Confederation of Indian Industry

Decentral energy and DISCOMs

CAN THEY CO-EXIST?

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DECENTRAL ENERGY AND DISCOMS

CAN THEY CO-EXIST?

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EXECUTIVE SUMMARY

The Indian Power Sector has recently achieved the distinguished feat of 100 percent household electrification. While this is a significant leap forward for the sector as a whole, it now faces a far greater challenge—that of providing cheap and reliable power 24X7 to all its consumers.

Despite making significant progress in this regard, long power cuts are still the norm for select states and districts in India. In this backdrop, emerging technologies pertaining to distributed energy systems are gaining momentum across the country.

Distributed energy systems refer to systems that generate, store and distribute energy in a localized manner for multiple applications—be it in the form of electricity, motive power or even thermal.

On the one hand, distributed systems such as rooftop solar have the potential to empower customers to move towards self-sufficiency—partially offsetting their dependence on relatively expensive grid power. With falling solar module prices and battery storage costs, renewable-based mini-grids possess the potential to provide cheap and reliable power to far-flung communities and marginal customers whom conventional utilities would find highly unviable to serve.

On the other hand, such systems are also perceived as a significant threat by DISCOMs, owing to their potential to impact their profitability—due to the possible migration of lucrative C&I customers away from the grid. Additionally, due to the variability inherent in such decentral energy systems, they also impose significant stress on network planning and investment for DISCOMs.

The example of global peers has, however, indicated that this migration towards decentral systems is here to stay and it is for the conventional utilities to adapt to the new paradigm and thrive in the changing business environment. In particular, DISCOMs would need to re-evaluate the role that they would play in the electricity value chain of the future and develop the capabilities necessary to participate in these value pools.

DISCOMs would need to move away from the conventional view of electricity as a “commodity” to the provision of energy as a “service”.

EMERGING PARADIGMS IN INDIAN POWER SECTOR

There has been a fundamental shift in the Indian Power Sector in the past 5 years with the emergence of a new paradigm.

For the past seven decades, India has lagged its peers in providing access to electricity to all its citizens. As recently as 2017, household electrification in India stood at 81 percent—the third lowest in South Asia. Nearly 240 million Indians lacked access to electricity while one out of every five people around the world without access to power lived in India. This had been the driving force behind the policy prerogative of 100 percent electrification.

With the introduction of the Saubhagya scheme, however, India has finally achieved 100 percent household electrification (except for a select few households in Chhattisgarh)—truly a cause for celebration given the scale of implementation. Under the Saubhagya scheme, last mile connectivity and subsidized electricity connections have been provided through grid extension. The scheme has covered about 40 million households over the past 3 years.

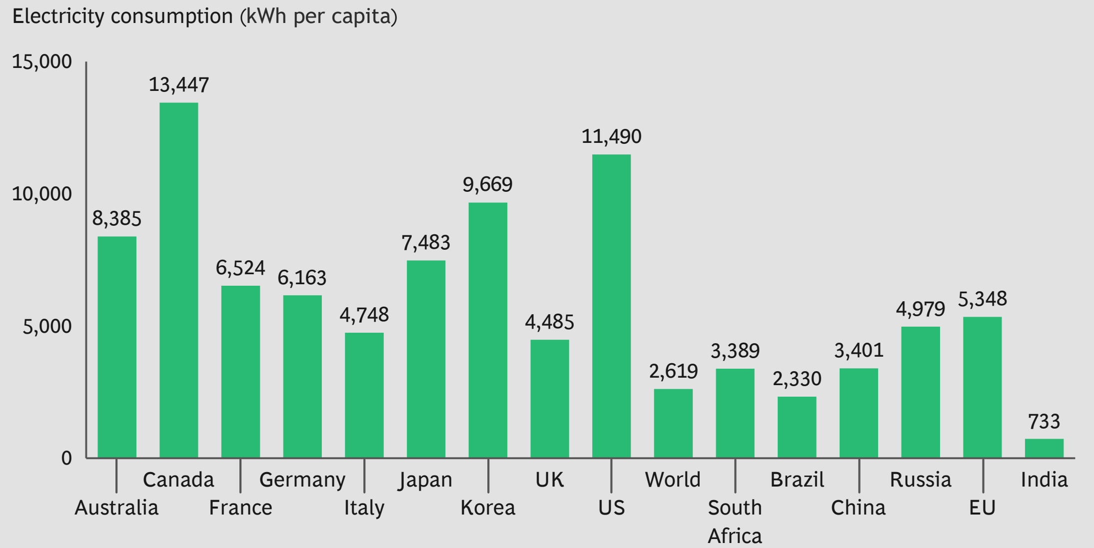
Even with this achievement, the Indian Power sector has only taken the first step towards making electricity an engine for future economic growth. Per capita electricity consumption, which is a key indicator of the importance of electricity in the economy, continues to lag significantly behind peers (Exhibit 1).

A significant cause of such low electricity intensity is the reliability of electricity supply. The nationwide village survey by the Ministry of Rural Development in 2017 indicated that only half the villages in the country receive more than 12 hours of electricity supply. Data from Prayas's Electricity Supply Monitoring Initiative (from 200 monitors across 23 States) shows that half the locations experienced outages of more than 15 hours per month, with rural areas witnessing 2-4 interruptions daily. Not surprisingly, India ranked 80th out of 137 countries on the reliability of electricity supply as per the 2018 Global Competitiveness Report.

Unreliable power supply has had cascading effects on the productivity of the economy. The World Bank estimates the downstream impact of power shortages on rural households and firms to be 1.42 percent of the Gross Domestic Product (GDP) per year and pegs it as the second largest economic cost for the country.

As India marches towards becoming a US$ 5 trillion economy by 2025, increasing the electricity intensity of the economy is critical to achieving this milestone. 100 percent electrification without reliable electricity supply is a wasted opportunity.

Exhibit 1 | Despite 100% Electrification, India's Per Capita Power Consumption Remains Far Below Global Average



Source: International Energy Agency (IEA) except India; Extracted from CEA report 2018; United Nations DESA; BCG Analysis.

Historically, the mandate of 24X7 electricity has fallen on the Distribution Companies (DISCOMs). The environment that the DISCOMs thus find themselves in is no doubt challenging. On the one hand, they continue to wrestle with legacy challenges such as high Aggregate Technical & Commercial (AT&C) losses in the network, the gap between Average Cost of Supply (ACS) and Annual Revenue Requirement (ARR) etc. On the other hand, they are also faced with the imperative of not only improving access, but also enhancing the reliability and duration of supply to all their customers. This becomes a problem particularly while serving marginal customers who have been introduced to the centralized electric grid in the recent past. DISCOMs face high costs in serving such marginal customers—especially in far-flung rural areas with limited potential to commensurately raise tariffs.

In this context, decentralized power is potentially the panacea for the ailments of the Indian Power Sector. In the current framework however, DISCOMs might tend to be wary and distrustful of decentralized power generation and its potential to decrease overall demand on the network. A case in point is the Unnat Jeevan by Affordable LEDs and Appliances for All (UJALA) scheme of distributing 20W LED tube lights and Bureau of Energy Efficiency (BEE) 5-star rated energy efficient fans to customers. While the scheme has done a commendable job in improving the energy efficiency of Indian households, it has also resulted in reduced demand growth for DISCOMs. Rooftop solar has also been treated with a similar skepticism by DISCOMs—a decentral solution with the potential to take away lucrative customers.

We believe that while DISCOMs are not entirely unjustified in their attitude towards decentral power, they should consider decentral power as a means to alleviate the problems that currently plague them. In this report, we hope to elucidate the potential benefits of the trend towards decentralized power. By adapting and co-opting the players in this space, DISCOMs can potentially move closer to the ideal of 24X7 cheap and reliable power supply to all. We also present select use cases from around the world on how DISCOMs have attempted to participate in the trend rather than restrict it.

24X7 universal electrification must be the new clarion call for the Indian Power sector as it moves into the next decade—with DISCOMs receptive to adapting and leveraging all possible means at their disposal to achieve the same.

