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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 agricultural 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 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

In November 2015, the Government of India (GoI) launched the Ujjwal DISCOM Assurance Yojana (UDAY), a scheme for operational and financial turnaround of power Distribution Companies (DISCOMs). Documents pertaining to this scheme estimated the total accumulated losses of DISCOMs in March 2015 to be Rs 3.8 lakh crores (MoP, 2015)—3.3% of the country’s Gross Domestic Product (GDP) for that year (MOSPI, 2017).

But these figures do not tell the whole story. The gravity of the problem is revealed further by the fact that UDAY is the third major bailout package for the distribution sector between 2001 and 2015 (PEG, 2018, p. 206).

That this problem has persisted over the years despite bailouts and reforms points to the important lacunae in identifying the fundamental reasons and addressing them.

From the early 1990s, a significant thread in the story of reforms related to the power sector and particularly the distribution sector in India is the financial unsustainability of the distribution sector. One of the reasons for this unsustainability has been the free or below-cost and subsidised supply of electricity to certain categories of consumers (PEG, 2018, p. 213). This has meant higher burden through cross-subsidies on other consumers, massive financial outgo from government coffers as direct subsidy, and breakdown in the financial stability of DISCOMs.

Agricultural supply has been singled out by many as the main cause of these developments (Department of Power, GoI, 1980; Planning Commission, 1994; AF-Mercados, 2014). Unsurprisingly, a major part of the reforms has been the push for the elimination of subsidies and increasing tariffs for agricultural consumers.

In the case of agricultural electricity supply, it has been argued that subsidised supply has also led to its poor quality. This is often described as a vicious cycle, with the DISCOM having little incentive to ensure quality and adequacy of supply to agricultural consumers as it loses money on every additional unit supplied due to tariffs that are below the cost of supply. The farmers, on the other hand, have little incentive to pay higher tariffs as they receive electricity at odd times, of uncertain quality, and insufficient quantity. Thus, farmers and DISCOMs are locked in what is referred to as a low-level equilibrium. Subsidised or free supply of electricity is also said to lead to an overextraction of groundwater resulting in sharp falls in groundwater levels and related problems of higher pumping costs and deterioration in groundwater quality. Rationalisation of agricultural tariffs, which is another word for increasing the tariffs towards the cost of supply, is advocated as necessary to tackle these problems as well.

The contribution of groundwater and hence electricity to agriculture production and growth has been steadily increasing over the years, and now groundwater is the dominant source of irrigation. Considering the critical position that agriculture occupies in the country’s economy, in ensuring

1. While DISCOMs are supposed to be compensated by the state governments for this loss, the payments by the state government are often delayed and may not cover the entire amount. Moreover, part of the loss due to tariffs below cost of supply is supposed to be covered by cross-subsidy, that is, charging other consumers higher tariffs than the cost of supply. This leads to resistance on part of consumers with high paying capacity.
food security for the population, providing livelihoods to the majority, and indeed as a way of life for most rural people, reforms, including tariff reforms, in agricultural electricity supply have far-reaching implications. Unfortunately, much of the analysis of the role of agricultural supply in the financial problems of DISCOMs, as well as suggestions to address these problems, have been narrowly focussed only on the power sector aspects. To appreciate all the dimensions of the problem, it is important to place it within the context of the linkages between agriculture, electricity and water. Barring a few exceptions, comprehensive and nuanced analysis bringing in insights from the agriculture and water sectors is missing. This is an important reason for our failure to effectively address agricultural supply related problems of the distribution sector. Also, solutions that can simultaneously address the problems of not only the DISCOMs but also the agriculture and water sectors have been difficult to come by for the same reason.

It is against this background of the persistent financial problems of DISCOMs, the onus placed on agricultural supply for these problems, and the far-reaching implications of reforms in agricultural electricity supply that we felt it important to examine this issue in a comprehensive manner. We have two key motivations. First, we would like to question the role of electricity supply to agriculture in the financial losses of DISCOMs. Second, we want to address the need for a comprehensive analysis of electricity supply to agriculture keeping in mind its linkages to the water and agriculture sectors.

The overall objective of this discussion paper is to bring out the linkages between electricity, water and agriculture, with the aim to inform policy and decision makers as well as other actors in the power sector about these linkages. We also highlight the need to take these linkages into consideration when planning agricultural electricity supply.

We present our analysis in the form of this Discussion Paper "Understanding the Electricity, Water, Agriculture Linkages", in two volumes. Volume 1 (which is this document) focuses on an overview of the linkages between electricity, water and agriculture. It provides a brief overview of the electricity sector related issues of power supply to agriculture. It further discusses the role that electricity has played in agriculture and groundwater development, as well as key issues of concern. It examines the likely impacts of reforms in agricultural electricity supply including tariff reforms on water, agriculture and farmers. Based on this analysis and discussion, some ideas for the way forward are set out.

The companion Volume 2 provides a detailed analysis of the electricity sector related issues of the linkage. 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. First it looks at the estimation of electricity consumption in agriculture and the impact of its over-estimation. Second, it assesses the distribution of the subsidy among consumers and subsidy financing. Third, it examines the issues surrounding power supply and service quality to agriculture.

We hope that this study will bring forth insights that can offer more effective and well-rounded suggestions to address the relevant problems.
2. A Word about Data Issues

Before we get into the key issues and their analysis, a word about the availability and quality of data would be in order here. To understand issues related to electricity supply to agriculture, some of the key parameters we need to analyse include the quantum of electricity supplied to agriculture, losses in the course of this supply, total installed agriculture load, number of pumpsets, alternative sources of energy for pumping like diesel, area irrigated by groundwater, other areas irrigated by pumping like surface lift commands, and groundwater availability and draft. Unfortunately, the quality of the data available for almost each and every one of these parameters is problematic. Issues include wrong estimates, large differences in figures from different official sources, lack of adequate time-series data with data often being available at only large time intervals, and so on.

While these data limitations do create problems in analysing the issue, we would like to emphasise that there is enough data and information available, especially when used with reasonable assumptions and proper corroborations, to allow us to draw important inferences and insights, and offer recommendations that would help address the issue effectively. Some examples are provided below to indicate the extent of the problems with the available data.

2.1 Wrong Estimates of Electricity Consumed by Agricultural Consumers

The most basic parameter related to this issue—how much electricity is consumed by agricultural consumers—itself is often not known. Partly, this is because much of this consumption is unmetered. But in such cases, the DISCOM is supposed to use appropriate methodologies to estimate agricultural consumption. In many cases, the estimation methodologies used are inadequate, inaccurate and lacking in rigour. Many times, losses are conflated with and presented as power consumed by agricultural consumers. Because of these issues, in many cases Electricity Regulatory Commissions have disallowed the estimates submitted by DISCOMs, forced them to bring out better estimates using surveys and appropriate methodologies, and revised (almost always downwards) the estimates of agricultural consumption. In spite of several such attempts, reasonably accurate estimates of agricultural consumption remain elusive in most states. These developments are discussed in detail in Section 3.1.

A direct corollary of this situation is that the accuracy of figures of transmission and distribution losses, including both technical and commercial losses of electricity, is questionable.

2.2 Inaccuracies in Groundwater and Irrigation Data

The "Report of the Working Group on Water Database Development and Management" set up by the erstwhile Planning Commission to provide inputs to the 12th Five Year Plan is quite explicit about the dismal condition of data related to groundwater and irrigation (Planning Commission, 2011). To quote one instance:

"There are considerable unexplained differences between the official estimates of land use and irrigated area at the State and National levels, and those generated by the National Sample Survey and the Planning Commission... (p. ix)"
Data currently being generated are inadequate to provide reliable estimates of groundwater potential and utilisation." (p. xi)

Another issue is that while the figures for areas irrigated by different sources (ground, surface, major, minor, etc) are available, these are for the net irrigated areas. Such source-wise breakup of irrigated areas is often not available for gross irrigated area. There is the additional issue that significant sections of the irrigated areas in the county are under conjunctive irrigation, that is, they are partly irrigated by surface water and partly by groundwater. But the relevant numbers are not always available and conjunctively irrigated areas are clubbed with either surface or groundwater irrigated areas.

2.3 Problems with Data on Number of Pump-sets and Energy Sources of Pumping

There are large discrepancies in the data on the number of pump-sets put out by different official agencies, as well as in the data related to various energy sources powering pump-sets. This is particularly so for the state-level data. For example, see figures given by various agencies for the number of electric pump-sets in Haryana in Table 1 below.

Table 1 Number of Electric Pump-sets, Wells/Tube-wells in Haryana
(Data from Various Official Agencies over the Years)

<table>
<thead>
<tr>
<th>Year of Reference</th>
<th>No of Electric Pump-sets, as per Central Electricity Authority (CEA)</th>
<th>Other Official Data</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-07</td>
<td>4,74,296</td>
<td>53,556</td>
<td>4th Minor Irrigation Census</td>
</tr>
<tr>
<td>2010-11</td>
<td>5,59,334</td>
<td>5,44,700</td>
<td>10th Agricultural Census</td>
</tr>
<tr>
<td>2013-14</td>
<td>5,85,589</td>
<td>3,15,176</td>
<td>5th Minor Irrigation Census</td>
</tr>
</tbody>
</table>

Source: (MoWR, 2014; MoAFW, 2015; MoWR, 2017)

Another example is that of Bihar, where the 4th Minor Irrigation (MI) Census for 2006-07 gives the number of wells/tube-wells using electricity as the power source as zero, and only 14 wells/tube-wells using diesel. More than 6.4 lakh wells/tube-wells are shown as powered by ‘other’ power sources.

2. The Central Water Commission’s Water Resources Information System (WRIS) of India defines net and gross irrigated area thus: Net irrigated area is the area irrigated during the year counting the area only once, even if two or more crops are irrigated in different seasons on the same piece of land. Gross irrigated area is the total irrigated area under various crops during the whole agricultural year, counting the area irrigated under more than one crop during the same year as many times as the number of crops grown. Inter-cultured or mixed crops are treated as one crop. (WRIS)

3. Note that while the CEA figures are for the number of pump-sets, the Agricultural and MI Census both give numbers for wells/tube-wells. These can be somewhat different considering the possibility of multiple pump-sets on the same well or multiple wells powered by the same pump-set. However, this is not enough to explain the large differences in the numbers in different years between these various agencies.

4. The 5th Minor Irrigation Census for reference year 2013-14, which has been released just as this report was being finalised, corrects this.
Similar discrepancies are observed for several other states like Uttar Pradesh (UP), Kerala, Madhya Pradesh (MP), West Bengal (WB), Andhra Pradesh (AP) and Bihar across data from the minor irrigation censuses (2006-07, 2013-14), the agricultural census (2010-11) and the CEA.

Another issue is that reliable data for how much diesel is used to power agricultural pump-sets is not directly available, and we have had to estimate it using various assumptions.

### 2.4 Disparity between Theoretical Estimations and Actual Agricultural Electricity Consumption

One important indicator of likely problems in the estimation of electricity consumption by agriculture is the wide gap between theoretical estimations for the required pumping energy, and actual agricultural consumption.

The official electricity consumption per unit of groundwater draft for irrigation in many states is considerably higher than the conservative theoretical estimation of the electricity requirement for groundwater pumping. For example, Maharashtra has a theoretical requirement\(^5\) of 0.34 kWh/m\(^3\) of groundwater draft for irrigation, whereas official electricity consumption in agriculture is close to 0.98 kWh/m\(^3\) of draft of groundwater. Such high electricity consumption is justified only if the average groundwater depth in the state is more than 90 m, whereas as per the Central Ground Water Board (CGWB), a miniscule 1-2% of the wells in the state have depth of water more than 20 m (CGWB, 2015, pp. 12-15).

While these data issues do create problems, we would like to reiterate that there is enough data and information available, especially when used with reasonable assumptions and proper corroborations, to allow us to draw important and major inferences.

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5. Assumptions used for these theoretical calculations are: (1) Depth/Head of groundwater extraction is about 30 m. (2) Pump + motor efficiency is 24% (Indian Pump's Manufacturing Association, 2016).
3. Electricity Use in Agriculture

Due to the rapid growth in groundwater irrigated area, there has been a sharp growth in the electricity use in the agriculture sector, especially since the 1980s. Electricity consumption of agriculture rose from 3,465 Million Units (MU) in 1969 to 1,87,493 MU in 2016. At one time, agriculture use constituted almost 27% of the total electricity consumption, though the share has fallen considerably after that, even as it has increased in absolute value (See Figure 1).

Figure 1: Growth of Electricity Consumption for Agriculture

Since agricultural electricity consumption has been subsidised—either directly or through cross-subsidies—this has created demands on the finances of the power sector and the state governments. Further, in a large number of cases, agricultural connections are unmetered, leading to several problems in estimating the consumption, hiding of technical and commercial losses like theft behind agricultural consumption, lack of accountability in the system, etc.

Due to this situation, cheap or free and unmetered agricultural consumption is seen as a key culprit responsible for many of the long-standing problems of the power sector like the financial health of electricity distribution companies, poor power quality of supply to agricultural consumers, and the impact of cross-subsidies on other categories of consumers.

We examine below some important details of agricultural electricity consumption, and the issues and concerns mentioned above.
3.1 Is Agriculture the Trouble Maker for the Electricity Distribution Sector?

There is some truth in the idea that electricity supply to agriculture has put the sector under financial stress. However, our analysis shows that the responsibility for financial losses cannot be laid solely at its door. Despite the focus on tariff subsidies to agriculture, not much attention has been paid to whether the subsidy goes to subsidise agricultural electricity consumption or pay for distribution losses of DISCOMs. Subsidy support is provided to some non-agriculture consumers (like domestic consumers and a few other categories), and this subsidy component has been increasing in the past few years. Moreover, some part of the subsidy to agriculture is neither covered by the government nor by cross-subsidy, and it contributes to the financial loss of the DISCOM. The payment of subsidy owed to the DISCOM by the state government is often substantially delayed, not paid in full or not fully claimed from the government, which results in additional stress for the DISCOM. As a result, the extent of the sector’s losses attributed to agriculture but actually due to factors other than agriculture has not been duly assessed. It is imperative to ascertain this to know if measures to reduce the subsidy are effective. In the following sections, we will examine the issues related to the estimation of agricultural electricity consumption, subsidy and the finances of the DISCOM. These issues are covered in greater detail in Volume 2 of this paper.

3.2 Estimation of Electricity Consumption for Agriculture

The level of metering of agricultural connections is quite low in many Indian states. Only 27% of electricity connections in agriculture were metered in 2012-13 in the major agricultural electricity consuming states: erstwhile undivided Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu (TN) and Uttar Pradesh.\(^6\) This is despite repeated recommendations by government agencies (GoI, 2001; Planning Commission, 1994; GoI, 1993) and repeated directives by state electricity regulatory commissions (SERCs) to meter existing agricultural electricity connections and issue new ones that are metered. Hence the true level of electricity consumption in agriculture is unknown.

Some electricity is lost in the distribution system during transit before it reaches the end consumer. This is the distribution loss. It is lost because of a technical loss (due to losses in the electricity lines and transformers) and a commercial loss (due to unaccounted consumption).\(^7\) 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 sales to consumers are unmetered, one cannot determine how much electricity is reaching the consumer and how much is lost as distribution loss. As agriculture is the recipient of much of the unmetered sales in many states\(^8\), the estimation of distribution loss is highly dependent on the estimation of unmetered agricultural consumption. Thus, overestimation of agricultural electricity consumption leads to underestimation of the distribution loss.

In order to understand how electricity consumption is overestimated, it is important to know how it is estimated.

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\(^6\) Analysis by Prayas (Energy Group) based on various regulatory petitions and orders.

\(^7\) 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 (TnD).

\(^8\) Except in Uttar Pradesh and Bihar that also have many unmetered domestic connections.
Figure 2 depicts the distribution system and how electricity is supplied to agricultural pump-sets. From a 33 kV distribution substation, typically there would be 3–4 agricultural feeders; on each feeder there would be 20 distribution transformers (DT); and on each DT, around 20 pump-sets. This is the common layout in cases where physical feeder separation has been done. Alternatively, there are mixed feeders supplying to a common load of village and agricultural pumps. Electricity consumed by irrigation pump-sets can be measured at three stages in the distribution system: 11kV agricultural feeder, DT or pump-set. If consumption is measured at the feeder or DT level, the electricity loss (distribution loss) between the feeder/DT and the pump-set has to be deducted to arrive at the pump-set consumption. Thus, there are three main approaches to estimate electricity consumption by irrigation pump-sets:

- **Agricultural consumption** is calculated based on the average consumption of pump-sets fitted with meters. Average consumption is recorded through sample surveys, consumption by a set of metered pump-sets or based on assumptions about hours of operation of the pump. It is called the benchmark consumption norm of a pump-set, which is usually expressed as kWh per pump-set capacity in Horse Power (HP) or kilo-watt (kW) per annum. This benchmark consumption is then applied to all the pump-sets to arrive at the total agricultural electricity consumption under the DISCOM. Usually there is a single benchmark for pump-set consumption in a DISCOM, but sometimes there are separate benchmarks for different seasons, different DISCOM administrative zones, permanent and temporary connections, etc.

- **Benchmark consumption of a DT** is calculated based on the average consumption of a sample of metered DTs with predominantly agricultural load. There can be separate benchmarks for different capacity DTs. Distribution loss below DT is deducted to arrive at the consumption by pump-sets.

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9. Substation = 33 kV substation; Feeder = 11 kV feeder; DT = Distribution Transformer; LT = Low Tension W
• Consumption by agricultural feeders as recorded in feeder meters is used. Distribution loss below feeder is deducted to arrive at consumption by pump-sets.

Although these are the three broad approaches of estimation, the exact estimation method differs from state to state. The state and DISCOM level estimation methodologies are described in Volume 2 of this paper.

Over the years, better estimates for agricultural electricity consumption and hence distribution loss have been made available in many states. During such instances, estimates of electricity consumption by agriculture have been revised downwards and distribution loss has been revised upwards. There was a spate of revisions in various states between 1998 and 2001 when state electricity regulatory commissions (SERCs) were established. This was because the SERCs brought greater scrutiny over the process of agricultural consumption estimation. Studies on agricultural electricity consumption were conducted in many state electricity boards. Electricity consumption by agriculture and TnD losses were revised in Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, West Bengal, Haryana, Punjab and Maharashtra (Honnihal, 2004; PSERC, 2002), with revisions as large as a 53% reduction in agricultural consumption and increase in TnD losses from 25.5% to 42%\(^\text{10}\) in Uttar Pradesh from 1998 to 2000 (Planning Commission, 2002). Agricultural consumption across the country actually declined from around 84,000 MU in 1996-97 to around 81,700 MU in 2001-02, which is quite uncommon, despite an increase in the number of electric pump-sets and an increase in overall sales of electricity. On the other hand, the TnD losses increased from 22.8% to 34% (CEA, 2015; Planning Commission, 2002; Planning Commission, 2001).

In recent times too, agricultural electricity consumption and distribution loss have undergone revision or ‘restatement’ when a more robust methodology has been adopted by a Regulatory Commission. This has happened for the year 2010-11 in Punjab, Haryana and Tamil Nadu, and for 2014-15 in Maharashtra. Again, the downward revision in agricultural consumption has been as large as 28% in Uttar Haryana Bijli Vitran Nigam Limited (UHBVNL), a Haryana DISCOM, which saw an increase in distribution loss from 24% to 33% (HERC, 2012). Electricity consumption in agriculture is overstated to such an extent that negative distribution losses have been reported on agricultural feeders in Punjab and Maharashtra, i.e. the curious phenomenon where electricity consumption by the agriculture pump-sets is more than the electricity input into the feeder (MERC, 2016; PSERC, 2016). Details of state-wise revisions in sales and losses are provided in Volume 2 of this paper.

Such restatement has multiple financial impacts on the distribution sector. First, the subsidy requirement from government and cross-subsidising consumers reduces. Second, DISCOMs have to bear a higher share of the financial loss. This is because distribution loss also results in financial loss to the DISCOM, as it is the energy that the DISCOM is purchasing but not getting revenue for. On the other hand, a DISCOM’s loss in revenue because of subsidised power to agriculture is recovered from consumers in the form of higher tariffs. Thus, when the distribution loss is revealed to be higher, the DISCOM cannot fully pass the resultant financial loss onto others. Third, DISCOMs lose face when distribution losses are revealed to be greater, but get a better image (with lenders, the government, etc) by showing low distribution loss by conflating it with agricultural consumption. This shows that hiding distribution loss as agricultural consumption helps DISCOMs.

\(^{10}\) Distribution and TnD losses are usually expressed as a percentage of the energy input to the DISCOM. We have used the same approach here.
However, if loss is actually reduced, the DISCOM would get more revenue by selling that energy. Our analysis shows that UHBVNL would have received 12% more revenue in 2010-11 had it actually sold the restated distribution loss. The details are provided in Section 2.3 of Volume 2 of this paper.

Faulty estimation of agricultural consumption follows from the many problems in the estimation methodologies. Although SERCs have brought more transparency in the estimation process, it remains far from satisfactory. DISCOM estimates for agricultural consumption are often not in line with the rainfall, groundwater and agricultural situation. However, alternate estimates derived from rigorous studies that will counter DISCOM estimates are not available with the SERCs. DISCOMs often do not share key data regarding agricultural estimation unless pressured to do so. Crucial data regarding total number of pump-sets and connected load are not reliable as they do not account for permanently disconnected and illegal pump-sets and load. This produces discrepancies in DISCOM data and that of other government agencies as discussed before in Section 2.3. Often unsubstantiated assumptions are employed regarding hours of operation by pump-sets based on hours of supply to agriculture. The actual hours of pump-set operation can be significantly lower than the stipulated hours of supply. This is because the rural power supply availability and quality is poor and pump-sets are not in operation throughout the year. Benchmark consumption of pump-sets should be computed from regular representative surveys, but these are not carried out.

