Annexure

Understanding the Electricity, Water, Agriculture Linkages

Volume 2: Electricity Supply Challenges

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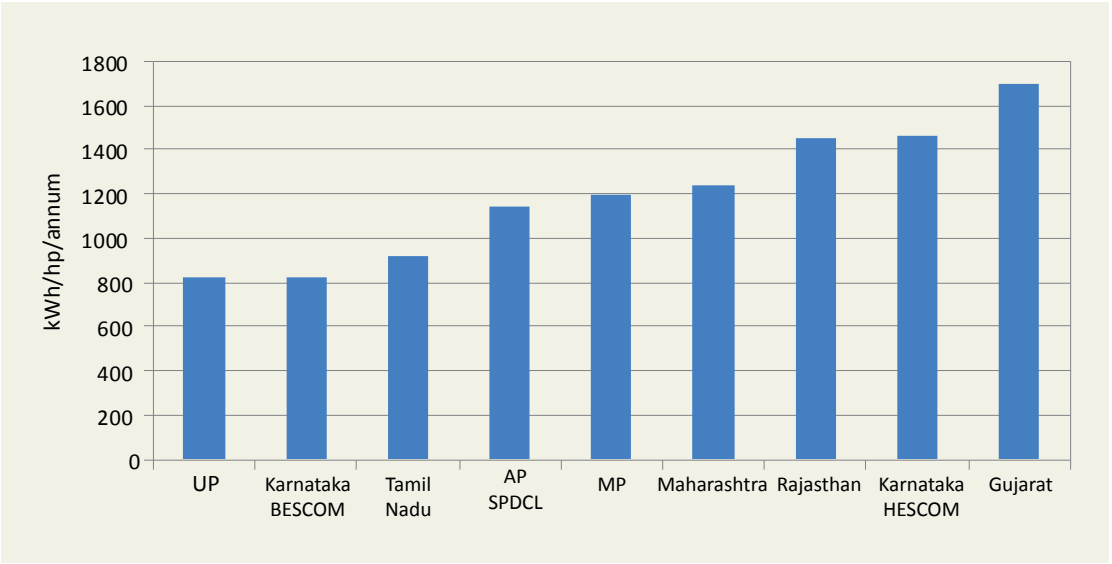
1. State Details of Agricultural Power Estimation

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

DISCOM	Agricultural Electricity Sales in MU	% of Metered Connections	% of Agricultural Sales in Total Sales	Benchmark Consumption Norm (Unmetered) kWh/ hp/annum	Distribution Loss
MSEDCL	23271	58%	25%	1,242	16%

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

1999-2000 to 2006	2006-07 to 2016	In 2016
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)	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.	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.

Table 3: Timeline of Agricultural Consumption Estimation in MSEDCL

Agricultural consumption and loss restatement of MSEB in 1999-2000	After the MERC was set up in 1999, agricultural electricity sales and T&D loss were restated. Agricultural sales went down from 27% to 16% of total sales and T&D 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.
Agricultural consumption and loss revision for 2006-07	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)
2006-07 to 2016	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.
Agricultural consumption and loss restatement for FY 2014-15	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 4: Revision of Agricultural Electricity Consumption and Distribution Loss of MSEDCL over the Years

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

1.2 Gujarat

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

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

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

DISCOM	Type	2009-10	2011-12 to 2013-14	2014-15	2015-16
UGVCL	Metered	650	970	992	992
MGVCL			1011	954	954
DGVCL			524	541	541
PGVCL		650	529	616	616
DISCOMs	Unmetered	1700	1700	1700	1700

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.[1]

1.3 Rajasthan

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

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

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.

1. 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.

Table 8: Agricultural Benchmark Consumption Norm in kWh/hp/annum

DISCOM/Year	2006-07	2009-10	2012-13	2014-15
		Metered		
JVVNL	No data	1268	1883	2317
AVVNL	1018	988	1475	1986
JdVVNL	865	1302	1429	2079
		Unmetered		
JVVNL	No data	1450	1450	1450
AVVNL	1450	1450	1450	1450
JdVVNL	1450	1450	1450	1450

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

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

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

	Period	Units	2009-10	2012-13
Permanent	April to July—4 months	kWh/hp/month	100	50
	August to September—2 months	kWh/hp/month	40	50
	October to March—6 months	kWh/hp/month	120	150
	Total 12 months	kWh/hp/annum	1200	1200
Temporary	April to July—4 months	kWh/hp/month	130	155
	August to September—2 months	kWh/hp/month	155	155
	October to March—6 months	kWh/hp/month	155	155
	Total 12 months	kWh/hp/annum	1760	1860

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

DISCOM	Agricultural Sales in MU	% of Metered Connections	% of Agricultural Sales in Total Sales	Benchmark Consumption Norm (Unmetered) kWh/hp/annum
TANGEDCO	10,821	0%	18%	923

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.

