiative, 2010).

3. Subsidy for Electricity Supply

The process of determination of agricultural tariffs and hence subsidy differs from state to state, details for which are provided in Section 3 of the Annexure. There is no clearly stated underlying rationale for the level of subsidy provided by state governments to agricultural consumers (for example, from studies to assess the level of subsidy required for farmers) As described before, the electricity subsidy to agriculture has been cited as an important contributing factor to DISCOM financial losses. Based on indicative analysis, the gap between the Average Cost of Supply[38] (ACoS) and the average agricultural tariff after subsidy (i.e. subsidy per unit of electricity supply to agriculture) increased from 56% of the ACoS in 1979-80 to 91% in 2013-14. This means that the tariff for the agriculture supply was 44% of the ACoS in 1979-80, and 9% in 2013-14.[39] In 2012-13, the Planning Commission pegged the total subsidy requirement of state DISCOMs in the country for agriculture at Rs 62,000 Cr (Planning Commission, 2014). Thus, the total subsidy requirement of agriculture is quite large, making it the largest subsidised consumer. However, it is not the only category with subsidised tariffs. Some domestic and other consumers are also subsidised.

3.1 Subsidy to Agriculture and Other Consumers

Agricultural consumers, some sections of domestic consumers (for example small domestic), and a few other consumers like power-loom, water works, animal husbandry, small industry, public lighting, etc. are charged tariffs less than their cost of supply. Therefore the DISCOM faces a revenue gap when supplying electricity to them. The revenue gap is the difference between the total cost of supplying power to a category, and the tariff revenue from that category.[40] It is an indicator of the subsidy required for the category. Similarly, there is a revenue surplus from consumers who pay tariffs higher than the cost of supplying power. Such consumers are called cross-subsidising consumers. The cross-subsidy is the sum of the revenue surplus from all such consumers. The sum of revenue gaps of all subsidised consumer categories is the total subsidy requirement or the total revenue gap. The revenue gap is met through government subsidy and cross-subsidy in different proportions in different states. But sometimes it is not fully covered by these. Such a revenue gap is referred to as uncovered revenue gap in this paper, and leads to financial losses to the DISCOM.

In order to analyse the distribution of the subsidy among consumer categories, we look at reports prepared by the Power Finance Corporation (PFC) for the years 2006-07, 2009-10, 2013-14 and

38. ACoS is the average cost to supply one unit to a consumer, including the cost of generation, transmission and distribution.

39. For 10 states with significant electricity consumption in agriculture. See footnote 42 for states considered. Sources: (Ministry of Power, 1980; Planning Commission, 1994; PFC, 2016) as well as various regulatory orders and petitions.

40. Revenue Gap of a category = (Revenue per unit of sales to a consumer category - ACoS for energy sold) * (Sales to that consumer category). Tariff revenue does not account for arrears. This has been calculated by the authors from data on revenue, sales and average cost of supply.

2015-16.[41] We analyse data for the states with high agricultural electricity consumption[42]. If one looks at the revenue gaps of different consumer categories, agriculture forms the bulk of the total subsidy required in many states. This is because agricultural tariff has been consistently low. Between 2006-07 and 2015-16, the revenue gap of agriculture for all the states analysed has grown from Rs 27,900 Cr to a little more than Rs 91,000 Cr, but its share in the total revenue gap has declined from 75% to 61%. On the other hand, the domestic category has a revenue gap that has grown from 9,200 Cr to 43,700 Cr in the same period, but its share in the total subsidy requirement has also grown from 25% to 29%. Consumers in low-tension (LT) industrial and high-tension (HT) industrial categories are also subsidised in a few states. Their revenue gap is small compared to others, but has been on the rise. In 2006-07, such consumers were subsidised only in Rajasthan. But in 2013-14 industrial LT was net-subsidised in Tamil Nadu, and both LT and HT were net-subsidised categories in Haryana and Uttar Pradesh, in addition to Rajasthan.[43] In 2015-16, industrial LT was net-subsidized in 4 states viz. Haryana, Maharashtra, Rajasthan and Tamil Nadu and industrial HT was net-subsidized in Maharashtra and Rajasthan. In fact, the Punjab government recently announced a subsidy to small, medium and large industrial consumers amounting to more than Rs 700 Cr, constituting 9% of the total government subsidy approved by the PSERC for 2017-18 (PSERC, 2018a; PSERC, 2018b, p. 102). The Haryana government also followed suit by announcing a tariff subsidy of Rs 2/kWh to new small and medium industry enterprises in certain areas of the state for 3 years from date of release of power connection (Industries and Commerce Department, GoH, 2018). Coming back to PFC data, the revenue gap for other subsidised categories has increased from 1% of the total revenue gap to 10% between 2006-07 and 2015-16.[44]

The decline in share of agricultural revenue gap in total revenue gap could be due to two factors. Firstly, electricity sales to non-agricultural categories have been rising faster than agriculture. Sales to agriculture have seen a modest rise of 7% per annum (pa) between 2006-07 and 2015-16, whereas sales to other subsidised categories like domestic, industrial LT and other categories (See footnote 44) has increased faster at 9%, 8% and 12% pa respectively during the same period. Unlike these categories, power supply to agriculture is being rationed, i.e. supplied for 7-10 hours a day through feeder separation, like in Gujarat, Punjab, Haryana, or limiting three-phase power supply, like in Andhra Pradesh and Rajasthan, or both, like in Maharashtra. Secondly, tariff[45] of non-agricultural categories as a percentage of the ACoS has been falling. However, the exact extent of the change in tariff of agricultural and domestic consumers is not clear, as PFC data may not capture subsidies by state governments on tariffs. For example, the PFC does not capture all the government subsidies for agriculture and a subsidy for public water works in Gujarat. The revenue gap figures given before may not be exact, but our observation about trends is likely to be true.

41. (PFC, 2010; PFC, 2013; PFC, 2016; PFC, 2018). Data is provided for state-owned DISCOMs. The PFC collects this data from audited accounts of DISCOMs wherever available. The accounts for Uttar Pradesh in the PFC data for 2015-16 are provisional, rest all are audited.

42. Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. Agricultural consumption in these states formed 97% of the total agricultural electricity consumption in the country in 2013-14.

43. There can be sub-categories within a consumer category, some of whom may be subsidised while others may not be subsidised or may even be cross-subsidising consumers. In such cases, a category is a net subsidised one if the total revenue from that category is less than the total cost of supply to that category.

44. Other consumer categories are Interstate sales, public lighting, public water works, bulk supply, railways and other small categories.

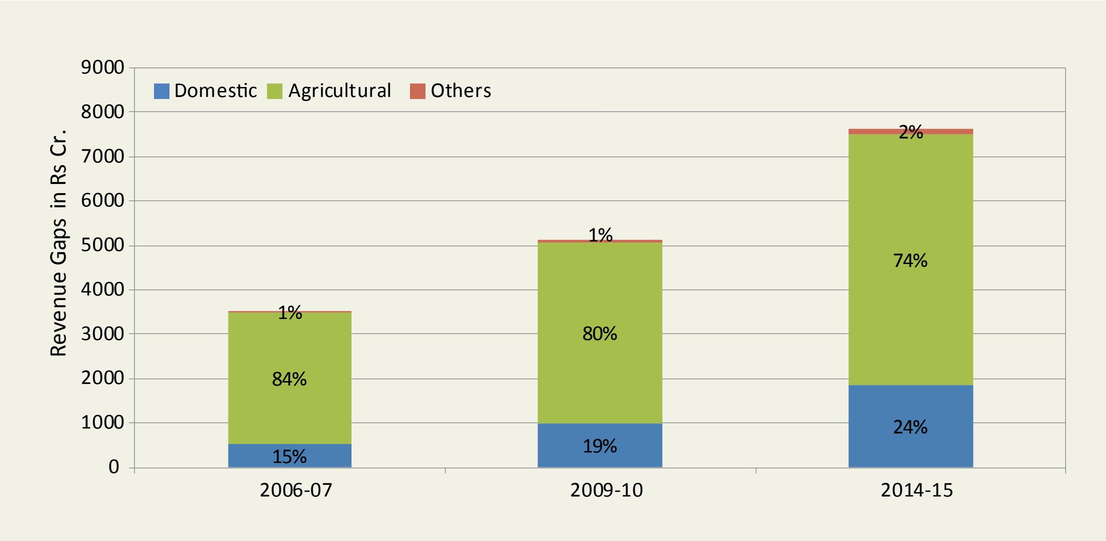
45. Here tariff stands for average tariff of a consumer category.

Box 3: The Curious Case of the Capped Subsidy in Gujarat

The government of Gujarat has been historically giving an hp based subsidy to DISCOMs to compensate them for the subsidised tariffs to unmetered agricultural consumers. This subsidy was capped at Rs 1100 Cr/annum on recommendation of the Asian Development Bank in 1999-2000. The Gujarat regulator, the Gujarat Electricity Regulatory Commission (GERC), determines agricultural tariff based on the available cross-subsidy and this hp based subsidy from the government. Since 2004, when the tariff was Rs 650-800/hp/annum, the GERC has been gradually revising the agricultural tariff. It stood at Rs 2400 per hp pa in 2013 (CAG, 2016). But the Gujarat government provides an additional subsidy over and above the hp subsidy to maintain a constant tariff to the farmer at Rs 650-800 per hp pa depending on pump size. Moreover, the fuel surcharges applicable to agricultural consumers, fixed charges for metered consumers and subsidy for public water works in rural areas are paid for by the government. These additional subsidies amounted to 3788 Cr in 2014-15, much greater than the capped subsidy of 1100 Cr (CAG, 2016).

A more accurate analysis requires data for several years from the regulatory process. Since time series data for 10 years for the required parameters is available for Punjab, and it is a state where electricity sales to agriculture formed more than a quarter of the total electricity sales in 2014-15, this state is considered for analysis.[46] As can be seen from Figure 6, the share of the revenue gap of domestic consumers in the total for Punjab has been rising (from 15% in 2006-07 to 24% in 2014-15), whereas that of agriculture has been declining (from 84% in 2006-07 to 74% in 2014-15).

Figure 6: Revenue Gaps of Subsidised Consumer Categories in PSPCL (Punjab)



Source: Various regulatory orders and petitions of PSPCL. Note: 'Others' includes small and large industrial, outside state sales and common pool consumers.