In instances where consumption is estimated using benchmark consumption of agricultural DTs, there are many issues with metering of DTs. A limited number of DTs are metered or a large portion of the available meter readings are unusable. Assumptions of losses from DTs to pump-sets are not periodically verified.

Metering existing unmetered pump-sets can be difficult, but DISCOMs are also issuing new unmetered connections, despite SERC directives to the contrary.

Past experience has shown that metering of all pump-sets is not practical in the medium term, except in a few situations, where agriculture connections are few, or where the farmers and DISCOM are ready to support metering. However, metering of all DTs and feeders is certainly possible and will go a long way in arriving at a better estimate of agricultural consumption. It is also important to conduct a periodic census of pump-sets and carry out third party verification of estimation.

### 3.3 Subsidy for Electricity Consumption

Electricity subsidy to agriculture is sourced through two sources: the state government and cross-subsidising consumers. Cross-subsidising consumers are often commercial and industrial consumers who pay tariffs that are higher than their cost of supply. This surplus is used to subsidise agriculture, domestic and other smaller consumers. The total subsidy requirement of agriculture is quite large, and it is the largest subsidised consumer. Total state government subsidy to the DISCOMs in the 10 states with the highest electricity consumption in agriculture was approximately Rs 50,000 crores in 2013-14, with majority of it availed for agricultural supply.11

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11. Source: Analysis by PEG from Comptroller and Auditor General of India (CAG) Reports on Public Sector Undertakings (PSUs) of various states; State Regulatory Orders and Petitions; and (PFC, 2016). The 10 states with the highest electricity consumption in agriculture are erstwhile Andhra Pradesh (undivided), 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. See Section 3.2 of Volume 2 of this paper for details.
Total subsidy to agriculture has been increasing over the years for two reasons: increase in the subsidy level of agriculture (subsidy per unit of electricity supply to agriculture), and increase in electricity consumption in agriculture. As can be seen in Figure 1, electricity consumption in agriculture has been growing. The subsidy level of agriculture has been increasing with the increasing cost of supplying electricity to consumers. The cost of electricity supply is the cost to supply one unit of electricity to a consumer, including the cost of generation, transmission and distribution. Unlike tariffs for other non-subsidised consumers, agricultural tariffs have not been able to keep up with this increase. Based on indicative analysis, the average cost of supply (ACoS) increased at an average rate of 8% per annum (pa) between 1979-80 and 2013-14, while agricultural subsidy level increased from 56% of the average cost of supply to around 90% in the same period. This means that the tariff for the agriculture supply was 44% of the ACoS in 1979-80 and 10% in 2013-14.

However, agriculture is not the only category that is subsidised. Some domestic consumers and other consumers are also subsidised. Data from the Power Finance Corporation (PFC) on the electricity consumption in agriculture was analysed for 10 states which account for 97% of electricity consumption by agriculture in the country. The analysis shows that the subsidy requirement of the domestic category has grown from a quarter of the total subsidy requirement of all subsidised consumer categories in 2006-07, to around 30% in 2015-16. On the other hand, the share of agriculture in the total subsidy requirement has declined from 75% to around 61%. Some consumers in industrial categories are also subsidised in a few states. In 2006-07, such consumers were subsidised only in Rajasthan. But in 2015-16, they were subsidised in Haryana, Maharashtra and Tamil Nadu in addition to Rajasthan. Their subsidy is small compared to others, but has been on the rise. Recently, the governments of Punjab and Haryana announced subsidies for industrial consumers (PSERC, 2018a; PSERC, 2018b, p. 102; Industries and Commerce Department, GoH, 2018).

Share of agriculture in total subsidy requirement has declined because of two factors. Firstly, sales to agriculture have not grown as fast as other categories, because of rationing of power. Secondly, tariffs of other subsidised categories have not increased with the cost of supply, or have seen additional subsidy (PFC, 2010; PFC, 2016). This analysis is indicative as PFC data has certain shortcomings. These shortcomings and results of an analysis using more reliable data from regulatory orders for the state of Punjab is discussed in Volume 2 of this paper.

State governments have been Shouldering a greater proportion of the total subsidy requirement of DISCOMs than cross-subsidy. Their contributions have also been increasing over time. With limits on increase in cross-subsidy, additional subsidy requirements have been coming from them. In Karnataka, for example, in the case of DISCOMs of Bangalore and Hubli, the government contribution to the total subsidy has gone up from 2% in 2007-08 to more than 60% in 2014-15. In Punjab, the government subsidy of Rs 5900 Cr accounted for 88% of the total subsidy in 2014-15.

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12. Cost of supply can depend on the consumer category that is being supplied. ACoS is the average of the cost of supply to all consumers.

13. Sources: Analysis by PEG from (Department of Power, GoI, 1980; Planning Commission, 1994; PFC, 2016) as well as various regulatory orders and petitions.

14. Agricultural sales grew by 7% p.a. between 2006-07 and 2013-14, whereas sales to other subsidised categories like domestic, industrial Low Tension [LT] and other smaller categories have increased faster at 9%, 10% and 16% pa respectively.

15. Source: PEG analysis from various regulatory petitions and orders from Punjab and Haryana. See Section 3.2 of volume 2 of this paper for details.
As mentioned earlier, some part of the total subsidy required by the DISCOM is not covered by the government or cross-subsidy, which results in a financial loss to the DISCOM. The subsidy requirement that is uncovered is high in Tamil Nadu, ranging from 70% of the total subsidy requirement (around Rs 8,900 Cr) in 2011-12 to 46% (6,600 Cr) in 2013-14. Usually, the higher the uncovered subsidy, the higher is the overall financial loss of the DISCOM. Not surprisingly, TN was among the three highest loss making DISCOMs in 2014-15.

To make matters worse for the DISCOM, the government subsidy payments are delayed or not paid in full or do not make up for the full government subsidy requirement of the DISCOM. These shortfalls are not insignificant when cumulative shortfalls are considered. The percentage of subsidy booked that was actually received by the DISCOMs was as low as 47% from 2008-09 to 2012-13 in Uttar Pradesh. Some state governments have large subsidy obligations to the DISCOM, and though the subsidy received as a proportion of subsidy booked may not be low, the shortfall will be a significant proportion of the DISCOM’s aggregate revenue requirement. If the cumulative subsidy shortfall were to be booked from the government in the year following the time period of shortfall (for example, in 2013-14 for Uttar Pradesh), then it would be as high as 42% of that year’s aggregate revenue requirement (ARR) in Uttar Pradesh and 21% in Haryana (HERC, 2016; UPERC, 2016). In Punjab, this shortfall is 17%, thus also significant. Details of the analysis in this section are discussed in Volume 2 of this paper.

These uncovered subsidies and shortfalls in government subsidy payments lead to additional short term borrowings at high interest rates for the DISCOMs and ultimately feed into their financial losses. Cash flow shortages due to non-payment of subsidies were likely made up by cutting back on operation and maintenance expenditure of the distribution infrastructure. This must have led to further deterioration in supply and service quality to agriculture (and thereby rural) consumers, which is discussed in the next section.

3.4 Poor Supply and Service Quality to Agriculture

Power to agriculture is subsidised, but the hours of supply to agriculture, and hence rural supply hours are significantly lesser than that for urban consumers. 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. Agriculture does not receive more than 10 hours of electricity supply a day in a majority of the states.

Surveys show that farmers receive fewer than scheduled hours of supply which are often erratic and with frequent interruptions and voltage fluctuations, causing farmers to incur avoidable expenditure on pump repairs due to motor burnouts. Transformer burnouts are a common occurrence, and there are long delays in getting the transformers repaired. Unreliability of supply makes farmers invest in higher capacity electric pumps as well as diesel pump-sets (Dossani & Ranganathan, 2004; World Bank, 2001).

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

17. Due to overloading because of transformer capacity being less than the cumulative load of pump-sets, poor maintenance, etc.
Recent evidence from the 5th Minor irrigation Census conducted by the Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR) for the year 2013–14 indicates that non-availability of adequate power is an important constraint responsible for the under-utilisation of 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 the underutilisation of 33% of the under-utilized tube-wells, the second highest cause after ‘less discharge of water’ which accounts for the underutilisation of 37% of these under-utilized wells and tube-wells. This constraint of inadequate power can be overcome using diesel pumps or buying water from farmers with higher capacity pump-sets.

The fact that diesel pumps are used as a backup option in the event of erratic power supply to electric pumps has been brought to notice before (World Bank, 2001). This can still be seen in 2013–14, despite electricity replacing diesel in irrigation pumping over time (see Figure 4). Out of total electric powered wells and tube-wells in states where electricity is the dominant source of irrigation, 4% use electricity and diesel conjunctively, with it being highest in Telangana (10%), Punjab and Haryana (both 6%) (MoWR, 2017). Running diesel pumps is costlier than running electric pumps. Thus only a few farmers can afford operating both, which is why their numbers are low. In spite of being expensive, farmers continue to use diesel with electricity, and it is safe to say that this is because electricity supply is unreliable and inadequate.

Safety of farmers is also an important issue. Irrigating fields during the night can be risky and hazardous, especially for women and old farmers. This is so not only because of the danger due to creatures such as snakes but also electric shock accidents. 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 (NCRB), the 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 (NCRB, 2016).

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 long delays in repairing transformers. Billing and collection of tariff from farmers are fraught with problems. Our interactions with farmers in Maharashtra revealed some instances of inflated bills received by farmers. Farmers complained that they spend a lot of time and money to get inflated metered bills corrected by the distantly located Maharashtra State Electricity Distribution Company Limited (MSEDCL) offices. In fact, consumer representatives have time and again pointed out that meter readings for metered pump-sets are not monitored on time or not monitored at all, which necessitates reassessment of bills issued (MERC, 2012, p. 29; Vernekar, 2018; Gadgil, 2018). 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). Sometimes farmers have to pay for replacing failed meters and transformers without reimbursement. Existing grievance redressal mechanisms are inadequate and inaccessible to farmers.

It is evident that DISCOMs have their own issues in metering, billing and collection, and 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 revenue from farmers, and farmers are the hardest hit because of the low quality of supply. Farmers try to overcome the problem with high capacity pump-sets or other methods, often worsening the situation. Thus power supply to agriculture is caught in a vicious cycle with no escape in sight, especially due to the growing trust deficit between the farmer and the DISCOM.

Raising tariffs for agriculture has been suggested as a solution to break this vicious cycle. But mere tariff increase without addressing the systemic problems in the distribution sector may trap DISCOMs and farmers in an even lower equilibrium and worsen the trust deficit. In fact, if power quality and service are not improved immediately after a tariff increase, poor farmers will have to bear the adverse impacts of both higher tariffs and poor quality. Improvement in power and service quality through higher tariffs is uncertain, largely owing to the current poor distribution infrastructure in rural areas and the lack of accountability of the DISCOM in ensuring improvements in supply and service quality. Thus raising tariffs may not result in an increase in the DISCOM revenue from agriculture unless power quality and service is improved prior to tariff increase.

3.5 Summary: Electricity in Agriculture

The above discussion presents, from a power sector point of view, nuances and details of the issues of concern related to agricultural electricity supply including DISCOM finances. This understanding also offers insights into which solutions will work and which may be less effective.

Similarly, an understanding of the issues in agriculture, water and groundwater sectors related to agricultural electricity supply is also crucial in designing effective solutions. These issues include the role that electricity has played in agriculture growth, the extent to which low and subsidised tariffs have led to overextraction of groundwater, inequitable distribution of the subsidies as they appear to benefit large farmers more, and the likely impact on farmers of raising electricity tariffs.

We now explore these aspects in detail.
4. Agriculture

No discussion on agricultural electricity supply can be complete unless it includes an understanding of the critical role that electricity has played in agricultural growth in India, and therefore, in ensuring food security for the country and employment for a vast majority of our population.

Further, solutions to address the financial troubles of DISCOMs and other related power sector issues, particularly those that are being attributed to agricultural supply, are unlikely to be effective unless they factor in this role that electricity has played in agricultural growth.

Agriculture, and in particular food grain production, has shown significant growth over the years since independence. The total production of foodgrains increased by close to five times from 1950-51 to 2010-11, as shown in Table 2. The main contributors to this growth have been rice and wheat, whose production added up to close to 75% of total food grains in 2010-11 as against 53% in 1950-51, especially in Northern states like Punjab and Haryana. The country has also witnessed a shift in cropping patterns away from coarse cereals like jowar, bajra and maize.

Table 2: Food Production in India (Million Tons)

<table>
<thead>
<tr>
<th>Year</th>
<th>Foodgrains</th>
<th>Pulses(^{18})</th>
<th>Oil Seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-51</td>
<td>50.82</td>
<td>8.41</td>
<td>5.16</td>
</tr>
<tr>
<td>1980-81</td>
<td>129.59</td>
<td>10.63</td>
<td>9.37</td>
</tr>
<tr>
<td>2010-11</td>
<td>244.49</td>
<td>18.24</td>
<td>32.48</td>
</tr>
</tbody>
</table>

Source: (MoA, 2013, p. 27)

The increase in production and productivity can be attributed to a combination of several factors like improved seeds, increased use of chemical fertilisers, better irrigation facilities, extension services, and procurement and price support.

Irrigation, largely driven by groundwater and electricity as we shall see, has played a very significant role in achieving this production. About 70% of the paddy and wheat production in India is from irrigated areas (MoA, 2016, p. 50; DES, MoA, 2016). Considering that the two crops constitute more than 75% of total food grain production in the country, we can see the significance of irrigation.

4.1 Shift in Irrigation Sources

Over the years, India’s irrigation has been increasingly shifting towards groundwater. Groundwater’s share in total net irrigated area has increased from about one-third in 1950s to almost two-thirds at present (DES, MoA, 2016) (Figure 3). In terms of area, while the net area irrigated by groundwater in

\(^{18}\) Note that pulses are included in foodgrains but we have presented the figures separately also to highlight the relatively slower growth in the production of pulses.
There are several reasons for this shift towards groundwater-based irrigation. One of the most important reasons is that groundwater based irrigation places much greater control in the hands of farmers especially in terms of the timing of irrigation. Greater control also allows optimal benefits of inputs like fertilisers, better seeds, etc, thus reducing the risk of spending on these inputs (Bhaduri, Amarasinghe, & Shah, 2006). Due to these and other reasons, the productivity of groundwater irrigated crops is significantly higher. Other reasons for the spread of groundwater irrigation include the difficulty of surface or canal irrigation reaching many areas, increasing costs of developing canal-based large surface irrigation systems, significant gaps between the potential created and utilised for many of the surface irrigation schemes, and the fact that groundwater irrigation systems are modular in nature and farmers can put them up individually making them easy to install. The advantages offered by groundwater are so significant that even in areas commanded by canals, farmers will often opt for groundwater-based irrigation, where part of the water drawn from the ground is the seepage of the surface schemes.

This extensive spread of groundwater irrigation has been facilitated by the spread of electrification as well as cheap, often free, supply of electricity to agricultural users. Sometimes the availability of such cheap electricity has been labelled as the driver of extensive groundwater use. But we would see it more as an enabler, whereas the several substantial advantages of groundwater use are really the drivers. One indication of this is the large number of farmers who, not being able to use electricity for pumping groundwater, have been using diesel driven pump-sets, even though these are significantly more costly to operate. We emphasise this distinction between a driver and an enabler, because it has important implications in the design of policy suggestions.

Figure 3: Trend of Source-wise Net Irrigated Area in India

Source: (DES, MoA, 2016)
It is not a coincidence that some of the highest agricultural growth in the country has come through groundwater-based irrigation. Several studies have highlighted the crucial role played by groundwater (and reliable electricity supply and procurement support) in high agricultural growth, in regions and years as far apart as Punjab in the 1960s-70s (Dharmadhikary, 2005), Gujarat in the first decade of the millennium (Shah & Das Chowdhury, 2017), and Madhya Pradesh in the last few years (Gulati, Rajkhowa, & Sharma, 2017).

The growth in agriculture and especially foodgrains production, the implications for food security and employment in the country, and the role of groundwater and hence electricity in enabling these developments is the significant other aspect of the subsidies and support provided to electricity supply for agriculture. It is often ignored when discussing about tariff and other reforms related to electricity supply to agriculture. It is imperative to take all these developments into consideration while planning reforms in the electricity supply to agriculture.
5. Groundwater Use and Electricity

Almost all the electricity that is used in the agriculture sector is used for pumping.\(^{19}\) Similarly, more than 85% of the total energy used for groundwater irrigation, or more accurately, pumped irrigation comes from electricity.\(^{20}\) It should be noted that pumping can include pumping from dug wells, tube-wells, as well as in some cases from surface sources. In addition, a small amount of electricity is also used for large surface lift schemes.\(^{21}\)

Table 3 shows the trend over the years in electricity used in agriculture and the amount of groundwater extracted.

Table 3: Groundwater Draft, Net Irrigated Area by Groundwater, and Electricity Consumption

<table>
<thead>
<tr>
<th>Financial Year</th>
<th>Net Annual Groundwater Availability (Billion Cubic Meter) (BCM)</th>
<th>Annual Groundwater Draft—Irrigation (BCM)</th>
<th>Net Area Irrigated by Groundwater (000 ha)</th>
<th>Electricity Consumption by Agriculture (BU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>398.7</td>
<td>212.4</td>
<td>36,385</td>
<td>88.9</td>
</tr>
<tr>
<td>2009</td>
<td>395.5</td>
<td>221.3</td>
<td>38,756</td>
<td>107.8</td>
</tr>
<tr>
<td>2011</td>
<td>397.6</td>
<td>222.2</td>
<td>39,172</td>
<td>126.4</td>
</tr>
<tr>
<td>2013</td>
<td>411.3</td>
<td>228.3</td>
<td>41,305</td>
<td>147.5</td>
</tr>
<tr>
<td>Decadal growth %</td>
<td>3.2%</td>
<td>7.5%</td>
<td>13.5%</td>
<td>65.9%</td>
</tr>
</tbody>
</table>

Source: (CGWB, Various years; DES, MoA, 2016; CEA, Various Years)

It can be seen that the relationship between agricultural electricity consumption and the extraction of groundwater is not straightforward, as between 2004 and 2013, the groundwater draft for irrigation and the net area irrigated by groundwater have grown by 7.5% and 13.5% respectively, whereas the official electricity consumption has increased considerably (by 66%) for the same period. The divergence between the growth rates of electricity consumption and groundwater extraction can be attributed to several factors. The first is the overestimate in the electricity supplied to the agriculture sector, which we have noted in the earlier sections. The second reason could be underestimation of the groundwater draft (GSDA, 2014). The third reason could be the

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19. The total ‘agricultural consumption’ reported by the CEA is essentially the consumption of irrigation pump-sets (CEA, 2016).

20. Figures for the share of electricity in the total energy used to power irrigation pumps (diesel is the other major source) are not available in official statistics. Figures for the quantity of diesel used for irrigation pumping are also not directly available. We have estimated the diesel use in irrigation, and from this and the CEA figures for electricity used in agriculture, have estimated the shares of the two in pumping energy for the year 2009-10. As given in the main text, 85% of the pumping energy in the country is provided by electricity. However, in terms of the numbers of wells and tube-wells powered by various sources, electricity powers 70% of wells and tube-wells, whereas 26% are diesel powered wells and tube-wells. The remaining 4% depend on various sources like solar, wind, animal power and other sources. (MoWR, 2017).

21. For example, Maharashtra has almost 1.1% of electricity sales for the High Tension (HT) Agriculture category which is mainly used for surface lift schemes (MERC, 2016, pp. 405,452).
falling groundwater levels in several areas, which imply the need for more energy to pump up the same amount of water. The use of electricity for increased lifting from surface sources could also be a factor, through the extent of this type of usage is not very high. Lastly, there is evidence of effective replacement of diesel by electricity in powering pump-sets especially since the mid-2000s (Figure 4), which would also have led to a growth in electricity use but not in groundwater extraction.

Figure 4: Trend of Diesel and Electric Powered Groundwater Irrigation Schemes in India

![Figure 4: Trend of Diesel and Electric Powered Groundwater Irrigation Schemes in India](image)

Source: (MoWR, 2001; MoWR, 2014; MoWR, 2017)

5.1 Falling Groundwater Levels and Subsidies

A major critique of subsidised electricity to agriculture is that it leads to unregulated pumping of groundwater as the marginal cost of pumping is very less, or zero. This leads to over-extraction of groundwater and falling groundwater levels.

Most of the major states have either free or low-priced electricity supply to agriculture, resulting in significant quantities of subsidies (direct state subsidy and cross-subsidies). Total annual state government subsidy to the sector was around Rs. 50,000 Cr in 2013-14 for 10 major states in terms of electricity consumption by agriculture, which gives us an idea of the extent of the subsidies, with most of them availed for agriculture supply. The weighted average electricity tariff payable by farmers in 10 major states was only around Rs 0.5 per kWh whereas the Average Cost of Supply (ACoS) was more than Rs 6 per kWh for 2013-14.

Coming to the status of groundwater use, Figure 5 shows the groundwater status in the country in terms of overexploited (red coloured), critical (yellow) and semi-critical areas (blue). The white regions on the map indicate areas classified as safe, whereas green regions represent saline groundwater status. This categorisation is done as per criteria that combine the stage of groundwater development (gross draft as a percentage of net groundwater availability) as well as the long-term trend of decline in groundwater levels.

Source: Analysis by Prayas (Energy Group) from (RBI, 2016), CAG Reports on PSUs of various states, State Regulatory Orders and Petitions, and (PFC, 2016).
This map shows that the overexploited areas are predominantly in the north and north-west part of the country, and also in the south-central areas. To understand the possible role of electricity tariffs, we compared the actual electricity tariffs\(^\text{23}\) payable by farmers in some major groundwater using states where the share of critical and overexploited blocks is high (Haryana, Punjab, Rajasthan, Tamil Nadu and Karnataka) and relatively low (Andhra Pradesh and Gujarat). Table 4 shows the electricity tariffs payable by farmers in these states and the detailed status of groundwater blocks.