24X7 UNIVERSAL ELECTRIFICATION— THE CHALLENGES

24X7 UNIVERSAL ELECTRICITY IN India has historically not been limited by supply or availability of generation resources. As indicated in Table 1, the all-India deficit for power has decreased to 0.6 percent (overall) and 1.6 percent (peak) from 10 percent (overall) to 12 percent (peak) about 10 years ago. In other words, the available generation capacity of the assets connected to the grid is on par with the demand for electricity. The low utilization of said generation assets is indicative of the fact that the malaise lies elsewhere.

The challenge of guaranteed and reliable supply of electricity for DISCOMs has always been one of affordability rather than availability—especially affordability to all segments of consumers.

There is a substantial gap in the cost of electricity in comparison to the value of electricity to the end user across segments. As evidenced by the persistent gap between the Average Cost of Supply (ACS) and the Average Revenue Requirement (ARR)—not all customer segments demonstrate a willingness to pay for the full cost of power that they receive.

Despite targeting zero gap under the Ujwal DISCOM Assurance Yojana (UDAY) scheme, the ACS-ARR gap stands at Rs. 0.26 / unit. This has resulted in alarming financial stress for DISCOMs across the country. The aggregate debt of DISCOMs stands at Rs. 2.6 trillion.

Thus, the potential economic value creation for select customer segments through guaranteed electricity supply does not offset the cost incurred for supplying electricity from a conventional centralized grid.

Under such a scenario, DISCOMs are forced to resort to load shedding to reduce their marginal cost of supply. The load shedding is particularly severe for rural customers whose tariffs remain artificially depressed due to economic and political reasons.

Any effort towards ensuring 24X7 universal electricity must thus begin by addressing the ACS-ARR gap for DISCOMs. There are predominantly two reasons for a persistent positive ACS-ARR gap:

- Legacy challenges of a centralized electricity network
- Commercial tariff distortions

In addition, it is to be noted that DISCOMs are not the only stakeholders in the electricity value chain who are working towards ensuring 24X7 electricity supply. Emerging global trends indicate that end customers are increasingly becoming more proactive in ensuring reliable and affordable power supply.

Table 1 | Energy Demand and Availability from 2009-10 to 2016-17

	ENERGY DEMAND				PEAK DEMAND			
	Requirement	Availability	Deficit	Deficit	Demand	Availability	Deficit	Deficit
	(GWh)	(GWh)	GWh	(%)	(MW)	(MW)	(MW)	(%)
2009-10	830594	746644	83950	10.11	119166	104009	15157	12.72
2010-11	861591	788355	73236	8.50	122287	110256	12031	9.84
2011-12	937199	857886	79313	8.46	130006	116191	13815	10.63
2012-13	998114	911209	86905	8.71	135453	123294	12159	8.98
2013-14	1002257	959829	42428	4.23	135918	129815	6103	4.49
2014-15	1067085	1028955	38130	3.60	148166	141160	7006	4.70
2015-16	1114408	1090850	23558	2.10	153366	148463	4903	3.20
2016-17	1142928	1135332	7596	0.66	159542	156934	2608	1.63

Source: CEA Report on "Growth of Electricity Sector in India from 1947-2017 (Table 8p/74)".

Legacy Challenges of a Centralized Electricity Network

Exhibit 2 enumerates the inefficiencies in centralized electricity value chains.

On the generation front, centralized electricity generation entails conversion of thermal energy (primarily coal) to electrical energy. Given the variation in technology, scale and operations & maintenance (O&M) practices of coal-based power plants, there is an inherent inefficiency in the conversion process. Further, there has been an increase in generation costs due to increased taxes and duties levied on coal—which utility scale distributors often cannot pass on to their customers (for example, electricity sale remains outside the ambit of the Goods and Services Tax).

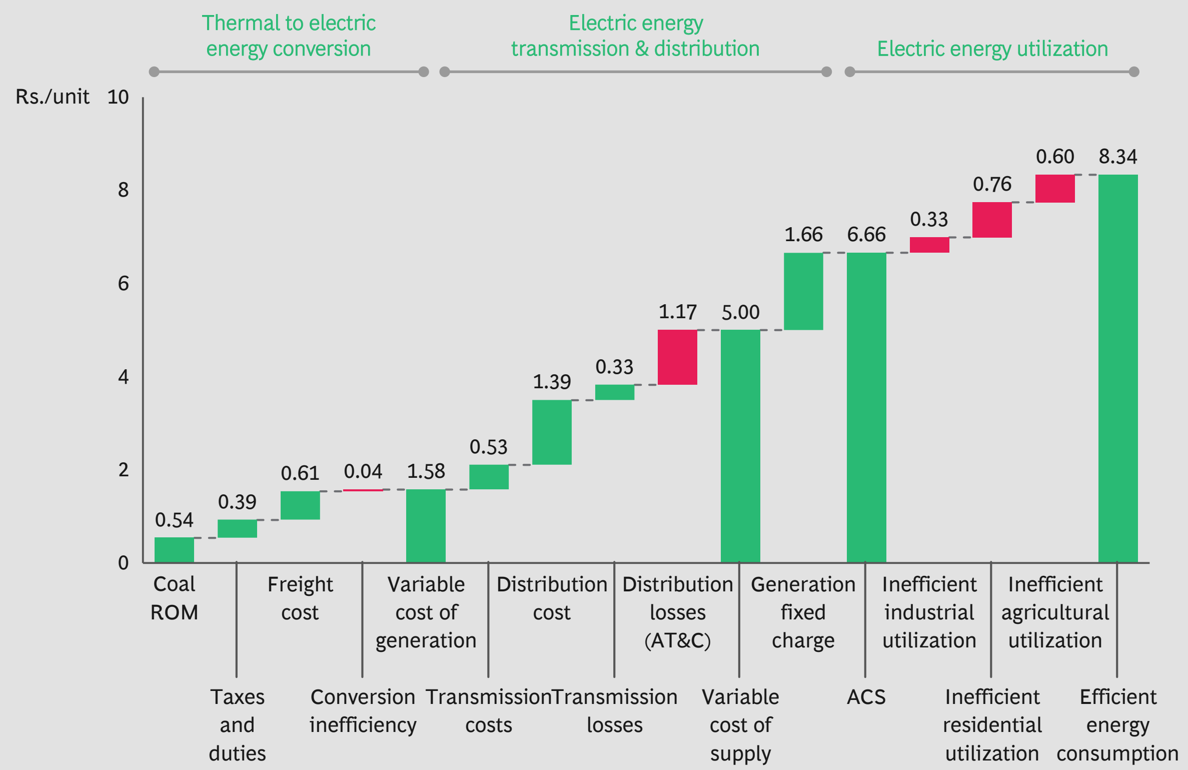
On transmission and distribution, AT&C losses in India have historically been high across states. As per the memoranda of understanding that states had signed under UDAY in fiscal year 2016, their DISCOMs were to initiate structural reforms by reducing AT&C losses by 900 basis points (bps) to ~15 percent in fiscal 2019. However, AT&C losses had fallen by only about 400 bps by December 2018 in comparison to pre-UDAY levels.

And finally, on the demand front, poor electrical energy utilization has been a big driver of inefficiency in the centralized electricity value chain. While there have been some efforts made to drive energy efficiency through the UJALA scheme, demand management remains an underdeveloped topic in India—a fact underscored by India having the lowest agricultural efficiency in the world in terms of electricity usage, in addition to significant residential inefficiency.

Commercial Tariff Distortions

Electricity remains a basis civic necessity and a political subject in India. In view of this, efforts to revise tariffs upwards to plug the ACS-ARR gap remain anemically slow in India. The UDAY scheme envisaged a tariff increase of 5-6 percent per annum across 3 years to bring tariff parity. However, the realized tariff increase has been limited to ~3 percent per annum.

Exhibit 2 | Multiple Inefficiencies Across the Centralized Electricity Value Chain



Source: Consultation Paper On Terms And Conditions Of Tariff Regulations, Central Electricity Regulatory Commission.

Further, economic and political realities have dictated a tariff distortion in the form of Cross Subsidy Surcharge (CSS). Agricultural and residential power tariffs remain heavily subsidized across India leading to an increased surcharge on commercial and industrial consumers. Exhibit 3 gives an example of the tariff distortion for a representative state.