46. The time series data used are trued up, i.e. the data are actuals rather than projections.

Table 5: Average Tariffs of Consumer Categories as a % of ACoS in Punjab

Year	Domestic	Non Domestic	Agricul-tural	Industrial (small supply)	Industrial (medium supply)	Industrial (large supply)	Outside State Sales	Others	Total
2006-07	75%	123%	1%	96%	106%	105%	113%	98%	69%
2009-10	68%	115%	0%	93%	104%	100%	203%	98%	63%
2014-15	73%	104%	0%	97%	102%	110%	36%	93%	71%

Source: PEG Analysis from various regulatory orders and petitions of the three years. Note: 'Others' includes public lighting, bulk supply, railways, and other smaller categories. Average tariffs will not be 100% of cost of supply under the 'Total' column as tariffs are after government subsidy i.e. end consumer tariffs.

Table 5 captures the average tariffs for different consumers as a percentage of ACoS for Punjab. It can be seen that the extent to which average tariff covers the ACoS has slightly declined for the domestic category and 'others'. Agriculture has seen more or less constant tariff. The category 'sales to other states' has changed from a cross-subsidising category to a subsidised category, presumably because of surplus power in Punjab. A similar analysis for average tariff as a percentage of ACoS for domestic consumers in Karnataka reveals that it has dropped from 91% to 82% and that for smaller categories like public water supply and public lighting has declined from 117% to 95% between 2007-08 and 2014-15, whereas the tariff for agriculture has been constant at zero.[47]

The category 'small domestic consumer' has traditionally been a subsidised category. Rural electrification efforts coupled with increasing tariff support have led to increased consumption by domestic consumers. This has in turn necessitated higher subsidy support. The domestic category has the second highest revenue gap after agriculture in the states with significant consumption in agriculture. The revenue gap for the domestic category is higher than that of agriculture in Tamil Nadu and Uttar Pradesh, on account of higher electricity sales to domestic.[48] These states also have many unmetered domestic connections. Tamil Nadu has a domestic category called 'huts', and they are not metered. Sales to this category, though only a small proportion of the total domestic sales, have risen from 148 to 440 MU, between 2010-11 and 2015-16, amounting to an annual growth of 24%. Uttar Pradesh had a substantial 42% of its domestic consumers unmetered in 2014-15[49]. The presence of unmetered sales has brought the need for benchmark consumption norms for domestic sales. If appropriate measures are not taken, these are likely to suffer from the same issues of overestimation of consumption and unaccountability of subsidy as agriculture in the future.

Governments in Tamil Nadu, Punjab, Uttar Pradesh, Andhra Pradesh, Madhya Pradesh and Karnataka extend regular support for poor domestic consumers, similar to that done for agriculture. In Tamil Nadu, all domestic consumers except those consuming at high levels receive this subsidy.[50] In Punjab, Haryana and Gujarat there is a subsidy for fuel surcharge levy on agricultural consumers (PEG, 2017c).

47. PEG analysis from various tariff filings of BESCOM and HESCOM (DISCOMs with the largest agricultural consumers).

48. Tariff petition data shows domestic revenue gaps higher than agriculture in 2015-16, with the former at 10,600 Cr and latter at 8,350 Cr.

49. For DISCOMs PuVVNL, PVVNL, MVVNL and DVVNL.

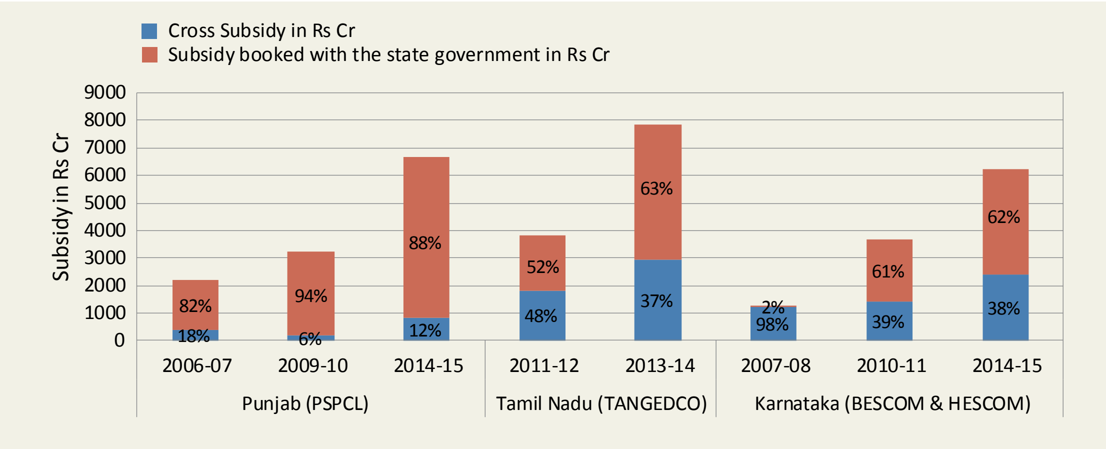
50. Maharashtra provides support to powerloom consumers, while Tamil Nadu subsidises places of worship and handloom consumers apart from powerloom consumers. But these are a small proportion of the overall subsidy.

3.2 Financing of Subsidy

This section looks at the financing of the total subsidy or total revenue gap, going beyond the agriculture revenue gap. It is well known that the total subsidy required for all subsidised consumer categories is sourced from the state government and cross-subsidising consumers (like industrial and commercial consumers). But what is less understood is that the government subsidy[51] outweighs the cross-subsidy, and the government's share in the total subsidy has been rising. An indicative analysis of the 10 states with significant agricultural electricity consumption shows that the government subsidy contributed more than 75% to the total subsidy, while the cross-subsidy contributed less than 25% in 2013-14.[52] This is not very surprising. With the national tariff policies of 2006 and 2016 advising SERCs to set tariffs such that the cross subsidy is within 20% of the cost of supply, there are limits on the subsidy that can be collected from cross-subsidising consumers (MoP, 2006; MoP, 2016).

As we have seen earlier, some states subsidise SERC determined tariffs. Often, increases in the agricultural tariff to make it reflect the cost of supply are passed onto state governments, and not to agricultural consumers. This stands out the most in the case of Tamil Nadu, whose Tamil Nadu Electricity Regulatory Commission (TNERC) revised agricultural tariffs from Rs 250/hp/annum in 2011-12 to Rs 1750/hp/annum in 2012-13 to a further Rs 2500/hp/annum in 2013-14. This resulted in a nearly ten times increase in government subsidy for agriculture from Rs 218 Cr to Rs 2091 Cr between FYs 2012 and 2014 (TNERC, 2013; TNERC, 2015). Cross-subsidy and government subsidy trends for a few states are shown in Figure 7.

Figure 7: Composition of Subsidy by Source of Finance



Source: Various regulatory orders and petitions of PSPCL, TANGEDCO, BESCOM and HESCOM.

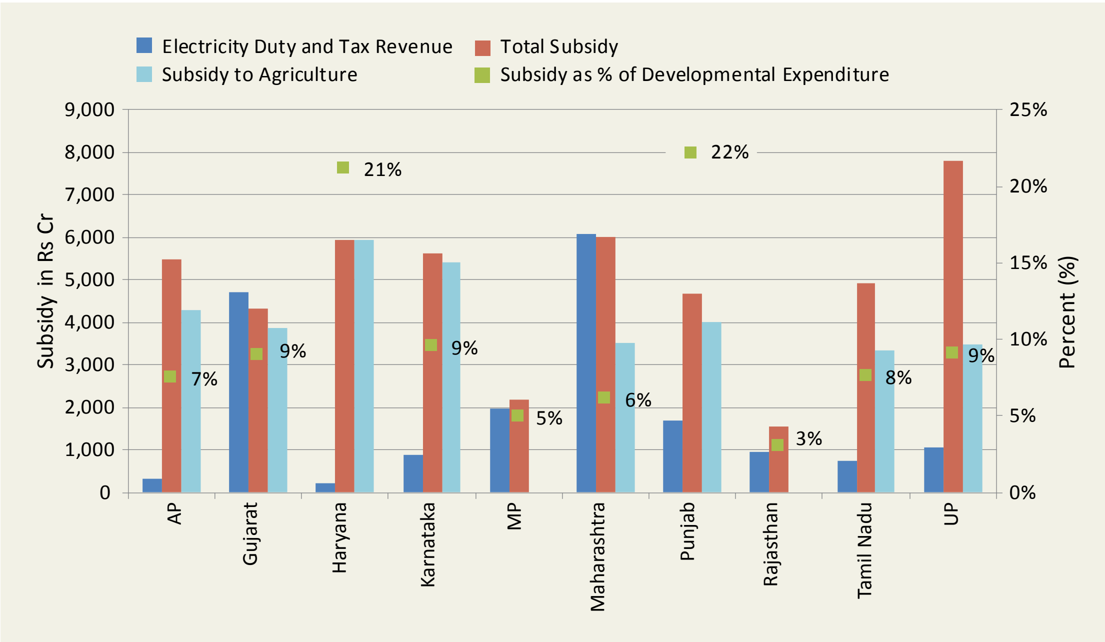
In Maharashtra, the government subsidy accounted for 51% of the total subsidy in 2012-13. In all these states, the governments shoulder more subsidies than cross-subsidising consumers. The share of the cross-subsidy has been decreasing in all states in the figure.

51. Subsidy booked by the DISCOMs from the state government.

52. Government subsidy is subsidy claimed by the DISCOMs from the government and was around Rs 49,000 Cr for the 10 states under consideration. Sources include state tariff orders, petitions and CAG audit reports of public sector units. For Madhya Pradesh, the source is (PFC, 2016), which is used due to a lack of data from other more reliable sources. For Uttar Pradesh, the subsidy figure from the CAG report is for 2012-13, due to a lack of data for 2013-14. The figure for 2013-14 would thus be higher. The cross-subsidy is computed from (PFC, 2016).

How do state governments finance these big subsidies? While all states allot a certain portion of their budget for the subsidy, in states like Maharashtra, Rajasthan, UP and Punjab, state governments also adjust their subsidy payments against the electricity tax or Electricity Duty(ED) revenue from DISCOM consumers.[53] In other words, DISCOMs retain the tax revenue that is owed to the government, and the government subsidy amount is reduced by that extent. Figure 8 compares electricity tax revenue and subsidy for a few states. It also shows subsidy as a percentage of the state developmental expenditure[54]. It can be seen that in a majority of the states, ED revenue is much less compared to their tariff subsidy obligation. The ED revenue is comparable to the subsidy only in Gujarat and Maharashtra. Thus, ED is one of the instruments used by some governments to finance subsidy. As expected, the agricultural states of Punjab and Haryana spend the highest on electricity subsidy as a percentage of their total developmental expenditure. For most others, it is below 10%.[55]

Figure 8: Electricity Duty and Tax Revenue and Government Subsidy in Rs Cr in 2013-14[56]



Source: PEG compilation from (RBI, 2016; CAG, 2016) and State Regulatory Orders and Petitions[57].

