# MINI-GRIDS IN UTTAR PRADESH
## POLICY LESSONS

A Centre for Science and Environment report

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## POLICY LESSONS

**A Centre for Science and Environment report**

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# Abbreviations

| | |
|---|---|
| AT&C | Aggregate technical and commercial |
| BU | Billion units |
| BM | Built-maintain |
| BOOM | Built-own-operate-maintain |
| CAGR | Compound annual growth rate |
| CEA | Central Electricity Authority |
| CELAMeD | Community engagement, load acquisition, and micro-enterprise development |
| CSR | Corporate social responsibility |
| DDG | Decentralised distributed generation |
| DDUGJY | Deen Dayal Upadhyaya Gram Jyoti Yojana |
| Dicoms | Distribution utilities |
| FiT | Feed-in-tariff |
| IPP | Independent power producer |
| KUSUM | Kisan Urja Suraksha Evam Utthaan Mahaabhiyan |
| LED | Light-emitting diode |
| MNRE | Ministry of New and Renewable Energy |
| O&M | Operations and maintenance |
| PCC | Portland cement concrete |
| PFC | Power Finance Corporation |
| PND | Power distribution network |
| PPA | Power purchase agreement |
| PVC | Polyvinyl chloride |
| RGGVY | Rajiv Gandhi Grameen Vidyutikaran Yojana |
| UDAY | Ujwal Discom Assurance Yojana |
| UPERC | Uttar Pradesh Electricity Regulatory Commission |
| UPNEDA | Uttar Pradesh New and Renewable Energy Development Agency |
| UPPCL | Uttar Pradesh Power Corporation Limited |
| UPSLDC | Uttar Pradesh State Load Despatch Centre |

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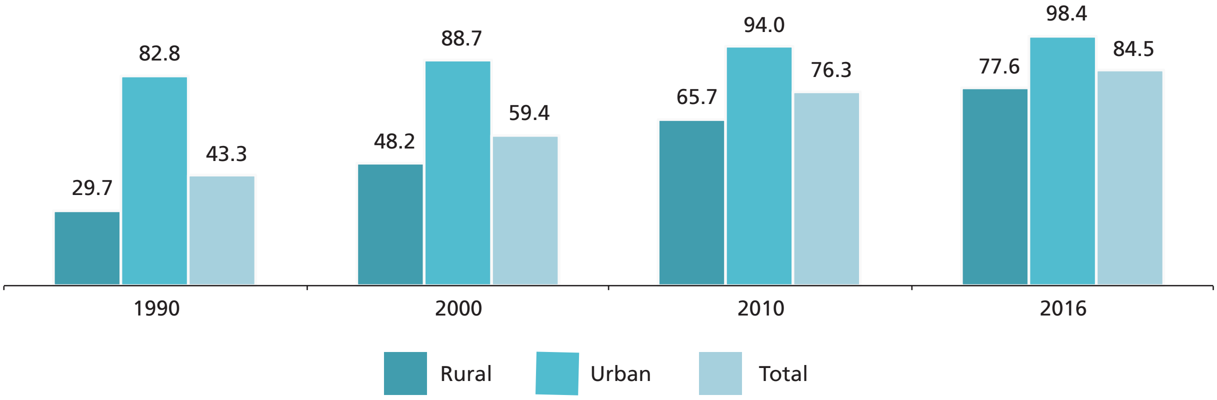
# 1. Introduction

Rural India is severely energy-starved. Till about thirty years ago, more than 70 per cent of the population living in the countryside did not have access to electricity. Even today, over one-fifth of the rural population in India continues to live without electricity access despite the massive growth in electricity infrastructure in recent years and the government's dedicated push to improve village electrification through Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) and its predecessor Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) (see *Graph 1: Growth in India's electricity access*).

### Graph 1: Growth in India's electricity access (%)

More than one-fifth of the rural population does not have access to electricity




*Source: World Bank*

India reached a major milestone in March 2018 by achieving 100 per cent village electrification. This means that the national grid has now expanded to reach all of the 5.9 lakh inhabited villages in the country and is supplying power to at least 10 per cent of the households living in these villages. The villages that remain to be connected to the grid are remote and inaccessible, due to difficult terrains, deep forests or extremism.

The challenge that now confronts the government is that of household electrification. At present, 84 per cent of the 22.23 crore households in India are connected to the grid. The proportion is even lower at 81 per cent in the rural India (see *Graph 2: Household electrification scenario in India*). The government is targeting 100 per cent household electrification by the end of 2018 under the Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) launched in October 2017 having an outlay of Rs 16,320 crore.

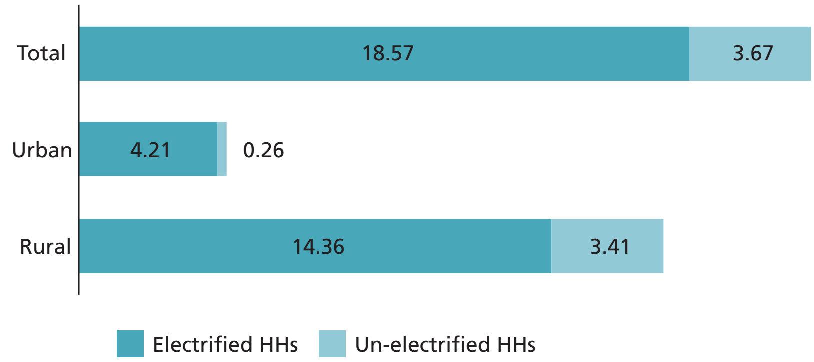
While it is unlikely that SAUBHAGYA targets will be achieved within the indicated timeline and budget, India could certainly achieve universal electrification in the coming decade or so. Even if that were to happen in the next few years, the bigger challenge for the government would be to ensure good quality and uninterrupted power supply to every rural household—

something that has not yet been achieved even in urban centers. Distribution companies who are financially stressed and face political pressure have found it difficult to raise tariffs to fully cover costs. To a certain extent, electricity thefts and poor billing are also results of political patronage. Without reforming the distribution sector, even if all households are connected over the next few years, discoms would be unwilling or unable to supply power to poor households.

In the backdrop of serious energy poverty, mini-grid systems based on renewable energy sources emerged as a solution to provide basic electricity access to a large number of households in rural India. The government supported mini-grid development by providing upfront capital subsidies, however there was no comprehensive policy enacted to support sector growth. Mini-grids has been seen by the government as a stop-gap solution till the time the grid reaches unconnected villages.

**Graph 2: Household electrification scenario in India (in crores)**

More than one-fifth of the rural population does not have access to electricity




Note: Data as of October 2017

*Source: SAUBHAGYA Portal*

## Electrification in Uttar Pradesh

In Uttar Pradesh—a state notorious for having one of the country's lowest rural electrification ratio of 57 per cent—mini-grid systems are playing a crucial role. There are currently about 1,850 mini-grid systems estimated to be operating in the state with an aggregate capacity of around 3 MW,[1] and the government's target is to increase this to 10 MW.[2]

Private mini-grids are backed by a mix of investors such as international impact investors, corporate social responsibility (CSR) funds from Indian companies, and even commercial funds. These private mini-grids have thrived in rural and remote areas of Uttar Pradesh during the past decade as distribution utilities (discoms) failed to provide grid connectivity to a majority of households or to supply adequate power to the connected households. Even as the government pushes towards 100 per cent household electrification, top state regulators and power industry officials believe that mini-grids continue to hold significance due to the sheer magnitude of the task in state.



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The business models for mini-grids—that have emerged so far—involve generating power from a small renewable energy unit (mostly solar- or biomass-based) and supplying it through a low cost distribution network at a 'commercially-viable' rate to unconnected or under-served rural consumers.

Access to electricity through such mini-grid systems comes at a very high cost for the consumers. The mini-grid operators have made a key assumption based on government pronouncements—the grid will be able to meet the power needs of all consumers in five to seven years. The business is thus structured to recoup investments within that period, which means that the tariffs charged are very high, in the range of Rs 20 to Rs 150 per unit, for small load and limited hours of supply in a day. Second, the generating assets and especially the distribution network (often just wire strung on a bamboo pole) are not designed for a long life, let alone for integration into the grid when it appears in their market.

The Uttar Pradesh government, aware of these issues of high tariffs and limited supply, introduced the state mini-grid policy in February 2016 to incentivize and regulate the sector.[3] The aim was to encourage development of a financially viable industry that provides affordable power for a minimum number of hours.

The policy offers 30 per cent state subsidy to mini-grid developers in addition to the central government subsidy of 30 per cent. In turn, it imposes limits on the tariff that can be charged to the households (flat amount that varies with the connected load and translates to a tariff of Rs 6–7 per unit) and mandates supply of a minimum of eight hours for household consumers. It also provides exit options to mini-grid operators if and when the grid begins to supply power to a large number of customers in their area making the mini-grid uncompetitive. The power supply terms and standards mandated under the policy are only applicable on projects which avail state government funding. For all other projects, tariffs are allowed to be set at a rate mutually agreed upon by developers and consumers.