At an economic level, low tariffs must be seen as an indicator of the value for the consumer. Persistently low tariffs indicate that the Indian consumer remains unwilling to pay for the current cost of electricity. Hence, it is imperative to systematically attack the inefficiencies in the centralized electricity value chain to reduce the ACS to consumers.

Considering that the existing efforts to reduce AT&C losses and improve energy utilization have had limited impact, it is necessary for DISCOMs to look beyond the traditional electricity value chain.

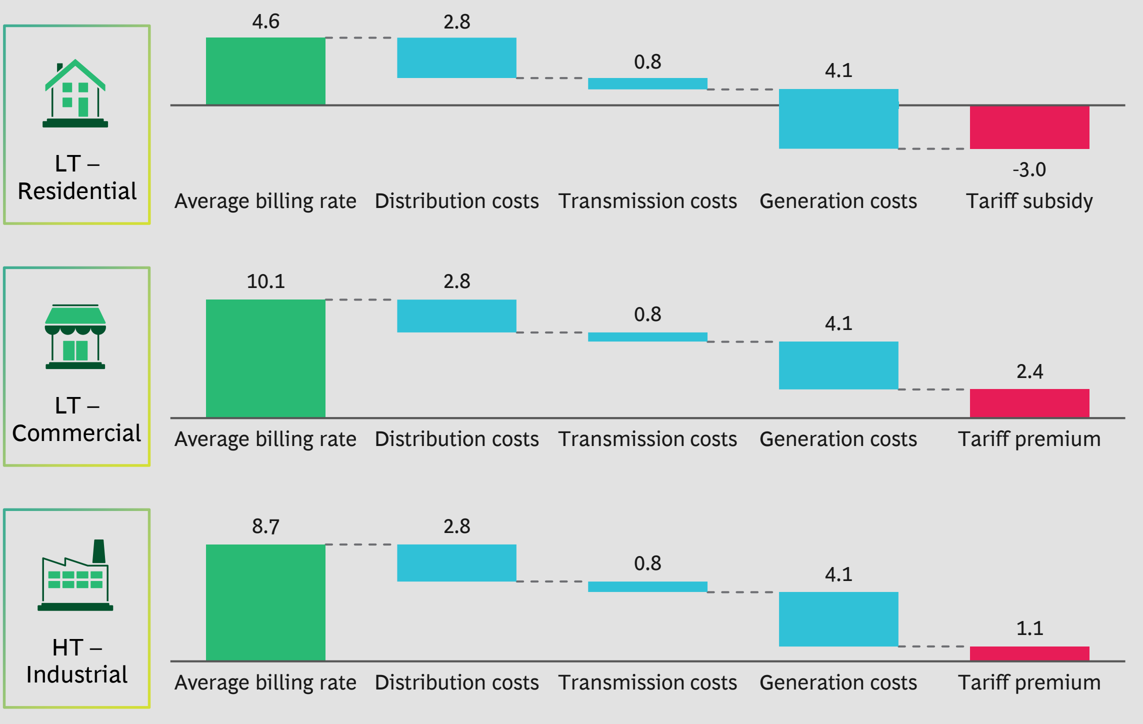
Emerging Global Trends—Decentral Energy Systems

It is to be noted that DISCOMs do not work in a vacuum. The power market involves multiple other stakeholders that include the central government, third party developers, EPC players and ultimately, the various customer segments themselves.

Customers have always been sensitive towards 24X7 energy supply. At an industrial level, customers have invested in captive / group captive power plants, micro turbines, etc. for energy security. Diesel Generator (DG) sets, inverters etc. have been a permanent fixture of Indian commercial and residential establishments. Tariff distortions like the CSS have only provided further impetus to customer-driven solutions.

Decentral energy systems are the key disruptor here. Decentral energy systems offer the end users options—to either choose to remain on the centralized grid and draw power from their

Exhibit 3 | Tariff Breakdown for Representative Markets



Note: Average billing rate represents sum of Demand Charge and Energy Charge. Typical demand charges – Rs. 2/kWh for Industrial users and Rs. 1/kWh for Commercial & Residential users.
Source: State Electricity Regulatory Commission Tariff Order for Representative State.

local DISCOM or, as is increasingly becoming the case, to choose to explore off-grid / local options for power supply, such as rooftop solar or mini-grids. While the existing solutions of captive generation / DG sets were capital intensive and not feasible for all customers, decreasing costs and multiple business models across decentral energy systems have increased the option set for the end customer.

With the entry of multiple third-party players offering such solutions for commercial and industrial customers, DISCOMs now also face the real threat of customers choosing to not draw power from the grid. For DISCOMs whose primary source of revenue remains the sale of power, this could be a major blow which could further exacerbate the legacy issues elaborated above.

A study of other developed economies would indicate that this migration of customers away from centralized power systems to decentralized power systems has now become a question of "When" rather than "If". It has thus become critical for DISCOMs to holistically evaluate decentral energy systems rather than just treat it as a threat to their current business model.

While DISCOMs may be justified in their wariness towards such solutions, it also becomes critical for them to evaluate how decentral energy systems can be leveraged to solve their own legacy issues which inhibit them from providing 24X7 universal power supply.

How would customers of the future adapt to ensure reliable power supply? What would be the structure of these futuristic decentralized electricity value chains and what could be the potential role of DISCOMs in such a landscape?

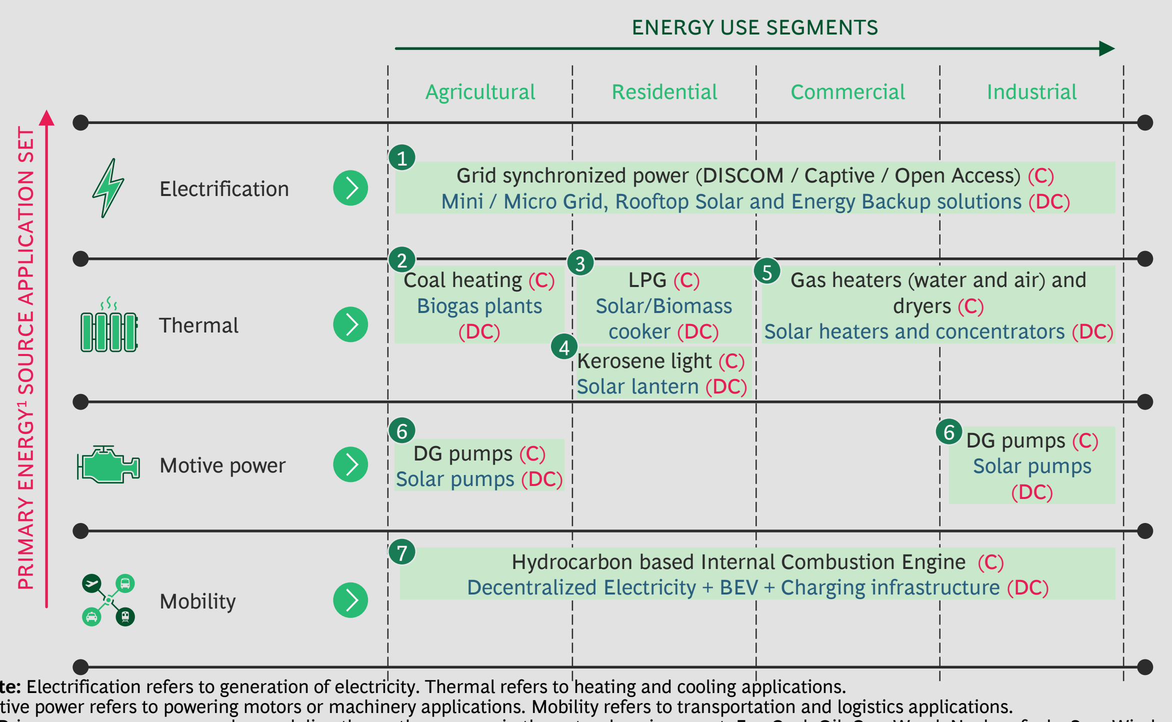
The following sections of this report detail the potential of decentral energy systems in achieving 24X7 universal electricity and the role DISCOMs could play in this effort.