\(^{23}\) The electricity tariffs are as of 2013-14 or for the latest available year. Most of these states have been receiving almost free power for at least the last 10 years.

Source: [CGWB, 2017]
Table 4: Groundwater Situation in 2013 in Selected States

<table>
<thead>
<tr>
<th>State</th>
<th>Electricity Tariffs (Payable by Farmers) (Rs/kWh) in 2013-14</th>
<th>Proportion of Blocks under Groundwater Stress</th>
<th>Safe blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Overexploited</td>
<td>Critical</td>
</tr>
<tr>
<td>Haryana</td>
<td>0.30</td>
<td>54%</td>
<td>12%</td>
</tr>
<tr>
<td>Karnataka</td>
<td>0</td>
<td>24%</td>
<td>8%</td>
</tr>
<tr>
<td>Punjab</td>
<td>0</td>
<td>76%</td>
<td>3%</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>0.9</td>
<td>66%</td>
<td>4%</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>0</td>
<td>31%</td>
<td>9%</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>0</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>Gujarat</td>
<td>0.4</td>
<td>10%</td>
<td>3%</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>1.5</td>
<td>14%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Source: (CGWB, 2017), Various Tariff Orders by SERCs

It can be seen that a direct correlation between low electricity tariffs and over extraction of groundwater is not uniformly applicable across states. For example, states like Punjab and Haryana have low tariffs and a high percentage of overexploited units; Rajasthan has high tariffs and a high percentage of overexploited units, whereas Andhra Pradesh and Gujarat have low tariffs but have a much smaller percentage of overexploited units. In all these states, groundwater is a significant or dominant source of irrigation.

Thus, it is clear that while at the level of an individual farmer, low priced or free electricity offers an incentive for unchecked lifting of groundwater due to low or zero marginal cost, there are several factors other than the tariff that will influence whether groundwater is excessively drawn. These factors include the quality of power and hours of supply, the duration for which cheap or free power has been available, the hydrogeology of the region, groundwater conservation efforts, farmers’ awareness, irrigation intensity and cropping patterns.

We examine some of these factors in the following sections. It is important to note here that while low tariffs can encourage or enable unchecked exploitation of groundwater, they can, and have facilitated institutions like water markets which help increase equity in access to the benefits of electricity and irrigation. We deal with this in Section 5.6 of this paper.

5.2 Cropping Pattern

The cropping pattern adopted by farmers is a major determinant of irrigation requirements and hence water withdrawals. One of the important considerations in this regard is the cultivation of crops that are unsuitable to the agro-climatic and eco-climatic characteristics of a region or season. Such crops often require very high inputs of water over and above rainfall, which is supplied by canal waters or groundwater. Some examples of this phenomenon are sugarcane farming in water-stressed areas of Maharashtra, or rice farming in Punjab.

Normally the cropping pattern is determined by agro-climatic considerations. However, because irrigation often enables overcoming some of the climatic limitations, market conditions become the major drivers of the crop choice for farmers. For example, Ashok Gulati, agricultural economist and a former chairman of the Commission for Agricultural Costs and Prices (CACP), points out...
that Punjab was not geographically suitable for paddy cultivation, and such cultivation, made possible by the Minimum Support Price (MSP) and procurement support, has had an impact on the environment and has become detrimental to the sustainability of agriculture (Gulati, Roy, & Hussain, 2017, p. 29).

The crop price support to farmers mainly through the MSP mechanism, along with the market availability for selling the agricultural produce especially through government procurement, influences the farmer’s selection of crops and hence corresponding electricity consumption for irrigation.

Ideally, the MSP and procurement policies should be formulated such that they encourage agro-climatically suitable crops. This helps reduce the irrigation cost and the total cost of production through reduced use of inputs and more efficient use of inputs. At the same time, it assures better margins for farmers. For instance, arid and semi-arid regions should encourage crops which require less irrigation, which is however not the case.

For example, the National Institution for Transforming India (NITI) Aayog, in its recent report, notes:

“Minimum Support Prices (MSPs) have distorted cropping patterns due to their use in certain commodities in selected regions. There has been an excessive focus on the procurement of wheat, rice and sugarcane at the expense of other crops such as pulses, oilseed and coarse grains. These distortions have led to the depletion of water resources, soil degradation and deterioration in water quality in the north-west. At the same time, eastern states, where procurement at the MSP is minimal or non-existent, have suffered.” (NITI Aayog, 2017, p. 28)

Thus, market support in terms of MSP and procurement has emerged as one of the main drivers for the choice of cropping pattern, and in turn, the driver or determinant of groundwater extraction. In the case of Punjab, where a water-intensive cropping pattern prevails in spite of depleting groundwater levels, we see that around 19% of all wells and tube-wells are powered by diesel24 (MoAFW, 2015, p. 180). This is despite the significantly higher operating costs due to the cost of fuel. Further, 6% of electricity powered wells and tube-wells in Punjab and Haryana had both electricity and diesel pumps for pumped irrigation in 2013-14, even though owning/renting and running both pumps can be significantly costlier. This indicates that the cost of energy to drive groundwater pumping is a lesser influence on groundwater extraction as compared to the factors that are pushing the prevailing cropping pattern. This factor becomes important in assessing whether agricultural electricity tariff reform will also help control excess withdrawal of groundwater.

The use of MSP and procurement policies to encourage a specific cropping pattern could require the use of different MSPs for different regions. This can have its own set of issues like farmers from other areas bringing their produce to sell into regions with higher MSPs, but these could be addressed by some other measures (like procurement only against land deed or proof of address). Undoubtedly, the aim of aligning cropping patterns to agro-climatic zones will need a regional focus including regional MSP and procurement policies, and solutions will have to be found for the obstacles to such policies. The CACP has suggested such an approach several times. For example, in its "Report on Price Policy for Kharif Crops of 2004-2005", it says.25

24. Our estimates also indicate that for 2014-15, in energy terms, diesel in Punjab provided 18% of the pumping energy.
“...the central government, in consultation with state governments develop a strategic, albeit region specific plan for agricultural diversification along with appropriate technological, infrastructural and policy support. If necessary, a pilot scheme on agricultural diversification should be launched in selected districts ...”.

Considering the importance of this issue, we have also suggested a similar pilot project in our recommendations.

5.3 Cost of Irrigation in the Cost of Cultivation

Market conditions and farmers' margins are among the key determinants of the cropping pattern. Farmers' margins are influenced by their costs of cultivation. It is important to understand the extent to which the cost of irrigation contributes to the cost of cultivation, as increases in electricity tariffs for farmers will influence the cost of irrigation for farmers dependent on groundwater.

Unfortunately, several shortcomings in the publicly available DES/CACP data on the cost of cultivation make it difficult to estimate the cost of irrigation in the total cost of cultivation. In the aggregate data for crop-wise cost of cultivation, there is no distinction between costs for irrigated and rainfed cultivation of the crop. Further, there is no distinction between costs of cultivation of crops irrigated by groundwater and surface water. In the disaggregated, raw data, some of these details are available, but the irrigation costs given do not separate fuel and electricity charges from capital costs, maintenance costs, etc, which could have helped to understand the role of electricity and the corresponding subsidy in the cost of cultivation for farmers.

To get around this data limitation, and since our main interest is in the cost of electricity needed to power groundwater irrigation, we have used another approach to estimate how an increase in tariffs would impact the cost of cultivation and in turn farmers' margins. The CEA regularly reports state-wise figures on the number of pump-sets in the country as well as the electricity used in agriculture which is essentially the electricity used for pumped irrigation. Based on these and the figures for the area irrigated by groundwater from the agricultural census, we estimate the electricity needed to irrigate one unit (hectare) of crop. Table 5 gives the relevant figures and the estimates of electricity needed to irrigate a hectare of crop in selected states, and therefore, the increase in pumping energy costs for farmers with every rupee increase in electricity tariff. The table highlights that an increase in tariff of electricity would have a significant impact on farmers' cost of cultivation. Note that electricity tariff is only one part of what the farmer has to pay for groundwater irrigation. In addition, he or she would also have to bear the capital cost of installing the well/tube-well and the pump-set, and other costs like maintenance and repairs.

26. These figures should be taken as indicative as there are several factors that introduce estimation errors. One, groundwater irrigated area would also include diesel driven irrigation, but in the absence of figures on diesel-driven groundwater irrigated area, and electricity being the dominant irrigation source in most states, we have assumed the entire irrigated area to be irrigated by electricity. The very low electricity use per hectare of irrigated area in Uttar Pradesh is due to this factor. In Uttar Pradesh, according to the 5th MI Census, diesel driven pump-sets constituted 85% of the total pump-sets in 2013-14. Thus, if the true area irrigated by electricity is taken, the impact of the rise in tariff on farmers' costs would be higher per ha, especially in states where diesel forms a significant source of pumping energy. Second, the groundwater irrigated area in the table is the net irrigated area whereas for proper estimation, we need to use the gross area irrigated by groundwater. Again, the figures for gross area irrigated by groundwater are not available. Last, while we have allocated all electricity use as driving groundwater irrigation, some of the pumping energy is used for surface lifts and hence will not be contributing to the groundwater irrigated area.
Table 5: Estimation of Electricity Tariff Impact on Cost for Water Pumping for Selected States in 2011

<table>
<thead>
<tr>
<th>State</th>
<th>Number of Electric Pump-sets (lakh)</th>
<th>Electricity Consumption in Agriculture (MU)</th>
<th>Groundwater Irrigated Area (Net) (lakh ha)</th>
<th>Electricity Consumption per Net Groundwater Irrigated Area (kWh/ha)</th>
<th>Increase in per Hectare Pumping Energy Cost for Farmer pa, for Every 0.5 Rs/kWh Increase in Electricity Tariff (Rs/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madhya Pradesh</td>
<td>13.7</td>
<td>6,962</td>
<td>47.9</td>
<td>1,455</td>
<td>728</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>34.9</td>
<td>15,765</td>
<td>16.7</td>
<td>9,450</td>
<td>4,725</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>29.1</td>
<td>17,319</td>
<td>25.3</td>
<td>6,854</td>
<td>3,427</td>
</tr>
<tr>
<td>Karnataka</td>
<td>18.2</td>
<td>12,659</td>
<td>19.0</td>
<td>6,678</td>
<td>3,340</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>21.0</td>
<td>9,410</td>
<td>20.3</td>
<td>4,642</td>
<td>2,321</td>
</tr>
<tr>
<td>Punjab</td>
<td>11.4</td>
<td>9,656</td>
<td>31.3</td>
<td>3,090</td>
<td>1,545</td>
</tr>
<tr>
<td>Haryana</td>
<td>5.6</td>
<td>6,490</td>
<td>16.1</td>
<td>4,024</td>
<td>2,012</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>9.0</td>
<td>7,690</td>
<td>106.7</td>
<td>721</td>
<td>361</td>
</tr>
</tbody>
</table>


We also try to estimate the impact with respect to the farmers’ incomes and/or margins by estimating the average net income of farmers (income from a crop after deducting the cost of cultivating it) for the dominant irrigated crops (mostly paddy and wheat) in a state. Table 6 shows that the impact of increase in tariffs is significant even when only paid out costs (A2) are considered, except in Haryana and in the case of wheat in Punjab, as paddy and wheat in these two states have substantially higher productivities. In Tamil Nadu, farmer income from paddy is not enough to cover the paid out cost for cultivation. When imputed costs are also taken into consideration, farmer income does not cover the cost of cultivation in all states in Table 6 (except in the case of Haryana and wheat in Punjab). Thus, an increase in tariff incurs a greater loss for farmers than before.

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27. Actual net incomes/margins might be even lower as many farmers do not sell everything they produce.

28. The crop for which the irrigated area is greater than 50% of the total irrigated area is chosen as the dominant irrigated crop. If no single crop has more than 50% of the total irrigated area, then multiple crops with large shares in irrigated area and whose total share is greater than 50% are chosen. Crop-wise irrigated area figures are from (MoAFW, 2015).

29. Transportation and insurance costs are not considered here.

30. A hectare of land may be cultivated multiple times in a year. To compare the electricity costs for a hectare of land, which are annual costs, to the cost of cultivation of and income from crops, which are seasonal values, we adjust the electricity costs downwards by a factor. This factor is the cropping intensity (ratio of gross cropped area to net sown area), which is a measure for the number of times a hectare of land is cultivated in a year.

31. Imputed costs include imputed costs of family labour, rent for own land, and interest on own capital. The sum of these imputed costs and the paid out costs is the C2 cost, which has been used by us when considering imputed costs.
Table 6: Impact of Rise in Electricity Tariff on Farmer Incomes (All Figures in Rs/ha) in 2010-11

<table>
<thead>
<tr>
<th>State</th>
<th>Crop</th>
<th>Farmer Gross Income from Crop</th>
<th>Cost of Cultivation (A2) of Crop</th>
<th>Farmer Net Income</th>
<th>Increase in Pumping Electricity Cost per Crop with every 1 Rs/KWh Increase in Tariff (Derived from Table 4)</th>
<th>Increase in Electricity Cost as a % of Farmer Net Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madhya Pradesh</td>
<td>Wheat</td>
<td>20,487</td>
<td>12,589</td>
<td>7,898</td>
<td>1,009</td>
<td>13%</td>
</tr>
<tr>
<td>AP</td>
<td>Paddy</td>
<td>36,033</td>
<td>29,583</td>
<td>6,450</td>
<td>5,743</td>
<td>89%</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>Paddy</td>
<td>29,383</td>
<td>31,775</td>
<td>-2,392</td>
<td>4,175</td>
<td>-175%</td>
</tr>
<tr>
<td>Punjab</td>
<td>Wheat</td>
<td>51,764</td>
<td>21,369</td>
<td>30,395</td>
<td>1,572</td>
<td>5%</td>
</tr>
<tr>
<td>Paddy</td>
<td>41,802</td>
<td>27,518</td>
<td>14,284</td>
<td>1,572</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Haryana</td>
<td>Wheat</td>
<td>54,663</td>
<td>18,071</td>
<td>36,493</td>
<td>2,130</td>
<td>6%</td>
</tr>
<tr>
<td>Paddy</td>
<td>57,900</td>
<td>22,884</td>
<td>35,015</td>
<td>2,130</td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

Source: PEG Analysis from MoAFW data. Farmer Income from a crop is estimated using crop-wise farm harvest prices (DES, MoAFW, 2013) and yields (DES, MoAFW, 2012a). Cost of cultivation is from (DES, MoAFW, 2012b).

5.4 Tariff Increase and Improvement in Quality of Service

While increase in power tariff for agriculture can have adverse impacts on the economics of the farmers, it is also argued that it can lead to improvement in the quality of power and service delivered to farmers (AF-Mercados, 2014, p. 17). It is said that the DISCOM will be motivated to provide better supply to farmers due to better revenue realisations, and also would have more resources for this purpose (World Bank, 2001). At the same time, it is argued that since farmers would be paying higher rates for electricity, they would demand better quality of supply, and this pressure from below would also lead to better quality of supply. Better quality of supply would also lead to lesser maintenance costs for transformers and motors and therefore lesser costs of irrigation.

However, given the trust deficit amongst farmers with regard to DISCOMs, and the fact that increasing tariffs would have significant impact on the farmers' economics, there is bound to be strong resistance to any such move. Hence, it is important to demonstrate improvement in quality first, before raising tariffs. Not only will this help build trust, but if improvements in the quality of power supply help farmers cut down motor maintenance and other costs, it would create more acceptability for raising tariffs. It is also important to make a commitment at the highest level on the trajectory of tariff increase, and also assure farmers that this trajectory would be linked to the quality of supply. Such a demonstrative effect can go a long way in gaining acceptance of farmers for any increase in tariffs.

For this purpose, measures to improve quality of supply should be put in place independent of tariff reforms, and indeed must precede them. This is particular so because an increase in tariff will not automatically lead to an increase in DISCOM revenue, especially if the quality of supply and service is not improved, and if such improvement is not demonstrated for some time, as people may not pay or will default.

5.5 Equity Issues

Since electricity supply to agriculture is subsidised with a contribution from public resources, questions about which crops and farmers benefit from the subsidy are crucial.
Let us first look at what crops are supported by the electricity subsidy. There is no official data to identify the crops which are dependent on groundwater and hence on power subsidies. For example, the Agriculture Census reports the net irrigated area under different irrigation sources (including groundwater). It also reports total cultivated and irrigated area under different crops. But there is no reporting of crop-wise, irrigation source-wise irrigated areas. Other data sources like Land Use Statistics and district statistics report the data in a similar manner (DES, MoA, 2016; GoM, Various years).

However to get a broad idea, consider the fact that almost two-thirds of the net irrigated area is irrigated from groundwater and almost four-fifths of India’s gross irrigated area is under five crops, namely paddy, wheat, sugar crops32, fibres (mainly cotton) and oilseeds (Figure 6). Therefore we can safely conclude that most of the groundwater and hence electricity subsidy caters to these crops.

Figure 6: Share of Crops in Gross Irrigated Area in 2010-11

![Graph showing the share of crops in gross irrigated area in 2010-11.](image)

Source: (MoAFW, 2015, p. 67).

Let us also look at how the subsidy is being distributed among various sections of farmers in terms of landholding size.

Capital intensiveness of modern tube-well technology can favour large farmers disproportionately, who can afford the higher capital costs for irrigation equipment to extract groundwater from greater depths (Gandhi & Namboodiri, 2009, p. 18).

The Agricultural Census 2010-11 of the Government of India provides information about land held, irrigated, source-wise irrigation, wells and tube-wells held by farmers, etc. for various land-holding size categories. This allows us to draw information about the distribution of groundwater use, and hence electricity subsidy amongst various holding size groups.

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32. The most widely prevalent sugar crop is sugarcane. Though area under sugarcane is small, considering its annual/1.5 year growth cycle and its need for frequent irrigation especially during no-rainfall period, its total water requirement is significantly higher especially in tropical belts (170–250 cm) and in Maharashtra (350 cm) (Kisan Suvidha). Similarly for cotton (8 months growth cycle), total water requirement is higher at around 80–90 cm than other crops (IIT Kanpur).
According to the Agricultural Census data, for the years 2010-11, there were almost 13.8 Cr total operational landholdings in India with around 15.96 Cr hectares of land. Out of these, around 42% of the total number of holdings did not receive any kind of irrigation. The proportion of area not receiving any irrigation is slightly higher at 48%. This essentially means that 42% of all landholders in the country are out of the ambit of any irrigation subsidy or support—surface or groundwater (though they may be benefitting from other water related programmes like watershed management programmes.)

The Agricultural Census divides farmers into five groups based on the land-holding size. The groups are: marginal (less than 1 ha), small (1-2 ha), semi-medium (2-4 ha), medium (4-10 ha) and large (more than 10 ha). Table 7 gives the number of holdings in each class and the land area operated by each class.

Table 7: Number of Holdings and Area Operated for Various Size Classes

<table>
<thead>
<tr>
<th>Size Class</th>
<th>Total Holdings (Number in lakh)</th>
<th>Total Area Held by the Size Class (lakh ha)</th>
<th>Holdings in the Class as % of Total Holdings</th>
<th>Area of the Class as a % of Total Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal</td>
<td>928</td>
<td>359</td>
<td>67.1%</td>
<td>22%</td>
</tr>
<tr>
<td>Small</td>
<td>248</td>
<td>352</td>
<td>17.9%</td>
<td>22%</td>
</tr>
<tr>
<td>Semi-medium</td>
<td>139</td>
<td>377</td>
<td>10.1%</td>
<td>24%</td>
</tr>
<tr>
<td>Medium</td>
<td>59</td>
<td>338</td>
<td>4.3%</td>
<td>21%</td>
</tr>
<tr>
<td>Large</td>
<td>10</td>
<td>169</td>
<td>0.7%</td>
<td>11%</td>
</tr>
<tr>
<td>All (Total)</td>
<td>1383</td>
<td>1596</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: (MoAFW, 2015).

Table 8 shows the distribution of wholly unirrigated holdings across land-holding classes, as well as the percentage of land-holding area of each class that is unirrigated.

Table 8: Countrywide Distribution of Land Holdings across Size Groups without Irrigation in Terms of Number and Area

<table>
<thead>
<tr>
<th>Size class</th>
<th>Number of Wholly Unirrigated Holdings as a Percentage of Total Number of Holdings of that Class</th>
<th>Unirrigated Area as a Percentage of Total Holdings Area of that Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal</td>
<td>40%</td>
<td>43%</td>
</tr>
<tr>
<td>Small</td>
<td>47%</td>
<td>50%</td>
</tr>
<tr>
<td>Semi-medium</td>
<td>46%</td>
<td>50%</td>
</tr>
<tr>
<td>Medium</td>
<td>43%</td>
<td>48%</td>
</tr>
<tr>
<td>Large</td>
<td>50%</td>
<td>51%</td>
</tr>
<tr>
<td>All (Total)</td>
<td>42%</td>
<td>48%</td>
</tr>
</tbody>
</table>

Source: (MoAFW, 2015)

33. 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.

34. Note that each class will have some landholdings as wholly unirrigated, and some as partly irrigated. The unirrigated area is the sum of the areas of wholly unirrigated holdings, plus the unirrigated area of partially irrigated holdings.
The distribution of land is highly skewed across the holding categories. This means that any benefit that is distributed according to land size will reflect this inequity. Farmers in the Large landholding category have just 0.7% of the total number of landholdings, but they operate 10.59% of the total area. Similar, the Medium category has 4.25% of the total number of landholdings, but operates 21.2% of the total area of land. Given this, it is not surprising that together, the two categories constitute 4.95% of total number of landholders, but have 28.1% of the total groundwater irrigated area. If we take groundwater irrigated area as a proxy for the electricity subsidy\(^35\), then these two categories of farmers take 28.1% of the total subsidy. Thus at one level, the distribution of electricity subsidy is skewed towards the large landholders, corelating with the inequity in land distribution.