However, the policy has been a letdown as till date not a single developer appears to have availed the state subsidy or is operating a project under its ambit. The developers and most independent policy analysts argue that the Uttar Pradesh mini-grid policy does not address the main concerns. The subsidy is not adequate to make the mandated tariff viable. Moreover, the exit options don't offer them sufficient comfort that they will be made whole once the grid enters their markets. Since all existing projects are outside the purview of the policy, mini-grid consumers in the state continue to pay high tariffs for a limited amount of power supply.

The high tariff of the mini-grids and reluctance of the developers to take state subsidy means that the energy access issue is not being adequately addressed. First, power demand is artificially constrained since poor households are able to afford only limited hours of such expensive supply. Second, supply growth is hobbled because of lack of financing. Developers are not accessing state government subsidies, which could have been used to raise additional financing, because the policy conditions are not considered viable for the projects. .

CSE held extensive consultations with Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA), Uttar Pradesh Electricity Regulatory Commission (UPERC), major mini-grid developers and investors, and also surveyed villagers dwelling in six mini-grid project areas to understand the landscape of mini-grid development and operations in Uttar Pradesh and suggest a way forward.

The analysis of Uttar Pradesh's existing household electrification scenario, the quality of grid-supplied power and the potential of electrification under the SAUBHAGYA scheme suggests that mini-grids will continue to remain relevant in the state over the next five to ten years. The state policy must be redesigned to reconcile two conflicting goals—adequate electricity supply to households at affordable rates, and fairly compensating developers so the mini-grids remain viable.



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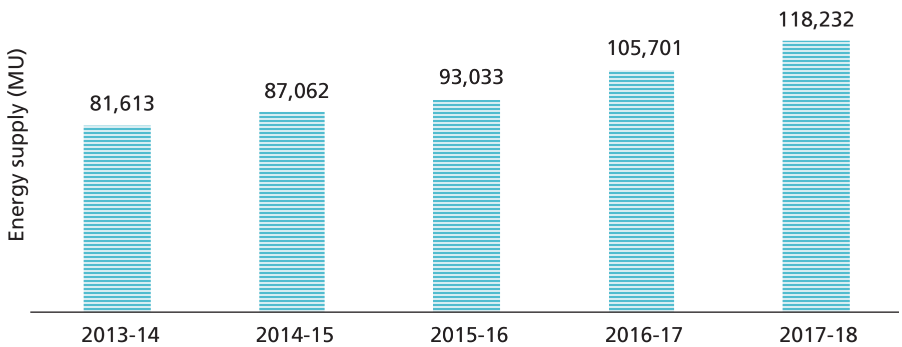
# 2. Power scenario

The recent focus of the central and state governments on increasing electrification and improving power supply has raised questions about the role that mini-girds can play in providing electricity access to rural populations in Uttar Pradesh. A closer look at the on-ground reality indicates that given the state's massive electrification challenges and the persistent power crunch, mini-grids will continue to find consumers over the next five to ten years.

**Understated deficits:** The aggregate electricity supply in Uttar Pradesh has increased at a compound annual growth rate (CAGR) of 7.7 per cent over the past five years (see *Graph 3: Growth in electricity supply in Uttar Pradesh*). This supported a sharp decline in the state's energy deficits to 1.5 per cent in 2017–18 from 15.6 per cent in 2014–15 (see *Graph 4: Trend in energy deficit in Uttar Pradesh during 2013–18)*. The state's peak deficit, however, still stands high at 10.9 per cent which is second highest in the country next to Jammu and Kashmir.

### Graph 3: Growth in electricity supply in Uttar Pradesh

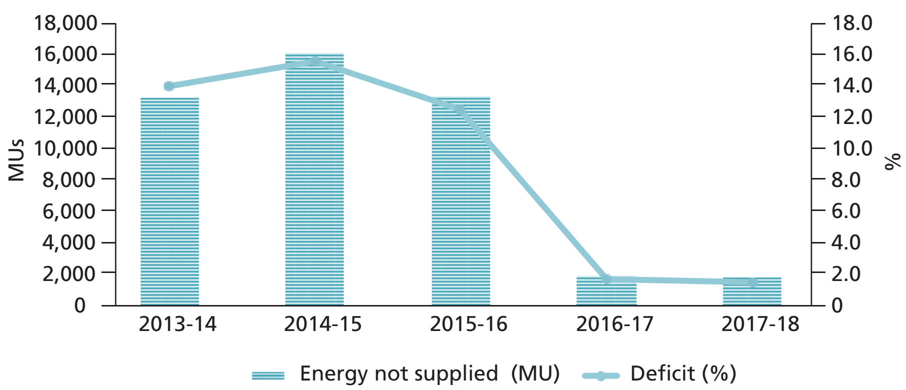
Power supply increased at 7.5 per cent CAGR in past five years




*Source: CEA*

### Graph 4: Trend in energy deficit in Uttar Pradesh during 2013–18

Energy deficits have declined drastically, but do not reflect the actual electricity demand




*Source: CEA*

However, the decline in energy deficits merely reflects the difference between energy demanded by discoms and supplied by the generating companies. The data does not account for actual consumer demand and thus severely understates actual deficit. And this only considers customers who are connected to the grid; demand of unconnected customers is not factored in. It is widely known that discoms don't always purchase electricity despite consumer demand even when consumers are able to pay. Discoms' tariff structure often means that supplying electricity means additional losses that exacerbate their already precarious financials.

The supply shortage, as defined, is anyway manageable—nationwide power supply is in surplus and part of local shortages are due to grid congestion, however, the fundamental reason for deficits is the financial weakness of discoms level, which has been an intractable problem.

**Paradox of 100 per cent village electrification:** According to Ministry of Power, all of the 97,813 villages in Uttar Pradesh have been electrified following the successful implementation of the DDUGJY. However, a village is deemed to be electrified if panchayat centers, certain public facilities such as main areas of gathering and at least 10 per cent of the households' have electricity. That is a very low bar to be classified as electrified village. Indeed, the data on household electrification tells a very different story—only 53 villages of the total 18,452 villages electrified under DDUGJY have achieved 100 per cent household electrification (see *Map 1: Villages with 100 per cent household electrification under* DDUGJY).

**Map1: Villages with 100 per cent household electrification under DDUGJY**

Only 53 villages electrified under DDUGJY have achieved 100 per cent household electrification

*Source: Garv Dashboard*



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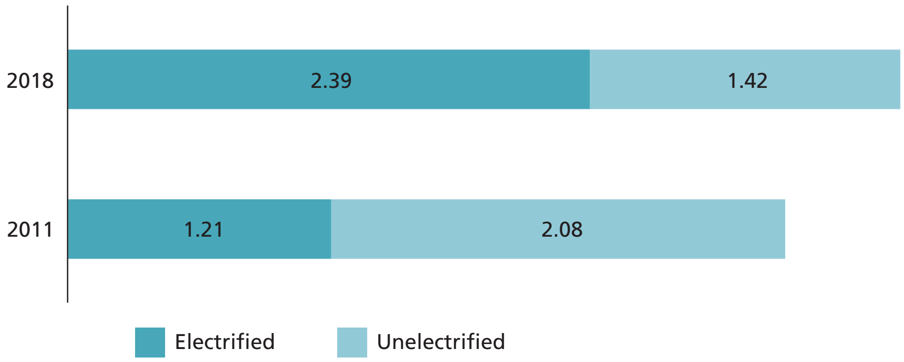
**Gap in household electrification:** As of May 2018, only 63 per cent of the households in Uttar Pradesh are connected to the electricity grid *(See Graph5: Household electrification scenario in Uttar Pradesh)*. The situation is worse in rural areas where the electrification ratio is 57 per cent. District level data presents an even more grim picture with rural electrification ratio of less than 30 per cent in Lalitpur, Jalaun, Sonbhadra and Jhansi, and 35–40 per cent in Chandauli, Fatehpur, Kanshiram Nagar, Bahraich, Kanpur Dehat, Saharanpur, Kanpur Nagar and Kaushambi. It is partly due to these low household electrification rates that mini-grids in Uttar Pradesh are still in business even in areas where grid has reached.