Note: Total and agricultural subsidy in Gujarat and Haryana includes subsidy for fuel surcharge on agricultural consumers.

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53. Most or all of this tax revenue is from electricity duty, and the remaining, if levied, is from tax on the sale of electricity.
54. Developmental expenditure includes expenditure on social services like education, healthcare, housing, etc and economic services like irrigation, agriculture, energy, industry, etc as categorized by the Reserve Bank of India. Subsidy is expressed as a percentage of developmental expenditure for a broad picture of the share of subsidy in state government finances.
55. Even though electricity duty and tax revenue is equal to the government subsidy in Gujarat and Maharashtra, it is much lesser than government subsidy in other states.
56. Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Karnataka and Madhya Pradesh governments also give subsidy to non-agricultural consumers, especially domestic consumers. In all of them agricultural subsidy forms the majority component, except Tamil Nadu and Uttar Pradesh where subsidy for domestic consumers is large.
57. Subsidy claimed by the DISCOMs from the government for agriculture for Madhya Pradesh is from PFC data, due to unavailability of data from other sources.

As mentioned earlier, some part of the total revenue gap of the DISCOM is not covered by the government or cross-subsidy, which results in a financial loss to the DISCOM[58]. Details of this uncovered revenue gap for Punjab, Tamil Nadu and Maharashtra are provided in Table 6. The uncovered revenue gap as a percentage of the total revenue gap is high in Tamil Nadu—ranging from 70% in 2011-12 to 46% in 2013-14. The higher the uncovered revenue gap, the higher the overall financial loss of the DISCOM, unless made up by non-tariff income. Not surprisingly, Tamil Nadu was among the three highest loss-making DISCOMs in 2014-15 (PFC, 2016). This situation is further aggravated by inadequate subsidy payments by state governments discussed in Section 3.3.

Table 6: Uncovered Revenue Gap in Rs 00 Crore

State	Year	Total Revenue Gap	Total (Govt+Cross) Subsidy Given	Uncovered Revenue Gap
Punjab	2006-07	35	22	13
	2009-10	51	32	19
	2014-15	76	67	9
Tamil Nadu	2011-12	127	38	89
	2013-14	145	79	66
Maharashtra	2012-13	124	82	42

Source: Prayas (Energy Group) analysis from regulatory orders and petitions of PSPCL, MSEDCL and TANGEDCO

Note: Numbers are indicative. 'Government subsidy' here is the subsidy booked by the DISCOM. The actual subsidy disbursed may be lower as discussed in the next section. This analysis is carried out only for 3 states where all the data required for the analysis was available.

3.3 Shortfall of Subsidy Payments by State Government

Often, DISCOMs do not receive the full subsidy required by them from the state government. This is because state governments do not release a part of the promised subsidy to the DISCOMs or do not make subsidy payments on time. This shortfall (the difference between the subsidy booked by the DISCOM from the government and the subsidy actually received from it) causes cash flow problems, requiring the already heavily indebted DISCOMs to incur short-term, high-interest borrowings. Data on the subsidy required, booked as well as received from state governments is not tracked and reported regularly in regulatory orders or petitions, except in Punjab. Hence, data presented in this section is mostly from Comptroller and Auditor General (CAG) reports.

It is possible that there is a shortfall because the subsidy actually required is higher than that booked from the government, rather than due to an inadequate subsidy payment by the government.[59] But in such cases, the DISCOMs should claim this subsidy from the government during subsequent subsidy payments, and the government should make these additional subsidy payments on time. A possible reason why this may not happen is that interest on borrowings undertaken to bridge the shortfall might be passed onto consumers, if it is not claimed from the government (CAG, 2016, p. 79). This would make DISCOMs and government complacent in fulfilling the full subsidy requirement.

58. Hence uncovered revenue gap=(sum of revenue gaps of all subsidized categories)-(government subsidy+cross subsidy). The total revenue gap is the gap between total expenditure and revenue of the DISCOM. The uncovered revenue gap here may not exactly match with the 'revenue gap' reported in regulatory orders as the former does not account for revenue gaps from previous years, incentives/disincentives by the SERCs for achievement/non-achievement of targets set by the commission and non-tariff income.

59. This can be the case if the government provides subsidy on the basis of projected sales to subsidised consumers and cost of supply, whereas the actual sales, cost of supply and hence the subsidy required are significantly higher. In Punjab and Tamil Nadu, where data on the subsidy requirement based on actual sales is available, the additional subsidy because of additional sales is claimed from the government during subsequent tariff processes and not included in the subsidy booked for that year.

The CAG report on public sector undertakings (PSUs) in Haryana has shown that the total shortfall in the subsidy payments by the Government of Haryana to the two DISCOMs UHBVNL and DHBVNL from 2011-12 to 2015-16 amounted to Rs 4870 Cr. On this, the UHBVNL had to bear a Rs 748.69 Cr interest burden for the extra borrowing because of the shortfall (CAG, 2016a). The Haryana government, with its high subsidy commitment, has had unpaid subsidies as far back as 2004-05 (World Bank, 2013). Table 7 presents the sum of the subsidy booked and subsidy received from the government and thus shortfalls accumulated over multiple years[60].

Table 7: Government Subsidy Booked and Received in Various States (Values in Rs Cr)

State	Time Period of Shortfall	Total Subsidy Booked by DISCOM(s) in the Time Period	Cumulative Subsidy Shortfall	Subsidy Shortfall as % of Total Subsidy Booked by DISCOM (s)	Interest Cost on Shortfall
Gujarat	2009-10 to 2014-15	23,511	2996	13%	891
Haryana	2011-12-2015-16	30,334	4870	16%	749 (UHBVNL)
Karnataka	2010-11 to 2014-15	26,543	2156	8%	
UP	2008-09 to 2012-13	29,187	15,453	53%	
Rajasthan (JdVVNL)	2005-06 to 2007-08	482	210	44%	
Punjab	2012-13 to 2017-18	36,596	5055	14%	

Source: (CAG, 2016b, p. 44; CAG, 2014, p. 59; CAG, 2016a; CAG, 2016; RERC, 2010, p. 18) and various regulatory orders of PSERC.

If this cumulative subsidy shortfall was claimed in the year following the time period of shortfall (for example, in 2015-16 for Gujarat), then it would be as high as 21% of the aggregate revenue requirement in Haryana and 42% in Uttar Pradesh[61] (HERC, 2016). In Punjab it would be 17%, thus also significant.

In some cases, the budgetary allocation of the state governments to subsidy has been lesser than the subsidy requirement of DISCOMs, resulting in some subsidy remaining unpaid, like in Gujarat (MoP, 2018a). The total outstanding subsidy from the Gujarat government on 31st March 2015 stood at Rs 3587 Cr (including shortfalls before 2009-10) and it has increased to Rs 4664 Cr on 3st March 2016 (GUVNL, 2016, p. 7).

Such shortfalls ultimately feed into the financial losses of DISCOMs. Cash flow shortages due to such shortfalls are likely made up by cutting back on operation and maintenance expenditure of the distribution infrastructure. This would lead to deteriorating service quality for agriculture (and thereby rural) consumers. If subsidy shortfalls continue, and DISCOMs losses mount, they are ultimately bailed out by governments using the money raised from tax payers.

60. Interest cost as a proportion of the cumulative shortfalls differs from state to state because of the inter-state differences in interest rates applied by the CAG and the duration of the shortfall.

61. ARR, that is the annual revenue requirement of a DISCOM, is the amount that is to be recovered from consumers through tariff. Its figures are also from various regulatory orders and petitions of the DISCOMs in these states.

4. Supply and Service Quality to Agriculture

4.1 Declining Hours of Supply to Agriculture

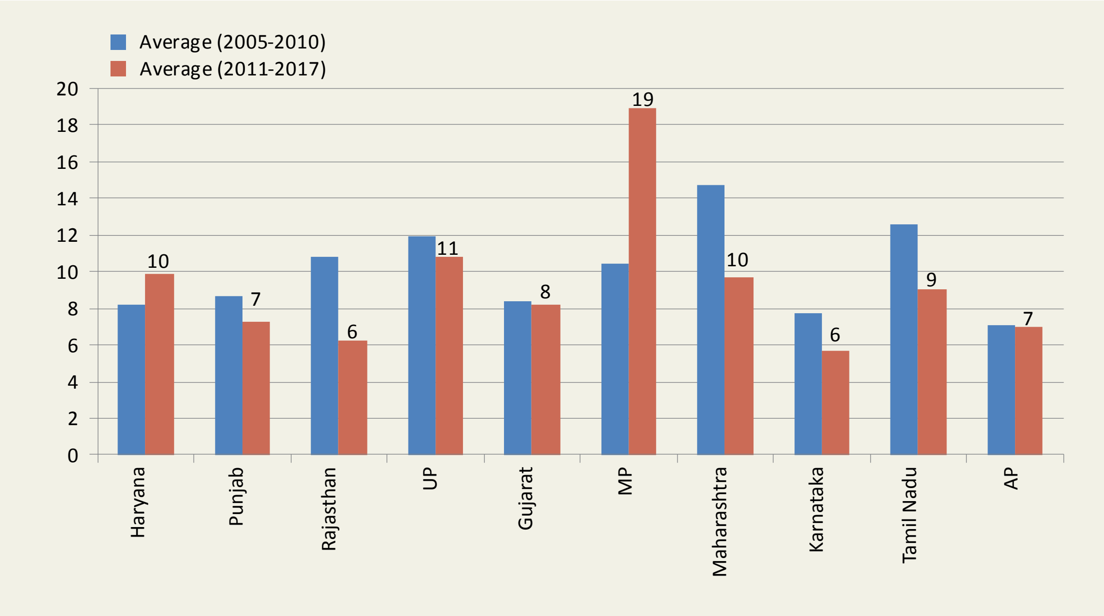
Power to agriculture is subsidised, but the hours of supply to agriculture are significantly lesser than urban consumers. Curtailing or rationing the hours of supply to agriculture is a way to curtail the electricity consumption of and the subsidy to agriculture consumers. Feeder separation has enabled this rationing. If no feeder segregation mechanism is present, rationing of electricity supply to agriculture entails rationing of supply to all load (domestic and commercial) on rural feeders. Hence the core objective of feeder separation, physical or virtual, is to isolate non-agricultural rural consumers from the problems of agricultural power supply like low supply hours, high power cuts and low voltages. But it also effectively controls the hours of supply to agriculture.

There is physical feeder separation, where rural feeders are physically segregated into agricultural and non-agricultural feeders, and virtual feeder separation, where three-phase power required by irrigation pump-sets is provided for a limited number of hours, and single-phase power for the rest of the day. Gujarat was the first state to complete physical feeder segregation in 2006 under the Jyotigram Yojana. Rural feeders have been separated or are undergoing separation in many other states.[62] Feeder separation also enables the DISCOM to provide electricity to agriculture at off-peak hours, when electricity demand from other consumers is low, which helps the DISCOM in load management.