INTRODUCTION TO DE-CENTRAL ENERGY SYSTEMS

GIVEN THE INEVITABLE MIGRATION towards decentral energy systems, it becomes critical to understand what exactly constitutes such systems. What are its elements and what fraction of the energy value chain would they eventually impact?

Decentral energy systems refer to any system that can generate, store (in some cases) and distribute energy in a localized manner. Such energy systems exist across the energy source application set and across customer segments for energy. Decentral energy systems exist for applications such as electricity, thermal, mo-

EXHIBIT 4 | Decentralized Systems with Applications Across the Energy Usage Landscape



Note: Electrification refers to generation of electricity. Thermal refers to heating and cooling applications. Motive power refers to powering motors or machinery applications. Mobility refers to transportation and logistics applications.
1. Primary energy sources can be used directly , as they appear in the natural environment. E.g. Coal, Oil, Gas, Wood, Nuclear fuels, Sun, Wind, Tides, Hydro, Geothermal.

Source: BCG Research.

tive power and even mobility. They also find potential use cases across customer segments—from agriculture to residential and industrial.

Exhibit 4 provides a glimpse of decentral solutions available across the energy usage landscape.

- **Electrification:** Renewable systems based on solar / biomass / hydro or a combination of these sources provide viable off-grid solutions for electricity generation. Mini grid solutions and rooftop solar coupled with storage are the key applications to be considered under decentralized electrification. They can be subdivided further basis the type of target usage segment and the specific part of the value chain that they impact—from generation to grid management etc. For this report, decentral generation shall refer to renewables based decentral generation.

- **Thermal:** Dependence on firewood has been found to be consistently high in India. The predominant use case for firewood is in heating and cooking. Decentralized solutions like biogas plants, solar lanterns, solar heaters and cookers can potentially serve as effective alternatives for such use cases.

- **Motive Power:** India currently has ~20 million grid-connected irrigation pumps. These pumps are a key driver of agricultural inefficiency in terms of electricity usage. Heavily subsidized agricultural tariffs across India have led to a distortion in the irrigation pumps market. Irrigation pumps are indiscriminately used with scant attention to electricity and water availability. Decentralized solutions in the form of solar pumps can be explored as an alternate to such grid-connected pumps.

- **Mobility:** Electric vehicles with swappable / distributed charging infrastructure are expected to provide a decentral solution for mobility.

DECENTRAL ENERGY SYSTEMS IN THE ELECTRICITY VALUE CHAIN

WHILE DECENTRAL SOLUTIONS EXIST for multiple use cases, the major focus of this report is to harness the potential of decentralized energy systems in the electricity value chain—from generation to end customer demand.

However, it is also important to understand why decentral energy systems have risen in prominence in recent times.

Why Decentral?

A combination of factors has created the perfect storm for the adoption of decentral energy systems. On the generation front, the increased adoption of decentral systems is driven by the increased viability of standalone renewable generation assets and accompanying battery solutions (Exhibit 5)

With both generation assets and the systems to manage them (such as battery storage) becoming increasingly economical, end customers can explore options such as micro / mini grids and off-grid power which were previously unviable in comparison to power supply from the grid.

In addition, the end user applications that can potentially utilize said decentral generation assets are increasingly being supported by the central government. Through its "Kisan Urja Suraksha evam Utthaan Mahabhiyan" (KUSUM) scheme, the government is subsidizing the solarization of grid-connected irrigation pumps—providing the option of buying back surplus solar power generation from such assets. The government is pursing aggressive targets for the same—with 1.75 million planned installations by 2021.

Application of Decentral Energy Systems in the Electricity Value Chain

A combination of the factors discussed above have led to two major applications of interest in the decentral electricity value chain in India:

- Rooftop Solar for Urban / Industrial / Commercial customers and
- Mini Grids with Solar Pumps for Rural / Agricultural customers.

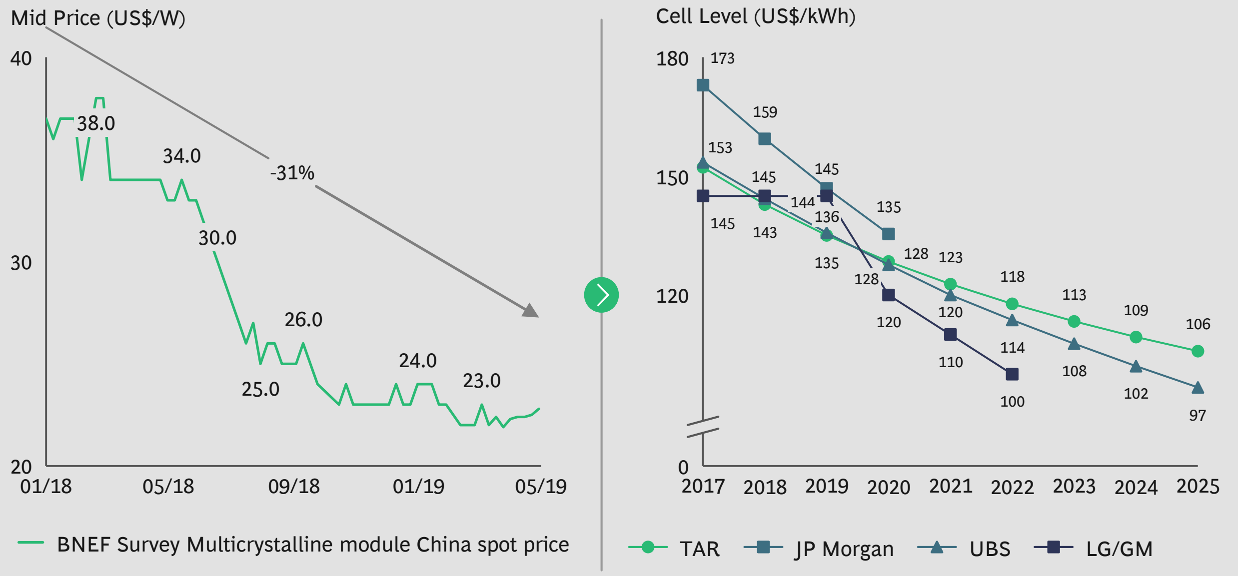
Rooftop Solar:

Rooftop solar refers to roof-mounted captive solar power installations—typically by large industrial, residential or commercial consumers—to offset their power purchase from the grid. The primary driver of such installations is the high tariff that these customers typically face—either through their presence in the higher "consumption bands" or because of the cross-subsidization of other marginal customer segments.

Exhibit 5 | Solar Cell and Battery Cost Curves have Shown a Declining Trend in the Recent Past

SIGNIFICANT DECLINE OBSERVED IN SOLAR MODULE PRICES IN RECENT PAST...

...WITH BATTERY CELL COSTS FOLLOWING A SIMILAR TREND INTO THE NEAR FUTURE



Note: TAR report D segment Battery Cell cost used at ~65 kWh, GM/LG + UBS Other Sources data points used to calculate BEV projection through 2030, also used to calculate TAR to 2030.
Source: BCG Analysis and Forecast, TAR Report, JP Morgan Global xEV Components Report, UBS Future of PowerTrain, BNEF Survey Multicrystalline module prices, Expert Interviews.

A steep decline in solar module prices and the cost of battery storage has led to a correspondingly steep decline in the levelized cost of electricity from rooftop solar projects—to the extent that soon, such projects would be highly competitive in comparison to grid power for these customers. (Exhibit 6)

Thus, rooftop solar represents a major opportunity to reduce the Average Cost of Supply for 24X7 electricity that these customers face by partially offsetting their purchase of high cost DISCOM power.