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 (dug wells or tube-wells) for every 100 large landholders, the same 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 landholders' land is irrigated by tube-wells or wells.\(^36\) Last but not the least, 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.

These various measures of inequity offer insights into how to structure agricultural electricity programmes including various subsidies so that the benefits reach the deserving in a more effective manner. For example, a capital subsidy to install wells/tube-wells for smaller farmers, who do not have access to any kind of irrigation, could help more of them get access to groundwater, and preferential electrification of pump-sets of this category of farmers would help them convert from diesel to electricity with less costly and more efficient pumping. Such an approach would need to be designed differently for each state or regions within states to reflect the region-wise differences. For example, states like Bihar, West Bengal and Uttar Pradesh, which have a higher number of marginal and small farmers who use diesel, could benefit from a preferential electrification programme. Incentivising solar pumps could also be an option for areas with large diesel use, and where groundwater is available at lower depths. Such an approach would need to also consider the groundwater status and stress in the area, and would be particularly useful in areas where groundwater is not stressed, or in areas with very little groundwater use, and in

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\(^35\) This may not always be true as some DISCOMs have a tariff structure which differentiates tariffs for agricultural consumers based on certain criteria, which can differ from DISCOM to DISCOM. Some DISCOMs charge higher tariffs for agricultural consumers with higher pump capacities, while the DISCOMs in Andhra Pradesh do this for multiple connections per consumer or a larger size of landholding. This would result in larger farmers receiving less subsidy and vice-versa. However, in most states, 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.

\(^36\) 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).
areas of high diesel use where such a scheme could be used to replace diesel pumps with electric pumps.\textsuperscript{37}

5.6 Water Markets

Informal water markets, run at the level of individual farmers, are fairly common in various parts of the country. In such markets, typically, small farmers who do not have any irrigation facilities purchase water from nearby farmers who have groundwater extraction facilities, or Water Extraction Mechanisms (WEM), as they are often referred to. The payments can be monetary, or non-monetary, like a share in the crop produced.

Such water markets help to provide irrigation to resource-poor farmers who do not have access to irrigation, and thus are an important means to advance equity. Not only that, but such water markets can provide a better, more equitable distribution of subsidies that go towards groundwater extraction like electricity and diesel subsidies. Before proceeding with this line of argument, we would like to add some qualifiers here.

The term 'water markets' encompasses many different types of arrangements, with large variations in their nature, scope and extent. In the context of groundwater pumping and agricultural electricity supply, two types of water markets are important. One is a market where groundwater is pumped up in peri-urban areas and supplied through tankers to urban areas mainly for domestic use, but also for commercial use. A significant extent of such pumping could happen on agricultural land, using agricultural power supply. Our study does not cover this type of water market, and our remarks regarding the potential of water markets in advancing equity do not pertain to such markets.

The second type of water market is the one we have described at the beginning of this section, where a farmer with an agricultural electricity connection and a WEM supplies water to other farmers. Such markets can vary in their scale and the kind of arrangement for payment in cash or kind. Such markets that are run on a small scale can help better use of capital investment like pumps and motors, and help those without access to WEMs also get water, and thus further equity. However, we recognise that some of these arrangements can also be exploitative (for example, a large section of the produce as a payment for water) or can also lead to reverse land-leasing.

Recent estimates of the extent of the water markets in India are not easily available, but earlier estimates indicate that the practice is widespread (Saleth, 1998). One indication of the extent can be the number of landholdings receiving groundwater-based irrigation per an operating well or tube-well. Data from the Agricultural Census for year 2010-11 shows that one operating well/tube-well irrigates the land of 2.3 landholders who are using groundwater irrigation, though it varies widely from state to state. In other words, it can be said that only 45% of the ground-water irrigated landholders own an operating well or tube-well. The remaining 55% landholders must receive it from a government or private community lift scheme or from one of the holders who own such a water extraction mechanism, the latter arrangement in effect being a water trade or water market.

\textsuperscript{37} There are some important issues of debate here, which have implications for the electricity supply to agriculture, but which are beyond the scope of this paper. We have outlined them in the Additional Note.
Electricity reforms especially those dealing with tariffs, supply rationing, connection policies, etc can have significant impacts on water markets.

For example, the feeder separation programme in Gujarat implemented from 2006 that led to effective rationing of the hours of power supply is reported to have had a considerable adverse impact on water markets in Gujarat. Small farmers in Gujarat, who were mainly water buyers in the market, were found to be adversely affected due to the limiting of hours of supply of electricity to agriculture. The prices of water through water markets were increased by around 30-50% even though electricity tariffs did not increase to that extent. This could be due to apprehensions of the water sellers due to limited and metered electricity supply (Shah, Bhatt, Shah, & Talati, 2008). The details of feeder separation and its impacts are discussed in detail in Section 5.7 of this paper.

On the other hand, in West Bengal, in 2010-11, the tube-well permit system was abolished, the electricity connection process was simplified and its costs reduced, and the electricity tariff structure was modified from unmetered to metered, and from flat rate tariff to time-of-day (TOD). The change resulted in some improvement in the access to small farmers who were earlier not able to afford the connection or could not get it due to the licensing system for connections. However, at the same time, due to the change from flat to metered tariffs, water rates went up, and many water sellers preferred to lease in the lands from water buyers' lands rather than sell water (Shah & Das Chowdhury, 2017). In effect, it appears that the reforms made it easier for more farmers to get connections, but the change in tariff regime has adversely impacted water buyers. The details of the impact are discussed in detail in Section 5.8.

These examples indicate that electricity sector reforms, particularly those dealing with tariffs, connections or distribution, can have significant impacts on small and resource-poor farmers, and these impacts needs to be assessed before designing such reforms.

To be able to use water markets to address the challenge of inequity, some measures like increased hours of electricity supply (over the current 8 hours or less than that in many states) especially during peak irrigation demand periods, supply in two or more spells in a day especially in hard rock areas, common flat rate tariff for all consumers irrespective of the metering, etc have been suggested.

With this understanding of the complexities of the linkages between electricity, agriculture and water, let us look at some of the measures implemented to address the issues related to agricultural electricity supply.

5.7 Agriculture Feeder Separation, Hours of Supply and Agricultural Consumption

A way to control the subsidy to agriculture consumers is to control the electricity consumption in agriculture. This can be done by curtailing or rationing the hours of electricity supply to agriculture. But rationing power to agriculture also means rationing power to other rural consumers because the rural power lines—or feeders, as they are called—on which pump-sets and agricultural consumers are located are the same. A way around this would be to physically separate rural power lines into two, one supplying to agricultural connections and the other supplying to the rest of the consumers in the village. This is called physical feeder separation. Another way would be to provide three-phase power for a limited number of hours, during which
agricultural pump-sets can run, and single-phase power for the rest of the day. This curtails
the hours for which pump-sets will operate, as irrigation pump-sets require three-phase power
supply, whereas most rural consumers can do with single-phase supply. This is called virtual feeder
separation. Although 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, it effectively also controls the hours of supply to agriculture.
Moreover, it 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.
(For more, please see Volume 2 of this paper.)

While virtual separation was implemented to some extent in Rajasthan and erstwhile undivided
Andhra Pradesh, Gujarat was the first state to complete physical feeder segregation of rural
feeders in 2006 under the Jyotigram Yojana, followed by Haryana around 2010, and Punjab around
2013. Feeders are undergoing physical separation in many other states (World Bank, 2013; Forum
of Regulators, 2014; MoP, 2017).38

DISCOMs have been rationing power to agriculture, sometimes by curtailing all rural power
supply or through either modes of feeder separation, and there has been a gradual reduction
in the hours of supply over time. In many states, agriculture now does not receive supply for
more than 10 hours a day, as for example, in Andhra Pradesh, Gujarat and Karnataka (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). This can be seen in Figure 7, which shows the daily hours of supply to
agriculture as an average of 2005-2010 and 2011-2017 in various states.39 For Uttar Pradesh, the
daily hours of supply shown are an average of those from 2011 to 2015 instead of 2011 to 2017.
The hours of supply in Uttar Pradesh declined between 2005-10 and 2011-2015 before increasing
again from 2016 onwards.

Figure 7: Three-Phase Average Daily Hours of Supply to Agriculture

![Figure 7: Three-Phase Average Daily Hours of Supply to Agriculture](image)

Source: (CEA, Various Years).

38. In Andhra Pradesh, Telangana, Haryana, Punjab, Karnataka, Maharashtra, Madhya Pradesh and Rajasthan.
39. CEA reports average hours of supply per day for every month. We have taken the average of these over the entire
time period.
Except Haryana and MP, all states have seen a decline in their hours of supply to agriculture. MP has been seeing a substantial growth in agricultural production driven by groundwater irrigation for the last few years, and the hours of supply seem to reflect this. These are the hours of supply as reported by the CEA, which reports the figures as submitted to it by the state governments and the DISCOMs.

The daily hours of supply to agriculture in Maharashtra declined from 14 hours to 10 hours in 2012 after the feeder separation scheme was implemented. It was decided that power supply would alternate between day time and night time. Electricity would be supplied for 10 hours at night and 8 hours during the day in rotation (MSEDCL, 2013).

In Haryana, the daily hours of supply to agriculture 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 connected load of irrigation pump-sets, that is the sum of all pump capacities, and average pump-set size grew faster after feeder separation. Between 2005-06 and 2008-09, load grew by an average rate of 7% pa (supply hours also grew from 7 to 14), while between 2010-11 and 2013-14 it grew by 25% pa. Similarly, average pump-set size increased by 4% pa before and 8% pa after feeder separation (CEA, Various Years). Although growth in connected load and average pump-sizes can also be a response to the declining groundwater levels, it is possible that reduced hours of supply led to farmers digging multiple wells and tube-wells and installing pumps of higher capacities.40

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 after the Jyotigram Yojana. (Shah, Bhatt, Shah, & Talati, 2008). In other states however, it is difficult to determine the change in the hours of supply to agriculture due to physical feeder separation based on available government data, as it is likely that power to agriculture was already being rationed. In Punjab, there is no prominent change in the hours of supply to agriculture. It was being supplied power for less than 9 hours before and after physical separation, indicating that agricultural supply was already limited in Punjab.

Some reports indicate that in Gujarat and Rajasthan, farmers faced lesser power interruptions and voltage fluctuations after feeder separation (World Bank, 2013). However at the same time, the feeder separation was also accompanied by a shrinkage of once thriving informal water markets in Gujarat. The power quality for farmers improved after the Jyotigram Yojana, thus benefitting pump-owners. But landless share croppers and water buyers, who are often poor marginal farmers, were pushed out of groundwater irrigation because of power rationing, reducing water availability in the water markets, and rising water prices (Shah & Das Chowdhury, 2017).

Similarly, no direct conclusions can be drawn regarding the impact of feeder separation on groundwater extraction, as there are several factors that affect groundwater use and withdrawal. However, there are some observations to be made regarding fall in hours of supply, growth in agricultural electricity consumption, connected load, pump size and groundwater withdrawal. Table 9 provides some important parameters related to electricity used in agriculture and groundwater for the states of Maharashtra, Rajasthan, Punjab and Uttar Pradesh for 2003-04 and

40. The growth in electricity consumption cannot be compared before and after separation as it was restated in 2010-11, due to a change in the estimation of electricity consumption in agriculture.
2012-13. These states have seen a fall in their hours of supply to agriculture between 2003-04 and 2012-13.41

Table 9 Electricity and Groundwater Related Parameters for Selected States

<table>
<thead>
<tr>
<th>State</th>
<th>Year for Data</th>
<th>Number of Pumpsets (lakhs)</th>
<th>Connect- ed Load (MW)</th>
<th>Consumption (MU)</th>
<th>Average Pumpset Size (kW)</th>
<th>Annual Ground Water Availability (BCM)</th>
<th>Draft for Irrigation (BCM)</th>
<th>Groundwater Development (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maharashtra</td>
<td>2003-04</td>
<td>25</td>
<td>7,187</td>
<td>10,572</td>
<td>2.9</td>
<td>31.2</td>
<td>14.24</td>
<td>48%</td>
</tr>
<tr>
<td></td>
<td>2012-13</td>
<td>39</td>
<td>14,518</td>
<td>20,069</td>
<td>3.7</td>
<td>31.5</td>
<td>15.93</td>
<td>54%</td>
</tr>
<tr>
<td>Increase over period (%)</td>
<td>56%</td>
<td>102%</td>
<td>90%</td>
<td>28%</td>
<td>1%</td>
<td>12%</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Rajasthan</td>
<td>2003-04</td>
<td>7</td>
<td>2,631</td>
<td>4,274</td>
<td>3.8</td>
<td>10.38</td>
<td>11.6</td>
<td>125%</td>
</tr>
<tr>
<td></td>
<td>2012-13</td>
<td>11</td>
<td>9,091</td>
<td>18,325</td>
<td>8.1</td>
<td>11.26</td>
<td>13.79</td>
<td>140%</td>
</tr>
<tr>
<td>Increase over period (%)</td>
<td>57%</td>
<td>246%</td>
<td>329%</td>
<td>113%</td>
<td>8%</td>
<td>19%</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>Punjab</td>
<td>2003-04</td>
<td>9</td>
<td>3,482</td>
<td>5,745</td>
<td>4.1</td>
<td>21.5</td>
<td>30.34</td>
<td>145%</td>
</tr>
<tr>
<td></td>
<td>2012-13</td>
<td>12</td>
<td>8,116</td>
<td>9,886</td>
<td>6.9</td>
<td>23.4</td>
<td>34.05</td>
<td>149%</td>
</tr>
<tr>
<td>Increase over period (%)</td>
<td>33%</td>
<td>133%</td>
<td>72%</td>
<td>68%</td>
<td>9%</td>
<td>12%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>UP</td>
<td>2003-04</td>
<td>8</td>
<td>3,581</td>
<td>4,952</td>
<td>4.3</td>
<td>70.18</td>
<td>45.36</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>2012-13</td>
<td>10</td>
<td>9,656</td>
<td>9,215</td>
<td>9.7</td>
<td>71.58</td>
<td>48.35</td>
<td>74%</td>
</tr>
<tr>
<td>Increase over period (%)</td>
<td>25%</td>
<td>170%</td>
<td>86%</td>
<td>126%</td>
<td>2%</td>
<td>7%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Karnataka</td>
<td>2003-04</td>
<td>14</td>
<td>5546</td>
<td>8992</td>
<td>3.9</td>
<td>15.3</td>
<td>9.75</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>2012-13</td>
<td>19</td>
<td>15413</td>
<td>16803</td>
<td>8.2</td>
<td>14.83</td>
<td>8.76</td>
<td>66%</td>
</tr>
<tr>
<td>Increase over period (%)</td>
<td>36%</td>
<td>178%</td>
<td>87%</td>
<td>110%</td>
<td>-3%</td>
<td>-10%</td>
<td>-6%</td>
<td></td>
</tr>
<tr>
<td>TN</td>
<td>2003-04</td>
<td>18</td>
<td>6666</td>
<td>9582</td>
<td>3.7</td>
<td>20.76</td>
<td>16.77</td>
<td>85%</td>
</tr>
<tr>
<td></td>
<td>2012-13</td>
<td>21</td>
<td>8282</td>
<td>10206</td>
<td>3.9</td>
<td>18.59</td>
<td>12.98</td>
<td>77%</td>
</tr>
<tr>
<td>Increase over period (%)</td>
<td>17%</td>
<td>24%</td>
<td>7%</td>
<td>5%</td>
<td>-10%</td>
<td>-23%</td>
<td>-9%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Electricity related data from the CEA except consumption figures which are from state regulatory data wherever available. Groundwater related data from the CGWB.

41. Some of these states were facing power shortages during the latter part of these seven years, with power availability picking up after 2012-13. Thus it is possible that the overall hours of supply were lower, and not just to agriculture. However, the fact remains that on an average the hours of supply to agriculture are lower than the last decade even after improved power availability. Thus, this can be attributed to rationing.
In all these states except Tamil Nadu, it can be seen that despite reduction in the hours of supply, connected load and electricity consumption have grown substantially. One likely reason for the increase in pump-set size is the declining groundwater levels. The other very likely reason is that farmers seem to have compensated for the reduction in the supply hours by increasing their pump-set size. Overestimation of electricity consumption could also be a factor in the increase in the reported figures of agricultural consumption.

In comparison, increases in groundwater extraction have been modest. There could be several reasons for this mismatch apart from a fall in groundwater tables and overestimation of electricity consumption. As described before in Section 2.3, one possibility is that some of the pumping (and hence part of the increase in electricity consumption) was used to pump from surface water sources. Another reason could be that diesel-based pumping was replaced by electricity-based pumping as indicated by the 5th MI census. Clearly this would imply an increase in electricity consumption without a rise in groundwater extraction. Underestimation of groundwater extraction could also be a contributing factor.

But all in all, this means that it is very likely that power rationing alone cannot curtail electricity consumption to the extent that electricity subsidy is significantly brought down. Farmers find a way around the lower duration of power supply. This is because farmers greatly need pumped irrigation. Hence 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.

5.8 Metering and Groundwater Permit Liberalisation in West Bengal

Unlike other states where electricity consumption in agriculture is significant, West Bengal successfully moved from a flat tariff regime to a use-based tariff by installing meters on all its electric irrigation pump-sets. This was possible because the number of electric pumps is much lower than other states and electricity-based pumping is still catching on in West Bengal. Further, farmers are charged a high metered tariff depending on when the electricity is used during the day (time-of-day tariffs). The tariff ranges from 2 to 4 Rs/kWh during off peak hours, and is as high as 7.5 Rs/kWh during peak hours. (WBERC, 2016). This tariff is significantly higher than the tariffs in other states, most of which are below 1 Rs/kWh. Therefore, this is seen as an important tariff reform.

In 2011, West Bengal's Water Resources Investigation and Development Department abolished the permit system which required tube-well owners to obtain groundwater permits. The permits were necessary for getting an electricity connection. At the same time, the DISCOM West Bengal State Electricity Distribution Company Limited (WBSEDL) also streamlined the process of getting an electricity connection, made it more transparent and reduced its cost from Rs 21,00042 to Rs 8,100. This liberalisation of permits and electricity connections has facilitated the growth of tube-wells with electric pumps. However, the shift from flat to metered tariffs has affected water buyers adversely. Not only have the water prices increased by 30–50%, metering has also reduced the bargaining power of water buyers who have to lease their land to pump-owners at paltry rentals in exchange of irrigation water (Mukherji, A et al, 2009; Shah & Das Chowdhury, 2017).

42. In addition, significant “unofficial” payments are reported.
6. Need for a Different Approach

From the above discussions, it is clear that the picture of a DISCOM ailing financially due to below-cost supply to agriculture, with a large burden on the state and other consumers which can be addressed by metering all agricultural connections and increasing tariffs close to cost of supply levels, is a linear picture that does not capture the complexities of the situation or the interlinkages between the electricity, agriculture and water sectors. It is a picture that does not take into consideration the other aspect of the subsidy, that is, the role played by this electricity in agricultural growth, food security, livelihood support, and employment generation. It is a picture that ignores that DISCOM’s themselves have often shown reluctance to fully meter the agricultural supply. It is a picture that disregards the likely impacts of tariff hikes on farmers. It does not take cognisance of the fact that the increase in tariffs does not automatically lead to better quality of service for farmers or even higher revenue and a reduction in electricity subsidy. In sum, it is a problematic formulation because it assumes that electricity supply to agriculture is primarily a power sector or a DISCOM level issue, whereas the reality is that it is an issue that has linkages with several other sectors, and needs to be seen from a larger social perspective.

Given this, we need a different approach to address this issue. First of all, agricultural supply, tariff revision and subsidies should not be seen only from the electricity/DISCOM standpoint. These aspects of agricultural electricity supply need to be seen from a lager social perspective, which takes into consideration the needs and situation of farmers. Further, it needs to bring in an understanding of the agriculture as well as water sectors.

Second, important initiatives in the water and agriculture sectors should be undertaken that would have a direct bearing on the use of groundwater and the electricity needed for this purpose. One such initiative that would be imperative to address the problems is to undertake large-scale, decentralised rainwater harvesting, soil and water conservation work. Such a programme can help raise the groundwater level and save pumping energy.43 With regard to agriculture, aligning cropping patterns to the eco-climatic characteristics of the area, using organics fertilisers, etc would be important initiatives. Given the focus of this paper on the electricity aspect of this issue, we will not go into details of these water and agricultural programmes, but instead, explore the initiatives with regard to the power sector.

An important starting point would be to work out the subsidy needed for electricity supply to agriculture based on a desired agricultural development plan. Such an estimation of subsidies should be carried out by the state government at the state or sub-state level. Such an estimation process should encompass the following key elements.

- All the important stakeholders such as representatives from ministries/departments of power, water resources and irrigation, agriculture, groundwater, DISCOMs, consumer and farmer representatives should be actively involved in the process of subsidy estimation.

43. At the same time, such programs resulting in increased groundwater storage can also lead to an increase in the number of wells and pumps, as there can be a race to tap the increased availability of groundwater. This can raise demand for electricity. Such programmes therefore need to be accompanied by an appropriate groundwater regulatory regime, like community wells (Ralegaon Siddhi) or no tube-wells for water intensive crops (Hivre Bazaar).
• The process should be carried out with a larger social perspective to improve the effectiveness and equity of the subsidy, keeping in mind the situation of different regions and different farmer size classes. Issues like the impact of the subsidy burden on state finances and DISCOMs should be considered, along with the impact of subsidy on ensuring food security, livelihood security, employment, agricultural growth, and sustainable use of groundwater.