Many states now have a system of rostering of supply, where power supply alternates between day time on a few days and night time on others. In many states today, agriculture does not receive more than 10 hours of electricity supply a day. Some examples are (APEPDCL, 2017; DGVCL, 2017; KERC, 2016, p. 200). In fact, the recent Power for All initiative of the central government promises 8-10 hours of power to agriculture, and 24x7 power to all other consumers (Josey & Sreekumar, 2015). Figure 9 shows averages of the official figures of the daily hours of supply to agriculture in various states from 2005-10 and 2011-17. These figures are as reported by DISCOMs to CEA. Actual hours of supply are not known, since there are no available measurements. But it would be lower because of frequent outages and the delays in restoring supply.

62. In Andhra Pradesh, Telangana, Haryana, Punjab, Karnataka, Maharashtra, Madhya Pradesh and Rajasthan

Figure 9: Three Phase Average Daily Hours of Supply to Agriculture



It is evident from Figure 9 that hours of supply to agriculture have been on the decline in many states except Haryana and Madhya Pradesh. Madhya Pradesh has been seeing a substantial growth in agricultural production driven by groundwater irrigation over the last few years, and the hours of supply seem to reflect this trend. For Uttar Pradesh, the daily hours of supply shown are an average of 2011 to 2015 instead of 2011 to 2017. The hours of supply in this state declined between 2005-10 and 2011-2015, before increasing from 2016 onwards. Having said this, Telangana has started providing 24 hour supply to agriculture from the end of 2017 (The Hans India, 2017). This is described in Box 4 in Section 4.5.

That feeder separation has resulted in a decline in the hours of supply to agriculture can be observed in a few states. In Haryana, the daily hours of supply to agriculture as published by the CEA reduced from 14 hours in 2009 to 6.5 hours in 2010 when feeders were physically separated, before climbing back to 12 hours in 2013. The same in Maharashtra declined from 14 hours to 10 hours after the feeder separation scheme was implemented. It was decided that 10 hours of supply would be given at night and 8 hours during the day in rotation (MSEDCL, 2013). Gujarat's villages, and hence irrigation pumps, were receiving 10-12 hours of three-phase power every day at the start of the millennium, which declined to 8 hours a day post the Jyotigram Yojana (Shah, Bhatt, Shah, & Talati, 2008).

Agriculture can face lower supply hours during power shortages. In Maharashtra, a load shedding protocol devised during the period of power shortages (circa 2005-2012) subjected agriculture dominated regions to higher load shedding hours than other regions with other consumers, with the difference being as large as 14 hours for agriculture, and 7.5 hours for other consumers in 2008 (MERC, 2008). According to the last load shedding protocol issued in 2013, load shedding is implemented at the feeder level.

Evidence suggests that feeder separation has had impacts on power quality and water markets as well. Farmers in Gujarat and Rajasthan faced lesser power interruptions and voltage fluctuations post feeder separation (World Bank, 2013). However, at the same time, feeder separation was also accompanied with shrinkage of the once thriving informal water markets in Gujarat, where water is sold by pump-owners to water buyers who are often poor marginal farmers. Landless share croppers and water buyers were pushed out of groundwater irrigation because of power rationing, reducing water availability, and rising water prices (Shah & Chowdhury, 2017).

4.2 Poor Supply Quality

Poor quality of electricity supply to agriculture and rural areas in general has been a long-standing problem. Recent evidence from the 5th Minor Irrigation Census for the year 2013-14 indicates that non-availability of adequate power is an important constraint for wells and tube-wells (MoWR, 2017). 28% of the total wells and tube-wells are found by the census to be underutilised and within these, non-availability of adequate power accounts for 33% of underutilised wells and tube-wells, the second highest cause after 'less discharge of water' (37%). Similarly, non-availability of power is a constraint for 28% of underutilised minor surface irrigation schemes. When wells and tube-wells facing inadequate power are seen as a percentage of total electric powered ones, they were 9% in 2013-14 in the 10 states with significant electricity consumption in agriculture which were analysed earlier in this report. This constraint regarding power supply can be overcome using diesel pumps or buying water from farmers with higher capacity pump-sets.

The use of diesel pumps as a backup for erratic power to electric pumps has been observed and studied before (World Bank, 2001). This can still be seen in 2013-14, despite electricity replacing diesel in irrigation pumping over time. Out of the total electric powered wells and tube-wells in states where electricity is the dominant source of irrigation, 4% use electricity and diesel conjunctively (MoWR, 2017). The proportion is higher in states such as Haryana, Punjab and Telangana.[63] Owning and running both diesel and electricity pumps can be expensive, because running diesel pumps is costlier than running electric pumps. Thus only a few farmers can afford this, which is why the number of conjunctive users is also low. Farmers in Punjab and Haryana receive higher margins for their produce and thus more of them can afford such conjunctive use of fuel and equipment.

The World Bank survey of 2,120 farmers in Andhra Pradesh and 1,659 farmers in Haryana in 2001 showed that farmers received fewer than scheduled hours of supply which was often erratic and with frequent interruptions and voltage fluctuations, causing them to incur avoidable expenditure on repairing pumps due to motor burnouts. Motor rewinding costs caused effective electricity costs to be higher than tariffs by 23% in Haryana and around 80% in Andhra Pradesh. Along with this, transformer burnouts[64] were a common occurrence, and long delays in getting the transformers repaired only exacerbated the situation and deprived farmers of timely water for irrigation. Unreliability of supply made farmers invest in higher capacity electric pumps as well as diesel pump-sets.

Safety of farmers is also an important issue. Irrigating fields during the night can be risky and hazardous, especially for women and old farmers. Accidents during pump-set operation, while coming into contact with low hanging conductors, and while attempting to repair failed transformers are common. As per the data provided by the National Crime Records Bureau, the

63. Total wells and tube-wells using electricity is the sum of those with electricity as the only source, and those with electricity along with diesel, solar and other energy sources, i.e. multiple energy sources involving electricity.

64. Often due to transformer capacity being less than the cumulative load of pump-sets.

number of deaths due to electricity accidents was nearly 10,000 in 2015, mostly occurring in rural areas, and this number has been increasing every year by 5-6% in the last two decades (National Crime Records Bureau, 2016).

4.3 Poor Service Quality

Agriculturists do not suffer because of the poor quality of power alone. They also suffer due to poor service delivery by the DISCOM. During the public process of tariff determination in many states, farmer groups and representatives have raised issues with respect to long waiting times for agricultural electricity connections and the delays in repairing transformers. Billing and collection of tariff from LT consumers are fraught with problems. Farmers are not billed regularly and have to travel long distances to pay their bills. A CAG report highlighted the delay in the generation and submission of bills of LT consumers to the IT section, resulting in a delay of recovery of about Rs 8000 Cr, more than 50% higher than the subsidy received by the MSEDCL for LT agriculture in 2015-16 (CAG, 2017, p. 73). All of this not only affects DISCOM finances adversely, but also puts an undue high burden on farmers.

Our interactions with farmers in Maharashtra revealed that sometimes farmers have to pay for replacing failed meters and transformers. Some instances of inflated bills received by farmers also came to light. Farmers complained that they spend a lot of time and money in getting inflated metered bills corrected from far-away MSEDCL offices. In fact, during the tariff process in Maharashtra, consumer representatives have pointed out that meter readings for pump-sets are not taken on time, or not taken at all (MERC, 2012, p. 29). In such cases, the practice is to issue bills on average consumption recorded in the past, but agricultural and rural household consumers often receive faulty, arbitrary bills under the name of average consumption. In one such instance, almost all of the 4800 metered agricultural consumers under a sub-division in rural Maharashtra were issued bills with the same meter readings for 4 quarters in a row in 2011 (MSEDCL, 2012). There have also been recent complaints from consumer organisations about inflated bills to farmers, and the MSEDCL has been asked to reassess them (Vernekar, 2018; Gadgil, 2018). In all of this, the existing grievance redressal mechanisms are inadequate and inaccessible to farmers. Although this experience is from Maharashtra, it is likely that this situation is not very different, and perhaps worse in other states.

DISCOM documents show that agricultural consumers have 'low collection efficiency' which means that they have low bill payment rates. For example, the collection efficiency for agricultural consumers in MSEDCL was 37%, whereas the average collection efficiency of all consumers was 95% (MSEDCL, 2016). The narrative around this low collection efficiency focuses on farmers' reluctance to pay bills and resistance to metering. This, again, is an incomplete narrative. DISCOMs have shown reluctance to metering in the past (PEG, 1996, p. 10) and continue to do so, as evident by the continued release of unmetered connections. DISCOMs have their own issues in billing and collection as well, as seen above. Hence they also have some responsibility to shoulder for the slow progress in metering and low collection efficiency.

It is easy to see why this situation has arisen. Cash-strapped DISCOMs do not invest in and maintain their rural distribution infrastructure to ensure quality supply and service because of low tariffs for farmers and other subsidised consumers, and farmers are the hardest hit because of the low quality of supply and service. DISCOMs lack trust in farmers because of low collection efficiency and low tariffs. On the other hand, given the problems in power availability, quality, metering, billing, and the anxiety of farmers that metering may lead to increased tariff, there is a trust deficit among farmers with respect to the DISCOMs. This has been described as farmers and utilities being trapped in a low equilibrium and a trust deficit (Dubash N. K., 2007; Sreekumar, 2015; Sant, Girish; PEG, 2007).

4.4 Breaking out of the Low Equilibrium and Trust Deficit

The 2001 World Bank study of farmers in Andhra Pradesh and Haryana discussed earlier, also examined their ability to pay for improvements in availability and reliability of supply, and found that farmers would have higher net incomes, irrespective of farm size category, if power became more reliable (World Bank, 2001). This, according to the World Bank, also showed that farmers were willing to pay for better quality supply. Similar findings were reported in another study in Andhra Pradesh from a sample of 449 farmers (Dossani & Ranganathan, 2004).

However, there is evidence to show that econometric studies on farmers' willingness to pay may not translate into reality. Farmers, even smaller ones, have to undertake big investments for digging of borewells mostly through their own savings, as can be seen in the Minor Irrigation Census. These carry the risk of drying up, thus nullifying the investment incurred, and might require digging deeper borewells and replacing pump-sets with more powerful ones. As opposed to the fixed and variable costs associated with this activity, canal irrigation charges are negligible. But neglect of surface irrigation schemes by the government along with increasing input costs and relative stagnation in incomes makes farmers unwilling to pay higher tariffs. (Narendranath, Shankari, & Reddy, 2005). More importantly, increase in net incomes of farmers is contingent on many assumptions regarding improvement in supply and service quality. If there is no significant improvement in these, a tariff hike is likely to impact farmers' net income even more adversely. Indeed, as described in Section 5.2, a tariff hike might have an adverse impact on farmers' incomes even if accompanied by some quality improvement. Thus, a hike in electricity tariffs is bound to witness resistance from farmers, thus resulting in little improvement in DISCOM revenues or reduction in the electricity subsidy.