**Graph 5: Household electrification scenario in Uttar Pradesh (in crores)**

Around 1.42 crore households in the state did not have power supply in May 2018



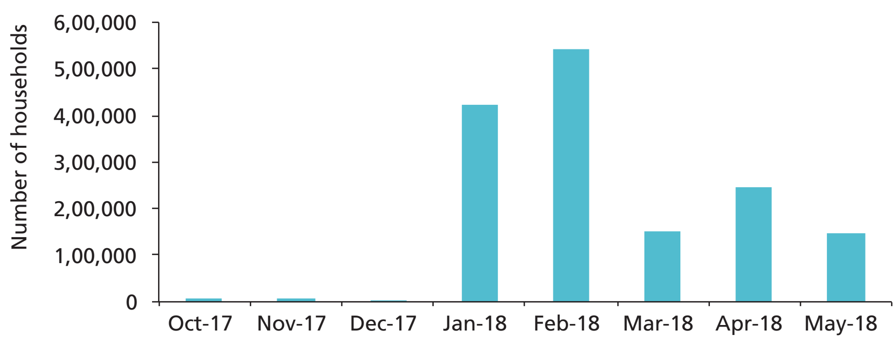

Note: Data for 2018 is as of 8 May

*Source: Census 2011, SAUBHAGYA portal*

For Uttar Pradesh, the target set under SAUBHAGYA at the time of its launch was to connect 1.45 crore rural households. In the following seven months, 15 lakh new households were connected to the grid (see *Graph 6: Monthly progress in rural household electrification in Uttar Pradesh)*. Achieving universal electrification by December 2018, as is the target, requires connecting over 16 lakh new households to the grid every month. But, at the current pace it would take another seven years for all households in the state to be connected.

**Graph 6: Monthly progress in rural household electrification in Uttar Pradesh**

15 lakh new households have been electrified in seven months




*Source: SAUBHAGYA portal*

One major challenge to achieving the 100 per cent household electrification target by the end of this year is the inadequate capital support of about Rs 4,000 per household provided under SAUBHAGYA. This would be barely sufficient to connect a house located close to an existing pole as it also includes cost of meter and the cost of limited in-home wiring.[4] The cost of connecting households in remote and sparsely populated villages could be substantially higher as these are likely to be located away from the existing pole span.

As per the Uttar Pradesh Power Corporation Limited's (UPPCL) Rural Electrification and Secondary System Planning Organization (RESSPO) Schedule for 2017–18, the cost of installing low tension (LT) overhead line could vary from Rs 1.5 lakh to Rs 3.1 lakh per km depending on the conductor type, conductor sizes, and span lengths. This excludes the cost of setting up new substation or distribution transformer which could cost a few lakhs (see *Annexure1: Cost of constructing rural distribution network in Uttar Pradesh*).

Installing meters could cost additional Rs 1,000 to Rs 2,000 per household (Rs 7,000-Rs 9,000 for prepaid meters). The low tension service line connecting a house to a pole itself could cost Rs 1,800 to Rs 3,000 per household for a single phase connection.

**Power supply and subsidy burden:** The next question is if the discoms would be able or willing to supply electricity to poor households. Power supply to them would need to be at subsidized rates. Also, there would be risks of low collection. Increased rural electricity supply due to addition of new household connections would substantially increase the subsidy burden on the Uttar Pradesh government.

Back of the envelope calculations indicate that for supplying power to the additional 1.29 crore rural households under SAUBHAGYA could increase the annual subsidy requirement of state discoms by Rs 2,000–Rs 3,400 crore for a small monthly supply of 30–50 units per household [assuming aggregate technical and commercial (AT&C) losses of 34 per cent as was the actual average for Uttar Pradesh discoms in 2015–16]. This would represent 23 to 40 per cent increase in the existing subsidy requirement of discoms [which was Rs 8,725 crores in 2015–16 as per the latest Power Finance Corporation (PFC) report on the performance of state utilities].[5] Even at lower AT&C loss levels of 25 per cent, the increase in subsidy burden would be substantial at 21 per cent–35 per cent. (See *Table 1: Subsidy requirement due to increased rural electrification in Uttar Pradesh under SAUBHAGYA*)



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### Table 1: Subsidy requirement due to increased rural electrification in Uttar Pradesh under SAUBHAGYA

Subsidy burden could increase by Rs 2,040–Rs 3,400 crore

| Particulars | Estimates | | | |
|---|---|---|---|---|
| Number of rural households yet to be electrified | 12,994,979 | | | |
| Electricity consumption per household | 30 units per month | | 50 units per month | |
| Increase in rural consumption post SAUBHAGYA | 390 MUs | | 650 MUs | |
| AT&C losses | 34 per cent | 25 per cent | 34 per cent | 25 per cent |
| Increase electricity procurement by discoms (due to AT&C losses) | 522 MUs | 487 MUs | 870 MUs | 812 MUs |
| Increase in procurement cost post SAUBHAGYA (assuming average cost of supply to be Rs 5.5 per unit) | Rs 287 crore | Rs 268 crore | Rs 479 crore | Rs 448 crore |
| Increase in revenue from new rural HH consumers (assuming revenue recovered to be Rs 3 per unit) | Rs 117 crore | | Rs 195 crore | |
| Gap (to be covered through subsidy) | Rs 170 crore | Rs 152 crore | Rs 284 crore | Rs 253 crore |
| Increase in annual subsidy burden | Rs 2,040 crore | Rs 1,819 crore | Rs 3,408 crore | Rs 3,031 crore |

Note: AT&C losses of 34 per cent and average cost of supply as for 2015–16 as per PFC report on utility performance.

*Source: CSE, 2018*

**Inadequate rural electricity supply:** Despite the likely delays in achieving SAUBHAGYA's targets, government officials and some industry observers think that Uttar Pradesh may be able to provide close to universal household 'connection-to-the-grid' in the next two to three years. However, it is unlikely that the UP government/discoms will be able to supply 24x7 electricity to all these households in the near future.

The *Uttar Pradesh Power for All* document released last year claimed that the electricity supply in rural areas has increased to minimum of 18 hours. Data from the Uttar Pradesh State Load Dispatch Centre (UPSLDC) indicates that average daily power supply in rural areas has improved to 18:35 hours from 11:38 hours two years ago. The Central Electricity Authority (CEA) data also indicates that the agricultural electricity supply in Uttar Pradesh during 2017–18 was 17:37 to 19:47 hours in a day. However, on-ground reports indicate a different reality. While power supply may have improved in several parts of Uttar Pradesh, it continues to vary from 10–16 hours per day in rural areas.[6]

CSE in December 2017 surveyed six villages across three districts in Uttar Pradesh with the aim to understand the electricity supply through grid and mini-grids (see *Annexure 1: Details of mini-grid systems surveyed in six villages in Uttar Pradesh*). The survey revealed that the rural electricity supply continues to be restricted, with the Dhankal Khera village in Unnao receiving 10–12 hours of supply and Tamakuhi Raj village in Kushinagar receiving 10–14 hours of supply (see *Table 2: Electricity supply scenario in villages surveyed by CSE*).



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**Table 2: Electricity supply scenario in villages surveyed by CSE**

Average electricity supply varied from 10–16 hours in a day

| Location | Total households | Rate of electrification | Average duration of grid power supply (Hours) |
|---|---|---|---|
| Sanda, Sitapur | 737 | 70.4% | 15–16 |
| Kamplapur, Sitapur | 132 | 95.5% | 12–16 |
| Katkutiyan, Kushinagar | 819 | 42.4% | 15–16 |
| Tamakuhi Raj, Kushinagar | 881 | 66.7% | 10–14 |
| Para Village, Unnao | 1212 | 24.0% | 12–16 |
| Dhankal Khera, Unnao | 101 | 80.2% | 10–12 |

*Source: CSE Survey*

In addition to the limited number of hours, surveyed consumers claimed that power supply in rural areas is often not available during the during peak hours in the morning and evening when electricity is most needed. This claim is also supported by the UPSLDC's power supply schedule for these villages which indicates two to four hours gap during the morning and evening peak demand periods (see *Table 3: Power supply* schedule in CSE-surveyed villages).

**Table 3: Power supply schedule in CSE-surveyed villages**

No power supply for nearly two to four hours during peak periods

| District | Substations | Power unavailable at peak times (29 April—5 May 2018) | Total duration (hours) |
|---|---|---|---|
| Sitapur | Muradabad control 1A | 7:00–9.15 | 2:15 |
| | Muradabad control 1B | 6:45 –8:45; 21:30 –23:00 | 2:30 |
| Kushinagar | Sarnath control 2A | 5:45 –8:15 | 2:15 |
| | Sarnath control 2B | 9: –11:30; 20:00 –21:30 | 2:30 |
| Unnao | Piniki control 2A | 5:45 –8:15; 19:45 –21:15 | 3:45 |
| | Piniki control 2B | 8:15 –10:45; 21:15 –22:45 | 2:30 |