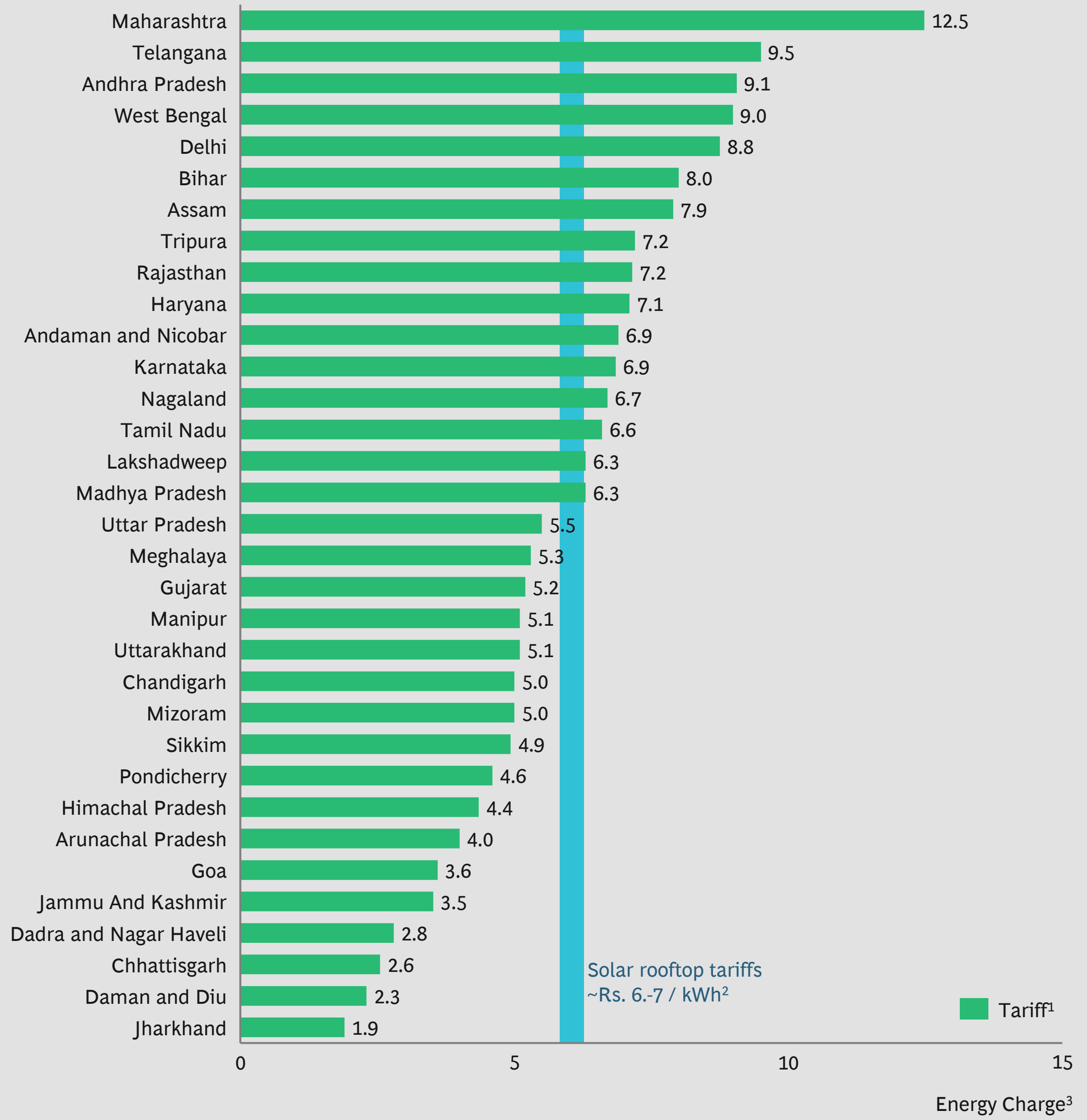
The government has also identified the potential of rooftop solar with a target of 40GW of installations by 2022.

Rural mini-grids:

With 100 percent electrification, nearly all locations enjoy access to power supply from the local DISCOM through the grid. However, it is to be noted that while these rural centers now have access to grid power—the power supply itself is not guaranteed. This is largely a result of depressed agricultural tariffs and inefficient electricity usage in irrigation applications. These reasons have severely limited the ability of DISCOMs to serve agricultural demand—forcing them to rely on load shedding in areas that they believe have a high cost to serve. Rural demand remains economically un-viable to serve under the current tariff regime.

For instance, multiple state DISCOMs—especially in prime agricultural growing belts of the country—continue to offer free power to farmers. This distortion in pricing leads to farmers often overdrawing on groundwater resources. To mitigate indiscriminate drawing, select states have also introduced metering and quota-based allocation of free electricity based on connected load. This, however, leads to an adverse incentive to farmers to over-size pumps to take advantage of cheap subsidized power. It is estimated that the realization from agricultural sector has been around 30 percent of the cost of supply with an annual agricultural subsidy burden of around Rs. 50,000 crores. Such a business model remains patently unviable for the DISCOMs.

Exhibit 6 | PV Rooftop has Become Attractive Against Grid-based Electricity

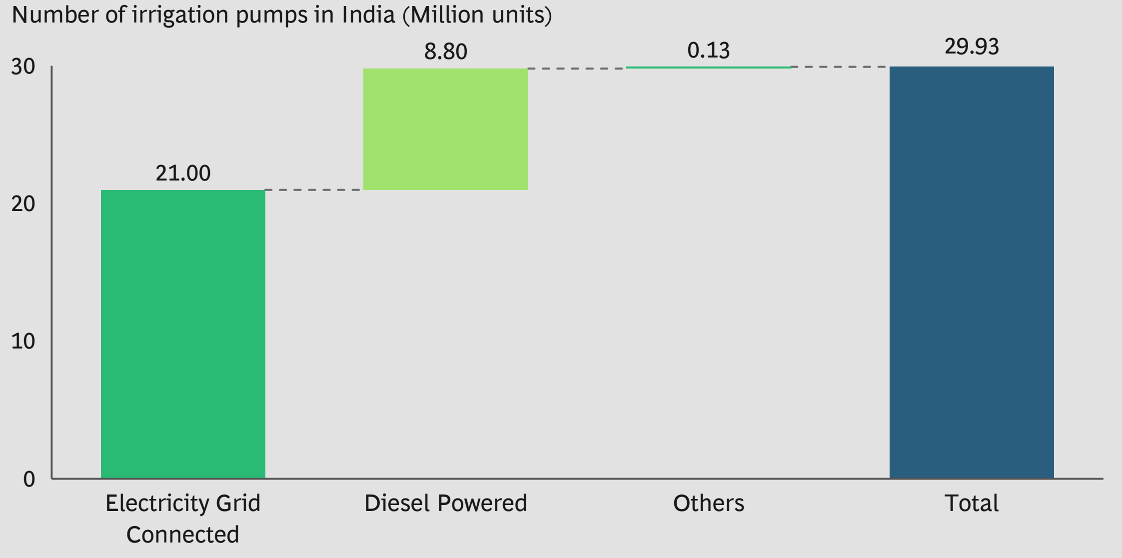


Source: 1. Energy charge for grid power purchase from DISCOM 2. Solar tariffs basis expert calls 3. Grid tariff taken as highest tariff band across different customer segments.(LT, HT, EHT) and usage (50 kwhr, 70 kwhr, 100 kwhr) through Sigma Insights data.
Tariffs as per FY '19 rates.

What is interesting, however, is that farmers who had been surveyed in this region had indicated that they are not unwilling to pay for power—on the precondition that said power is of a high quality i.e reliable and available. DISCOMs, it seems, are stuck in a vicious cycle. They are unable to provide high quality power to agricultural customers due to depressed tariffs and customers are unwilling to pay higher tariffs due to poor quality of power.

Intermittent supply of electricity has a cascading impact on the local economy. For instance, reliable round-the-clock supply of electricity is critical during the peak growing season in rural economies. Further, load shedding / power availability for only a part of the day translates into significant productivity losses for medium and small manufacturing units in these rural economies. To mitigate the impact of unreliable power supply, customers are thus forced to resort to alternate high-cost options such as diesel-power irrigation pumps. In addition to the high operating and capital costs—these options also pollute the environment.

Exhibit 7 | Electric Pumps Contribute 70%; Diesel Pumps have 29% Share



Source: : CEEW, Shakti Foundation.

Exhibit 7 demonstrates how India is still reliant on alternate options such as diesel-powered irrigation pumps to ensure stable motive power delivery

Rural mini-grids are an emerging use case for decentralized energy systems which can complement the centralized grid in providing 24X7 cost-effective electricity in rural areas.

Such mini grids utilize solar or biomass for generating electricity locally along with localized storage solutions. The electrical energy so generated is used for both residential and commercial applications. In addition, solar pumps are utilized to reduce the electricity load on the grid. While operational in both the on and the off-season, the power generated by these solar pumps provides an extra source of electricity for the mini-grid.