In order to break out of this trust deficit, it is important to demonstrate improvements in service and supply quality[65] before raising tariffs and consulting farmers about the quantum of increase in tariffs. To achieve this, measures to improve quality of supply should be put in place independent of tariff reforms, and indeed must precede them. Ideas for measures regarding tariff are covered in Section 7.3.

4.5 Agricultural Load Management and Benefit to the DISCOM

Agriculture is supplied with electricity for a few hours a day, which is typically 7-10 hours. Usually the total connected load (in a state or for a DISCOM) of all agriculture consumers is divided into 2-3 groups, and electricity is supplied to these groups during different times of the day, mostly during off-peak hours and in 2 or 3 spells. Let us illustrate this with an example.

Consider a DISCOM providing a total of 7 hours of supply, and all the agriculture pump-sets it supplies to being divided into two groups A and B. Assume that group A would get supply from 0600-1000 and 0000-0300, while Group B would be supplied from 0300-0600 and 1300-1700. The DISCOM has a lot to gain from this load management arrangement, due to the following reasons.

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65. In addition to measures in the agricultural sector discussed in the next section.

a. Supply to agriculture is provided for a few hours in a day, to a group of pump-sets at a time, and hence the energy requirement of the DISCOM reduces, reducing the power purchase cost.
b. The total load is divided into two groups and supply provided in non-peak hours, hence the peak load requirement reduces. Agriculture cannot operate during the other hours. Since the total generation capacity available for a state or DISCOM has to match the peak demand, any reduction in peak demand requirement reduces the requirement for power capacity. The financial benefit is higher, since costly generation is scheduled during peak time.
c. The supply hours are during off-peak time and hence the DISCOM load curve is flatter. This implies that power stations need not be backed down, and the utilisation of the distribution infrastructure is optimal. This reduces the cost to the DISCOM, since fixed costs have to be paid (to generators or DISCOMs) irrespective of actually purchasing power or utilising the distribution infrastructure.

The benefits to the DISCOM due to this flexibility of supplying power to agriculture are evident, but we have not come across studies which quantify these. Surveys and our interactions with farmers indicate that day time supply is often preferred by farmers, since farms are located far from homes and operating pumps in the night can be hazardous. Moreover, farmers' requirements for water vary from season to season and also depend on the crop. In many areas, ground water availability is limited, and continuous pumping may not be possible for more than 5 hours. After this, a few hours rest is required to recharge the ground water. A uniform norm for the supply hours and the duration of agriculture power supply for the whole DISCOM (often for the whole state) is convenient for the DISCOM, but not for the farmer. Recently, some states have been increasing the hours of supply to farmers, and even providing day time supply or even 24 hours of supply as described in Box 4.

Farmers and researchers have suggested that the actual hours of supply should be decided after discussions with farmer associations, based on their inputs on ground water availability and cropping patterns. Options like solar pump-sets or solar feeders provide quality day time supply for agriculture. These are discussed briefly in Section 7.3. A deeper discussion can be found in Section 4 of the Annexure.

Box 4 : 24 x 7 Supply or Day Time Supply for Agriculture

Many states have been experiencing power surplus from 2017 onwards, and there are plans to increase the hours of supply to agriculture in some states. Telangana (which until recently was providing 9 hours of agriculture supply) has been proposing 24 x 7 supply to agriculture from 2018, with pilot operations in 3 districts from mid-2017 and in the entire state from end-2017. According to news reports, this requires an additional investment in the distribution system of Rs 12,000 crores and power of 2100 MW to provide 24 x 7 supply to 23 lakh pump-sets (Telangana State Portal, 2017; The Hindu, 2017). 24 x 7 supply is convenient for farmers, since they can choose the time for irrigation, and could reduce distribution transformer burnouts. This is because the overloading of distribution transformers could reduce, since all farmers may not operate the pump-sets at the same time. But this will happen only if the auto-starters (which start the pump whenever power supply is available) are removed, which in turn requires that farmers acquire confidence about the quality of supply. Another important point is that considering the limited ground water availability in Telangana, water would be pumped only for 4-5 hours after which 4-5 hours will be needed for recharge. Andhra Pradesh, another state with surplus power, has been providing 7 hours of supply during the day time from 2017 onwards, and has plans to extend this to 9 hours from 2018. The merits and demerits of these schemes can only be assessed based on reports on their performance.

Agriculture power supply is currently provided in 2 or more spells (each 3-4 hours long) for a total 7-9 hours in most states. The total connected load of agriculture connections is reported to be 10-15,000 MW for big states (Maharashtra, TN, Punjab etc). Hence if 24 x 7 power is to be provided, around 5-6000 MW additional capacity and at least a two-fold increase in distribution infrastructure will have to be planned.

5. Linkages to Agriculture and Groundwater

Section 1 outlines the relationship between subsidised electricity supply and the growth in groundwater irrigation and agricultural production. However, subsidised electricity is now being considered responsible for the excessive extraction of groundwater. Reduction in subsidy for electricity supply has been proposed as a solution for this. The subsidy is also considered to benefit large farmers more than small farmers. These issues transcend the power sector, and have linkages beyond it. In this section, we examine these issues and the effectiveness of solutions related to electricity pricing to address them.

5.1 Drivers Behind Electricity Use and Excessive Extraction of Groundwater

Subsidised flat tariff is seen as an important driver, even the primary driver behind the inefficiency in electricity use, through inefficient pump-sets, and inefficient use of water through excessive water pumping, as there is no marginal cost for electricity and water consumption. It is true that subsidized flat tariff is one of the factors responsible for this. But one must make a distinction between a driver and an enabler. If subsidised electricity is indeed the chief driver behind groundwater extraction, reduced subsidies should lower groundwater extraction. However, while metering and raising tariffs can raise water use efficiency, whether they will also reduce groundwater extraction is questionable (Mukherji, A et al., 2009). This is because the linkage between excessive extraction of groundwater and electricity subsidy is not so straightforward. Upon comparing the electricity tariffs for farmers in different states where groundwater irrigation is the dominant source of irrigation, with the status of groundwater blocks in these states, it can be seen that the correlation between low tariffs and overextraction is not uniformly applicable across states. Although electricity tariffs are low, the percentage of groundwater stressed blocks varies considerably across these states. For details, please see Section 5.1 of Volume 1 of this paper.

What this means is that the demand for groundwater is also driven by factors other than the price of electricity. An important factor here would be the choice of crop. Rise in food grain production following the green revolution was accompanied by a shift in cropping patterns from coarse cereals like jowar, bajra, and maize to water-intensive rice and wheat. Considering that almost two-thirds of India's net irrigated area uses ground water, and that almost four-fifths of this area grows five crops—namely paddy, wheat, sugarcane, fibres (mainly cotton) and oilseeds—one can conclude that most of the groundwater and electricity subsidy is being utilised by these crops. Typically, paddy, wheat, sugarcane and cotton use more water than coarse cereals.

This cropping choice is driven by the productivity, marketability, assurance of procurement, and selling price of the crop—the market price or the minimum support price (MSP). Sugarcane, which is a water-intensive crop, is procured by sugar factories, thus making it an attractive crop among farmers, as in Maharashtra. Irrigated wheat and paddy have higher productivities and provide its cultivators with higher incomes. MSPs often favour crops which might not be suitable for the agro-climatic and groundwater conditions of a state. As long as agricultural policies place water-intensive crops like paddy and sugarcane at an advantage over other crops, any step towards commercial pricing of electricity for agriculture may not result in a shift in the cropping pattern to crops which consume less water, even in water-scarce areas. And unless farmers get a remunerative and assured price for crops which consume less water, reduction in subsidy for electricity to agriculture may not lead to a decrease in groundwater extraction. Thus, though subsidised electricity is an enabler, the main driver behind excessive groundwater extraction is the cropping pattern in water-stressed areas. Please see Section 5.2 of Volume 1 of this paper for details. Furthermore, it is important to note that inefficient use of water is also a result of the frequent interruptions and odd hours of electricity supply, which makes farmers use auto-starters for their pump-sets. With an auto-starter, the pump automatically starts running when electricity supply is available and can keep running for the entire duration of supply.

5.2 Impact of Rise in Electricity Tariff on Cost of Cultivation and Farmer Income

The cropping pattern is predominantly determined by market conditions and farmers' margins. It is important to understand how irrigation costs and electricity tariffs affect the cost of cultivation and hence farmers' margins. Unfortunately, the publicly available Directorate of Economics and Statistics (DES) / Commission for Agricultural Costs and Prices (CACP) data on the cost of cultivation does not provide the cost of electricity-based pumping. Thus, we have computed indicative figures for the cost of electricity consumption per hectare of groundwater irrigated area for different states using CEA data for electricity consumption in agriculture (which is essentially the electricity used for pumped irrigation), Agriculture Census Data for groundwater irrigated areas, and electricity tariffs to the farmer from regulatory data.[66]

We look at the cost impact of increase in tariff on the net income to the farmer or farmer margin on cultivating dominant irrigated crops in a state.[67] The net income to the farmer is computed after deducting the cost of cultivation per hectare of the dominant irrigated crop from the gross income per hectare to the farmer. Out of the states considered for this analysis (Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Punjab and Haryana), it can be seen that the impact of an increase in tariff on the net income of the farmer is significant in Andhra Pradesh, Madhya Pradesh and Tamil Nadu for paddy, wheat and paddy respectively. In Punjab and Haryana where crop productivity is high, the tariff impact is not so significant. This is the case when paid out costs are included in the cost of cultivation. When imputed costs are also added to the paid out costs, the gross income of the farmer is less than the cost of cultivation for crops in most states (including paddy in Punjab), let alone the cost due to increase in electricity tariffs. This analysis is detailed in Section 5.3 of Volume 1 of this paper.

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66. Note that the groundwater irrigated area will also include the area irrigated by diesel pumps (figures for which are not available), and it is net irrigated area (irrigated area is counted only once in the year), and not gross irrigated area (which accounts for multiple irrigations in a year). Figures for both diesel irrigated area and gross irrigated area are not available. The CEA's electricity consumption in agriculture also includes a very small component of consumption by surface lift pumps. Thus, these figures are indicative. Please see to Section 5.3 of Volume 1 of this report for details.