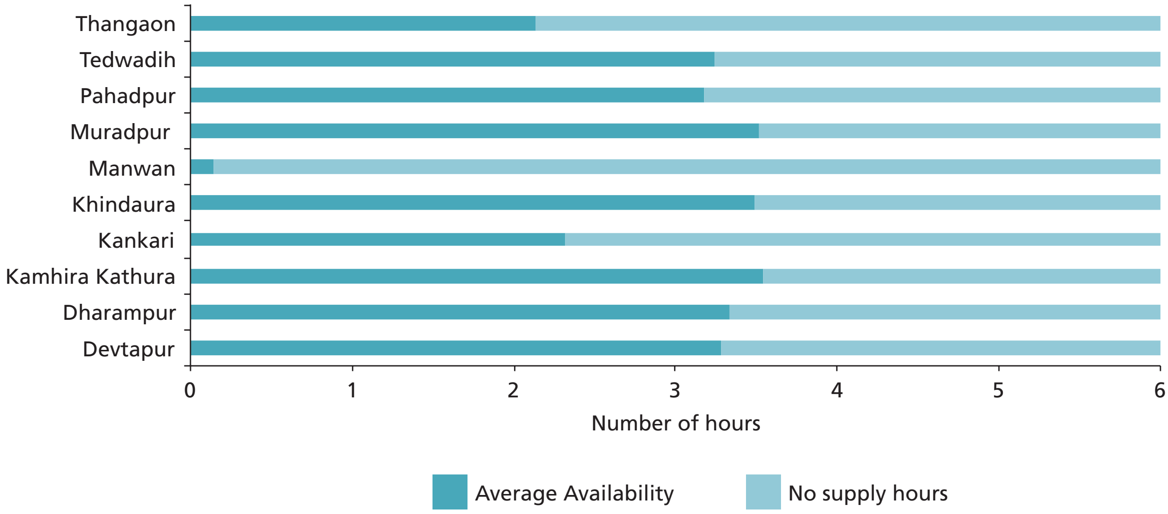
Note: Peak demand time is between 6 and 10 in the morning and evening

*Source: UPSLDC, CSE survey*

The data on actual power supply provided on the 'Watch Your Power' portal of Prayas (Energy group) also points to major gaps in rural supply during peak hours of requirement. For instance, in the 10 villages of Sitapur district, the power supply during the peak evening hours in April 2018 ranged from as low as 14 minutes in Manwan village to 4:36 hours in Sahdipur village *(see Graph 7: Average power availability in Sitapur district).*

### Graph 7: Average power availability in Sitapur district

Supply during evening peak hours in 10 villages averaged around 3:20 hours




Note: Data for April 2018; peak evening hours include six hours from 5 PM–11 PM

*Source: watchyourpower.org, Prayas (Energy Group)*

Due to such supply shortages, especially when it is needed the most, mini-grid developers have been able to compete with the much cheaper grid supply. In all of the six villages surveyed by CSE, mini-grid projects were operating in parallel to the grid-supply. The grid was the main source of supply in these villages with varying rate of household electrification (see *Table 4: Number of households served by mini-grids in CSE-surveyed villages*), but was supplying power for a limited duration of 10-16 hours in a day, primarily in off-peak hours.

### Table 4: Number of households served by mini-grids in CSE-surveyed villages

Mini-grid systems are co-existing with discom grids

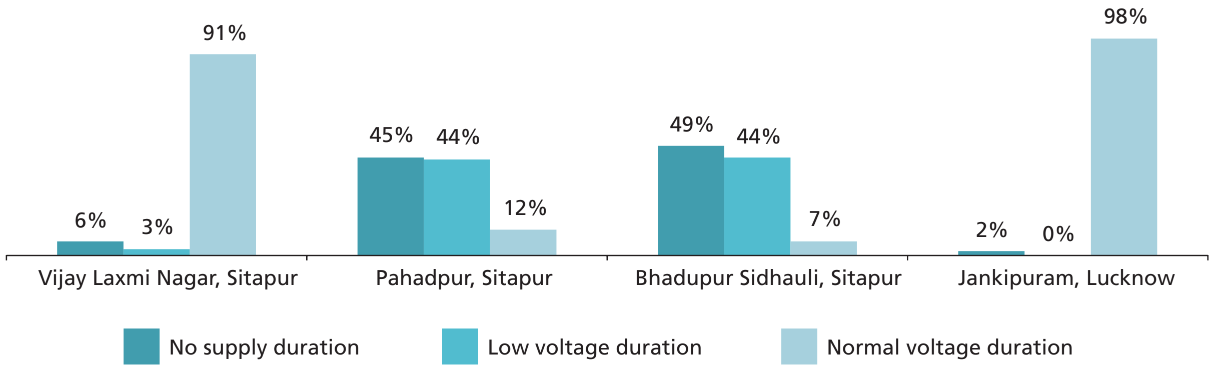
| Location | Total households | Number of mini-grid connections |
|---|---|---|
| Sanda, Sitapur | 737 | 120 |
| Kamplapur, Sitapur | 132 | 70 |
| Katkutiyan, Kushinagar | 819 | 85 |
| Tamakuhi Raj, Kushinagar | 881 | 75 |
| Para Village, Unnao | 1,212 | 35 |
| Dhankal Khera, Unnao | 101 | 30 |

*Source: CSE Survey*

**Prioritized supply to urban consumers:** The increased power supply in Uttar Pradesh in recent years (from 81 BUs in 2013–14 to 109 BUs in 2017–18) has not solved the challenge of access in rural areas as increased supply seems to have primarily benefitted urban consumers. The disparity in power supply between rural and urban centers is clearly evident across the state.

**Graph 8: Power supply position to domestic consumers in Uttar Pradesh during April 2018**

Power supplied in villages for far fewer hours than in the urban areas




Note: Data for 720 hours in April 2018

*Source: watchyourpower.org, Prayas (Energy Group)*

In Sitapur district, for instance, domestic consumers living in the town area of Vijay Laxmi Nagar received power for 94 per cent of the 720 hours during April 2018; whereas, consumers in Paharpur village and Bhadupur Sidhauli block area received it for only 55 per cent and 51 per cent of the time, respectively. Significantly, the low voltage supply duration in Vijay Laxmi Nagar was only 3 per cent, while it was 44 per cent in both Paharpur and Bhadupur Sidhauli. In contrast, the Jankipuram area in the state capital of Lucknow received power for 98 per cent of the time in April, all of which was at normal voltage level. (See *Graph 8: Power supply position to domestic consumers in Uttar Pradesh during April 2018*)

Supply to rural areas has never been prioritized by discoms in Uttar Pradesh due to technical, commercial and political reasons. It is associated with higher network losses (usually more than double compared to urban areas) due to lengthy distribution lines, inadequate size of conductors, long distance between distribution transformers and load centers, and overrated distribution transformer etc.

But perhaps the main reason is commercial. The tariff rates charged from rural consumers are very low. Customers without metered connection were charged only Rs 180 per kW per month, which was increased to Rs 300 per kW per month in December 2017. In addition, electricity is effectively supplied free for a significant percentage of consumers due to the low billing and collection rates in rural areas. While these issues might get addressed in the coming years, with SAUBHAGYA and Ujwal Discom Assurance Yojana (UDAY) schemes focusing on improving metering and billing efficiencies and rationalizing tariff, the issues as of now remains unresolved.



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# 3. Mini-grid segment

**Policy and regulation:** Mini-grids flourished in Uttar Pradesh—and the rest of India—in an unregulated environment as the Electricity Act, 2003 allowed private operators to supply electricity in rural areas without licensing requirements or tariff regulations. The National Electricity Policy, 2005 and the Rural Electrification Policy, 2006 also emphasized development of decentralized distributed generation (DDG) along with local distribution networks wherever grid-based electrification was not feasible. The central government thus supported DDG projects through village electrification schemes such as DDUGJY and its predecessor RGGVY.

Uttar Pradesh in 2016 became the first state in India to implement dedicated mini-grid policy and regulations. These were introduced with the objective of ensuring access to power at affordable rates, providing viable exit options, and encouraging development of standard distribution networks. Unfortunately, these have had a little impact as no developer has set up projects under the state policy. *(Details of mini-grid policy and regulation, their impact, and analysis are discussed in detail in the following chapter)*

**Installed system capacity:** Of the 1,850 mini-grids operating in Uttar Pradesh, over 90 per cent are very small installations of 1 kW or less capacity (see *Table 5: Size distribution of mini-grids installed in Uttar Pradesh)*. The distribution networks associated with such small systems are flimsy and capable of handling only limited loads of one light-emitting diode (LED) bulb (of 5–10 W) and mobile phone charging (15 W). These systems cannot be leveraged to enable grid connectivity.

**Table 5: Size distribution of mini-grids installed in Uttar Pradesh**

Majority of existing mini-grid system are very small in size

| Range of installed capacity | Number of mini-grids |
|---|---|
| Less than 1 kWp | 1,627 |
| 1–30 kWp | 30 |
| 30–50 kWp | 43 |
| 50–100 kWp | 10 |
| Over 100 kWp | 14 |

Note: The list may not be exhaustive.

*Source: Compiled from various sources*

All mini-grid systems surveyed by CSE have been installed with load inhibitors and provided a 20–60 W connection to each household. Even the relatively large mini-grids set up by UPNEDA serve a load of around 150 W per



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household. In contrast, regular grids are designed with 500 W as the load per rural household. The small loads supplied by mini-grid systems are inadequate to stimulate social and economic growth—empirical studies indicate a strong correlation between per capita electricity consumption, and social and economic development indices.[7] Increase in economic prosperity and aspirations of rural consumers will render the existing mini-grid infrastructure redundant.