• Since one of the central considerations, one which influences how much water and electricity is used, is the cropping pattern, such agricultural plans must propose cropping patterns aligned to the agro-climatic characteristics of each region, including surface and groundwater resources. The actualisation of a shift towards such cropping patterns can be achieved through a mix of measures including market and procurement support, value addition avenues, restructuring of the irrigation system, etc. For example, Ashok Gulati and his co-authors recommend that in Punjab "the government should facilitate diversification away from rice towards maize and horticulture by creating ... value chain development" (Gulati, Roy, & Hussain, 2017, p. 34).

Such an exercise may lead to different plans for different regions of the state. The Tariff Policy, notified by the Ministry of Power on 28th January 2016, in some ways anticipates such regional differentiation. It recommends that in fixing agricultural tariffs, the need to use groundwater sustainably should be kept in mind, and that different levels of tariffs and subsidies could be set for different parts of a state depending on the state of groundwater table to prevent excessive depletion of groundwater. It also suggests higher subsidy for poorer farmers of regions where adverse groundwater conditions require higher quantity of electricity for irrigation. (MoP, 2016, p. section 8.3(3)).

Such a planning process can help work out the optimal groundwater needs for irrigation and hence the optimal and most efficient levels of subsidies for electricity. Apart from helping optimise subsidies, such planning will also put the justification of subsidies on a more rational and stronger footing, leading to greater acceptability.
7. The Way Forward

To be able to adopt such an approach, it would be necessary to also address some of the gaps in the current knowledge and understanding of the agriculture-electricity-water linkage. It would also be of utmost importance to have accurate and more reliable data. Further, it would be advisable to try out some of the measures that can address these issues at a smaller scale before extending them at the state or regional level. Thus, the way forward should include

1. Additional research and studies
2. Efforts to improve data availability and quality
3. High level efforts to break the vicious cycle
4. Pilot scale projects to test and demonstrate solutions

7.1 Additional Research and Studies

Some of the areas which require more studies and development of a better understanding include

- How the use of water and electricity is influenced by different kinds of electricity tariffs—flat, metered, unmetered, free, etc.
- Which crops are being grown on pumped water, driven by electricity.
- Testing of pump-set efficiencies under field conditions. The electric pump-set's pumping efficiency / performance varies greatly depending on the field situation. Better estimates of efficiencies under field conditions will also aid verification of officially reported electricity consumption based on the groundwater usage and depths.
- The economics of farmers for different crops and different landholding classes.
- The impacts of tariff changes on farmers' economies.
- Distribution of electricity subsidy among farmers for a better understanding of who benefits from the electricity subsidy.
- Water markets, and whether and how these help benefits of electricity and electricity subsidy reach more people. Equity aspects of water markets. Impacts of tariff increase on water markets.
- Comprehensive assessment of earlier measures like feeder separation on farmers' economics, water markets, ground water depletion, DISCOM finances, etc.

These are only some important suggestions. Most of these aspects would need to be studied in the context of different crops, different farmer landholding classes, and different agro-climatic regions.

7.2 Efforts to Improve Data Availability and Quality

We have already highlighted the parameters where issues of data availability and quality are a concern. Some of these include better estimates and measurements of electricity use in agriculture, of extent of areas irrigated by ground and surface water and through conjunctive use, of
groundwater extraction, etc. Here we mention only some of the ways to improve data availability and quality as this has been dealt with by several other agencies, for example, the Working Group on Water Database Development and Management for the 12th Five Year Plan.

First of all, there is a need to recognize data as a critical concern and accord it the due space in planning, budgets and implementation of programmes of various ministries, departments and agencies. For example, in spite of feeder separation having been implemented, this data is not used in Gujarat to estimate agricultural electricity consumption.

Second, better coordination amongst the various agencies who are gathering data would help cross-checking and corroboration leading to more accurate data. For example, some irrigation and pumping related data is gathered and recorded by multiple agencies and programmes like the Agricultural Census, Minor Irrigation Census, Agriculture and Water Resources Departments of state governments, etc. These agencies could coordinate with one another. Further, better integration of the data gathered by different agencies can go a long way in addressing many of the data issues. For example, DISCOMs or SERCs can coordinate with the Minor Irrigation or Agriculture Census agencies to carry out a census of pump-sets. Similarly, they can coordinate with the CACP to collect state-wise data on electricity consumption by different crops in agriculture as has been done by the Punjab Electricity Regulatory Commission in 2002-03.

Another very important measure would be to strengthen new sources of data collection and interpretation like satellite imagery and crowd sourcing along with their calibration using ground-level data and integration with data from other sources like various censuses. Such efforts will not only open up new sources of data but also provide synergies with existing data sources.

### 7.3 High Level Efforts to Break the Vicious Cycle

We have discussed earlier the vicious cycle with respect to agricultural electricity tariffs and farmers' willingness to pay, and how the initiative to break this low-level equilibrium has to come from the DISCOMs for various reasons, including the trust deficit. Given the stubbornness of the problem and its widespread prevalence, there is a need for concerted effort coming from the highest level with the highest priority. This would have to be a program with similar commitment and resource allocation as in the rural electrification program that was rolled out in 2005. This programme would also need to take into consideration the linkages with groundwater and agriculture as have been discussed in this report.

### 7.4 Pilot Scale Projects to Test and Demonstrate Solutions

We suggest some measures which can be tried out as pilots. Such testing will help refine the design of these measures, provide insights about their efficacy, demonstrate to what extent they can fit into the larger plans, and help upscale them.

#### 7.4.1 Distribution Transformer and Feeder Metering with Census of Pump-sets

One major issue is that the agricultural consumption measurement process is not trustworthy, mainly because of unmetered supply to the sector. Therefore, implementing feeder-level or DT-level metering can help to provide data for supply at least up to the feeder/DT level. This would improve the estimation of agricultural supply. In addition, it is also observed that the number of pump-sets and connected load per pump-set is not verified regularly and hence often results in outdated
data. Non-working/disconnected pump-sets, changed capacities after rewinding of the pump-sets, or change in the pump-set are also not taken into account. It would be useful to carry out such verification in a census mode in select locations as pilot projects along with the feeder/DT level metering. Together, these measures would help improve the estimation of agriculture supply as well as make it more accountable.

7.4.2 Metering Individual Pump-sets for a Group of Farmers

Some groups of farmers (like those in the Udupi district) are willing to have metering of their electricity consumption for irrigation and are ready to pay tariffs based on the actual use. Such areas can be identified for group level metering—that is, metering of each individual connection for the entire group of farmers. Such group level metering can help provide calibration for a larger estimation of agricultural consumption. Such voluntary group-level metering can be incentivised through improvement in quality of supply and service after the metering, and the provision of additional facilities like a visit by a DISCOM representative to the area at a mutually agreed time for the collection of bills.

A Direct Benefit Transfer (DBT) arrangement can also be tested in such a situation for the delivery of subsidy, in order to understand the challenges in implementation. Each farmer will have a specific quota for the electricity consumption at the subsidised rate, and additional consumption will be charged at the ACoS without any subsidy. This can help in the conservation of electricity and groundwater. The decided subsidy based on the quota will be deposited in the bank accounts of farmers. Such an arrangement can also incentivise farmers if they use electricity less than their quota. The CACP (2016) has also made a similar recommendation of a per hectare quota of water and electricity, with farmers being incentivised “by cash rewards equivalent to unused units of water/power at the rates of their domestic resource costs.”

7.4.3 Distribution Transformer Associations

Distribution Transformer Associations should be formed on the lines of Water User Associations. The main objectives would be to reduce power theft in the high theft areas, thereby controlling losses, increasing accountability and improving the power quality. Bringing in more equity in the distribution would be another important objective. This would help provide overall better service to the farmers in the association. Improvement of billing and collection efficiency in such areas can be useful for the power distribution companies. The association can have the powers to determine tariffs internally, to collect electricity charges, and supervise maintenance of the electricity distribution system. Such an arrangement, apart from improving distribution efficiency, has the potential to bring in more equity and help shift cropping patterns, though the latter would also depend on many factors external to the association like marketing, price and procurement support.

7.4.4 Capital Subsidy for Purchase of Energy Efficient Pumps for Small Farmers

High capital cost of wells/tube-wells and pump-sets is often an obstacle especially for poorer and small farmers to access groundwater based irrigation. A subsidy to meet part of these initial or

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44. The electricity tariffs at the DT level can be decided by the ERCs as part of their tariff process. The association members can decide internally about the tariffs applicable based on the area irrigated, use of water, crops grown, farmers’ ability to pay, etc. Such tariffs could also be telescopic in nature. They could also introduce criteria to prevent misuse of subsidies, for example, by “farm houses” of the rich.
upfront expenses can help such farmers access groundwater irrigation. This would be particularly useful in areas with few and sparse electric pumps, such as certain areas in Bihar, Uttar Pradesh, Odisha and other eastern and north-eastern states. Such schemes are already present in some states. We suggest that such schemes be linked to the purchase/installation of energy-efficient pump-sets, thus creating long-term benefits for both, the farmer and the DISCOM. Moreover, in areas where the electricity network is poor or inadequate and groundwater is available at lower depths, such schemes can promote solar pumps. This can help ensure more equity in electricity access and groundwater usage especially for the farmers who currently do not have access or have limited access to electricity and irrigation facilities. Attention should be paid to the level of groundwater exploitation in the area when designing such schemes. Another option of procurement through an UJALA like model with mass procurement of pumps through competitive bidding and performance guarantee can be explored to ensure lower costs and higher quality of the pump-sets.45

7.4.5 Safety Measures

The rural distribution network is often not maintained well, with low hanging wires, DTs without fences, and poor quality pump-set switch-boards. This is often on top of a lack of adequate grievance redressal mechanisms. A pilot project for rolling out enhanced safety measures for the electricity infrastructure and good grievance redressal can help improve the confidence of farmers in the distribution companies and bridge the trust gap.

7.4.6 Hours of Power Supply Based on Cropping Pattern and State of Groundwater Aquifers

The power supply duration can be adjusted in order to help to grow particular, agro-climatically suitable crops in an area. In addition, the duration can also be decided considering the state of ground water aquifers in the region and seasonal variations in irrigation requirements. It should be ensured that the power supply be good in terms of quality and sufficient in quantity to enable the farmers to fulfil the planned irrigation requirement. However, this would need to take into consideration impacts on water markets and impact on water buyers. One way to address it may be to provide capital subsidy so that those without access to water extraction mechanisms (WEMs or pump-sets) can acquire such WEMs and thus would not remain dependent on water markets. Another issue to be considered would be that a major determinant of cropping pattern choice is often the market, price and procurement support. So these aspects may also need to be built into the pilot project.

7.4.7 Block/DT/Feeder Level Electricity Tariffs Based on Cropping Pattern and State of Aquifer

Additionally, or alternatively, the electricity tariffs and hence corresponding power subsidy can be decided based on the status of ground water aquifer in a block or a feeder/DT area, and an appropriate cropping pattern. As mentioned earlier, the tariff policy also suggests this. The caution with respect to cropping pattern mentioned in the previous suggestion (7.4.6) should also be kept in mind here.

45. At present, Energy Efficiency Services Limited (EESL) has initiated some steps in this direction (EESL).
7.4.8 A Procurement and Price Regime to Encourage Shift Towards Appropriate Cropping Pattern

The public procurement of region-suitable crops grown by farmers should be strengthened at the selected area at a fair price. This can help dissuade farmers from water-intensive crops (especially in water-stressed area) and help them recover their cost of cultivation and make an appropriate profit as well. However, such a policy itself may have some implications for subsidy, an aspect which should be examined. Pilot projects would help identify such issues.

7.4.9 Community-driven Regulation of Groundwater Extraction and Recharge

Several initiatives are attempting to put in place Aquifer Based Participatory Groundwater Management at small geographic levels as an alternative model of groundwater management (ACWADAM). This is based on mapping the aquifer at a local level. Such initiatives can also be paired with some of the pilots mentioned earlier that deal with electricity distribution so as to develop a model for a sustainable and equitable management of groundwater.

7.5 Drawing Lessons for Areas Covered by New Groundwater Based Programmes

There are several regions where the government has plans to implement programmes on the lines of the “green revolution”, driven mainly by the development of groundwater resources. It is critical that these programmes be informed by lessons drawn from the experiences so far of the linkages between groundwater, electricity and agriculture development. For example, one such programme is the Bringing Green Revolution to Eastern India (BGREI).

The BGREI was "... initiated in 2010-11 to address the constraints limiting the productivity of 'rice based cropping systems' in eastern India comprising of seven (7) states, namely Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, Eastern Uttar Pradesh and West Bengal" (Department of Agriculture & Cooperation, 2015, p. 1). The goal of the programme is "to harness the water potential for enhancing rice production in eastern India which was hitherto underutilised."

Clearly, there is a lot of water potential in these seven states, particularly groundwater potential. Data from the CGWB for 2013 shows that these seven states had a total of 206 BCM of annual replenishable groundwater, that is, 46% of the country’s total of 445 BCM (CGWB, 2017). Out of this, water available for future irrigation development (that is, total available water minus water already being extracted and water reserved for future domestic and industrial use) in these seven states is 98 BCM, or 60% of the 162 BCM available in the country. Thus, there is excellent potential to base agricultural development on this available groundwater. However, there is a need to avoid the serious problems that have arisen in the electricity, water and agriculture sectors where similar groundwater-based development has taken place. This needs to be emphasised because the BGREI currently seems to be going along the same path.

46. It should be noted that these estimates pertain to the seven states including the entire state of Uttar Pradesh, whereas in this state the BGREI programme extends only to the eastern part. However, even leaving out Uttar Pradesh, the remaining six states have 29% of the annual replenishable groundwater of the country, and 48% of the total groundwater remaining for future use.
The very first objective of the BGREI is “to increase production and productivity of rice and wheat by adopting latest crop production technologies.” That is, other crops seem to be relegated to a secondary position, whereas elsewhere, crop diversification is being seen as the need of the hour. In terms of the proposed interventions, “BGREI comprises of three broad categories of interventions: (i) block demonstrations; (ii) asset building activities such as construction of shallow tube-wells/bore-wells/dug wells, pump-sets, seed drills, etc; and (iii) site-specific activities for facilitating petty works such as construction/renovation of irrigation channels/electricity for agricultural purposes in a cluster approach for convenience and cost effectiveness” (Department of Agriculture & Cooperation, 2015, p. 1). Given the very similar approaches to earlier interventions, it is crucial that lessons learnt from elsewhere be used to inform the design of the BGREI and similar interventions.
8. Conclusion

Groundwater has emerged as the lifeline of India. It is the dominant source of irrigation in the country. This is because groundwater has significant advantages in terms of control in the hands of farmers, in terms of productivity, in terms of modularity and also in furthering equity. For all these reasons, it is certain that groundwater's dominance will continue and its extent increase. Therefore, it is important to address the several serious issues that have emerged around groundwater, electricity and agriculture, all of which are interrelated.

There are strong and complex interlinkages between the agriculture, water and electricity sectors. It is practically impossible to address the issues of one without addressing holistically the other sectors and the interlinkages. This is partly the reason why the problems are intractable even after several efforts to address them. We have tried to explore and lay out various facets of these interlinkages, attempted to look at the sectors in an integrated manner, and proposed certain approaches to address the issues of concern.

The mainstream discourse around agriculture's role in the financial loss of DISCOMs is limited to low electricity tariffs and lacks the emphasis on many key systemic problems of the distribution sector. Agricultural electricity consumption is overestimated and so is subsidy. DISCOMs benefit at the expense of the state governments and electricity consumers and it is agriculture that gets attributed with losses that are not its own. Many DISCOMs and state governments are caught in an unhealthy cycle where DISCOMs subsidise their inefficiencies under the guise of agricultural consumption, and governments do not fulfil their subsidy obligations. Deteriorating DISCOM finances and distribution infrastructure result in poor power supply and service which imposes substantial financial costs on farmers. These systemic problems have to be resolved before asking poor and indebted farmers to pay higher tariffs. This is because raising tariffs will not increase DISCOM revenue if power quality and service is not improved prior to tariff increase. The subsidy burden cannot be addressed unless more reliable estimates of agricultural electricity consumption are available. That being said, a new, integrated approach to subsidy is required to bring DISCOM finances in order without burdening farmers who are saddled with low incomes and high debt.

Our analysis shows that it would be important to first reduce the inefficiencies in the sectors, address the trust deficit to gain confidence of farmers and the users of electricity and groundwater, and increase accountability of the power sector. Only after these steps should measures like electricity tariff rise, higher water charges, and full metering at the farmer level be implemented based on requirements. This is because such measures are unsustainable and ineffective in an environment where there is a trust deficit and lack of proper accountability.

At the same time, there is a need to address the crucial issue of cropping patterns, which is one of the most important drivers of the groundwater and electricity used. A shift towards crops that are suitable to the local eco-climatic characteristics, and putting in place proper marketing and price support to ensure decent returns to farmers from such crops, is essential to address the problems of excessive withdrawals of ground (and surface) water, as well as achieve moderation or optimality in electricity use. In areas where extensive use of groundwater is not yet taking place, there is opportunity to incorporate these approaches from the beginning. These measures need to
be combined with extensive, decentralised land-water conservation and rainwater harvesting to help sustainable use of groundwater, to ensure that groundwater levels do not fall, and in turn to help keep electricity use in check. Introduction of solar-based pumping in appropriate schemes can also help cut down subsidies while ensuring that irrigation needs are being met.

It is certain that only an integrated and comprehensive approach will be able to address the serious issues that currently plague the electricity sector in terms of subsidies, DISCOM finances and quality of supply to agricultural consumers, as well as related issues regarding groundwater use and agriculture. While this is no doubt a challenge, it is equally a source of hope and optimism. We believe that the understanding of the issues and problems presented by us, as well as our recommendations, will play a useful role in realising this hope.
9. Additional Note: A Few Words on Groundwater Resource Use and Equity

When we talk about equity and sustainability in the context of groundwater use, there are some important issues of debate which have implications for the electricity supply to agriculture, but which are beyond the scope of this paper. For one, would helping more and more farmers in an area to get access to their own pumping equipment lead to higher groundwater withdrawals and depletion? Or would it help farmers shift from being water buyers in a water market to being independent of the water market, thus giving them more control, without affecting the effective groundwater withdrawals? Another issue is if farmers, especially small and marginal farmers in an already groundwater stressed area, are discouraged, or even banned from getting their own pump-sets, would it be privileging those who were early installers of groundwater pumping machinery, most likely to be bigger farmers? This is linked to the question of who, if anyone, owns groundwater. Today, in practice, groundwater is treated as the private property of the owner of the land, who assumes a right to pump up as much groundwater as he desires. Since groundwater is a unified resource, this has implications for other users, and ultimately, on equitable use of the resources, apart from environmental consequences of resource depletion. These issues can be addressed only by recognising that groundwater is a common pool resource and a public resource, and by bringing in a regulatory regime that ensures sustainable use as well as equitable distribution. Some elements of such a regime would be participatory groundwater management which treats groundwater as a common property resource, prioritising the use of groundwater for basic needs, food security and sustenance agriculture (all of which are recognised as a priority in the National Water Policy 2012), and for livelihood security, encouraging appropriate cropping patterns, and putting in place public groundwater infrastructure as against private pump-sets.
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11. List of Abbreviations

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<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ACoS</td>
<td>Average Cost of Supply</td>
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<td>AP</td>
<td>Andhra Pradesh</td>
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<td>ARR</td>
<td>Aggregate Revenue Requirement</td>
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<td>AT&amp;C Losses</td>
<td>Aggregate Technical and Commercial Losses</td>
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<tr>
<td>BCM</td>
<td>Billion Cubic Metre</td>
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<td>BU</td>
<td>Billion Units</td>
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<tr>
<td>CACP</td>
<td>Commission for Agricultural Costs and Prices</td>
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<td>CAG</td>
<td>Comptroller and Auditor General of India</td>
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<tr>
<td>CEA</td>
<td>Central Electricity Authority</td>
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<td>CGWB</td>
<td>Central Groundwater Board</td>
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<td>Cr</td>
<td>Crore</td>
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<td>DHBVNL</td>
<td>Dakshin Haryana Bijli Vitran Nigam Limited</td>
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<td>DISCOM</td>
<td>Distribution Company</td>
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<td>DT</td>
<td>Distribution Transformer</td>
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<td>EESL</td>
<td>Energy Efficiency Services Limited</td>
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<td>FY</td>
<td>Financial Year</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GoH</td>
<td>Government of Haryana</td>
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<td>Gol</td>
<td>Government of India</td>
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<td>Ha</td>
<td>Hectare</td>
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<td>HERC</td>
<td>Haryana Electricity Regulatory Commission</td>
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<td>HT</td>
<td>High Tension</td>
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<td>KERC</td>
<td>Karnataka Electricity Regulatory Commission</td>
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<tr>
<td>kW</td>
<td>Kilo-Watt</td>
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<td>kWh</td>
<td>Kilo-watt hour</td>
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<td>LT</td>
<td>Low Tension</td>
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<td>MI</td>
<td>Minor Irrigation</td>
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<td>Ministry of Agriculture &amp; Farmers’ Welfare</td>
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<td>Ministry of Water Resources, River Development &amp; Ganga Rejuvenation</td>
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<td>MSEDCL</td>
<td>Maharashtra State Electricity Distribution Company Limited</td>
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<td>MT</td>
<td>Million Tonnes</td>
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<td>MW</td>
<td>Mega Watt</td>
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<td>PEG</td>
<td>Prayas (Energy Group)</td>
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<td>PFC</td>
<td>Power Finance Corporation</td>
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<td>PSERC</td>
<td>Punjab State Electricity Regulatory Commission</td>
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<td>PSPCL</td>
<td>Punjab State Power Corporation Limited</td>
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<td>Public Sector Undertakings</td>
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<td>Reserve Bank of India</td>
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<td>SERC</td>
<td>State Electricity Regulatory Commission</td>
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<tr>
<td>ToD</td>
<td>Time of Day</td>
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<td>T&amp;D</td>
<td>Transmission and Distribution</td>
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<td>UDAY</td>
<td>Ujwal Discom Assurance Yojana</td>
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<td>UHBVNL</td>
<td>Uttar Haryana Bijli Vitran Nigam Limited</td>
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<td>UP</td>
<td>Uttar Pradesh</td>
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<td>UPERC</td>
<td>Uttar Pradesh Electricity Regulatory Commission</td>
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<td>Water Extraction Mechanism</td>
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<td>WB</td>
<td>West Bengal</td>
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<td>WRIS</td>
<td>Water Resources Information System</td>
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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.
Understanding the Electricity, Water & Agriculture Linkages

Volume 2: Electricity Supply Challenges

Prayas (Energy Group)
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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 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.