67. The dominant irrigated crops in the states under consideration are wheat and paddy.

5.3 Equity Aspects of Groundwater Irrigation and Pumping

In 2010-11, around 42% of the total number of operational landholdings did not receive any kind of irrigation. The proportion of area not receiving any irrigation is slightly higher at 48%[68]. This essentially means that 42% of all operational land holders in the country are out of the ambit of any irrigation subsidy or support, either surface or groundwater.

Moreover, the distribution of land is highly skewed across the holding categories. This means that any benefit that is distributed as per the landholding size will reflect this inequity. Thus, the medium and large land-holders, who constitute 4.95% of the total number of landholders, have 28.1% of the total groundwater irrigated area. If we take groundwater irrigated area as a proxy for the electricity subsidy[69], then these two categories of farmers receive 28.1% of the total subsidy. However, for all the categories of farmers, the share in the total groundwater irrigated areas is on par with their share in the total area of landholdings.

Inequities are also seen in other ways. For example, while there are 66 wells or tube-wells for every 100 large landholders, this ratio is only 15 for marginal landholders, and 18 for small landholders. This likely reflects the high capital costs involved in putting in a well or tube-well, and the ability or lack of it to undertake such expenditure, which in turn is likely related to the landholding size. Similarly, almost 20% of all land held by large landholders is irrigated by tube-wells or wells, but only 10% of the marginal landholder's land is irrigated by tube-wells or wells.[70] Finally, electricity powers only 45% of wells and tube-wells of marginal landholders, while it powers a higher percentage (between 72-79%) of wells and tube-wells of all other categories.

Capital subsidies for electric or solar pumps to small and marginal farmers without access to groundwater, especially in areas where use of diesel pumps is high (like Bihar, West Bengal, and Uttar Pradesh) can help in alleviating this inequity. However, capital subsidies will have to be designed keeping in mind the groundwater situation in an area.

While metering of pump-sets and charging farmers based on consumption of electricity can help reduce the inequity in groundwater use for irrigation, West Bengal's experience with metering, where large groundwater markets exist, shows otherwise. Not only have the water prices increased by 30-50% here, metering has also reduced the bargaining power of water buyers who have to lease their land to pump-owners at paltry rentals in exchange for irrigation water (Mukherji, A et al., 2009; Shah & Chowdhury, 2017). Thus, measures such as pump-set metering for equity related aspects have to be thought through and must be preceded by pilots and rigorous studies.

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68. It may be pointed out that this is different from the proportion of net cultivated area that is not receiving irrigation, because the total holdings area is more than the net cultivated area.

69. DISCOMs differentiate tariffs based on pump-size, consumption in the case of metered consumers and other criteria, which may reduce the inequity in the distribution of electricity subsidy. But in practice, the threshold for higher tariffs is quite high, and most agriculture consumers do not cross that threshold. Or the thresholds are not strongly enforced and most agricultural consumers fall in the category with the lowest tariff, like in Andhra Pradesh, rendering such tariff differentiation futile.

70. However, if we count all sources of irrigation including canals and other sources, 31% of all land held by marginal farmers is irrigated, which is the same as that for large farmers. This percentage for other categories ranges from 23% (semi-medium) to 28% (medium).

6. Summary of Observations

In the previous sections, we have analysed the issues related to the estimation of agricultural consumption, its financial impact on the DISCOM, quality of supply to agriculture, and inter-linkages of electricity supply with water and agriculture. Based on our analysis in the previous sections, we summarise our key observations here. In the next section, we present our suggestions to address the challenges with regard to these issues. Moreover, with efforts to bring a second green revolution to the eastern states and rising rural electrification, it is important to examine the lessons of the past and plan for solutions.

Agricultural Consumption is Overestimated and Continuous, and Long-Lasting Improvements in the Estimation Process are Needed

Section 2 describes how the statistics on electricity consumption by agriculture are questionable, shown by the revision in consumption estimates in many states and presence of negative feeder losses. It is also highly likely that agricultural consumption is significantly lower than reported in states which have not carried out systematic studies in this regard in recent times. This thus brings into question the reported growth of agricultural electricity consumption at 6% pa since 2000-01.

Restatements have often been a result of strong SERCs, like in Punjab, and civil society groups, like in Maharashtra. However, once a restatement is done and a process to estimate agricultural consumption is established, DISCOMs become complacent in implementing the changes effectively or handing new issues that emerge, leading to unsubstantiated increases in agricultural consumption. This necessitates another round of an arduous public regulatory process and results in multiple restatements of agricultural consumption and distribution loss, as shown in Table 3. Thus, improvements in estimation should not be a one-time exercise as a fallout of public and regulatory pressure, but a continuous process with adequate monitoring, as well as checks and balances embedded in it.

DISCOMs gain by hiding loss as agricultural consumption

A lack of energy accounting in the distribution system has given rise to unaccountability in agricultural consumption estimation, subsidy and ultimately financial losses to DISCOMs. Moreover, there have been limited attempts by DISCOMs to remedy the state of affairs. State governments and cross-subsiding consumers are financing theft and DISCOM inefficiencies under the guise of agricultural consumption. DISCOMs can put off responsibility in improving efficiency, and can present a more acceptable picture of low losses. On the other hand, agriculture is attributed with financial loss and subsidy that are not its own.

Agriculture's Role in the Financial Loss of DISCOMs is Overstated

It is true that agriculture tariff is low in most states and zero in some states. Since agricultural consumption is 20-30% of the total consumption, subsidy support to agriculture is indeed high. But rationing of power supply and connections to agriculture has helped to slow down its consumption growth and subsidy requirements. Many states are undertaking feeder separation that is likely to further limit the subsidy required. However, there are a few other factors, which have not received sufficient attention. Subsidy to other consumer categories, especially domestic consumers, is on the rise. There have also been many delays or shortfalls in subsidy receipts from the government, either because of partial payment or DISCOMs not booking the full subsidy requirement from the government, a situation which is likely to get worse with limits to increases in cross-subsidy, and increasing subsidy requirements from the state government.

Credibility of Distribution and AT&C Losses are in Question

Since there are doubts about agricultural consumption, there are doubts about the credibility of the level of distribution loss. Loss reduction targets are an important indicator of DISCOM performance and distribution loss is a part of AT&C losses, which are anchors for many policies and bailout schemes like UDAY where state governments take over a major portion of past liabilities of DISCOMs. UDAY has targets for reduction in AT&C losses to decide the eligibility of the DISCOM to receive further financial assistance. However, since the level of present losses itself is unknown, targets for loss reduction become quite pointless.

Raising Electricity Tariff to Agriculture Alone is Not a Solution

As discussed in Sections 4 and 5, a higher electricity tariff (even if the increase is modest and within the paying capacity of farmers) may not solve problems in isolation, unless there are simultaneous measures in power quality, agricultural marketing and groundwater conservation. It has been recognised that increases in tariff are politically unattractive. But more importantly, it is also doubtful whether tariff increases can effectively reduce the financial losses of DISCOMs. The subsidy quantum may not be controlled until there are reliable estimates of agricultural consumption. The revenue recovery from agriculture will be low if the quality of supply is not improved before increasing tariffs. And improvement in power and service quality through higher tariffs is uncertain, largely owing to the poor distribution infrastructure in rural areas and the lack of accountability of the DISCOM in ensuring improvements in supply and service quality.

Given the importance of agriculture for food security and the current agricultural distress, we feel that electricity supply to agriculture has to be subsidised. The level of subsidy itself can be determined by the state governments based on factors like the cropping pattern, groundwater availability, size of landholding and farmer incomes. This alternative approach to subsidy determination is described in greater detail in Section 6 of Volume 1 of this paper. However, at the same time, it is true that universal free power for agriculture can lead to the neglect of efficiency by the farmer, and the neglect of metering and quality of supply by the DISCOM.

Universal Pump-Set Metering is Difficult and May Be Suboptimal in the Medium Run

Metered connections should be incentivised through lower tariffs as opposed to unmetered ones, but past experience has indicated that universal metering of pump-sets is not practical in the short or medium run. Farmers will resist such a measure, since the quality of supply is poor and there is a fear of harassment or future tariff increases. As we have seen earlier, DISCOMs are not regular in reading meters because of which a large number of bills that are issued in rural areas are not based on actual meter readings. Moreover, continued issuance of unmetered connections by DISCOMs and government subsidy for unmetered connections instead of metered connections has shown that the slow metering of pump-sets is not attributable to resistance on part of farmers alone. In addition, pump-set metering may not be a solution for all areas and contexts as seen in West Bengal. Having said this, metered connections can be encouraged after improving the quality of electricity supply and its service. And there are certain areas where pump-set metering can work, where farmers themselves come forward and ask for it. This is discussed in Section 7.3.

Supply Quality to Agriculture Has to Improve

Section 4 has covered how farmers bear the cost of low hours of supply (at hours suitable to the DISCOM) and the long delays in repairing networks. There is no credible data on the actual hours of supply to agriculture. In states where feeder separation is not implemented, rural supply is as bad or good as agricultural supply. Duration and times of supply are decided by the DISCOM based on the power situation and not on factors like cropping pattern, rainfall, ground water availability, and irrigation preferences. Due to this thorny issue, DISCOMs have lost credibility in the eyes of farmers. The DISCOM and SERCs have to take the first steps to rebuild their credibility through effective monitoring of supply and service quality, and gradual improvement in the quality of supply before raising tariffs.

7. Suggestions

Considering the low incomes and high risks in agriculture, levying higher charges on farmers should not be the immediate priority. Making the system more accountable, making agricultural consumption estimation more reliable, and improving the supply and service quality should be prioritised. Indeed, breaking out of the trust deficit between DISCOMs and farmers will require DISCOMs, SERCs and the government to take the first steps. Without these, agriculture will continue to be an easy scapegoat for the financial problems of the electricity distribution sector, and effective solutions will continue to remain elusive.

In this section we offer some broad and specific suggestions to address issues of agricultural electricity consumption estimation, subsidy and supply quality highlighted in previous sections. Our suggestions fall into three broad areas. First, an integrated approach to electricity supply, which also takes into consideration its linkages with agriculture and water, is required. Second, we make some specific suggestions to improve estimation. Third, we offer ideas for pilot projects which will help to gather data about the linkages between electricity, water and agriculture and thus provide valuable inputs for scaling up of proposed solutions.

7.1 Integrated Approach to Electricity Supply

Figure 10: Approach to Electricity Supply

Given the agro-climatic and socio-economic diversity in our country, and the complex nature of the inter-linkages between electricity, water and agriculture, a single approach cannot address the complex and diverse issues involved. Solutions have to be context specific and disaggregated at the state or regional levels, and integrated across the electricity, water and agriculture sectors.