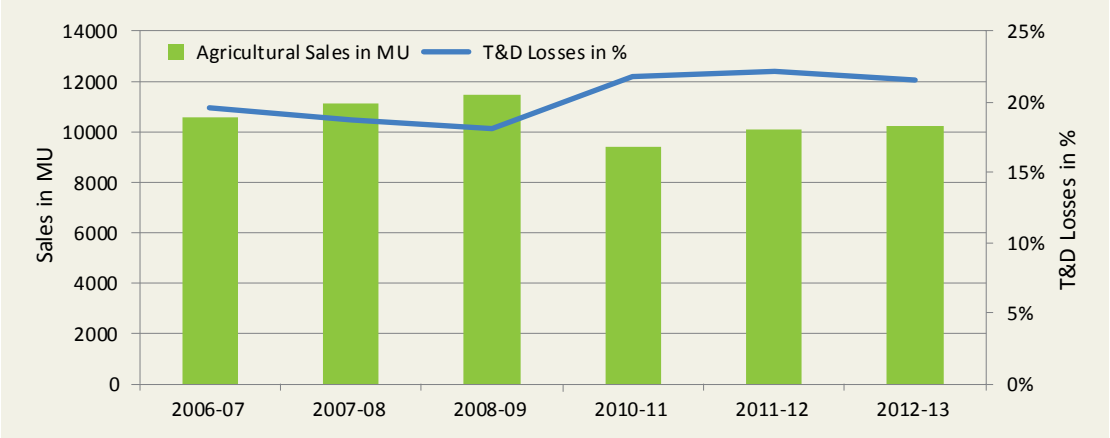
Table 12: Agricultural Benchmark Norm in kWh/hp/annum[2]

Year	2003-04	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
TANGEDCO	1051	1051	1051	1051	951	923	966

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.[3] 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

DISCOM	Agricultural Sales in MU	% of Metered Connections	% of Agricultural Sales in Total Sales
DVVNL, MVVNL, Poorv VVNL, Pashchim VVNL	8192	9%	16%

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

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

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

DISCOM	Estimation of Agricultural Consumption by the DISCOMs	Estimation of Agricultural Consumption as recommended by KERC
CESC	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.	The DISCOMs have to deduct the energy losses prevailing in 11 kV lines, DTs & LT Lines after an energy audit, and not make any assumptions about the losses.
HESCOM, BESCOM, GESCOM	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.	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).

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

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

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

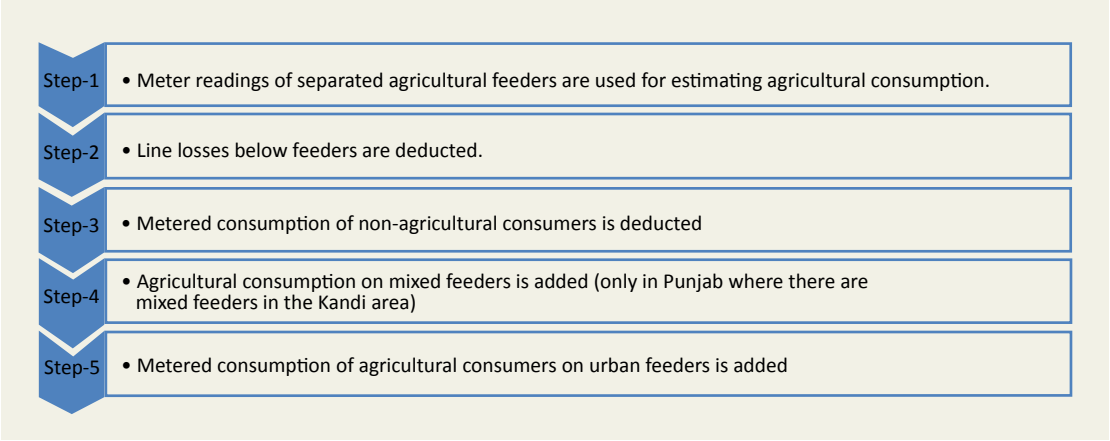
Table 17: Selected Parameters for Punjab in 2013-14

DISCOM	Agricultural Sales in MU	% of Metered Connections	% of Agricultural Sales in Total Sales
PSPCL	9191	close to 0%	25%

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

There is only one DISCOM in Punjab, namely PSPCL. The methodology for agricultural consumption estimation is the same in Punjab and Haryana. It as follows:

Figure 3: Agricultural Consumption Estimation in Punjab and Haryana



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.