![Diagram showing integrated approach](image)
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

<table>
<thead>
<tr>
<th>Year</th>
<th>Food grain production in Million Tonnes (MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-51</td>
<td>50.82</td>
</tr>
<tr>
<td>1980-81</td>
<td>129.59</td>
</tr>
<tr>
<td>2010-11</td>
<td>244.49</td>
</tr>
</tbody>
</table>

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 Cr1, 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). 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 (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 (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

---

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, 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
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. 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). 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 and average tariffs to the farmer (after subsidy) in different states in the 2012-2014 period. 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.

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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 Pradesh10, Punjab and Tamil Nadu11. 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 system12 and how electricity is supplied to agricultural pump-sets. From a 33 kV substation, there would typically be 3-4 agricultural feeders13, on each feeder there would be some 20 DTs and on each DT, around 20 pump-sets14. 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

<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
<th>States using the approach</th>
</tr>
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<tbody>
<tr>
<td>Based on benchmark consumption norm for agricultural pump-sets</td>
<td>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.</td>
<td>Maharashtra, MP, Gujarat, Rajasthan, TN, UP, Karnataka (MESCOM, HESCOM, BESCOM, GESCOM)</td>
</tr>
<tr>
<td>Based on benchmark consumption norm of DTs</td>
<td>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)</td>
<td>Telangana, AP</td>
</tr>
<tr>
<td>Based on Energy Input into Agricultural Feeders</td>
<td>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.</td>
<td>Punjab, Haryana, Karnataka (CESC)</td>
</tr>
</tbody>
</table>

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. 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, 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. 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” (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)20. 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 SERCs were established in

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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&T 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&T losses in the period 1996-2001.21

Figure 5: Revision in Agricultural Sales and T&T 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

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

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. 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.

Table 4: Restatement of Agricultural Electricity Sales and Distribution Loss

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Agricultural Sales</td>
<td>23%</td>
<td>21%</td>
<td>16%</td>
<td>14%</td>
</tr>
<tr>
<td>Distribution Loss</td>
<td>14.2%</td>
<td>16.4%</td>
<td>17.6%</td>
<td>21.8%</td>
</tr>
<tr>
<td>Agricultural Sales in MU</td>
<td>25,685</td>
<td>23,271</td>
<td>11,206</td>
<td>9619</td>
</tr>
<tr>
<td>Sales overreported by</td>
<td>10%</td>
<td>16%</td>
<td>5%</td>
<td>39%</td>
</tr>
</tbody>
</table>

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 UHBVN and DHBVN (not included here), the agricultural sales for 2010-11 as reported by the UHBVN 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 DISCOM25. 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

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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 (UHBVN)\textsuperscript{28}. This additional revenue would raise existing revenues by 3% in MSEDCL, 5% in TANGEDCO, 1% in PSPCL and 12% in UHBVN. 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\textsuperscript{29} as on March 2014 is more than 19 million (CEA, 2015).\textsuperscript{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).\textsuperscript{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

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

\textsuperscript{29} CEA data is collected from DISCOMs.

\textsuperscript{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).

\textsuperscript{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.\textsuperscript{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.

\textbf{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).

\textsuperscript{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. 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.

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. 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.

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. 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 agriculture37.

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 TtD 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).

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 (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. 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. 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.\textsuperscript{41} We analyse data for the states with high agricultural electricity consumption\textsuperscript{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.\textsuperscript{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.\textsuperscript{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\textsuperscript{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.

\textsuperscript{41} 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.

\textsuperscript{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.

\textsuperscript{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.

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

\textsuperscript{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. 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.

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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

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Non Domestic</th>
<th>Agricultural</th>
<th>Industrial (small supply)</th>
<th>Industrial (medium supply)</th>
<th>Industrial (large supply)</th>
<th>Outside State Sales</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-07</td>
<td>75%</td>
<td>123%</td>
<td>1%</td>
<td>96%</td>
<td>106%</td>
<td>105%</td>
<td>113%</td>
<td>98%</td>
<td>69%</td>
</tr>
<tr>
<td>2009-10</td>
<td>68%</td>
<td>115%</td>
<td>0%</td>
<td>93%</td>
<td>104%</td>
<td>100%</td>
<td>203%</td>
<td>98%</td>
<td>63%</td>
</tr>
<tr>
<td>2014-15</td>
<td>73%</td>
<td>104%</td>
<td>0%</td>
<td>97%</td>
<td>102%</td>
<td>110%</td>
<td>36%</td>
<td>93%</td>
<td>71%</td>
</tr>
</tbody>
</table>

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. 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.49 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 PuVNL, PVNL, MVNL and DVNL.
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 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. 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.

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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. 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. 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%.

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

Source: PEG compilation from (RBI, 2016; CAG, 2016) and State Regulatory Orders and Petitions. Note: Total and agricultural subsidy in Gujarat and Haryana includes subsidy for fuel surcharge on agricultural consumers.

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

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

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.

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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\(^6\).

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

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

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\(^6\) (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 31\(^{st}\) March 2015 stood at Rs 3587 Cr (including shortfalls before 2009-10) and it has increased to Rs 4664 Cr on 3\(^{rd}\) 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.

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62. In Andhra Pradesh, Telangana, Haryana, Punjab, Karnataka, Maharashtra, Madhya Pradesh and Rajasthan
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 sharecroppers 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 burnouts64 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 serious concern about 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 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.

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.
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.
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.

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 methodology71 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 prerequisite 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 blocks72 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

<table>
<thead>
<tr>
<th>Pilot</th>
<th>Objectives</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Solar Agricultural</td>
<td>Better estimates of agricultural consumption and quality of supply, reduction in subsidy, welfare of farmers</td>
<td>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.</td>
</tr>
<tr>
<td>Feeder</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh</td>
<td>Kilo-watt hour</td>
</tr>
<tr>
<td>LT</td>
<td>Low Tension</td>
</tr>
<tr>
<td>MERC</td>
<td>Maharashtra Electricity Regulatory Commission</td>
</tr>
<tr>
<td>MESCOM</td>
<td>Mangalore Electricity Supply Company Limited</td>
</tr>
<tr>
<td>MI</td>
<td>Minor Irrigation</td>
</tr>
<tr>
<td>MP</td>
<td>Madhya Pradesh</td>
</tr>
<tr>
<td>MoP</td>
<td>Ministry of Power</td>
</tr>
<tr>
<td>MPSEB</td>
<td>Madhya Pradesh State Electricity Board</td>
</tr>
<tr>
<td>MSEDCL</td>
<td>Maharashtra State Electricity Distribution Company Limited</td>
</tr>
<tr>
<td>MT</td>
<td>Million Tonnes</td>
</tr>
<tr>
<td>MU</td>
<td>Million Units</td>
</tr>
<tr>
<td>MW</td>
<td>Mega Watt</td>
</tr>
<tr>
<td>MYT</td>
<td>Multi-Year Tariff</td>
</tr>
<tr>
<td>MVVCL</td>
<td>Madhyanchal Vidyut Vitran Nigam Limited</td>
</tr>
<tr>
<td>PEG</td>
<td>Prayas (Energy Group)</td>
</tr>
<tr>
<td>PFC</td>
<td>Power Finance Corporation</td>
</tr>
<tr>
<td>PSERC</td>
<td>Punjab State Electricity Regulatory Commission</td>
</tr>
<tr>
<td>PSPCL</td>
<td>Punjab State Power Corporation Limited</td>
</tr>
<tr>
<td>PSU</td>
<td>Public Sector Undertakings</td>
</tr>
<tr>
<td>PuVVNL</td>
<td>Purvanchal Vidyut Vitaran Nigam Limited</td>
</tr>
<tr>
<td>PVVNL</td>
<td>Pashchimanchal Vidyut Vitran Nigam Ltd.</td>
</tr>
<tr>
<td>RBI</td>
<td>Reserve Bank of India</td>
</tr>
<tr>
<td>RERC</td>
<td>Rajasthan Electricity Regulatory Commission</td>
</tr>
<tr>
<td>SEB</td>
<td>State Electricity Board</td>
</tr>
<tr>
<td>SERC</td>
<td>State Electricity Regulatory Commission</td>
</tr>
<tr>
<td>ToD</td>
<td>Time of Day</td>
</tr>
<tr>
<td>T&amp;D</td>
<td>Transmission and Distribution</td>
</tr>
<tr>
<td>TANGEDCO</td>
<td>Tamil Nadu Generation and Distribution Corporation</td>
</tr>
<tr>
<td>TNERC</td>
<td>Tamil Nadu Electricity Regulatory Commission</td>
</tr>
<tr>
<td>TSERC</td>
<td>Telangana State Electricity Regulatory Commission</td>
</tr>
<tr>
<td>TSNPDCL</td>
<td>Northern Power Distribution Company of Telangana Limited</td>
</tr>
<tr>
<td>TSSPDCL</td>
<td>Southern Power Distribution Company of Telangana Limited</td>
</tr>
<tr>
<td>UDAY</td>
<td>Ujwal Discom Assurance Yojana</td>
</tr>
<tr>
<td>UHBVNL</td>
<td>Uttar Haryana Bijli Vitran Nigam Limited</td>
</tr>
<tr>
<td>UP</td>
<td>Uttar Pradesh</td>
</tr>
<tr>
<td>UPERC</td>
<td>Uttar Pradesh Electricity Regulatory Commission</td>
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<tr>
<td>UPPCL</td>
<td>Uttar Pradesh Power Corporation Limited</td>
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</table>
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Beneficiaries of IPS Subsidy and Impact of Tariff Hike (1996)
http://www.prayaspune.org/peg/publications/item/93

Agricultural Pumping Efficiency in India: The Role of Standards (1996)
http://www.prayaspune.org/peg/publications/item/92.html

How Reliable are Agricultural Power Use Data? (1997)
http://www.prayaspune.org/peg/publications/item/94.html

Efficient well-based irrigation in India: Compilation of Experiences with Implementing Irrigation efficiency (2010)
http://www.prayaspune.org/peg/publications/item/149.html

Strategic Actions for Rapid Implementation of Energy Efficiency (2011)
http://www.prayaspune.org/peg/publications/item/156.html

http://www.prayaspune.org/peg/publications/item/303.html

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http://www.prayaspune.org/peg/publications/item/350.html

Many Sparks but Little Light: The Rhetoric and Practice of Electricity Sector Reforms in India (2018)
http://www.prayaspune.org/peg/publications/item/332.html
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.
Annexure

Understanding the Electricity, Water, Agriculture Linkages

Volume 2: Electricity Supply Challenges

Ashwini Dabadge | Sreekumar N | Shripad Dharmadhikary | Rutuja Bhalerao

Prayás (Energy Group)

September 2018

Prayás (Energy Group)
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1. State Details of Agricultural Power Estimation

Benchmark consumption norms for pump-sets are used for estimating electricity consumption in agriculture in many states. This is the electricity consumption per hp in a year. Figure 1 gives the norms for different states, mostly in 2014-15. In Karnataka, they are used for projecting metered and unmetered consumption.

Figure 1: Pump-Set Norms in Different States

Note: The norm in Madhya Pradesh is for 2012-13 and in Karnataka for 2013-14. The Karnataka norms are originally expressed in kWh/pump/annum but are converted to kWh/hp/annum from average pump capacity in the DISCOMs. The Uttar Pradesh norm was stipulated in 2014. BESCOM and HESCOM had the highest agricultural consumers among all the DISCOMs in 2014-15, hence considered here. The norm in SPDCL is for 2017-18.

This annexure elaborates on the different methodologies and processes employed by DISCOMs for agricultural power consumption and SERCs in each state as well as their issues. It is divided into three sections, based on the broad categorisation of estimation methodologies of electricity consumption in agriculture. This categorisation depends on whether the benchmark consumption is estimated for a pump-set, DT or feeder.

Benchmark Consumption Norms of Pump-Sets

1.1 Maharashtra

Table 1: Selected Parameters for Maharashtra in 2014-15

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Electricity Sales in MU</th>
<th>% of Metered Connections</th>
<th>% of Agricultural Sales in Total Sales</th>
<th>Benchmark Consumption Norm (Unmetered) kWh/hp/annum</th>
<th>Distribution Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSEDCL</td>
<td>23271</td>
<td>58%</td>
<td>25%</td>
<td>1,242</td>
<td>16%</td>
</tr>
</tbody>
</table>

Source: Regulatory Orders and Petitions of MSEDCL
History of Estimation of Agricultural Consumption in Maharashtra

The history of estimation of agricultural consumption in Maharashtra since 1999 is long and eventful. With strong public and civil society participation and oversight by the MERC, the agricultural estimation methodology and the data on agricultural electricity provided by the MSEDCL has been under constant scrutiny. Owing to the pressure from the civil society and consumer representatives, the data put out by MSEDCL in the public is more detailed, which enables independent evaluations. It is only through prolonged public pressure and relentless questioning of agricultural consumption data that agricultural consumption and distribution losses have been re-stated thrice since the MERC was set up. The different agricultural estimation methodologies stipulated by the MERC over time and issues with their implementation are provided in Table 2.

Table 3 summarises the major events in the history of agricultural consumption estimation in Maharashtra, while Table 4 provides details of restatement of the agricultural consumption and distribution loss over the years. The level of disaggregation is as follows: State->Zone->Circle. A big state will have about 8-10 zones, each covering 2 or 3 districts. Under each zone there are 2-3 circles, each covering a district.

Table 2: Methodologies of Estimation of Agricultural Consumption by MSEDCL over the Years

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<tr>
<td>Energy audit data of energy pumped into sample agricultural feeders was used for estimation. Meter readings that were available for a continuous period of 300 days were used. Circle-wise pump-set norms were derived using agricultural connected load and number of consumers under the feeder, which were then averaged to zone-wise norms and ultimately to the state norm (MERC, 2002, pp. 107-110). The final sample size was small and there were problems with the representativeness of the sample. For e.g., the final number of feeders with meter readings for a continuous period of 300 days were 34% of sample feeders in 2000-01. As a result, only 0.4% of the total connected load was included in the final sample. The line loss under the feeder was not estimated, and hence was included in the agricultural consumption. (MERC, 2002)</td>
<td>Bills of metered consumers (around half of total consumers) and their connected load in every zone were used to arrive at zone-wise pump-set norms. These were used to estimate agricultural consumption in every zone, aggregated to the state level consumption. Abnormal billing records were filtered, viz., zero connected load, average billing, negative consumption, high connected load, etc, for all the zones (MERC, 2006, pp. 90-95). The final sample size was larger than the one in the previous methodology, covering 23% of agricultural consumers (MERC, 2006). However, several instances of average billing were highlighted by consumer representatives raising questions over reliability of billing data.</td>
<td>On agricultural feeders where positive losses were seen, agricultural consumption was estimated using the pump-set norm derived from bills of metered consumers. On agricultural feeders where negative losses were seen, the energy input into the sample feeders was taken as agricultural consumption, and a pump-set norm was derived using this and the connected load under the feeder. (MERC, 2016, pp.102-108). Line losses under the feeder were not taken into account. Thus re-statement is conservative.</td>
</tr>
</tbody>
</table>
After the MERC was set up in 1999, agricultural electricity sales and T&TD loss were restated. Agricultural sales went down from 27% to 16% of total sales and T&TD loss went up from 18% to 31% of total energy input. MERC directed MSEDCL to release only metered connections to agricultural consumers. In time it was hoped that when there would be enough metered consumers, their consumption, would help in estimating agricultural consumption, rather than depending on meter readings from a limited number of feeders.

In the tariff order of 2006-07, agricultural sales and distribution loss as projected by the MSEDCL for 2006-07 were revised as the estimation methodology changed. Agricultural sales projections were revised downwards by 35%. (MERC, 2006)

There was a fall in the number of unmetered agricultural connections and load, with hours of supply to agriculture remaining the same as compared to the previous year. But MSEDCL reported a rise in unmetered agricultural sales in 2009-10. The commission noticed this anomaly and tempered down the agricultural sales figure by using the benchmark consumption norm of 2007-08.

When estimate of agricultural sales under agricultural feeders, which was computed using bills of metered consumers, was compared with energy input into the agricultural feeder, sales were found to be greater than energy input, resulting in negative feeder losses on 39% of agricultural feeders. Only 4% of the 23% rise in agricultural sales over 2013-14 could be attributed to rise in agricultural load and consumers, rest was attributed to the increase in hours of operation. Very long hours of operation of pump-sets per hp were reported in drought-prone areas than those where water-intensive sugarcane was grown (Prayas Energy group, 2016). Thus the commission used a different methodology to estimate agricultural consumption in 2014-15 and compute provisional estimates for 2015-16. This resulted in restatement of agricultural sales, distribution loss and the pump-set norm (kWh/hp/annum) for unmetered consumption. (MERC, 2016). Agricultural sales estimates fell by 14% in 2015-16 after restatement. The distribution loss, which had been consistently declining since 2006-07, shot up.

<table>
<thead>
<tr>
<th>Year</th>
<th>Parameter</th>
<th>As estimated by MSEDCL</th>
<th>As approved by MERC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-07 (Projections)</td>
<td>Agricultural sales in MU</td>
<td>14,968</td>
<td>9702</td>
</tr>
<tr>
<td></td>
<td>Assumption for hours of operation of a pump per annum</td>
<td>2290</td>
<td>1318</td>
</tr>
<tr>
<td></td>
<td>Distribution loss</td>
<td>27%</td>
<td>35%</td>
</tr>
<tr>
<td>2009-10 (Actuals)</td>
<td>Agricultural sales in MU</td>
<td>7653</td>
<td>7069</td>
</tr>
<tr>
<td></td>
<td>Pump-set norm in kWh/hp/ annum</td>
<td>1165</td>
<td>1288</td>
</tr>
<tr>
<td></td>
<td>Distribution loss in %</td>
<td>20.60%</td>
<td>21.32%</td>
</tr>
<tr>
<td>2014-15 (Actuals)</td>
<td>Agricultural sales (MU)</td>
<td>25,685</td>
<td>23,271</td>
</tr>
<tr>
<td></td>
<td>Distribution loss</td>
<td>14.17%</td>
<td>16.36%</td>
</tr>
<tr>
<td></td>
<td>Pump-set norm in kWh /hp/ annum</td>
<td>1,436</td>
<td>1,242</td>
</tr>
<tr>
<td>2015-16 (Provisional Estimates)</td>
<td>Agricultural sales (MU)</td>
<td>27505</td>
<td>24,105</td>
</tr>
<tr>
<td></td>
<td>Distribution loss</td>
<td>14.51%</td>
<td>18.24%</td>
</tr>
<tr>
<td></td>
<td>Pump-set norm in kWh /hp/ annum</td>
<td>1439</td>
<td>1242</td>
</tr>
</tbody>
</table>
1.2 Gujarat

Table 5: Selected Parameters for Gujarat DISCOMS in 2012-13

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Sales in MU</th>
<th>% of Metered Connections</th>
<th>% of Agricultural Sales in Total Sales</th>
<th>Benchmark Consumption Norm (Unmetered) kWh/hp/annum</th>
<th>Benchmark Consumption Norm (Metered) kWh/hp/annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>UGVCL</td>
<td>7630</td>
<td>37%</td>
<td>51%</td>
<td>1700</td>
<td>970</td>
</tr>
<tr>
<td>PGVCL</td>
<td>5870</td>
<td>54%</td>
<td>34%</td>
<td>1700</td>
<td>1011</td>
</tr>
<tr>
<td>MVGCL</td>
<td>987</td>
<td>68%</td>
<td>14%</td>
<td>1700</td>
<td>524</td>
</tr>
<tr>
<td>DGVCL</td>
<td>628</td>
<td>57%</td>
<td>6%</td>
<td>1700</td>
<td>529</td>
</tr>
<tr>
<td>Total</td>
<td>15,115</td>
<td>51%</td>
<td>30%</td>
<td>1700</td>
<td></td>
</tr>
</tbody>
</table>

Source: PEG compilation from various tariff orders and petitions.

The benchmark pump-set norm is used for the estimation of unmetered consumption, which is common to all DISCOMs. However, for projection of metered consumption, all DISCOMs use separate agricultural norms. DISCOMs claim that they do not give out any unmetered connections. The UGVCL, followed by the PGVCL, have the highest agricultural consumption among the 4 DISCOMs. The rationale behind the norm is not available in the public domain. The norm was stipulated in 2004 at 1700 kWh/hp/annum on the recommendation of the Mishra Committee, which assessed agricultural consumption (GERC, 2006, p. 44). It has been the same till 2016, till the time of writing this paper. Metered consumption is projected for the future by computing pumps-set benchmark consumption. There is a large disparity between the metered and unmetered benchmark consumption that remains unexplained. These can be seen in Table 6:

Table 6: Benchmark Consumption Norms for Agriculture in kWh/hp/annum

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>UGVCL</td>
<td>Metered</td>
<td>650</td>
<td>970</td>
<td>992</td>
<td>992</td>
</tr>
<tr>
<td>MGVCL</td>
<td>1011</td>
<td>954</td>
<td>954</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DGVCL</td>
<td>524</td>
<td>541</td>
<td>541</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PGVCL</td>
<td>650</td>
<td>529</td>
<td>616</td>
<td>616</td>
<td></td>
</tr>
<tr>
<td>DISCOMs</td>
<td>Unmetered</td>
<td>1700</td>
<td>1700</td>
<td>1700</td>
<td>1700</td>
</tr>
</tbody>
</table>

The benchmark consumption by unmetered consumers is higher than that of metered consumers. The GERC-determined flat tariff for unmetered consumers (if converted to a per unit tariff) is higher than the tariff for metered consumers. However, the Gujarat government has been extending subsidy to unmetered consumers to keep their tariff constant at Rs 665-806/hp/annum. This removes the incentive for unmetered consumers to shift to metered connections.