Electricity supply to agriculture is not solely an electricity sector or DISCOM issue. Policy decisions regarding electricity supply, be it subsidy, metering, disbursal of connections or hours of supply, need to be taken after consulting with farmers and government departments of irrigation, agriculture and water. In spite of the discussion around rationalising the electricity subsidy, the current approach towards subsidy determination lacks a strong rationale. The level of subsidy should be decided based on studies regarding subsidy requirement of, impacts on different actors and parameters. It has to be estimated through a disaggregated plan that not only minimises the burden on state governments and DISCOMs, but also does not affect farmers' incomes and livelihoods adversely, while promoting sustainable use of groundwater. These issues are elaborated further in Section 6 of Volume 1 of this paper.

Direct transfer of electricity subsidy by the government to the farmers' bank accounts is being actively discussed in policy circles. The rationale behind such a move is to link the subsidy directly to the use of electricity, plug leakages in the subsidy, and help target the subsidy to the needy. However, apart from issues with access to the banking system and a lack of financial literacy of the rural poor, such a measure would require metering of all pump-sets, which as seen before is fraught with problems. Unlike the present situation, state governments would have to make the subsidy payments on time and in full, otherwise farmers will have to reel under the pressure of paying for the full cost of supply. If a flat subsidy on the basis of flat tariffs is transferred, the subsidy itself will have to be determined by the cost of supplying to a particular level of electricity consumption, and the system of conflation of agricultural consumption with losses will continue. Direct benefit transfer will thus fail in its goal of preventing subsidy leakage. However, this is a solution that can be tried as a pilot in areas with pump-set metering, and relatively better rural electricity and banking infrastructure.

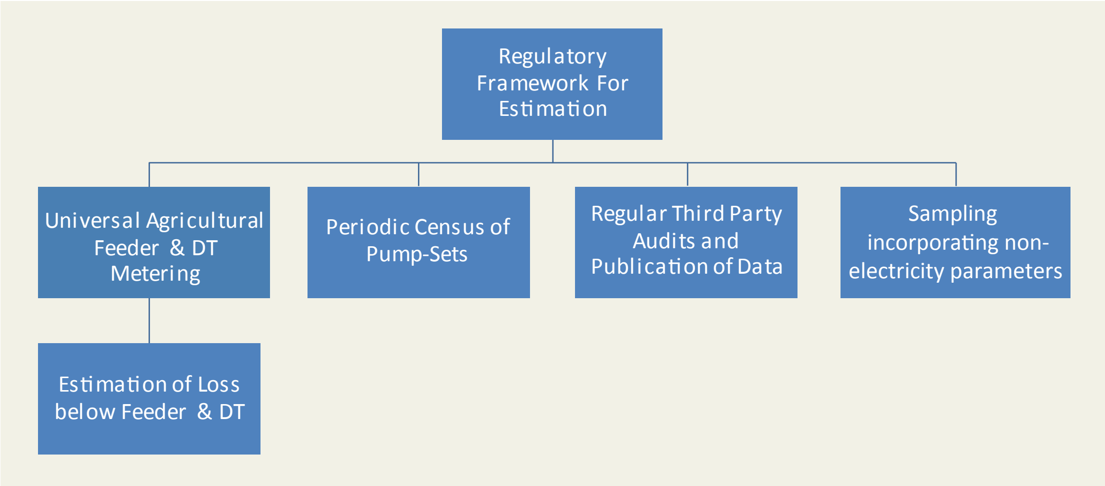
This integrated approach should also be adopted in the electricity sector, with different actors like SERCs, DISCOMs, farmer and consumer groups, and state governments coming together to improve processes of consumption estimation and establish public disclosure mechanisms for subsidy and power quality to agriculture. A central agency, like the Forum of Regulators, should establish a framework for the estimation process, incorporating details on sampling, metering, pump census and energy audits. This process could also include ideas to correlate electricity consumption with cropping or ground water use. For example, DISCOMS and SERCs can co-ordinate with the CACP for state-wise data on electricity consumption by different crops in agriculture, as has been done by the Punjab Electricity Regulatory Commission in 2002-03. Regulators should annually monitor if this framework is being adhered to. Penalties for the DISCOM in the case of failure to improve the estimation process in a reasonable time frame can be instituted. The PSERC's initiative to disallow 1% of agricultural consumption of the PSPCL for failure to comply with directives could be followed by other commissions. (PSERC, 2017, p. 274).

Improvements in agricultural consumption estimation need to be backed by policy. Government financial assistance and loans to DISCOMs must have conditions regarding feeder and DT metering and putting energy audit data in the public domain in an easily accessible format. Civil society groups and researchers can use this data to suggest improvements in estimation.

There should be more transparency in the calculation of subsidies and receipts. The break-up of the subsidy for different consumers and details of the subsidy booked and received from the state government should be available in the public domain. There should be a separate monitoring of the supply and service for farmers and rural consumers. Proactive steps should be taken by the DISCOMs and SERCs to improve the complaint handling process for farmers. Separate public hearings for the quality of supply and service can be undertaken for this purpose.

7.2 Improving Estimation of Agricultural Electricity Consumption

Figure 11: Steps to Improve the Estimation Process



Representative Sampling of Pump-Sets and Feeder and DT Metering

Universal metering of pump-sets is not practical in many areas, but universal metering of DTs and feeders is certainly possible. This is not an additional exercise for DISCOMs, as under the UDAY scheme, all states have committed to complete metering of all feeders and DTs. This data can be directly used for estimation of agricultural consumption, like the ISI methodology[71] in Telangana, or corroborate existing methodologies based on pump-set benchmark consumption norms.

When consumption is estimated using pump-set norms through pump-set metering, a pre-requisite for credible estimates is representative, stratified sampling of pump-sets that covers all agro-climatic zones, cropping patterns, and different groundwater and rainfall levels. At the very least, DISCOMs must carry out sampling at the circle level. Periodic surveys to revisit norms and third party audits of sampling and metering are essential.

Yet, merely installing meters on pump-sets and feeders/DTs is not enough. Care must be taken that these meters are working, meter readings are taken regularly, are accurate, and that both the regularity of readings and their accuracy are validated by third party audits. Automatic meters, which remove arbitrariness and save costs in meter readings, should be installed on feeders and gradually on DTs. Since estimates depend on the estimation of loss below the DT/feeder, loss levels in the distribution system have to be estimated reliably through metering of sample pump-sets for the cultivation of different crops. Third party energy audits should be periodically taken up by SERCs.

71. Methodology for agricultural consumption estimation devised by the Indian Statistical Institute (ISI), Hyderabad. Details of this methodology are in Section 1 of the Annexure.

Periodic Census of Pumps

Periodic census of agricultural pump-sets should be carried out to determine their number, operation status and connected load. This could be done by the DISCOM or the government. The recent Andhra Pradesh government initiative of geo-tagging bore-wells and the KERC's directive in 2016 to conduct a census of pumps are steps in the right direction (Groundwater Department, Government of Andhra Pradesh; KERC, 2016b). Since this is a time consuming and resource intensive exercise, efforts can be co-ordinated with agencies responsible for such regular surveys, like the Minor Irrigation and Agriculture Census Data. The definitions of parameters on which data is collected should be standardised across surveys. Voluntary load disclosure schemes are a good way to regularise connections.

Importantly, this data is required at all levels of policy for different sectors, be it agriculture, electricity or groundwater-based irrigation. However, this data is not available at the level of accuracy, granularity (if not aquifer level then district or electricity distribution circle level) and frequency (updated once every few years) as is desired anywhere.

7.3 Pilot Projects

In order to implement solutions, they have to be tested for effectiveness first. Pilot projects are the best way to do this and address the many data gaps. These pilots will help in assessing the ground level challenges and response from farmers, electricity distribution companies and other actors. Measures taken to address issues surrounding the linkages should have the following objectives: a realistic estimation of agricultural consumption, control of the subsidy burden on governments and cross-subsidising consumers, more sustainable use of groundwater, better quality of electricity supply and service, and the welfare and safety of farmers. Ways and means have to be found to bridge the trust deficit between farmers and DISCOMs. Our observations and suggestions are indicative and need to be discussed with all major actors in order to contextualise them.

The pilot can be carried out in a group of blocks[72] or districts. A baseline survey studying the socio-economic conditions of the area has to be carried out. Post the pilot, studies analysing the impacts of the pilot on a range of applicable parameters like electricity and water use, agricultural production and productivity, subsidy, cropping pattern, power quality, groundwater levels, and access to groundwater for marginal and small farmers have to be carried out. Table 8 gives a list of the pilots that can be conducted, along with their broad outlines.

Table 8: Pilot Projects

Pilot	Objectives	Description
Solar Agricultural Feeder	Better estimates of agricultural consumption and quality of supply, reduction in subsidy, welfare of farmers	All the pump-sets on an 11 kV feeder are supplied by solar power, generated by a 1-2 MW solar plant located at a convenient location in that area. This plant is connected to the DISCOM supply, so that when required, power can be drawn and if solar power is high, it can be exported to the grid. Considering the fixed cost of solar generation (over 20-25 years) and the increasing cost of grid supply, a solar feeder with efficient pumps would be cheaper than grid supply in just 2 years. For details, see Annexure 3. This can be done in the states frequently discussed in this paper where electricity subsidy is high and quality is poor.