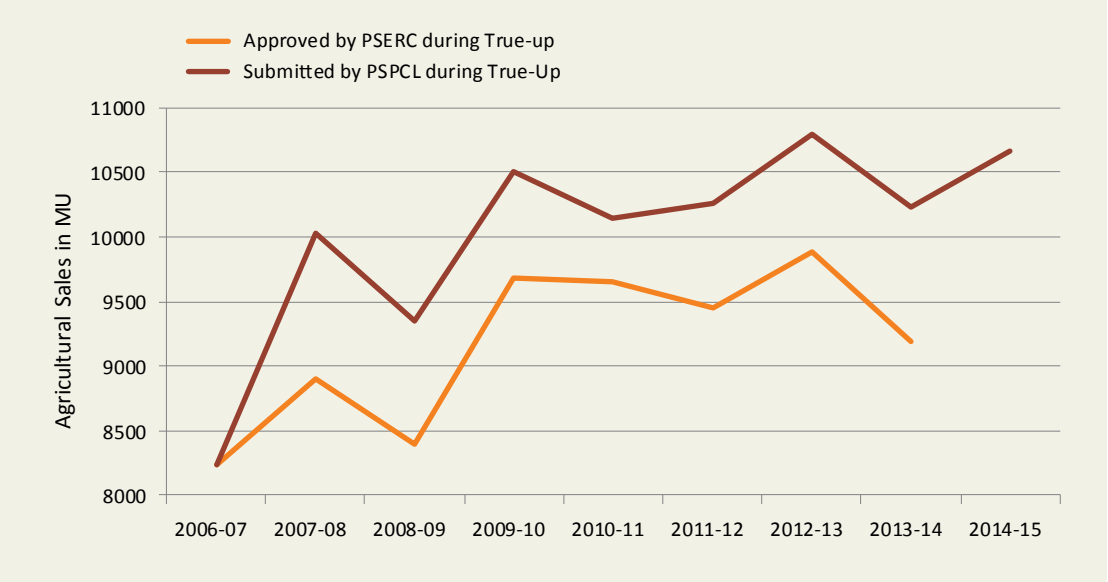
Even before the new methodology for estimation was adopted by the PSERC, it had been taking various measures to ensure the accuracy of the agricultural consumption estimates. In 2002, the PSERC referred to a study by Punjab Agricultural University[4] to revise PSPCL's benchmark norm of 1930 kWh/kw/annum (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

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.[5] The study found that even after correcting for the higher pump capacities discovered though 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



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[6] 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

DISCOM	Agricultural Sales in MU	% of Metered Connections	% of Agricultural Sales in Total Sales
UHBVNL	4042	52%	20%
DHBVNL	4664	69%	18%

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.

2009-10. The corresponding distribution losses went up from 25.9% in 2009-10 to 33.3% in 2010-11 (HERC, 2016, p. 185). The DHBVNL also saw an unexplained fall in agricultural sales, and a higher distribution loss at 24% than what was projected using the old methodology (22.9%) (HERC, 2012b, p. 134). The UHBVNL had greater agricultural sales than the DHBVNL in 2010-11, and thus it shows the sharpest change in the two parameters. Figure 5 and Figure 6 show agricultural sales and distribution loss over the years, and the sudden change in them in 2010-11.