**Major developers and investors:** Of the total, 16 mini-grid projects have been set up UPNEDA (see *Annexure 3: List of projects set up by UPNEDA as demonstration projects*). These are relatively large-scale projects of over 30 kWp capacity set up with the agency's internal corpus to demonstrate that large mini-grids catering to a mix of household and commercial load are a sustainable business model. The first of these was a 250 kWp project set up in Phakirpur, Kannauj to supply electricity for 24 hours a day to a range of 346 consumers. Electricity from these projects is being provided free of cost, though UPNEDA suggests that tariffs would be in the range of Rs 4–5 per unit for households and Rs 11 per unit for water pumping based on their financial analysis.

All remaining mini-grid systems are owned and operated by private sector companies and individual entrepreneurs. OMC Power is the largest mini-grid developer in the state operating around 75 projects and is constructing another 10. The operational projects total around 2.52 MW with a minimum size of 18 kWp and maximum size of 68 kWp. Husk Power Systems (HPS), another major mini-grid developer, has installed small biomass power plants of 30 kW–50 kW serving 300–400 consumers. Recently, the company also set up six hybrid systems in Kushinagar district comprising 20 kW solar capacity and 32 kW capacity of biomass gasification and one day of battery back-up. Other major mini-grid developers in the state include Boond Engineering, Tara Urja, MeraGao Power, DESI Power, Smart Power India, FreeSpanz, among several others.

**Funding sources:** The private mini-grid sector development has primarily been supported by capital subsidies from private sources. These include soft loans, equity investments from development funds and impact investors, and grants from international development organizations. A few projects have also been set up with the help of CSR funds. Role of government subsidies has been limited, with a handful of projects of OMC Power and Husk Power set up with MNRE's subsidies of 30–50 per cent. No project has so far been set up using subsides from the Uttar Pradesh state government.

In recent months, mini-grid companies have also raised financing from foreign investors. OMC power received an investment of Rs 59 crores from Mitsui, a Japanese company, in August 2017.[8] However, this investment is aimed at providing renewable energy to telecom towers in the country that are dependent either on diesel or unreliable grid electricity. In January 2018, Husk Power announced that Shell Technology Ventures, Swedfund International and ENGIE Rassembleursd' Energies would make an equity investment of $20 million in the company.



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**Operational models:** Varied business models have emerged for commercial mini-grid operations depending on company's objectives and local requirements/conditions.[9]

OMC Power was one of the first companies in India to develop a business model for mini-grids that is popularly known as the Anchor–Business–Community (ABC) model. Under this, power supply from a solar generation unit is prioritized for an anchor load comprising commercial and industrial users (typically one or two telecom towers), followed by businesses (small enterprises, shops, banks, and petrol pumps) and then households.[10]

In this model, the size of generation unit depends primarily on the requirement of the anchor load. The model is less risky as the predictable load from the anchor consumer offers guaranteed source of revenue. These systems are typically developed in large villages with good commercial and industrial electricity demand. Their distribution systems are often set up parallel to the discoms' infrastructure in rural communities with an inadequate power supply.

The model adopted by TARA Urja also relies on commercial loads to make mini-grids commercially viable. However, the company focuses on building demand for the generated power by stimulating local businesses and enterprises through a programme called Community Engagement, Load Acquisition, and Micro-enterprise Development (CELAMeD).

HPS's mini-grids are located in remote rural villages with plentiful supply of rice husks. The power generated through biomass gasification is supplied through insulated wires strung from bamboo poles. HPS uses two primary revenue models—built-own-operate-maintain (BOOM) and the built-maintain (BM). Under the BM model, mini-grids are built and maintained by HPS but owned and operated by local entrepreneurs.

In contrast to these, Mera Gaon Power (MGP) sets up small solar DC systems comprising two to four panels of 120 Wp, offering only basic services of lighting and phone charging for 6–7 hours. These projects are focused on small unconnected settlements with about 50 households where grid integration is not likely over 2–3 years. Their customer base primarily includes poor households and micro-enterprises who are billed on pre-payment basis using community-based collection methods. The business model relies on low capital and operational costs, with a projected return of more than 30 per cent at a repayment period of less than three years.

**Service standards and tariffs:** The mini-grid systems in Uttar Pradesh have been set up to supply electricity for limited number of hours—usually four to six hours in a day. HPS is perhaps the only mini-grid company that aims to provide a 24-hour electricity supply through its mini-grid systems; however their projects are not operating at full capacity due to low demand.

Tariff charged by mini-grid operators is several times higher than that for grid



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supplied power and there are wide-variations across installed systems and consumer categories (see *Table 6: Tariffs of mini-grids operating in Uttar Pradesh*). While these tariffs can range from Rs 20–Rs 150 per unit—however this information is hidden, for obvious reasons—by charging consumers based on the load they bought. For instance, MGP charges consumers Rs 120 every month for a 20 W system.

**Table 6: Tariffs of mini-grids operating in Uttar Pradesh**

Effective tariff rates mini-grid projects is several times higher than grid supplied power

| Company | Costs of connection | Effective tariff rate (Rs per unit) | Duration of effective usage (hours) |
|---|---|---|---|
| OMC Power | 15 Watt –Rs 110 | 40.7 | 6 |
| Husk Power | 34 Watt –Rs 230 | 37.6 | 6 |
| | 50 Watt –Rs 300 | 33.3 | |
| | 100 Watt –Rs 630 | 35.0 | |
| Boond Engineering | 20 Watt –Rs 60 | 16.7 | 6 |
| | 60 Watt –Rs 350 | 32.4 | |
| MeraGao Power | 20 Watt –Rs 120 | 28.6 | 7 |

*Source: Compiled from various sources*

The high tariffs are partly driven by the high fixed cost of installing generation plant and distribution system for a small capacity. However, the main reason for high tariffs is the short payback period of these projects due to mini-grid operators' fear of becoming redundant when the grid's supply to consumers becomes reliable. Another widely followed practice is to simply set tariff at the highest rate that the consumers can afford to pay. Households, consuming merely lifeline-level electricity (often less than 10 units per month), have no leverage with the mini-grid operators to demand better rates. Companies use information on the household's expenditure on lighting (typically purchase of kerosene oil) in a certain area as the benchmark of how much households would be willing to pay. The high tariffs are justified with the rationale that mini-grid provided electricity is a better alternative to spending even more money to buy kerosene oil for lighting. Many operators also cite consumer surveys that show a high degree of satisfaction with mini-grid's services to defend exorbitant tariffs.



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## Government subsidies supporting corporates with deep pockets?

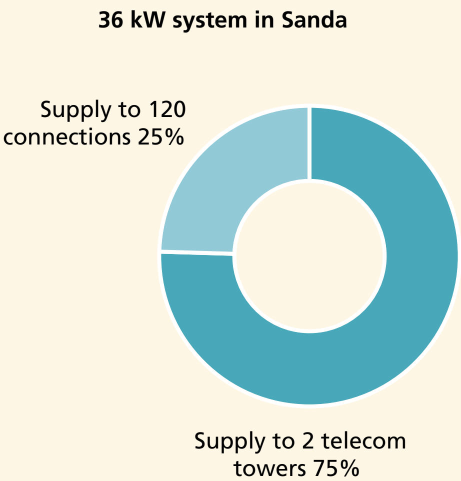
A vast number of mini-grids in Uttar Pradesh rely on telecom towers to provide anchor load support. These towers improve bankability of mini-grid projects by providing consistent and stable 24/7 power demand, as well as a steady cash flow under long-term PPAs signed with telecom companies. The issue with this model is that it effectively diverts government subsidies and development funds to help telecom companies reduce their expense on costly diesel for running these towers.

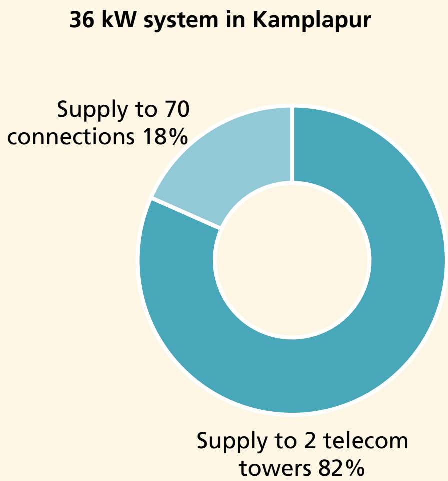
Such mini-grids are doing little to address the energy access issues for rural consumers—less than one-fifth of the power generated by such micro-grids is actually being supplied to them. For instance, 36 kW solar-based mini-grid system in Sanda, Sitapur supplies around 30–40 units daily to each of the two telecom towers it serves, while the aggregate daily power supplied to other connections (households) is only 12–13 units. A similar system in Kamplapur also has similar supply patterns. (See *Graph 9: Average daily power supply pattern of two mini-grids in Sitapur*)

The model for anchor load-based mini-grid system must evolve to serve local commercial establishments. This would help achieve the twin objectives of establishing commercial viability of the project and increasing local incomes.