72. A block is an administrative division comprising of several villages

DT and Feeder Metering with Census of Pumps-sets	Better estimates of agricultural consumption	Automatic meters can be used for metering. Loss below the DT and feeder has to be measured and consumption of other rural consumers under the DT/feeder has to be accounted for accurately. Census of pump-sets will not only take a headcount, but will also record pump capacities, efficiencies, and hours of operation. This can be implemented by an external agency with the help of the DISCOM, and results can be validated by the SERC.
Metering of a Group of Pump-sets	Better estimates of agricultural consumption and quality of supply, reduction in subsidy, more sustainable use of groundwater	Past experience in Maharashtra and Karnataka show that there are certain groups of farmers who are ready to meter their pump-sets and pay metered tariffs in exchange of better quality of supply and service. These should be identified and supply and service quality should be closely monitored by the SERC. Bills have to be issued by the DISCOM on time and collection of payments can be done on a mutually agreed time by a DISCOM representative, in the absence of more sophisticated digital payment systems.
Distribution Transformer Associations	Better estimates of agricultural consumption and quality of supply and service, more sustainable use of groundwater and safety	Distribution Transformer Associations can be established on the line of Water Users Associations which manage surface irrigation. They can be a link between the DISCOM and farmers and can be responsible for distribution of bills, collection of payments, and resolution of issues like transformer and meter failure and power failure. They can also monitor groundwater stress experienced by farmers and help in cropping pattern determination in the community. They can also educate farmers on safe use of electricity.
Capital Subsidy for New Pump-sets	Higher access to groundwater irrigation for small farmers (farmer welfare)	This can be done in groundwater abundant areas. In order to provide access to groundwater irrigation to poorer farmers, especially those who are buying irrigation water. Capital subsidies can be provided on energy-efficient pump-sets. Electricity connections for these pump-sets should be released speedily. Areas where use of diesel pumps is high, like Bihar, WB and UP, can be prioritised. In such areas, this subsidy can also be given to solar pump-sets as water is available at lesser depths and electricity networks are poor.
Improvement in Power Quality, Safety and Grievance Redressal	Better quality of supply and service	The trust deficit between farmers and the DISCOM can be bridged by demonstrating improvements in supply and service quality. Grievance redressal centres should be present at every district headquarter, and separate public hearings can be organised by the SERCs on quality of supply and service. This should include all the separate quality of supply indicators for rural areas as well as electricity accidents.
Block Level Hours of Supply	Reduction in subsidy, more sustainable use of groundwater	DISCOMS can schedule hours of supply to agriculture at the block level, after consultations with farmers about their irrigation requirements and taking into consideration the cropping pattern of the area and state of groundwater aquifer. Crops suitable to the agro-climatic zones should be supported by adequate MSP and have assured procurement by the government or have direct links to the market that will give farmers a remunerative price for their produce. Areas with groundwater stress can be prioritised.
Block Level Tariffs	Reduction in subsidy, more sustainable use of groundwater	DISCOMs can charge tariffs to farmers, again depending on the crops grown and state of groundwater aquifer and after consultation with farmers. Farmers should get a remunerative and assured price for their produce in order to change the cropping pattern to a more sustainable one as described in the previous point. There should be improvement in supply and service quality. Areas with groundwater stress can be prioritised.

Ideas suggested by others include distributing power subsidy among all farmers, including those not having access to irrigation, by directly delivering to their bank accounts (Kumar, et al., 2017); allocating low cost power to agriculture consumers through DISCOMs as suggested by T L Sankar (Sankar, 2002) and by PEG (PEG, 2013); establishing separate electricity supply companies for agriculture with low-cost power (Gujarat Krushi Vij Grahak Suraksha Sangh, 2007); and solar power harvesting by farmer co-operatives as suggested by IWMI-TATA researchers (Shah, Durga, Verma, & Rathod, 2016).

8. Annexure

This volume has an annexure. It has the following sub-sections:

1. State Details of Agricultural Power Estimation (methodologies of estimation of agricultural electricity consumption employed by different states)
2. Impact of Restatement of Agricultural Sales and Loss (calculation of the impact of agricultural electricity sales and distribution loss re-statement on DISCOMs)
3. Determination of Agricultural Electricity Tariff (determination of electricity tariff for agriculture by different states)
4. Solar Agricultural Feeder (solar agricultural feeder as a solution for problems associated with the electricity-agriculture-water linkages)

It can be found on the Prayas (Energy group) website at http://www.prayaspune.org/peg/publications.html.

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10. List of Abbreviations

ABR	Average Billing Rate
ACoS	Average Cost of Supply
AP	Andhra Pradesh
APEPDCL	Eastern Power Distribution Company of Andhra Pradesh Limited
APERC	Andhra Pradesh Electricity Regulatory Commission
APSPDCL	Southern Power Distribution Company of Andhra Pradesh Limited
ARR	Aggregate Revenue Requirement
AT&C Losses	Aggregate Technical and Commercial Losses
AVVNL	Ajmer Vidyut Vitran Nigam Limited (Ajmer DISCOM)
BEE	Bureau of Energy Efficiency
BESCOM	Bangalore Electricity Supply Company Limited
BU	Billion Units
CACP	Commission for Agricultural Costs and Prices
CAG	Comptroller and Auditor General of India
CEA	Central Electricity Authority
CESC	Chamundeshwari Electricity Supply Corporation Limited
CGWB	Central Groundwater Board
Cr	Crore
DES	Directorate of Economics and Statistics
DHBVNL	Dakshin Haryana Bijli Vitran Nigam Limited
DISCOM	Distribution Company
DT	Distribution Transformer
DVVNL	Dakshinanchal Vidyut Vitran Nigam Ltd
EESL	Energy Efficiency Services Limited
FY	Financial Year
GERC	Gujarat Electricity Regulatory Commission
GESCOM	Gulbarga Electricity Supply Company Limited
GoH	Government of Haryana
HERC	Haryana Electricity Regulatory Commission
HESCOM	Hubli Electricity Supply Company Limited
HT	High Tension
JdVVNL	Jodhpur Vidyut Vitran Nigam Limited (Jodhpur DISCOM)
JVVNL	Jaipur Vidyut Vitran Nigam Limited (Jaipur DISCOM)
KEB	Karnataka Electricity Board
KERC	Karnataka Electricity Regulatory Commission
kW	Kilo-Watt

kWh	Kilo-watt hour
LT	Low Tension
MERC	Maharashtra Electricity Regulatory Commission
MESCOM	Mangalore Electricity Supply Company Limited
MI	Minor Irrigation
MP	Madhya Pradesh
MoP	Ministry of Power
MPSEB	Madhya Pradesh State Electricity Board
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MT	Million Tonnes
MU	Million Units
MW	Mega Watt
MYT	Multi-Year Tariff
MVVCL	Madhyanchal Vidyut Vitran Nigam Limited
PEG	Prayas (Energy Group)
PFC	Power Finance Corporation
PSERC	Punjab State Electricity Regulatory Commission
PSPCL	Punjab State Power Corporation Limited
PSU	Public Sector Undertakings
PuVVNL	Purvanchal Vidyut Vitaran Nigam Limited
PVVNL	Pashchimanchal Vidyut Vitran Nigam Ltd.
RBI	Reserve Bank of India
RERC	Rajasthan Electricity Regulatory Commission
SEB	State Electricity Board
SERC	State Electricity Regulatory Commission
ToD	Time of Day
T&D	Transmission and Distribution
TANGEDCO	Tamil Nadu Generation and Distribution Corporation
TNERC	Tamil Nadu Electricity Regulatory Commission
TSERC	Telangana State Electricity Regulatory Commission
TSNPDCL	Northern Power Distribution Company of Telangana Limited
TSSPDCL	Southern Power Distribution Company of Telangana Limited
UDAY	Ujwal Discom Assurance Yojana
UHBVNL	Uttar Haryana Bijli Vitran Nigam Limited
UP	Uttar Pradesh
UPERC	Uttar Pradesh Electricity Regulatory Commission
UPPCL	Uttar Pradesh Power Corporation Limited

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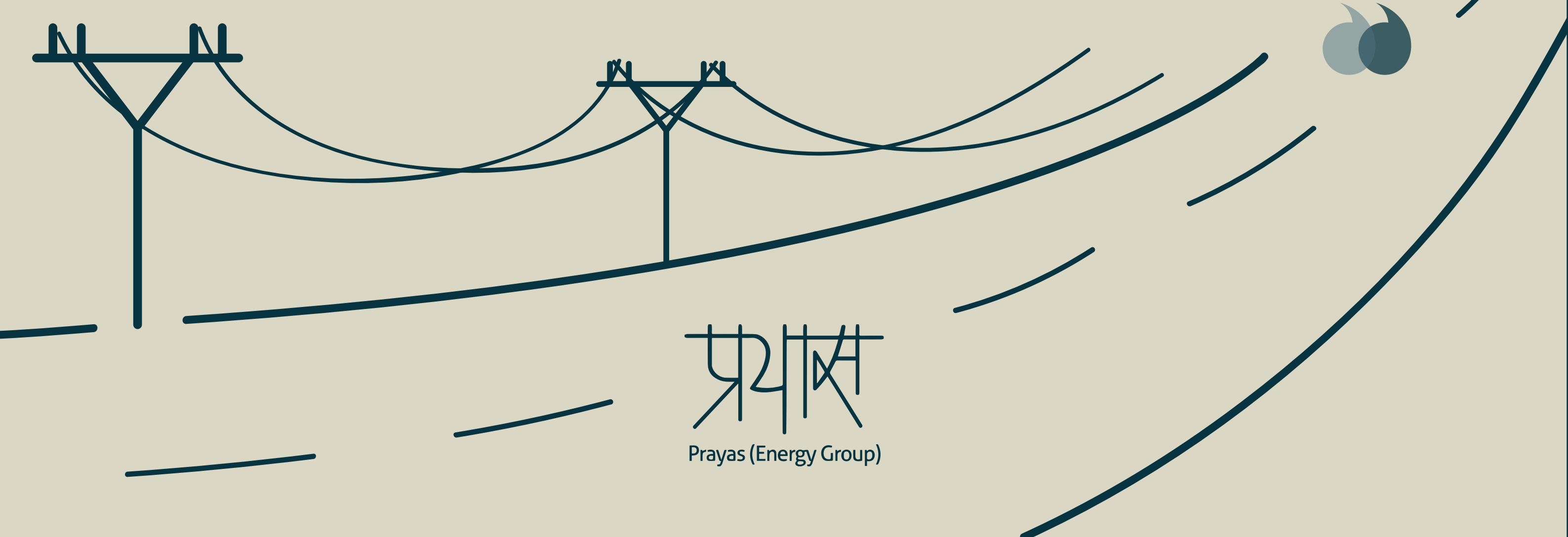
Agriculture occupies a critical position in the country's economy, ensuring food security, providing livelihoods, and indeed as a way of life for most rural people. Due to many reasons, growth in agriculture has been largely driven by groundwater based irrigation, powered by electricity. It is also certain that the dominance of groundwater will continue in the coming years.

From the early 1990s, a significant thread in the story of reforms in electricity sector has been the financial unsustainability of the distribution sector. One of the reasons cited has been the subsidised supply of electricity to agriculture. Subsidised supply has also been held responsible for poor quality of supply and excessive use of groundwater. Increasing the agriculture electricity tariffs has been a major suggestion for improving distribution sector finances.

In spite of several decades of this approach, the problems persist. An important reason for this is the failure to acknowledge the strong and complex linkages between the electricity, water and agriculture sectors, and to recognise that it is practically impossible to address the issues of one without comprehensively addressing challenges in all the other sectors.

With this in mind, this discussion paper in two volumes brings out the linkages between electricity, water and agriculture sectors. It also highlights the need to take these linkages into consideration when planning agricultural electricity supply. Volume 1 of the paper focuses on an overview of the linkages and Volume 2 provides a detailed analysis of the electricity sector related issues of the linkage.

It is our hope that this discussion paper would catalyse a healthy discussion among actors in electricity, water and agriculture sectors, towards a better understanding of the challenges and evolving sustainable solutions.



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