Figure 5: Agricultural Sales and Distribution Loss: UHBVNL

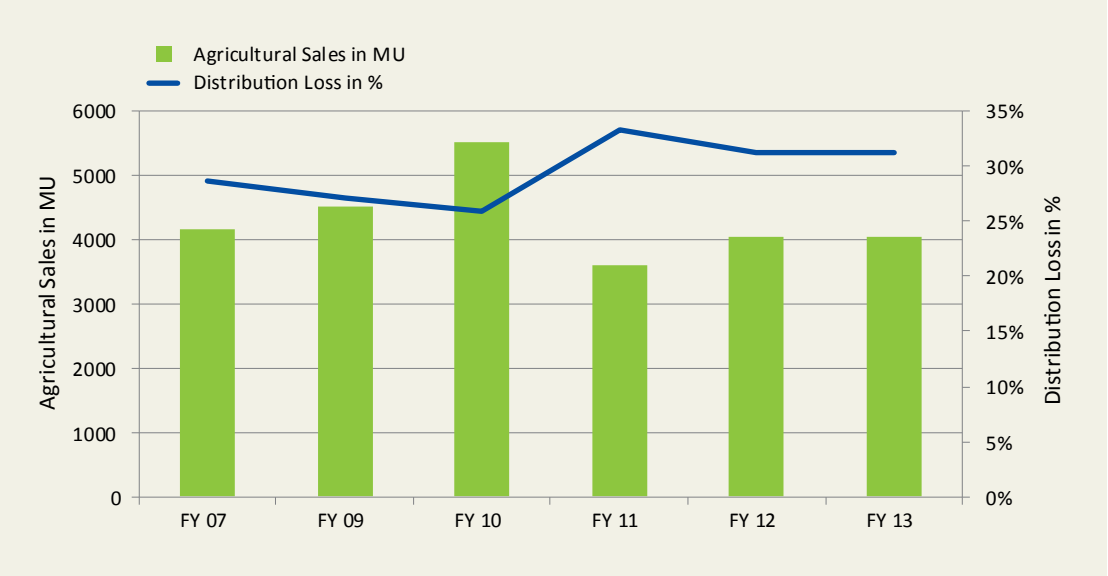
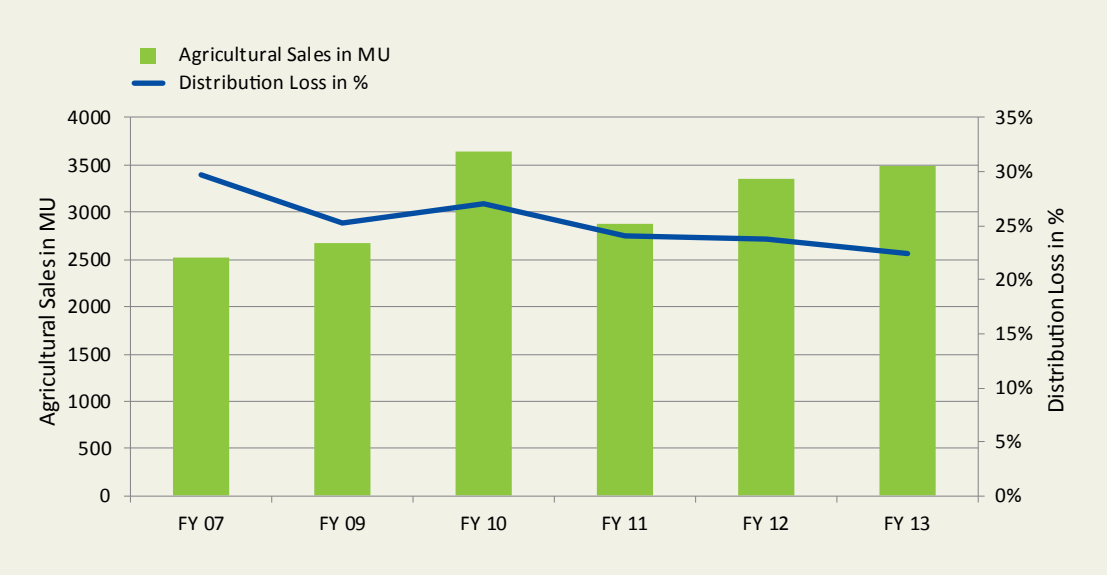


Figure 6: Agricultural Sales and Distribution Loss: DHBVNL



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).

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

DISCOM	Agricultural Sales in MU	% of Metered Connections	% of Agricultural Sales in Total Sales
APSPDCL, APEPDCL, APNPDCL, APCPDCL	20,817	Close to 0%	28%

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 mandal[7]. 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

Impact of Restatement of Agricultural Sales				
DISCOM	**Year**	**Quantum of Higher Distribution Loss in MU**	**Sales Revenue Foregone in Rs Cr**	**Revenue Foregone as % of Total Revenue from Sale of Power**
MSEDCL	2014-15	2414	1139	3%
TANGEDCO	2010-11	3444	872	5%
PSPCL	2010-11	560	140	1%
UHBVNL	2010-11	1423	367	12%

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

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

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

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

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

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

Particulars	Calculation	Values
PSPCL T&D Losses in % (old methodology)	(A)	17.98%
Actual T&D Losses in % (new methodology)	(B)	19.13%
Actual Energy Input in MU	(C)	39,875

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.