Gujarat completed the separation of its rural feeders in 2006. The UGVCL and PGVCL have also metered 73% and 75% of its distribution transformers respectively as of September 2016. (GERC, 2017, p. 206; GERC, 2017, p. 203) Energy pumped into agricultural feeders and DTs can give a better estimate of agricultural consumption. The UGVCL internally studied this data from sample agricultural feeders and DTs during 2006-07 and 2008-09. The average consumption for
metered and unmetered consumers in 2008-09 was 1406 kWh/hp/annum. However, another internal study revealed the average consumption of unmetered consumers to be higher at 1734, 1907 and 1859 kWh/hp/annum in the three respective years from 2006-07 to 2008-09. But the study used theoretical distribution losses, the computation of which is not clear, to arrive at the average consumption. Even after this study, the benchmark consumption norm was retained at 1700 kWh/hp/annum. (GERC, 2009, p. 116). Later, a comprehensive study to obtain a realistic assessment of consumption of agriculture pumps for the 4 DISCOMs was reportedly carried out by an independent agency for the GERC in 2014. However, this study is not available in the public domain.\footnote{The study is titled “Trends in Energy Consumption in Agriculture: An Analysis of Performance of Power Distribution Companies (DISCOMs) in Gujarat” and was carried out by the Gujarat Institute of Development Research, Ahmedabad.}

1.3 Rajasthan

Table 7: Selected Parameters for Rajasthan DISCOMS in 2014-15

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Sales in MU</th>
<th>% of Metered Connections</th>
<th>% of Agricultural Sales in Total Sales</th>
<th>Benchmark Consumption Norm (Unmetered) kWh/hp/annum</th>
<th>Benchmark Consumption Norm (Metered) kWh/hp/annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>JVVNL</td>
<td>5244</td>
<td>92%</td>
<td>30%</td>
<td>1450</td>
<td>2317</td>
</tr>
<tr>
<td>AVVNl</td>
<td>4762</td>
<td>86%</td>
<td>37%</td>
<td>1450</td>
<td>1986</td>
</tr>
<tr>
<td>JdVVNL</td>
<td>8807</td>
<td>82%</td>
<td>55%</td>
<td>1450</td>
<td>2079</td>
</tr>
<tr>
<td>Total</td>
<td>18,813</td>
<td>87%</td>
<td>40%</td>
<td>1450</td>
<td>2317</td>
</tr>
</tbody>
</table>

Source: PEG compilation from various tariff orders and petitions, and (PFC, 2016).

DISCOMs in Rajasthan claim that they do not disburse any new unmetered agricultural connections. Every year, the DISCOMs give targets for fixing meters for existing unmetered consumers. The share of metered agricultural consumers in Rajasthan in 2014-15 was 88\%, possibly the highest in all states under consideration here. However DISCOMs in the state have a special metering arrangement where transformers (called super transformers) have meters, and pump-sets connected to these are considered metered (RERC, 2011a, p. 13; RERC, 2011b). Agricultural consumption is estimated based on a benchmark consumption norm for a pump-set, and metered consumption is projected using metered pump-set norms. The unmetered norm was 1296 kWh/hp/annum in 2005. A study on agricultural estimation commissioned by the Rajasthan regulator, the Rajasthan Electricity Regulatory Commission (RERC) estimated the average consumption that was significantly higher. It stood between 2350 to 5860 kWh/hp/year. However, the RERC considered it higher than the maximum consumption by a pump-set under 8 hours daily supply, which was the stated hours of supply to agriculture at the time, and rejected the norm. It decided to revise it to 1450 units/hp/annum in 2006 in proportion to the increase in the metered average consumption from 2004-05 to 2005-06. The unmetered norm thereafter has been the same till date. Table 8 shows the metered and unmetered norms used by the 3 DISCOMs.
Table 8: Agricultural Benchmark Consumption Norm in kWh/hp/annum

<table>
<thead>
<tr>
<th>DISCOM/Year</th>
<th>2006-07</th>
<th>2009-10</th>
<th>2012-13</th>
<th>2014-15</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metered</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JVVNL</td>
<td>No data</td>
<td>1268</td>
<td>1883</td>
<td>2317</td>
</tr>
<tr>
<td>AVVNl</td>
<td>1018</td>
<td>988</td>
<td>1475</td>
<td>1986</td>
</tr>
<tr>
<td>JDVVNL</td>
<td>865</td>
<td>1302</td>
<td>1429</td>
<td>2079</td>
</tr>
<tr>
<td><strong>Unmetered</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JVVNL</td>
<td>No data</td>
<td>1450</td>
<td>1450</td>
<td>1450</td>
</tr>
<tr>
<td>AVVNl</td>
<td>1450</td>
<td>1450</td>
<td>1450</td>
<td>1450</td>
</tr>
<tr>
<td>JDVVNL</td>
<td>1450</td>
<td>1450</td>
<td>1450</td>
<td>1450</td>
</tr>
</tbody>
</table>

Source: PEG Compilation from various Rajasthan regulatory orders

Box 1: Rajasthan and Gujarat: Discrepancy Between Benchmark Consumption of Metered and Unmetered Pump-sets

Pump-set norms for Gujarat and Rajasthan have been the same since 2004 and 2006 respectively. Both states estimate benchmark consumption of metered and unmetered consumers separately, to facilitate better projection of future consumption. The consumption per hp pump-set for metered consumers is significantly different than that for unmetered consumers in recent years as can be seen in Table 6 and Table 8. Metered tariff is differentiated from flat rate tariffs, however since tariffs are low, consumption would be determined more by water requirement for irrigation than by tariffs. Hours of supply to both types of connections would also be the same. Hence such a large difference between metered and unmetered norms cannot be fully explained.

1.4 Madhya Pradesh

Table 9: Selected Parameters for Madhya Pradesh DISCOMS in 2014-15

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Sales in MU</th>
<th>% of Metered Connections</th>
<th>% of Agricultural Sales in Total Sales</th>
<th>Benchmark Consumption Norm (Unmetered) kWh/hp/annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP Purv Kshetra VVCL</td>
<td>4039</td>
<td>0%</td>
<td>32%</td>
<td>1200</td>
</tr>
<tr>
<td>MP Madhya Kshetra VVCL</td>
<td>4406</td>
<td>0%</td>
<td>32%</td>
<td>1200</td>
</tr>
<tr>
<td>MP Paschim Kshetra VVCL</td>
<td>6533</td>
<td>0%</td>
<td>42%</td>
<td>1200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14,978</strong></td>
<td><strong>0%</strong></td>
<td><strong>38%</strong></td>
<td><strong>1200</strong></td>
</tr>
</tbody>
</table>

Source: PEG compilation from various tariff orders and petitions.

Almost all of Madhya Pradesh’s agricultural consumers were unmetered in 2015 (MP Purv Kshetra VVCL, MP Madhya Kshetra VVCL, MP Paschim Kshetra VVCL, 2016; MPERC, 2016). Both the number and share of agricultural consumers who are metered has been declining. In fact, the share of consumers who have meters is almost zero in 2016-17, down from 23% in 2007-08 (Central, Western and Eastern DISCOMs of Madhya Pradesh, 2009). In 2004-05, the unbundled
utility Madhya Pradesh State Electricity Board (MPSEB) used a benchmark consumption norm of 1146 kWh/hp/annum (MPERC, 2004). It was segregated into different norms for permanent and temporary connections subsequently. The norm for permanent connections was 1200 and that for temporary connections was 1560 in 2007-08 (MPERC, 2007). Thereafter, the norms were further segregated on season, and single-phase and three-phase basis. The norms are computed based on the stated hours of supply by the DISCOM to these different segments. The norms are the same for all DISCOMs. Table 10 shows the norms for rural areas for various years.

Table 10: Agricultural Benchmark Consumption Norms for Various Years

<table>
<thead>
<tr>
<th>Period</th>
<th>Units</th>
<th>2009–10</th>
<th>2012–13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April to July—4 months</td>
<td>kWh/hp/month</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>August to September—2 months</td>
<td>kWh/hp/month</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>October to March—6 months</td>
<td>kWh/hp/month</td>
<td>120</td>
<td>150</td>
</tr>
<tr>
<td>Total 12 months</td>
<td>kWh/hp/annum</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Temporary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April to July—4 months</td>
<td>kWh/hp/month</td>
<td>130</td>
<td>155</td>
</tr>
<tr>
<td>August to September—2 months</td>
<td>kWh/hp/month</td>
<td>155</td>
<td>155</td>
</tr>
<tr>
<td>October to March—6 months</td>
<td>kWh/hp/month</td>
<td>155</td>
<td>155</td>
</tr>
<tr>
<td>Total 12 months</td>
<td>kWh/hp/annum</td>
<td>1760</td>
<td>1860</td>
</tr>
</tbody>
</table>

Note: The norms in 2012-13 are for three-phase.
Source: (MPERC, 2014, p. 5; MPERC, 2016b, p. 12).

The commission has been monitoring the progress of metering of agricultural DTs regularly, and till date 25% of agricultural DTs have been fitted with meters (MPERC, 2016a, p. 10). However, it seems that the data of energy input into these DTs is not being used to gauge agricultural consumption by either DISCOMs or the MPERC. There has been no study on agricultural estimation to verify if the benchmark norms being used are representative.

Temporary Agricultural Connections

DISCOMs issue temporary agricultural connections that are mostly unmetered, with higher tariff and advance payment of connection charges. They were credited with playing a role in increasing the area under irrigation (Shah, Banerjee, Roy, & Singhania, 2012). However, extending temporary connections with makeshift distribution infrastructure at a large scale like this is risky and unsafe. These have been reducing over time. From 16% of total agricultural connections in 2011-12, they have fallen to 5% in 2014-15.

1.5 Tamil Nadu

Table 11: Selected Parameters for Tamil Nadu in 2013-14

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Sales in MU</th>
<th>% of Metered Connections</th>
<th>% of Agricultural Sales in Total Sales</th>
<th>Benchmark Consumption Norm (Unmetered) kWh/hp/annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>TANGEDCO</td>
<td>10,821</td>
<td>0%</td>
<td>18%</td>
<td>923</td>
</tr>
</tbody>
</table>

Source: PEG compilation from various Tamil Nadu tariff orders and petitions, and (CEA, 2015)
A sample of agricultural connections was fitted with meters to arrive at a benchmark pump-set norm. This sample consists of 5% metered connections from every circle. The readings are supposed to be taken every month and hence the norm is revised every year. The projection of future consumption is based on the expected growth in consumers and the connected load in the middle of the year.

**Restatement of Agricultural Consumption and T&D Loss**

Before the present methodology was adopted, TANGEDCO was estimating consumption using another sample of pump-sets, but it was not as representative as the sample used at present. The new methodology, adopted in 2011, yielded different benchmark consumption, which was lower than the norm being used before. This norm and method was used from 2012-13 onwards for estimation and projection of consumption. Table 12 provides the agricultural benchmark norms used for projecting consumption for various years.

**Table 12: Agricultural Benchmark Norm in kWh/hp/annum**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TANGEDCO</td>
<td>1051</td>
<td>1051</td>
<td>1051</td>
<td>1051</td>
<td>951</td>
<td>923</td>
<td>966</td>
</tr>
</tbody>
</table>

Source: PEG compilation from various Tamil Nadu tariff orders.

From Figure 2 we can see the drastic change in agricultural electricity sales and T&D losses in 2010-11. Agricultural sales were lower whereas T&D loss was higher in 2010-11. We can also see that agricultural sales were rising before 2010-11, prior to the sudden reduction that can be attributed to a change in estimation methodology. Agriculture sales reduced from 11,499 MU in 2008-09 to 9410 in 2010-11, and T&D losses went up from 18.14% in 2008-09 to 21.78% in 2010-11. Provisional true-up numbers are considered here as final true-up of DISCOM financials has been done only for the last 5 months. True up is regulatory approval of actuals of certain financial and physical parameters of the DISCOM through a public process. If final trued-up agricultural sales of 9410 MU are taken into account, the sales inflation would be higher at 19%, instead of 17%. Thus the restatement is conservative.

**Figure 2: Agricultural Sales and T&D Loss**

Source: PEG compilation from various tariff orders and (CEA, 2008-2010).

2. (Various Tariff orders)
3. No actual agricultural sales data is available for 2009-10.
1.6 Uttar Pradesh

Table 13: Selected Parameters for Uttar Pradesh in 2012-13

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Sales in MU</th>
<th>% of Metered Connections</th>
<th>% of Agricultural Sales in Total Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVNL, MVNL, Poorv VNL, Pashchim VNL</td>
<td>8192</td>
<td>9%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Source: PEG compilation from various Uttar Pradesh tariff orders and (PFC, 2016).

There are 4 DISCOMs in Uttar Pradesh that have agricultural consumers. The Kanpur Electricity Supply Company Limited (KESCO) does not have any agricultural consumers. These 4 DISCOMs estimate consumption of agricultural consumers using a benchmark consumption norm for pumps, which is common to all DISCOMs. The norm was last revised in 2014 to 1230 kWh/hp/annum from 820 kWh/hp/annum stipulated in 2004 (UPERC, 2016a). The basis for the norm is not available in the public domain.

1.7 Karnataka

Table 14: Selected Parameters for Karnataka DISCOMs in 2014-15

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Sales in MU</th>
<th>% of Agricultural Sales in Total Sales</th>
<th>Benchmark Consumption Norm in kWh/pump-set/annum (Metered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CESC</td>
<td>2294</td>
<td>44%</td>
<td>8195</td>
</tr>
<tr>
<td>MESCOM</td>
<td>1086</td>
<td>26%</td>
<td>4597</td>
</tr>
<tr>
<td>HESCOM</td>
<td>5267</td>
<td>57%</td>
<td>8244</td>
</tr>
<tr>
<td>BESCOM</td>
<td>5930</td>
<td>25%</td>
<td>8284</td>
</tr>
<tr>
<td>GESCOM</td>
<td>2982</td>
<td>49%</td>
<td>9838</td>
</tr>
<tr>
<td>Total</td>
<td>17,559</td>
<td>36%</td>
<td></td>
</tr>
</tbody>
</table>

Source: PEG compilation from various Karnataka tariff orders.

Every DISCOM estimates agricultural consumption differently. However, the KERC has recommended changes in the methodology or a different methodology altogether as elaborated in Table 15.

Table 15: Methodologies for Estimation of Agricultural Consumption in Karnataka DISCOMs

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Estimation of Agricultural Consumption by the DISCOMs</th>
<th>Estimation of Agricultural Consumption as recommended by KERC</th>
</tr>
</thead>
<tbody>
<tr>
<td>CESC</td>
<td>Data from meters on agricultural feeders segregated under Niranthara Jyothi Yojana is used for estimation. The distribution loss assumed was 15% to arrive at the net consumption. This method was adopted in 2016.</td>
<td>The DISCOMs have to deduct the energy losses prevailing in 11 kV lines, DTs &amp; LT Lines after an energy audit, and not make any assumptions about the losses.</td>
</tr>
<tr>
<td>HESCOM, BESCOM, GESCOM</td>
<td>Benchmark pump-set norms computed using sample meter readings of predominantly agricultural DTs are used for estimation. The norm is in the form of kWh/pump-set/annum and is revised every year.</td>
<td>KERC has been directing HESCOM, BESCOM and GESCOM to measure agricultural consumption using meter readings of segregated agricultural feeders and deduct losses after an energy audit (KERC, 2016b).</td>
</tr>
</tbody>
</table>
MESCOM Same as HESCOM, BESCOM and GESCOM

The Commission has directed MESCOM to furnish actual readings of metered pump-sets, in view of substantial progress achieved in metering of IP sets and use it to estimate agricultural consumption (KERC, 2016a, p. 28).

For projecting consumption to future years, the commission uses a norm of kWh/pump-set installation/annum based on latest actual agricultural consumption data and projects the number of pump-set installations. Converting some of them into kWh/hp/annum wherever data on actual or projected average capacity of a pump-set is available, we get the following norms:

Table 16: Benchmark Consumption Norms in Karnataka

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Norms in kWh/installation/annum</th>
<th>Average Pump Capacity</th>
<th>Norms in kWh/hp/annum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013-14</td>
<td>2017-19</td>
<td></td>
</tr>
<tr>
<td>CESC</td>
<td>8195</td>
<td>7843</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1639</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1569</td>
</tr>
<tr>
<td>MESCOM</td>
<td>4597</td>
<td>4280</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No data</td>
</tr>
<tr>
<td>HESCOM</td>
<td>8244</td>
<td>8244</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1467</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1467</td>
</tr>
<tr>
<td>BESCOM</td>
<td>8284</td>
<td>8037</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>828</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>804</td>
</tr>
<tr>
<td>GESCOM</td>
<td>9838</td>
<td>9503</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No data</td>
</tr>
</tbody>
</table>

Source: PEG compilation and calculation from various Karnataka tariff orders.

Issues with Estimation

In CESC in Karnataka, where the feeder-based method is being exercised, the distribution loss was assumed to be 15% without any energy audit. BESCOM and HESCOM have the highest number of agricultural consumers. Paying heed to the comments of many stakeholders about conflation of agricultural consumption with losses, the KERC has issued directives to all DISCOMs to carry out a census of pump-sets. (KERC, 2016b). It is pertinent to note that in spite of segregating a large number of agricultural feeders, BESCOM had not started putting the data on energy drawn by these feeders to use, to arrive at better estimates of agricultural consumption in its petition for tariff revision, until the commission directed it to do so during a technical validation session of the petition data (KERC, 2016c).

Energy Input into Agricultural Feeders

1.8 Punjab

Table 17: Selected Parameters for Punjab in 2013-14

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Sales in MU</th>
<th>% of Metered Connections</th>
<th>% of Agricultural Sales in Total Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSPCL</td>
<td>9191</td>
<td>close to 0%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Source: PEG compilation from various Punjab tariff orders and petitions.
Before the feeder-based agricultural estimation methodology was adopted in 2013, the PSPCL was using a sample of metered agricultural pump-sets (which was 9.3% of the total agricultural consumers as on March 2013), to estimate pump-set benchmark norms. The commission noted that this sample size was very small and there had been no progress in the metering of agricultural consumers to continue use of this methodology.

Currently agricultural consumption is estimated using the feeder methodology and projected using a normative growth rate of 5% on present estimates. The feeder-based method is more robust as more than 99% of rural feeders were already segregated by April 2012, and 96% of total agricultural load is on these exclusive agriculture feeders. Furthermore, when agricultural consumption was estimated using the old methodology of sample metered connections, more than 40% divisions of PSPCL had claimed negative losses from April 2012 to December 2012. Similar trends were observed from the scrutiny of the data for FY 2010-11 and FY 2011-12 (PSERC, 2016, p. 17). This discovery made the switch to the new method essential.

Even before the new methodology for estimation was adopted by the PSERC, it had been taking various measures to ensure the accuracy of the agricultural consumption estimates. In 2002, the PSERC referred to a study by Punjab Agricultural University4 to revise PSPCL’s benchmark norm of 1930 kWh/kw/annum (from sample metered pump-sets) to 1700 kWh/KW/annum (PSERC, 2002). Later, the PSERC conducted voluntary disclosure schemes in Punjab, where depending on the circle, the connected loads disclosed by the farmers were higher by 1.5% to 5% than the load data with the DISCOMs (PSERC, 2009). For determining agricultural consumption for 2007-08, the PSERC appointed an independent agency to study the reliability of data in the sample of metered

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4. From Tariff Order 2002-03 for PSPCL: “The study is being conducted since 1971 for the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. The data is used by the Commission for Agriculture Costs and Prices and the study is based on sampling methodology covering different zones in Punjab on the basis of soil type, cropping pattern and irrigation facilities. Punjab has been divided into three homogeneous zones—(i) Paddy-Wheat-Maize zone (ii) Paddy-Wheat zone (iii) Cotton-Wheat zone. The sampling covers Tehsil, cluster of three villages and individual farmers. The study provides electricity consumption per hectare for wheat, paddy, American cotton and other crops. Based on the area under each of the above crops in a year, the total electricity consumption for the above crops is arrived at.” (PSERC, 2002)
pump-sets, which was used for estimation of agricultural consumption. The study found that even after correcting for the higher pump capacities discovered through the voluntary disclosure scheme, the agricultural sales figures were inflated by 11% by the PSPCL. It had booked consumption higher than what the connected load and supply hours to the sample pump-sets would make possible (PSERC, 2009). The same agency showed that agricultural sales reported by the PSPCL were inflated by 10.2% during the first 3 quarters of 2008-09. Thus the PSERC tempered down the agricultural sales estimates for all of 2008-09 by 10.2% (PSERC, 2010). The same was done for FY 2009-10 (PSERC, 2011, p. 12).

For the new method that is being used at present, the commission differed with PSPCL on the share of agriculture in the total sales on mixed feeders. The PSERC estimated the share of agricultural sales to be 30%, while the PSPCL insisted that the share was 45% based on the share of the bills of unmetered agricultural consumers in the bills of total consumers (PSERC, 2016, pp. 18,20,22). Figure 4 gives the difference in agricultural sales estimates submitted by PSPCL and approved by the commission over the years.