### Graph 9: Average daily power supply pattern of two mini-grids in Sitapur

Less than one-fourth of power supply from these mini-grid systems is for household connections




*Source: CSE, 20184.*



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# 4. Policy and regulations

The government of Uttar Pradesh introduced a mini-grid policy in February 2016 to address the issues of high tariffs and low supply hours. The policy assumed that the demand of power in rural areas is low and that mini-grid would be an ideal solution to provide clean and sustainable power to domestic, agriculture and commercial establishments in areas where grid has not reached or does not provide sufficient electricity. The policy thus aimed to put in place an investment climate that stimulates private sector participation in decentralized renewable energy generation.

The key features of the UP mini-grid policy are:

- **Introduction of state subsidy:** The policy announced that in addition to the 30 per cent central government subsidy, the UP government would provide 30 per cent subsidy to the mini-grid projects based on viability gap funding, which in turn would be determined by reverse bidding. The developers have been given an option to set up mini-grids without availing state subsidies, in which case they can operate outside the purview of this policy in terms of tariff and service requirements of supply.
- **Service standards:** Projects receiving state subsidies are required to comply with certain service standards within six months of the plant's commissioning:
    - ✓ Mandatory minimum of eight hours of electricity supply for residential consumers (three hours in the morning and five hours in the evening) and six hours for production and commercial needs every day. Surplus to be supplied to other consumers.
    - ✓ Project operation on BOOM basis, with 10 years' operations and maintenance (O&M) by developer
- **Fixed tariffs:** Developers that avail state subsidy are directed to charge Rs 60 per month for a load of 50 W and Rs 120 per month for a 100 W connection from residential consumers. For loads of more than 100 W, tariff can be mutually decided by consumers and developers.
- **Exit options:** Developers have been given two exit options in case the grid begins to supply a large number of customers in the market serviced by the mini-grid:
    - ✓ The power generated by the mini-grid can be sold to the discom at a tariff decided mutually by the developer, discom and UPERC.
    - ✓ The project may be transferred to the discom at a price decided mutually between the developer and the discom.

The mini-grid policy was followed by release of Mini-Grid Renewable Energy Generation and Supply Regulations by the UPERC in April 2016.[11] The regulation defined mini-grids as projects that produce electricity through renewable energy-based plants of up to 500 kW capacity and supply electricity through a power distribution network (PDN). This includes an option for a mini grid project to sell electricity to the discom in rural areas.

In this, the UPERC defined a set of technical standards for setting up a mini-grid PDN, depending on the size of the project:

- For mini-grids with over 50 kWp capacity: Stringent technical and safety standards are applicable—either UPPCL guidelines for design and construction of distribution lines or the CEA regulations for Measures relating to Safety and Electric Supply. For interconnection with UPPCL's grid, the mini-grid PDN must follow UPPCL's distribution network code and comply with CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013.
- For mini-grids of less than 50kWp capacity: Simplified technical standards are applicable—PDN must have poles made of portland cement concrete (PCC), with aluminum cable covered by polyvinyl chloride (PVC) and supported by galvanized iron. Connections to customers must be made through junction boxes mounted on the pole.

Implementation of these standards is currently through a grievance mechanism, triggered by consumer complaint lodged with the UPERC or the relevant public authority. A formal procedure to enforce service standards on mini-grids will be defined under the UPNEDA Implementation Guidelines for mini-grid policy, which is in draft stage.

## Missing points

The Uttar Pradesh mini-grid policy aimed to address the issue of energy access gap by providing un-served and under-served rural populations an alternate source of affordable and reliable source of electricity. While mini-grid developers had been working in the state for a very long time, introduction of the policy granted them legitimacy. It has eased project execution by making it easier for mini-grid developers to approach prospective customers/panchayats regarding investing in their villages.

But, the policy has not been able to ensure affordable and reliable electricity supply for rural households. Its terms and standards are only applicable on projects which avail state government funding. For all other projects, tariffs are allowed to be set at a rate mutually agreed upon by developers and consumer. The policy has failed to entice developers to set up projects with state subsidies with not a single project developed under it. Thus, developers continue to operate like they used to before the policy was announced and charge household consumers a high tariff rate for limited hours in a day, while businesses and telecom towers remain primary customers.

- **Unviable tariff rates:** The state policy requires mini-grid developers to sell electricity to households at Rs 6–7 per unit if they chose to avail the state subsidy. Developers argue that this tariff rate is too low for projects to be financially viable even with the additional 30 per cent subsidy. UPNEDA argues this should not discourage investors as the tariff limit is only for household consumers. However, in most cases especially for small mini-grid installations, the 'other segment' demand (from commercial or small industrial consumers) is often not sufficient. Alternatively, it would mean



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that the operators will serve mainly commercial consumers, which defeats the main goal of improving household access.

In case of small mini-grid projects, such as developed by MGP and Boond Engineering, a 1 kWp capacity system generates sufficient power to meet the lighting and mobile charging needs of about 30 households. While such a system can provide 24x7 electricity, the demand is often limited to about six hours every day. In such low demand profile, a tariff rate of Rs 6–7 per unit is not sufficient to recover even the subsidized fixed costs and the O&M costs.

Large mini-grid developers, such as OMC Power and HPS, also argue along the same lines. With the currently available MNRE subsidy of 30 per cent, these developers charge household consumers a tariff of Rs 16–40 per unit of electricity, despite much higher rates imposed on commercial anchor loads. Developers maintain that an additional 30 per cent state subsidy will not be sufficient to make the operations sustainable at Rs 6–7 per unit tariff for households.

- **Uncertain exit options:** Two exit options have been provided by the policy for mini-grid systems operating in areas where the grid starts supplying to customers—the developer can either feed power to the grid or can sell the project to the discom. There are commercial uncertainties associated with both these options.

  The tariff at which mini-grid developers will sell power to the grid would be determined at the time of exit/integration with the grid, but there is no clarity on how these will be calculated. The developers legitimately fear that the tariff may not be adequate for their survival—i.e. it may not be calculated on the basis of their project cost and levelized cost of energy. UPERC, under discom influence, may well decide tariffs on the basis of costs of solar/biomass projects operating in the region or the average cost of power purchase for the discom—both of which may be insufficient.

  Similarly in case of the second exit option, the parameters on which the purchase price of the project will be determined have not been laid out. Project developers would like, logically, to recover their investments, therefore, would prefer to be paid the residual value of the project. However, a discom may not have any interest in buying the mini-grid's distribution assets and is likely to offer no more than a fraction of the value of the generating assets.

  Both the available exit options require mini-grid developers to install a distribution network that meets the existing standards and codes of the grid infrastructure. This is not the norm currently and most developers are installing low quality wires and cables with metallic poles that do not meet these standards because the load is so small, that for a 30–50 kWp plant does not need such high investment. Installing distribution network that meets the grid codes would increase investment manifolds for the mini-grid developer making investments unviable.



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# 5. Integrating mini-grids

Indian national grid is fast expanding and universal electricity access could become a reality within the next decade. Improving grid-based supply is currently viewed as a threat to the mini-grid business. However, developing business models that support interaction between the two grids can help achieve the twin targets of making mini-grids a sustainable business while improving affordability of its power supply. This would also help avoid duplication of efforts and investments in setting up parallel distribution networks.

None of the existing mini-grids in India are integrated with the national grid. However, there are multiple locations where these co-exist and consumers have the option to choose from either of the suppliers or have both connections. The parallel operations model however does not have long-term viability as these mini-grids will find buyer only till grid-supply is unreliable and unable to meet household needs. With grid-based power supply gradually improving, more sophisticated models will need to emerge to support interaction of two grids.

There is currently limited understanding of mini-grid-national grid integration and interaction, however there are a number of models that could be explored:

- **Tail-end generation for grid or open access consumer:** Mini-grid developer will continue operations as independent power producer (IPP) post integration with the national grid. The generated power will be sold to the grid under a power purchase agreement (PPA) or to an open access consumer at mutually agreed upon price. In both these cases, the mini-grid distribution network will be abandoned and sold off to the local discom, depending on its condition.

- **Distribution franchisee with a generation asset**: Mini-grid developer will continue to operate as a distribution franchisee, buying power from the local discom and selling it to rural consumers at the prevalent tariff rate. Mini-grid's distribution network will be purchased (and upgraded, if needed) by the discom, and the franchisee will be allowed to access it. The generation asset will continue operations as an IPP feeding power into the grid.

- **Grid integration with net-metering:** Mini-grid developer will continue to own and operate generation and distribution assets, while the entire system is interconnected to the grid with bi-directional metering. The mini-grid system will export power to the grid in case of surplus and import power in case of deficits, and the balance could be settled on a net-metering basis. Thus, the mini-grid continues integrated acts of generation and distribution, while transacting with the grid to balance demand and supply.