PSPCL T&D Losses in MU	D=A*C	7170
Actual T&D Losses in MU	E=B*C	7629
Restated Distribution Loss in MU	F=(E-D)	459
ABR in Rs/kWh	(G)	3.05
Sales Revenue Foregone in Rs Cr	H=F*G/10	140

Source: PEG calculation from (PSERC, 2014)

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

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

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).

4. Solar Agricultural Feeder

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

ABR	Average Billing Rate
ACoS	Average Cost of Supply
AP	Andhra Pradesh
APEPDCL	Eastern Power Distribution Company of Andhra Pradesh Limited
APERC	Andhra Pradesh Electricity Regulatory Commission
APSPDCL	Southern Power Distribution Company of Andhra Pradesh Limited
ARR	Aggregate Revenue Requirement
AT&C Losses	Aggregate Technical and Commercial Losses
AVVNL	Ajmer Vidyut Vitran Nigam Limited (Ajmer DISCOM)
BEE	Bureau of Energy Efficiency
BESCOM	Bangalore Electricity Supply Company Limited
BU	Billion Units
CACP	Commission for Agricultural Costs and Prices
CAG	Comptroller and Auditor General of India
CEA	Central Electricity Authority
CESC	Chamundeshwari Electricity Supply Corporation Limited
CGWB	Central Groundwater Board
Cr	Crore
DES	Directorate of Economics and Statistics
DHBVNL	Dakshin Haryana Bijli Vitran Nigam Limited
DISCOM	Distribution Company
DT	Distribution Transformer
DVVNL	Dakshinanchal Vidyut Vitran Nigam Ltd
EESL	Energy Efficiency Services Limited
FY	Financial Year
GERC	Gujarat Electricity Regulatory Commission
GESCOM	Gulbarga Electricity Supply Company Limited
GoH	Government of Haryana
HERC	Haryana Electricity Regulatory Commission
HESCOM	Hubli Electricity Supply Company Limited
HT	High Tension
JdVVNL	Jodhpur Vidyut Vitran Nigam Limited (Jodhpur DISCOM)
JVVNL	Jaipur Vidyut Vitran Nigam Limited (Jaipur DISCOM)
KEB	Karnataka Electricity Board
KERC	Karnataka Electricity Regulatory Commission
kW	Kilo-Watt
kWh	Kilo-watt hour
LT	Low Tension
MERC	Maharashtra Electricity Regulatory Commission
MESCOM	Mangalore Electricity Supply Company Limited
MI	Minor Irrigation
MP	Madhya Pradesh
MoP	Ministry of Power
MPSEB	Madhya Pradesh State Electricity Board
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MT	Million Tonnes
MU	Million Units
MW	Mega Watt
MYT	Multi-Year Tariff
MVVCL	Madhyanchal Vidyut Vitran Nigam Limited
PEG	Prayas (Energy Group)
PFC	Power Finance Corporation

PSERC	Punjab State Electricity Regulatory Commission
PSPCL	Punjab State Power Corporation Limited
PSU	Public Sector Undertakings
PuVVNL	Purvanchal Vidyut Vitaran Nigam Limited
PVVNL	Pashchimanchal Vidyut Vitran Nigam Ltd.
RBI	Reserve Bank of India
RERC	Rajasthan Electricity Regulatory Commission
SEB	State Electricity Board
SERC	State Electricity Regulatory Commission
ToD	Time of Day
T&D	Transmission and Distribution
TANGEDCO	Tamil Nadu Generation and Distribution Corporation
TNERC	Tamil Nadu Electricity Regulatory Commission
TSERC	Telangana State Electricity Regulatory Commission
TSNPDCL	Northern Power Distribution Company of Telangana Limited
TSSPDCL	Southern Power Distribution Company of Telangana Limited
UDAY	Ujwal Discom Assurance Yojana
UHBVNL	Uttar Haryana Bijli Vitran Nigam Limited
UP	Uttar Pradesh
UPERC	Uttar Pradesh Electricity Regulatory Commission
UPPCL	Uttar Pradesh Power Corporation Limited