Figure 4: Agriculture Sales of PSPCL in MU

![Agricultural Sales of PSPCL in MU](image)

Source: Various Tariff Orders of PSPCL.

As can be seen from the figure, there is no significant variation in agricultural sales estimates submitted by the PSPCL and those approved by the PSERC after the adoption of the feeder-based method for estimating agricultural consumption from 2010-11 onwards, as the PSERC was keeping a close scrutiny of the agricultural consumption estimation even before that. Even then, there are some issues with the estimation process, and the PSPCL has not been complying with the PSERC directives in this regard.

5. The agency had to: a) determine the connected load based on revised pump-capacity data gathered during voluntary disclosure schemes of the PSPCL and b) verify that consumption by a pump-set does not exceed its maximum consumption given its revised capacity and power supply hours.
Issues with Estimation

1) Distribution losses of 11kV and below

The distribution loss below 11kV is computed based on target total T&d loss for PSPCL for that year. For example, after deducting the actual transmission loss of 2.5% from the T&d loss target of 17% for 2013-14, the distribution loss was calculated to be 15.2%. The loss in the distribution system above 11kV was subtracted from this to arrive at the loss of 11 kV and below—as 12.2% (PSERC, 2016, p. 75). But the T&d loss, after reestimating agricultural consumption, was estimated to be higher at 19.2% (PSERC, 2016, p. 80). Thus the loss below 11kV would be higher than 12.2%. The PSPCL has repeatedly failed to carry out an energy audit of 11kV feeders in spite of the PSERC’s directives.

2) Faulty agricultural feeder data entry

Data on energy pumped into agricultural feeders was entered on an average basis for a substantial number of feeders. The PSPCL booked 373 MU on average basis during 2013-14 and 517 MU during 2014-15, claiming that meters were faulty. After a detailed examination of the matter, it was observed that PSPCL booked excess energy to the tune of 34.6% of the average energy booked for 2013-14. The commission thus decided to reduce the input energy on the feeder booked on an average basis by 34.6% during FY 2013-14 and 2014-15. In most cases, average units were booked on agricultural feeders to keep 11 kV bus bar losses at the grid sub-stations below 1% (PSERC, 2016, pp. 72-73).

1.9 Haryana

Table 18: Selected Parameters for Haryana DISCOMs in 2014-15

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Sales in MU</th>
<th>% of Metered Connections</th>
<th>% of Agricultural Sales in Total Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHBVNL</td>
<td>4042</td>
<td>52%</td>
<td>20%</td>
</tr>
<tr>
<td>DHBVNL</td>
<td>4664</td>
<td>69%</td>
<td>18%</td>
</tr>
</tbody>
</table>

Source: PEG compilation from various Haryana tariff orders and petitions.

Haryana DISCOMs claim that they have not released unmetered connections since 2000 (HERC, 2010, p. 40). The DISCOMs segregated their rural feeders in the year 2009-10, after which they started estimating agricultural consumption using data on energy pumped in agricultural feeders.

Before 2011, unmetered consumption was estimated on the basis of the average load factor of the metered consumption. Projections were done on trends in growth in load factor, average connected load in the past, and supply hours to metered and unmetered consumers (HERC, 2008, p. 47). Line losses below the 11kV feeder are calculated as the difference between energy input and energy billed, presumably for metered consumers.

Restatement of Agricultural Sales and Distribution Loss after Change in Methodology

Although there was no official restatement, after the adoption of the new methodology using feeder meter data, the agricultural sales of UHBVNL for 2010-11 fell by 34% from the levels in

---

6. When meters are faulty or the readings are not recorded, an average of past meter readings of the pump-set/feeder is considered.
As can be seen in the figures, there is a sharp decline in sales and rise in loss during the period of restatement, in contrast to the trend before when agricultural sales were rising and loss was falling. In fact, when the UHBVNL was asked about its drastic increase in distribution loss in 2010-11, the DISCOM itself admitted the reason to be the adoption of the feeder-based method (UHBVNL, 2013, p. 14) (HERC, 2015a, p. 54).

Figure 5: Agricultural Sales and Distribution Loss: UHBVNL

Figure 6: Agricultural Sales and Distribution Loss: DHBVNL

As can be seen in the figures, there is a sharp decline in sales and rise in loss during the period of restatement, in contrast to the trend before when agricultural sales were rising and loss was falling. In fact, when the UHBVNL was asked about its drastic increase in distribution loss in 2010-11, the DISCOM itself admitted the reason to be the adoption of the feeder-based method (UHBVNL, 2013, p. 14) (HERC, 2015a, p. 54).
Benchmark Consumption Norms of Distribution Transformers

1.10 Andhra Pradesh and Telangana

Table 19 gives the selected parameters for erstwhile undivided Andhra Pradesh in 2013-14, as Telangana state came into existence in 2014. After the division of Andhra Pradesh into the two states, the DISCOMs were also divided between them. Today Andhra Pradesh has two DISCOMs: the Southern Power Distribution Company of Andhra Pradesh Limited (APSPDCL) and the Eastern Power Distribution Company of Andhra Pradesh Limited (APEPDCL), while Telangana has the Southern Power Distribution Company of Telangana Limited (TSSPDCL) and the Northern Power Distribution Company of Telangana Limited (TSNPDCL).

Table 19: Selected Parameters for Erstwhile Undivided Andhra Pradesh DISCOMs in 2013-14

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Agricultural Sales in MU</th>
<th>% of Metered Connections</th>
<th>% of Agricultural Sales in Total Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>APSPDCL, APEPDCL, APNPDCCL, APCPDCL</td>
<td>20,817</td>
<td>Close to 0%</td>
<td>28%</td>
</tr>
</tbody>
</table>

Source: PEG compilation from various Andhra Pradesh tariff orders, petitions, (CEA, 2015) and (PFC, 2016).

Almost all pump-sets in Andhra Pradesh and Telangana are unmetered. The APSPDCL, which has higher agricultural sales and more consumers, has 8 lakh unmetered agricultural connections as of March 2014, which constitute 96% of total agricultural connections of the APSPDCL (ASPDCL, 2015). Earlier in the APEPDCL, benchmark pump-set norms were computed using meter readings from a sample of predominantly agricultural DTs, line losses below the DT, and connected load on these DTs in each revenue mandal7. This norm and the total connected load in each mandal were used to arrive at the mandal-wise agricultural consumption, which were aggregated to DISCOM-wide consumption (APERC, 2016). However, the Andhra Pradesh electricity regulatory commission (APERC) recommended a methodology devised by the Indian Statistical Institute, Hyderabad (ISI-hence called the ISI methodology) and approved by the APERC in 2009-10. This method computes a DT level benchmark norm for DTs of every capacity from a sample of agricultural DTs, and extrapolates this to all the DTs for each capacity. This method is not sensitive to the number of agricultural pump-sets below the DT, or the total number of pump-sets. Both the APSPDCL and APEPDCL have recently made a transition to this methodology (APERC, 2017).

Issues with Estimation

• The share of invalid DT meter readings has been high. Valid here means that the DT meter is working and meter readings are available throughout the year. The share of such valid meter readings in sample meter readings was 49% and 37% from November 2004 to October 2005 in the APEPDCL and APSPDCL respectively (APERC, 2006, pp. 210,262). This deteriorated further, with valid readings being only 6% from October 2012 to September 2013 in the APSPDCL. Thus only 1.7% of total pump-sets were accounted for in the sample during this period. (APSPDCL, 2014). Thus, the APERC directive issued in 2006 for the percentage of valid meter readings to be 50% (Tariff Order 2006-07) does not seem to have been followed.

• The consumption norms for the present methodology used by the DISCOMs are not available in the public domain. All four DISCOMs of Andhra Pradesh and Telangana have switched over to the ISI methodology.

7. Mandal is equivalent of 'block' in English
2. Impact of Restatement of Agricultural Sales and Loss

A lower estimate of agricultural electricity sales implies higher distribution loss. If efforts are made to reduce the loss to the level earlier reported by the DISCOM before restatement of loss, the extra electricity available can be sold to paying consumers. This is actually a foregone revenue to the DISCOM. We use the average billing rate (ABR)\(^8\) and the restated loss to quantify this foregone revenue for states where agricultural sales and distribution loss have undergone recent restatement: Maharashtra, Tamil Nadu, Punjab and Haryana.\(^9\) These states have seen a restatement because of a change in the methodologies of agricultural consumption estimation.

Table 20: Financial Impact of Restatement

<table>
<thead>
<tr>
<th>DISCOM</th>
<th>Year</th>
<th>Quantum of Higher Distribution Loss in MU</th>
<th>Sales Revenue Foregone in Rs Cr</th>
<th>Revenue Foregone as % of Total Revenue from Sale of Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSEDCL</td>
<td>2014-15</td>
<td>2414</td>
<td>1139</td>
<td>3%</td>
</tr>
<tr>
<td>TANGEDCO</td>
<td>2010-11</td>
<td>3444</td>
<td>872</td>
<td>5%</td>
</tr>
<tr>
<td>PSPCL</td>
<td>2010-11</td>
<td>560</td>
<td>140</td>
<td>1%</td>
</tr>
<tr>
<td>UHBVNL</td>
<td>2010-11</td>
<td>1423</td>
<td>367</td>
<td>12%</td>
</tr>
</tbody>
</table>

2.1 Maharashtra

The impact of restatement can be quantified by comparing MSEDCL's estimates of distribution loss using the old methodology of agricultural consumption estimation with MERC's estimates of the same through the revised methodology of estimation.

Table 21: Sales Revenue Foregone in Maharashtra in 2014-15

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Calculation</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSEDCL Distribution Loss in % (old methodology)</td>
<td></td>
<td>14.17%</td>
</tr>
<tr>
<td>Actual Distribution Loss in % (revised methodology)</td>
<td></td>
<td>16.36%</td>
</tr>
<tr>
<td>MSEDCL Distribution Loss in MU (old methodology)</td>
<td>(A)</td>
<td>15,653</td>
</tr>
<tr>
<td>Actual Distribution Loss in MU (revised methodology)</td>
<td>(B)</td>
<td>18,067</td>
</tr>
<tr>
<td>Restated Distribution Loss in MU</td>
<td>C=(A-B)</td>
<td>2414</td>
</tr>
<tr>
<td>ABR in Rs/kWh</td>
<td>(D)</td>
<td>4.12</td>
</tr>
<tr>
<td>Sales Revenue Foregone in Rs Cr</td>
<td>E=C*D/10</td>
<td>1139</td>
</tr>
</tbody>
</table>

Source: PEG calculation from (MERC, 2016). Note that AG stands for agriculture.

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8. ABR is the average billing rate or the revenue per unit of sale of power. ABRs of all states here are after/excluding subsidy.

9. This is one way of quantifying it. There can be other ways as well, like looking at the avoided power purchase cost which can give even greater numbers for the effect of restatement. But since power purchase is a function of many other factors, and for the sake of consistency across states, revenue foregone has been calculated. Regulatory treatment of restatement can differ across states.
SERCs set targets for distribution loss, and if these targets are not met, a higher financial loss is incurred than anticipated. Multi-Year Tariff (MYT) regulations\(^{10}\) in Maharashtra state that distribution losses are controllable expenses, and that only a third of the loss incurred due to actual distribution losses being higher than targets by the commission, can be passed onto the consumers in the form of higher tariffs (MERC, 2011). The rest has to be borne by MSEDCL. Financial losses due to uncontrollable factors like subsidised agricultural sales, on the other hand, can be passed onto consumers. Had there been no restatement, the inflated agricultural sales would not have been recognised as a distribution loss and the consumers would have had to bear this loss.

### 2.2 Tamil Nadu

The impact of restatement can be quantified by comparing TANGEDCO's projections of distribution loss using the old methodology of agricultural consumption estimation with its estimates of the actuals through the new methodology, both approved by the commission.

#### Table 22: Sales Revenue Foregone in Tamil Nadu in 2010-11

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Calculation</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution Loss in % (old methodology)</td>
<td></td>
<td>17.60%</td>
</tr>
<tr>
<td>Actual Distribution Loss in % (new methodology)</td>
<td></td>
<td>21.78%</td>
</tr>
<tr>
<td>Distribution Losses in MU (new methodology)</td>
<td>(A)</td>
<td>14,981</td>
</tr>
<tr>
<td>Actual Distribution Loss in MU (old methodology)</td>
<td>(B)</td>
<td>12,176</td>
</tr>
<tr>
<td>Restated Distribution Loss in MU</td>
<td>C=(A-B)</td>
<td>2805</td>
</tr>
<tr>
<td>ABR in Rs/kWh</td>
<td>(D)</td>
<td>3.1</td>
</tr>
<tr>
<td>Sales Revenue Foregone in Rs Cr</td>
<td>E=C*D/10</td>
<td>872</td>
</tr>
</tbody>
</table>

Source: PEG Calculation from (TNERC, 2010) and (TNERC, 2012).

MYT regulations of TNERC, similar to Maharashtra, state that 50% of expenses incurred because T&D loss targets were not achieved can be passed through to consumers, and the rest have to be absorbed by TANGEDCO (TNERC, 2009).

### 2.3 Punjab

The PSPCL submitted agricultural sales for 2010-11 using the old methodology, whereas the PSERC estimated these using the new methodology resulting in restatement. The PSERC has been routinely revising agricultural sales, thus the restatement in 2010-11 is not as noteworthy as in the case of other states.

#### Table 23: Sales Revenue Foregone in Punjab in 2010-11

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Calculation</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSPCL T&amp;D Losses in % (old methodology)</td>
<td>(A)</td>
<td>17.98%</td>
</tr>
<tr>
<td>Actual T&amp;D Losses in % (new methodology)</td>
<td>(B)</td>
<td>19.13%</td>
</tr>
<tr>
<td>Actual Energy Input in MU</td>
<td>(C)</td>
<td>39,875</td>
</tr>
</tbody>
</table>

10. DISCOMs project their expenditure and revenue for the next 5 years which is approved by the SERCs, in order to bring stability and predictive power to tariff setting.
According to the PSERC Tariff Regulations, financial loss on account of distribution loss being higher than the target has to be fully borne by the DISCOM.

### 2.4 Haryana

The revision in agricultural sales and loss can be seen after comparing the UHBVNL's estimates using the old methodology with the HERC's estimates using the new methodology.

Table 24: Sales Revenue Foregone in UHBVNL in 2010-11

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Calculation</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHBVNL ’s Distribution Loss in % (old methodology)</td>
<td>(A)</td>
<td>33%</td>
</tr>
<tr>
<td>Actual Distribution Loss in % (new methodology)</td>
<td>(B)</td>
<td>24%</td>
</tr>
<tr>
<td>UHBVNL Distribution Loss in MU</td>
<td>(C)</td>
<td>3606</td>
</tr>
<tr>
<td>Actual Distribution Loss in MU</td>
<td>(D)</td>
<td>5029</td>
</tr>
<tr>
<td>Restated Distribution Loss in MU</td>
<td>E=(D-C)</td>
<td>1415</td>
</tr>
<tr>
<td>ABR in Rs/kWh</td>
<td>(F)</td>
<td>2.6</td>
</tr>
<tr>
<td>Sales Revenue foregone in Rs Cr</td>
<td>G=F*E/10</td>
<td>367</td>
</tr>
</tbody>
</table>

Source: PEG calculation from (HERC, 2012a), (UHBVNL, 2011)
3. Determination of Agricultural Electricity Tariff

The process of determination of agricultural tariffs differs from state to state. The SERC decides agricultural tariff on the basis of the available cross-subsidy, and the state government announces subsidy on this tariff, which helps to keep the tariff to the farmer low. This is done in Rajasthan, Madhya Pradesh and Maharashtra. For example, in Rajasthan, the tariff decided by the SERC for general agricultural consumers for FY 2014-15 was Rs 4.50 /kWh and Rs 600/hp/month in the case of metered and unmetered consumers respectively. The subsidy promised by the Rajasthan government was Rs 3.60/kWh and Rs 515/hp/month, and hence the tariff to the farmer was Rs 0.9/kWh and Rs 85/hp/month (RERC, 2016, p. 171). In Punjab, Andhra Pradesh, Tamil Nadu and Karnataka (for pumps below 10 hp, which covers most pump-sets) the tariff determination is similar. However the state government subsidises the entire tariff as determined by the SERC to provide free power to agricultural consumers in these states. For example, the PSERC in Punjab had determined agricultural tariff at Rs 4.58/kWh for 2016-17, and the payment of this tariff came from the state government (PSERC, 2017, p. 137). In Haryana and Uttar Pradesh, as there is no cross-subsidy for agricultural consumers, the state government provides the entire subsidy for concessional tariffs to agriculture (HERC, 2017, pp. 246-7; UPERC, 2016b, p. 114). The corresponding process in Gujarat is described in Box 3 in Section 3.1 of the main discussion paper (Vol 2). Thus, there is no clearly stated underlying rationale to the level of subsidy provided by the state governments to agricultural consumers (For example, there are no studies which assess the level of subsidy required for farmers ).
Electricity powered agriculture pump-sets are the mainstay for agriculture in many states. But this area has many challenges for the farmer, DISCOM and the state government. Farmers invest heavily in well-based irrigation, but are unhappy with the poor quality of electricity supply. The DISCOM is unhappy with the low revenue from a large number of consumers spread over a large area. The state has to bear the subsidy burden to support a low tariff for the farmers. This can be as high as Rs 15,000-20,000/pump-set/year.

Solar power offers some hope by way of providing quality electricity supply during the day time, which is convenient to the farmer. The DISCOM also finds it attractive since it reduces the burden to allocate costly generation capacity for agriculture. It is environment friendly and reduces distribution losses, if solar generation is closer to the pump-set locations.

There are three possible solar options for agriculture pumping—large centralised solar plants, solar powered agriculture feeders, and solar pump-sets. All options need to be encouraged, but prioritised based on the strength and weakness of each option in different circumstances. Solar pump-sets are being promoted by the central government and many state governments, but their offtake has been slow. Large scale solar plants have been increasing and are a welcome addition to the power supply options. But for agriculture supply, especially in states where water has to be pumped from great depths, we feel that solar powered agriculture feeders are a more farmer-centric and equitable option. In addition, the investment burden on the government is lower, the quality of supply is better, and maintenance is easier. In this option, all the pump-sets on a 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 substation, so that when required power can be drawn, and if solar power generation is high, it can be exported to the grid.

There are several potential benefits from this approach, both qualitative and quantitative, as briefly described below:

- Assured and reliable hours of supply to agriculture in day time.
- Improved quality of supply (better voltage profiles and fewer interruptions) resulting in potentially less pump burn outs.
- The solar agriculture feeder option is significantly more cost-effective and manageable as compared to individual solar pumps. For the farmer, the challenges of safety and security associated with solar pump-sets are not an issue in this option.
- Replacement of existing in-efficient pumps with 5-star efficiency pumps which can reduce power requirement by 30-40 per cent), can make the scheme even more cost effective. That can bring down the effective cost of solar power for agriculture by about 25 per cent, after accounting for the cost of new pumps.
- 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.

Solar feeder is thus an investment programme with good returns, compared to the subsidy driven solar pump-set programme, with the central government providing 30-40% and state
governments providing 40-50% capital subsidy. The solar agriculture feeder idea was suggested by Prayas in 2014-15 (PEG, 2015) and discussed in Maharashtra, Gujarat and Andhra Pradesh. Two pilot projects in Ahmednagar and Solapur districts of Maharashtra are being planned in 2016 (MAHAGENCO, 2016; MAHAGENCO, 2016). Tariff quoted in these pilot projects is very attractive, lower than Rs 3/unit. The government of India recently announced a scheme for solar power for agriculture which includes plans for grid connected solar plants of up to 2 MW capacity along with off-grid solar irrigation pumps (PIB, 2018). In addition to this, the MSEDCL has recently invited bids for procurement of power from 2 MW to 10 MW capacity solar power projects to be developed in 218 talukas over 20 districts in Maharashtra under the ‘Mukhyamantri Saur Krushi Vahini Yojana’ of the Maharashtra government. The total capacity of these projects will be around 1000 MW (MSEDCL, 2018).
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### 6. List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ABR</td>
<td>Average Billing Rate</td>
</tr>
<tr>
<td>ACoS</td>
<td>Average Cost of Supply</td>
</tr>
<tr>
<td>AP</td>
<td>Andhra Pradesh</td>
</tr>
<tr>
<td>APEPDCL</td>
<td>Eastern Power Distribution Company of Andhra Pradesh Limited</td>
</tr>
<tr>
<td>APERC</td>
<td>Andhra Pradesh Electricity Regulatory Commission</td>
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<tr>
<td>APSPDCL</td>
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<tr>
<td>ARR</td>
<td>Aggregate Revenue Requirement</td>
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<tr>
<td>AT&amp;C Losses</td>
<td>Aggregate Technical and Commercial Losses</td>
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<tr>
<td>AVVNCL</td>
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<tr>
<td>BEE</td>
<td>Bureau of Energy Efficiency</td>
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<tr>
<td>BESCOM</td>
<td>Bangalore Electricity Supply Company Limited</td>
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<tr>
<td>BU</td>
<td>Billion Units</td>
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<tr>
<td>CACP</td>
<td>Commission for Agricultural Costs and Prices</td>
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<tr>
<td>CAG</td>
<td>Comptroller and Auditor General of India</td>
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<td>CEA</td>
<td>Central Electricity Authority</td>
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<td>Chamundeshwari Electricity Supply Corporation Limited</td>
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<td>CGWB</td>
<td>Central Groundwater Board</td>
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<td>Crore</td>
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<td>Directorate of Economics and Statistics</td>
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<td>Energy Efficiency Services Limited</td>
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<tr>
<td>kW</td>
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<td>Prayas (Energy Group)</td>
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<td>Power Finance Corporation</td>
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<td>Transmission and Distribution</td>
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<td>Tamil Nadu Generation and Distribution Corporation</td>
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