Potentially backed by storage solutions, the mini-grid is dependent on the main centralized grid only to the extent of managing fluctuations in the overall demand in the network. As a result, rural economies can become self-sufficient for their power consumption requirements.

DISCOMs stand to gain significantly from mini-grids, as they reduce the number of high-cost marginal customers that DISCOMs would need to serve and who would also need to be directly subsidized for their consumption.

In addition, given the impetus of the central government to promote the adoption of solar pumps (to the extent of 60 percent+ financing assistance), these assets can potentially also be on par or significantly cheaper than alternatives currently available in the market—such as DG sets and electrical pumps.

A conflation of the above factors would serve to significantly reduce the financial burden on DISCOMs that are already under a significant amount of stress due to under-recoveries on tariffs.

It is also to be noted that while these decentral solutions present a significant opportunity for the power sector as a whole, they are faced with their own set of challenges that limit their ability to explosively expand in the current policy environment.

The following sections of the report explore these potential barriers to the growth of rooftop solar and rural mini-grids while also exploring the current stance of DISCOMs towards such solutions and their concerns.

BARRIERS TO INCREASED PENETRATION OF DECENTRAL ENERGY APPLICATIONS

ROOFTOP SOLAR AND RURAL mini-grids present a significant opportunity for the Indian power sector to bridge the viability gap which is currently holding it back from achieving 24X7 reliable power supply.

The barriers limiting the penetration of these applications are a mix of regulatory, social and economic factors. Five key barriers among them are:

- Limited awareness among customers
- Policy framework from the DISCOMs and state regulators
- Supplier side constraints
- High ticket size of the upfront investment
- Inability of decentral generation to function round the clock

Limited Awareness Among Customers

Awareness of benefits and the presence of potential large vendors is a critical factor for the adoption and trial of rooftop solar and rural mini-grids.

However, the rooftop solar segment in particular has to contend with low awareness. The target market segment of large commercial and industrial customers has limited awareness of the key benefits—be it the reduction in the overall electricity bill, the ability to augment supply of electricity in areas with long power cuts or its contribution in generation of green electricity.

Policy Framework from the DISCOMS and State Regulators

The presence of a well-defined regulatory framework is a pre-requisite for investor interest in any segment. A transparent policy and a simple approval procedure would greatly build investor confidence for investments in the sector. The same is also true for decentral energy systems. However, both rooftop solar and rural mini-grids face significant challenges on the policy front.

Rooftop Solar:

Local DISCOMs and state regulators are the key stakeholders in framing the policy for rooftop solar and for processing and approvals of rooftop solar installations. Thus, cooperation between DISCOMs and state regulators is imperative for end customers to not only have a simple and effective installation process but also to avail the benefits from rooftop solar.

The policy framework for subsidies, installation, net metering, billing and administration has however been an area of significant debate across states in the recent past.

- **Net metering policy**
  State regulators and DISCOMs together control the policy formulation within a state on rooftop solar. Currently, while many states have net metering policies in place, some of the high rooftop solar potential states such as Tamil Nadu and Uttar Pradesh do not have provisions for net metering across all customer segments (Exhibit 8). States such as Karnataka have put the implementation of the policy on hold. The policy has also seen multiple changes and roll-backs in high-potential states—which has created a highly uncertain business environment for potential vendors & installers for rooftop solar in the state.

- **Approval process**
  DISCOMS are the final approving authority for net metering applications and are solely responsible for the installation of net-meters for approved cases. The approval and meter-installation process, however, has a long lead time in multiple states (>6 months in select states)

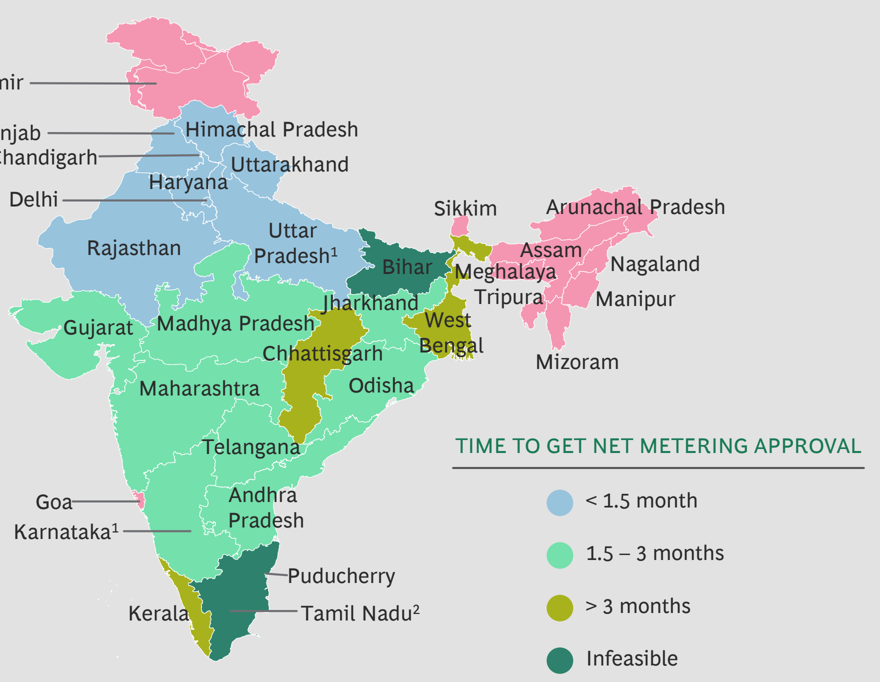
- **Subsidies**
  While multiple states had introduced subsidies in the past, these have been scaled back or completely rolled back in some places (Exhibit 9). Additionally, subsidies are credited to rooftop solar providers. The delays in processing for these subsidies and the corresponding working capital burden on small-scale rooftop solar providers places significant stress on their profitability—especially given the slim operating margins.

- **Billing:**
  Support of DISCOMs is critical in bill generation for customers of rooftop solar—as benefits of rooftop solar accrue to end customers only when they observe a reduction in their electricity bills. It is thus important that generated bills factor in the reduction in number of units owing to solar generation.

Rural mini-grid

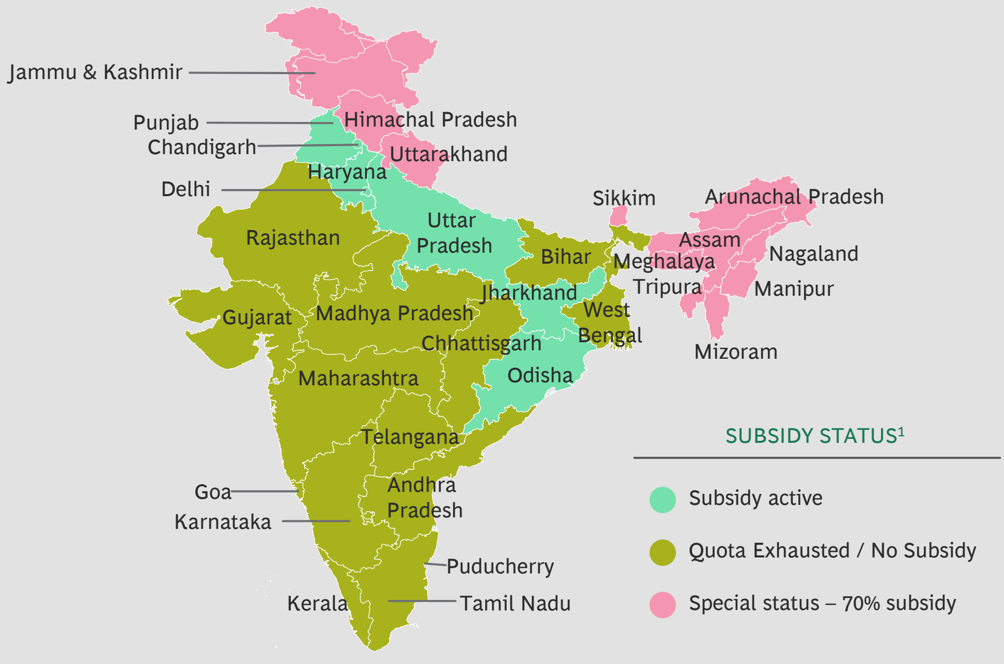
Given that a rural mini-grid would involve coordination between the local DISCOM, State

EXHIBIT 8 | Net Metering Policies Vary Across States - Absent in Some States and with Varying Times for Approval in Other States



Source: BCG Research, as of June 2019.
1. Net metering only for metered Agricultural, Residential or Domestic Category Consumers.
2. Net metering only for LT customers.