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### Financial support for mini-grid network development in Uttar Pradesh

On an average, the cost of developing distribution networks in rural areas is around Rs 2 lakh per km, given a single phase LT line cost of Rs 1.5 lakh per km and a distribution pole cost of over Rs 25,000. Brookings India estimates that the cost for wiring could vary from Rs 5,000 to Rs 10,000 per household depending on the density of houses. The actual cost of household connectivity under SAUBHAGYA for a district in western Uttar Pradesh is also turning out to be Rs 8,200 per household. Assuming 5 per cent of the total rural households in Uttar Pradesh are served by mini-grids, the investment requirement for developing distribution infrastructure will be Rs 1,460 crores. For covering 10 per cent of the rural households the investment requirement would increase to Rs 2,920 crores.

- **Back-up power supplier:** Mini-grids will continue as a source of back-up supply that operates when grid fails to supply (i.e. act as a flexible generation source). These generators will be adequately compensated with high per unit generation tariffs for providing flexibility and back-up services. Under this, the mini-grid operator will retain the generation asset, while the distribution network will be taken over the discom.

A number of policy, regulatory and market issues need to be addressed for mini-grids and national grid to co-exist under any of these models. While there is limited policy and regulatory guidance for mini-grids development in India, there is even little attention given to the issue of grid integration.

The draft amendments to the National Tariff Policy, 2016, released recently, talk about the risks of the grid reaching the mini-grid served areas and urges states to develop regulatory framework for compulsory purchase of power into the grid from these projects.[12] The existing CEA regulations for connectivity of distributed generation resources notified in 2013 are not relevant for mini-grid interconnection. These are essentially modeled on international guidelines and set standards for connecting distribution sources at lower than 33 kV level.[13]

In Uttar Pradesh, the state policy and regulation provide developers with two integration options—selling the generated power to the discom or selling the assets to the discom. As discussed in the previous chapter, the developers have opted to stay away from these because of the uncertainty over commercial terms of agreement.

So far, mini-grid operators have had an independent run, with limited interaction with state government and the discom which has led to limited trust between involved parties. The regulations drafted for mini-grids should thus very clearly define the commercial terms of agreement upfront for all possible transactions (sale-purchase of power or generation and distribution assets).

Further, the distribution networks currently being set up by mini-grids developers are inadequate to support grid interactivity and are most likely to be abandoned once the grid reaches. To avoid junking of investment in distribution assets and enable integration, regulations should ensure that mini-grid distribution networks meet technical standards of operations and safety established for the national grid.



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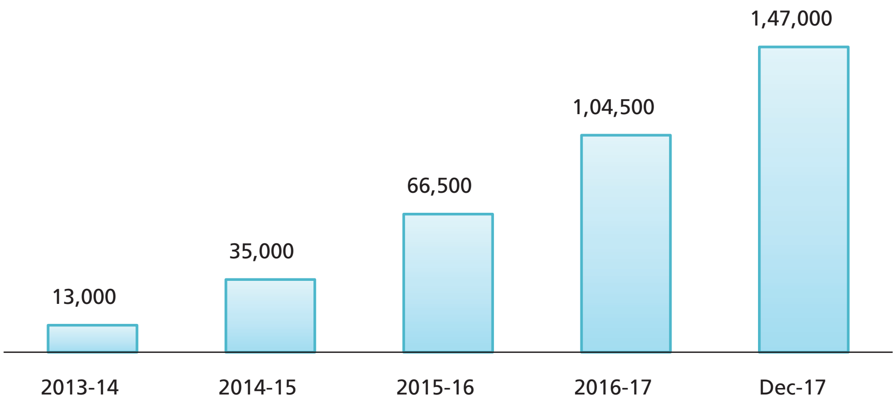
# 6. Solar pumps for energy access

Solar water pumping systems provide an affordable and sustainable solution for meeting the irrigation requirements of agriculture, given the erratic nature of power supply in rural areas and the high cost of diesel. The government's policy focus on solarization of irrigation over the past four-five years has helped increase their installed base from 13,000 in 2014 to 147,000 in December 2017[14](see *Graph 10: Growth in solar water pumps installed in India).* These pumps have primarily been installed by state renewable development agencies with capital subsidy of almost 90 per cent, collectively provided by state governments and the Ministry of New and Renewable Energy (MNRE).

**Graph 10: Growth in solar water pumps installed in India**

1.34 lakh solar pumps were installed between March 2014 and December 2017




*Source: MNRE*

The government is now scaling up the targets and subsidies for solar water pumps in order to achieve its objective of installing one million solar power pumps by 2021. Under the recently announced Kisan Urja Suraksha Evam Utthaan Mahaabhiyan (KUSUM) schemes, the government will provide a financial assistance of Rs 48,000 crore to install solar water pumps aggregating 28,250 MW in capacity and Rs 140,000 crore in investment value over the next five years.[15]

KUSUM is more broad-based compared to the earlier MNRE scheme. Under this, the capital subsidy support has been increased to 60 per cent shared equally by the centre and state governments, an additional 30 per cent will be financed through a bank loan while remaining 10 per cent will be paid by farmers. The government is also promoting grid-connected pumping system for the first time with the objective that any generated surplus power can be sold back to the grid.



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The government's massive push for solar pumping systems points to doubts in the grid's capability to provide adequate electricity supply in the coming years. Such large-scale distribution of pumps could result in excessive water withdrawal and have a significant impact on the already depleting water tables, which needs to be analyzed in detail. Moreover, use of solar pumps for only drawing water would mean underuse of assets and low return on investment—it makes little economic sense.

Investments in solar pumps can be optimized by expanding such systems to create mini-grids. This could have multiple benefits, such as provide electricity access to households, discourage excessive/unnecessary water usage, provide alternate source of income to farmers, and help discoms meet RPO.

The MNRE's 2014 solar pump scheme had mentioned the idea of creating solar-based mini-grid systems to supply electricity to a cluster of irrigation pumps . This would require a number of high efficiency pumps to be connected to a feeder transformer based on solar PV plant of 25–500 kWp capacity.[16]

This model of solar-powered mini-grid supporting pumps has been included in KUSUM. The first component of the scheme envisages installation of 10,000 MW of ground-mounted solar capacity across barren lands to power electric pumps. For this, no capital subsidy will be provided to farmers, instead discoms will be provided a generation-based incentive of Rs 50 paise per unit to procure surplus power generated from these sets. NITI Aayog has estimated that solar-powered agricultural feeders with efficient pumps would be roughly 40–50 per cent more cost-effective than installing individual solar pumps.[17]

International Water Management Institute has deployed one such pilot in Dhundi village of Gujrat.[18]Under this project, six solar pumps aggregating a capacity of 56.4 kWp have been linked together to form a mini-grid which has then been connected to the grid. The surplus solar power produced by the pumps is sold to the local discom for a feed-in-tariff (FiT) of Rs 4.63 per kWh under a 25-year PPA. Farmers have been provided an additional green energy bonus of Rs 1.25 per kWh and a water conservation bonus of Rs 1.25 per kWh, increasing the effective FiT to Rs 7.13 per kWh. These pumps collectively generate 85,000 kWh electricity per year—of which around 40,000 kWh is used for irrigation and the rest is solar to the grid.

In an alternate model, such a mini-grid set up could be utilized to power households instead of feeding power into the grid. There could still be more models of solar pump and mini-grid interaction that can be explored to resolve issues of limited/no electricity and irrigation water access in a given area.

Creating avenues to utilize surplus power generated by solar power pumps through mini-grids could help in checking groundwater depletion, while creating an alternate/low-risk avenue for farmers to earn income as well as reducing the rural electricity subsidy burden on discoms and state governments. This would also require optimum pricing—what would be a sufficient tariff rate to motivate farmers to move away from a water selling model to an electricity selling model?



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# 7. Policy learnings

State mini-grid policies need to be designed to address the fundamental issue of providing adequate, reliable and affordable electricity access to rural households. The experience with Uttar Pradesh mini-grid policy indicates that mini-grid developers would need to be adequately motivated, compensated and incentivized to ensure this. Policy must clearly define minimum supply standards in terms of number of supply hours for households especially during peak hours at a tariff rate which is reasonable compared to the rates charged from other rural consumers. The policy must also envisage long-term roles for mini-grid projects and provide clarity on operational and commercial terms of agreement.

Following are some crucial lessons from UP mini-grid policy experience:

- **Growth targets:** Set targets for mini-grid development (in terms of aggregate installed capacity over 10 years). This should be rational, based on survey/assessment of rural requirement by the energy department or local discom or the state renewable energy development agency as well as a realistic assessment of pace of household electrification and increase in supply by the grid.

- **Monitor growth:** Mechanisms should also be established to monitor and track progress achieved against the target. A data repository of basic information must be set up with the state renewable energy development agency and updated regularly.

- **Define regulations for mini-grids:** At present mini-grid is an unlicensed segment and is not governed by the rules and regulations of the grid. They need to be brought under the regulatory purview with defined minimum supply and operational standards.