Exhibit 9 | Subsidies were Introduced to Push Rooftop Solar Adoption—Have Now been Scaled Down or Completely Rolled Back



Source: BCG Research.
1. As of June 2019.

Electricity Regulatory Commission (SERC), central authorities and interested third party developers, a transparent policy, laying out the responsibilities of each stakeholder is critical

While the central government has made significant progress in the launch of subsidies for financing of solar pumps (under the "KUSUM" scheme), the policy for micro-and mini-grid creation lacks the same degree of clarity.

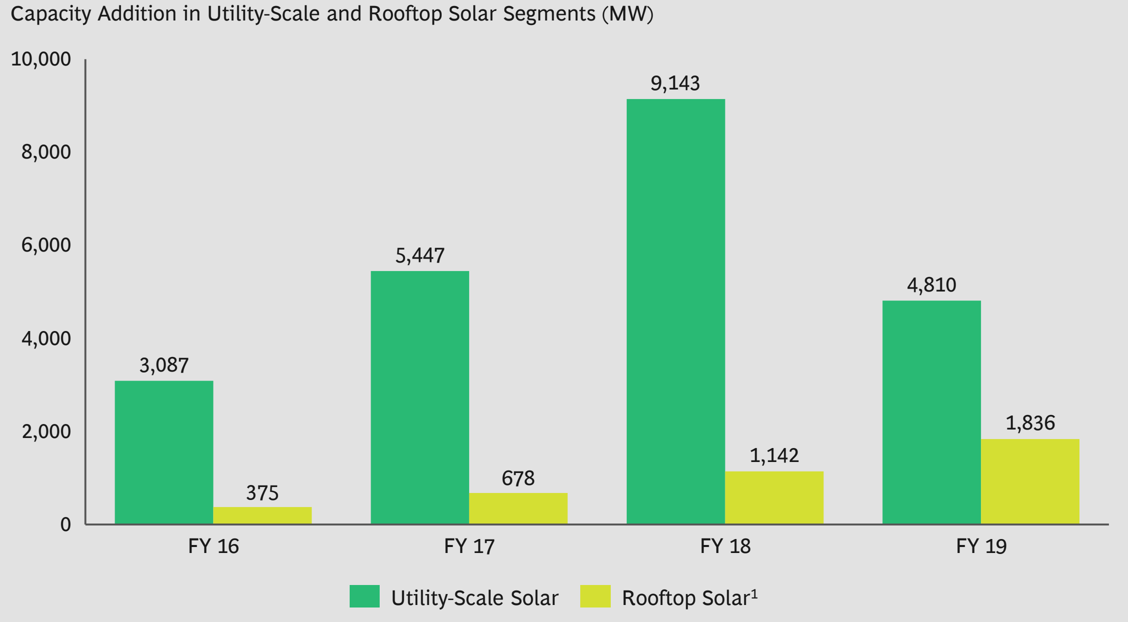
The government had introduced a draft national policy for the same in 2016 via the Ministry of New & Renewable Energy (MNRE). However, the policy is currently still under consideration by the national government with limited clarity on a potential ratification date. In addition, different states have had varying degrees of success in developing their own policy framework for decentralized generation. For instance, the Uttar Pradesh government had leveraged the Rural Electrification Policy (2006) to develop a state specific mini-grid policy in 2016, while the Jharkhand Renewable Energy Development Agency and CEED introduced a similar draft policy, only as late as 2018.

Supplier Side Constraints

Supplier side constraints exist in the rooftop solar market due to availability of other more accessible and larger solar markets—both from the perspective of business development and execution. Rooftop solar remains a nascent market for the suppliers as they gradually work towards gaining the requisite experience and wherewithal to operate in this segment. A few of the constraints faced by suppliers are elucidated below:

- **Competition from utility-scale solar:** Utility scale solar has seen explosive growth and increased government focus in the recent past; this focus, coupled with increased clarity on government policy and approvals has resulted in a 3-5x increase in installed capacity per year (2016-2019) for utility-scale solar when compared to rooftop solar capacity (See Exhibit 10)

Exhibit 10 | Majority Capacity Additions Being Made in Utility Scale Solar; Rooftop Solar Capacity Addition is Smaller but Growing



Source: Bridge to India.
1. Includes on-ground decentralised installations.

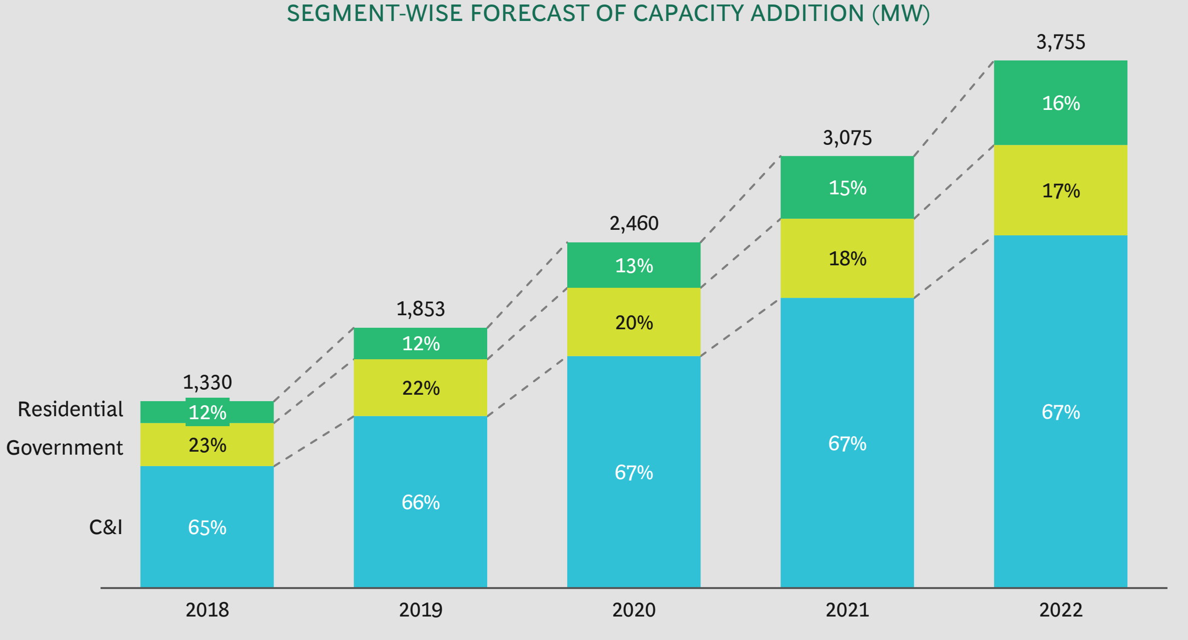
- **Higher potential for large capacity rooftop solar:** Within rooftop solar as well, the government, Commercial and Industrial (C&I) customers are estimated to have 80 percent of the total potential capacity addition till 2022, as per Bridge to India estimates (Exhibit 11). Residential and Small and Medium Enterprise (SME) customers—given their small ticket size—are far less attractive segments for the rooftop suppliers

- **Legacy reasons:** The portfolio of large rooftop solar suppliers is dominated by utility-scale solar and large-scale government or C&I projects (Exhibit 12). Owing to legacy reasons, these large companies come with the pedigree and project sales rhythm of Engineering, Procurement & Construction (EPC) companies—i.e. they participate in a few large deals per year with a focus on project execution. As opposed to a conventional project-based Business to Business (B2B) model, residential and SME sales need significant focus on channel development and sales process coupled with minimal customization and installation effort. This is incongruous with the capabilities and mindset of these large suppliers who would need to develop new capabilities to succeed in the residential and SME segments. This transition is in progress and is unlikely to be completed in the short-term.