    - Mini-grid systems should be designed to provide minimum 8 to 12 hours of supply to rural households including mandated supply power during peak hours.
    - At least half of the total power generated by the mini-grid systems should be supplied to household consumers.
    - Grid codes and safety standards must be defined for mini-grid distribution network in line with the regulations for discom grid to support and enable interaction between the two systems.

## TARIFFS AND INCENTIVES

- **Tariffs:** The tariff charged from the household consumers served by mini-grid systems should be same as that charged from rural consumers of local discom. The difference between the levelized cost of energy supplied by the mini-grid system and the mandated tariff should be coved through government subsidy. **Direct benefit transfer** to households can be explored



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for effective implementation of the subsidy. Another approach could be that projects are given **generation-based incentives** linked to power supplied to household consumers.

- **Capital support for generation asset:** Capital subsidy should be provided for developing the generation asset of the mini-grid based on viability gap funding through reverse bidding with a feed-in-tariff for power supplied to households. The existing 30 per cent cap on state subsidy (set under the Uttar Pradesh policy) would need to be reviewed to make projects viable at the feed-in-tariffs. The government must fix capital cost benchmarks before the competitively bidding projects.

- **Support for distribution network:** Funding support should be provided for setting up the mini-grid distribution network in line with the grid codes and safety standards through central government-funded electrification schemes (like SAUBHAGYA).

- **Exit options:** Commercial terms of agreement for all operational models of mini-grid and discom grid integration (tail-end generation, distribution franchisee, net-metering, back-up generation etc.) must be clearly defined.

    - **Price of assets:** Price of mini-grid generation and distribution assets should take into account its residual value. ERCs should provide guidelines / benchmarks to determine the residual value.
    - **Tariff for power:** The tariffs rates should be based on project cost and levelized cost of energy. Regulations must also be defined by the ERC to indicate the process of determining the tariff rate at which power will be sold to /purchased from the discom.
    - **Dispute settlement:** Mechanisms must be established for timely settlement of commercial disputes between mini-grid developers and discoms.



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# Annexures

## Annexure 1:

### Cost of constructing rural distribution network in Uttar Pradesh (in Rs)

| Particulars | Estimates |
|---|---|
| 33 kV line | 5.9–8.6 lakh per km |
| 11 kV line | 2.3–4.8 lakh per km |
| Three phase LT overhead line | 1.8–3.1 lakh per km |
| Single phase LT overhead line | 1.5 lakh per km |
| Pole for 11 kV line | 26,000–80,000 per pole |
| 33 kV substation | 1.4–2.8 crores |
| Increasing capacity of 33 kV substation | 57  lakh to 1.2 crores |
| 11/0.4 kV substation of 400 kVA | 7.5–10.3 lakh |
| 11/0.4 kV substation of 100 kVA | 1.4–3 lakh |
| 11 kV/230 V transformer | 65,000 |

*Source: UPPCLRESSPO Schedule 2017–18*

## Annexure 2:

### Details of mini-grid systems surveyed in sixvillages in Uttar Pradesh

<table>
<tr><th>Location</th><th>District</th><th>Mini-grid developer</th><th>Size of the plant</th><th>Number of connections</th><th>Other details</th></tr>
<tr><td rowspan="2">Sanda</td><td rowspan="2">Sitapur</td><td rowspan="2">OMC Power</td><td rowspan="2">36 kW solar</td><td rowspan="2">120 connections and two telecom towers</td><td>30–40 units per tower per day</td></tr>
<tr><td>12–13 units per day for other connections</td></tr>
<tr><td rowspan="2">Kamplapur</td><td rowspan="2">Sitapur</td><td rowspan="2">OMC Power</td><td rowspan="2">36 kW solar</td><td>70 connections</td><td>30–40 units per tower per day</td></tr>
<tr><td>Two telecom towers</td><td>8–9 units per day to households</td></tr>
<tr><td rowspan="2">Katkutiyan</td><td rowspan="2">Kushinagar</td><td rowspan="2">Husk Power</td><td rowspan="2">20 kW solar + 32 kW biomass gassifier</td><td>85 connections</td><td rowspan="2">Biomass gassifier was run once since the plant's installation in March 2017 for someone running AC</td></tr>
<tr><td>15 Households + 70 shops</td></tr>
<tr><td rowspan="2">Kuberastan</td><td rowspan="2">Kushinagar</td><td rowspan="2">Husk Power</td><td rowspan="2">20 kW solar + 32 kW biomass gassifier</td><td>65 connections - all shops</td><td rowspan="2">Most customers have 50 and 100 watt connections</td></tr>
<tr><td>1 KW connection for cyber café</td></tr>
<tr><td>Tamakuhi Raj</td><td>Kushinagar</td><td>Husk Power</td><td>20 kW solar + 32 kW biomass gassifier</td><td>75 connections</td><td>Most customers have 50 and 100 watt connections</td></tr>
<tr><td>Para Village</td><td>Unnoi</td><td>Boond</td><td>1 kW solar DC system</td><td>60-watt—6 connections 20-watt—28 connections</td><td>Effective rate is 1 paise per minute for a bulb</td></tr>
</table>



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| | | | | | |
|---|---|---|---|---|---|
| Shankar Khera | Unnoi | Boond | 1 kW solar DC system | 27 connections in 70 household villages | People who misuse the connection, draw excess power, the system short circuits and the connection is removed for those people (the connections reduced from 30 because of misuse) |
| DhankalKhera | Unnoi | Boond | 1 kW solar DC system | 30 connections in 60 household villages | - |

## Annexure 3:
### Scheduled rural power supply in CSE's surveyed districts

| District | Substations | Scheduled hours (29 April–5 May 2018) | Scheduled hours (6–12 May 2018) | Total hours |
|---|---|---|---|---|
| Sitapur | Muradabad control 1A | 01:30–7:00<br>9:15–12:15<br>14:15–23:45 | 00:15–8:45<br>11:15–15:00<br>17:00–22:45 | 18 |
| | Muradabad control 1B | 23:00–6:45<br>8:45–12:30<br>15:00–21:30 | 00:00–5:30<br>7:45–10:15<br>12:30–22:30 | 18 |
| Kushinagar | Sarnath control 2A | 00:30–5:45<br>8:15–11:00<br>13:00–23:00 | 23:30–5:15<br>7:45–11:30<br>13:30–22:00 | 18 |
| | Sarnath control 2B | 21:30–9:00<br>11:30–15:30<br>17:30–20:00 | 22:15–8:00<br>10:00–14:00<br>16:30–20:45 | 18 |
| Unnao | Piniki control 2A | 21:15–5:45<br>8:15–12:00<br>14:00–19:45 | 23:45–7:30<br>9:30–12:30<br>15:30–22:15 | 18 |
| | Piniki control 2B | 22:45–8:15<br>10:45–16:00<br>18:00–21:15 | 21:45–8:30<br>11:00–14:30<br>16:30–20:15 | 18 |

*Source: UPSLDC*



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## Annexure 4:

### List of projects set up by UPNEDA as demonstration projects

| Location | Installed capacity (KWp) | Number of consumers | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Domestic | Street light | Pump | Atta Chakki | Shops | Others | Total |
| Bchuakhera, Unnao | 35 | 94 | 15 | - | - | - | - | 109 |
| Vaivah, Auraiya | 150 | 885 | 30 | 20 | 7 | 45 | 2 | 989 |
| Kudarcoat, Auraiya | 175 | 1,080 | 40 | 25 | 10 | 160 | 4 | 1,319 |
| Motipurkalan, Shrawasti | 142 | 873 | 30 | 25 | 6 | 25 | - | 959 |
| Muzaffarpur, Azamgarh | 170 | - | - | - | - | - | - | 558 |
| Patabhoj, Sitapur | 160 | 462 | 30 | 9 | 3 | - | 7 | 511 |
| Bhachkahi, Shrawasti | 100 | 240 | 20 | 35 | 1 | - | 7 | 303 |
| Madarnagar, Unnao | 150 | 520 | 18 | - | - | 21 | - | 559 |
| Sirsawan, Moradabad | 100 | 890 | 50 | - | 3 | 102 | - | 1,045 |
| Chandaur, Raibareilly | 230 | 527 | 50 | 21 | 2 | - | 1 | 601 |
| Phakirpur, Kannauj | 250 | - | - | - | - | - | - | 346 |
| Tetarpur, Gazipur | 100 | 485 | 20 | 6 | 2 | 3 | - | 516 |
| Padmakpur, Pratapgarh | 315 | 310 | 51 | 16 | 6 | 142 | 3 | 528 |
| Mazrapurab, Lakhimpur | 100 | 660 | 20 | 5 | 2 | 2 | - | 689 |
| Chandanchauki, Khiri | 100 | 274 | 25 | 3 | 1 | 40 | - | 343 |
| Chorpaniya, Sonbhadra | 55 | - | - | - | - | - | - | - |
| Total | 2,332 | 7,300 | 399 | 165 | 43 | 540 | 24 | 9,375 |

*Source: Uttar Pradesh New and Renewable Energy Development Agency*

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