- **Fragmentation** The rooftop solar market is highly fragmented with the market leaders having a market share of only ~6-7 percent each. There are two new kinds of suppliers that are emerging: small local players (for example, system integrators) and Private Equity (PE) / Venture Capital (VC)-backed players.

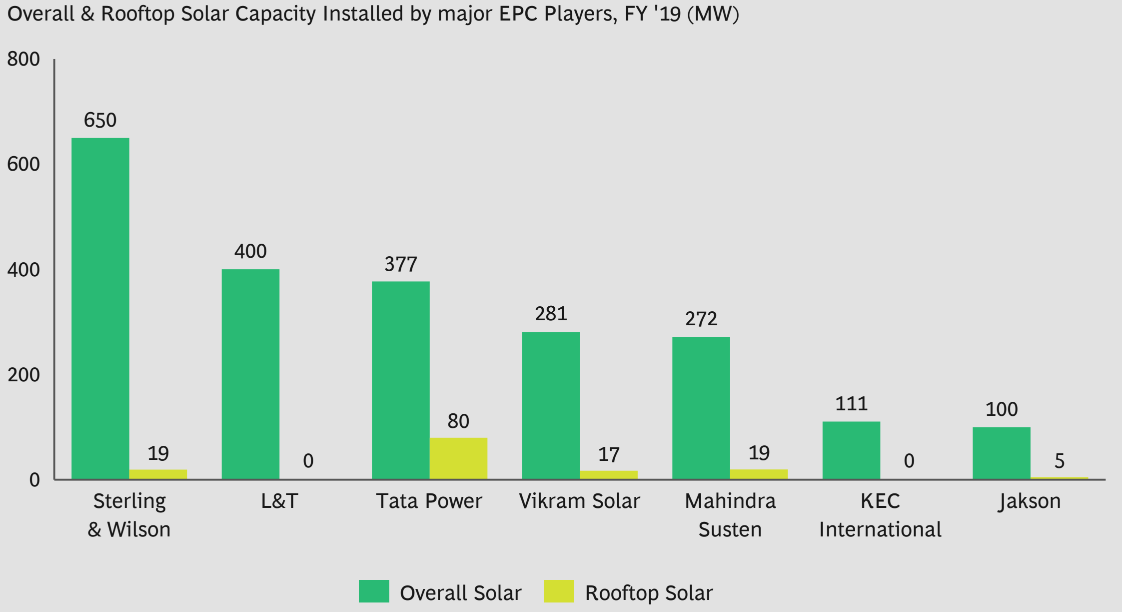
  The small players have limited ability to support their working capital requirements owing to the long subsidy processing lead times and hence, only focus on customers / states where subsidies are either not needed or processed directly to the customer. Consequently, they are able to target only a small fraction of the overall residential and SME market.

Exhibit 11 | Commercial and Industrial Segments Estimated to be more than Two Thirds of the Total Capacity Addition Until 2022; Residential to be Only ~15%



Source: Bridge to India; BCG Analysis.

Exhibit 12 | Major Suppliers of Solar Installations Focus on Utility Scale Solar; Rooftop Solar is a very Small Portion of the Portfolio



Source: Bridge to India, BCG Analysis.

The PE / VC-backed suppliers have a larger geographic footprint and can focus on the small ticket customer segments. However, growth in this segment of companies is still in its nascent stage. Given the high valuation expectations and the slim operating margins in the business, it will be interesting to observe how these companies evolve and adapt.

High Ticket Size of the Upfront Investment and the Long Payback Period

Both rooftop solar and rural mini-grids require significant upfront investments with long payback periods. A typical rooftop solar installation of about 10 kW (1000 sq. ft. roof size) in the residential segment requires an investment of ~Rs. 5 lakhs—a significant amount for the conventional middle-class customer. Likewise, investments in mega-watt scale rural mini-grids would involve significant upfront investments for setting up the distribution network and in creation of the generation assets. Considering the limited initial purchasing power of the target demographic, there is limited scope for the end customers to invest in the capex of these projects themselves.

There are two models that can alleviate this ticket size challenge: the first one is financing and the second is the opex "Pay-as-you-go" model:

- **Financing:** Akin to other industries with a similar ticket size (for example, automobiles), the presence of varied financing options in the market could be a potential driver of growth. However, financing for rooftop solar projects is in its initial stages and available only with a very select set of suppliers. Similarly, the absence of an efficient rural financial system can hamper the growth of rural mini grids.

- **Opex model:** An opex model transfers the initial capital expenditure to the supplier with the customer only required to pay for the electricity generated from the project—be it rooftop solar installations or rural mini-grids. Such a model converts the capital expenditure into variable cost, thereby removing the high initial ticket size hindrance and converting it into smaller monthly payouts comparable with the monthly electricity bills (while reducing the actual electricity bill itself).

  For the suppliers, this model increases their upfront investment in the system and the requirement for strong financial backing. An opex model would also require the supplier to develop capabilities in monthly payment collections and in the O&M of the installed assets to ensure that the customer commitments are met in an efficient manner.

Inability of Rooftop Solar to Function Round the Clock

An inability to generate power round the clock is the last major deterrent to the adoption of rooftop solar for decentral generation. As the irradiation varies through the day and is absent entirely at night, a rooftop solar system cannot completely replace the electricity grid connection for the customer. The same can be said for a solar-based RE mini-or micro grid, as well.

Additionally, the prohibitively high cost of batteries for storage, despite a declining trend in costs, also serves as a deterrent for RTC supply.

All the above factors play a significant role in stifling the penetration of decentral energy systems and will need to be addressed in the near future. While there has been some progress on these fronts in the recent past, the pace of change—both with suppliers and with DISCOMs—would need to increase to meet the growing demand.

CHALLENGES OF DECENTRAL ENERGY SYSTEMS—DISCOM PERSPECTIVE

Decentral energy systems such as rooftop solar and rural mini-grids represent a significant opportunity for the Indian power sector to improve access and reliability of power supply. However, not all stakeholders are equally enthused by this prospect. In particular, DISCOMs—being key stakeholders in the electricity value chain—have multiple reservations regarding the proliferation of such decentral systems. On the other hand, DISCOMs are also equally cognizant of the fact that these emerging technologies represent a significant opportunity for them to evolve and resolve their legacy issues.

In particular, the biggest concerns of these DISCOMs pertain to two key domains:

- Impact of rooftop solar and rural grids on DISCOM profitability, and
- Impact of decentralized energy systems on network operation and investments

Impact of Rooftop Solar and Rural Grids on DISCOM Profitability

As described in the preceding sections, DISCOMs are already facing significant challenges in maintaining profitability and repaying their debt. The gap between ACS and the ARR has been a major cause for concern across the country. In this situation, the prospect of widespread adoption of decentral energy systems imposes multiple stresses on their profitability.

Lucrative Customer Segments Moving Away

The C&I segment of customers represent the most lucrative customer segment for DISCOMs—to the extent that the tariffs charged to C&I customers are implicitly channeled to subsidize the tariff charged to residential / agricultural customers. In addition, C&I customers represent a significant fraction of the total demand (in terms of units of power consumed) for DISCOMs. Correspondingly, these C&I customers have also been the driver for significant investment in creating dedicated network resources (for example, Dedicated transformers and high voltage lines). The business cases for such investments are typically contingent on the long-term revenue prospects from these C&I customers.

However, by the same token, C&I customers represent the segment most likely to adopt decentral energy systems—both from the perspective of awareness about such solutions and from the perspective of financial wherewithal to make high upfront investments. In addition, the high tariffs charged to such C&I customers makes the business case for decentralized generation more lucrative for this customer segment—especially given the fact that power & fuel represent a significant fraction of the overall costs incurred by such customers.

We have identified four main drivers for decentral systems to become attractive to these customer segments: high existing tariffs, higher ability to make upfront investments, power & fuel being a significant fraction of overall costs, and higher ability to operate and maintain these resources:

- **High existing tariff (refer Exhibit 3):** The tariffs charged by DISCOMS to the commercial and industrial segments are typically much higher than the tariff charged to the residential customer segment. The cost of generation from rooftop solar / mini-grids is largely segment-agnostic. This makes the payback period on the investment much more attractive for these C&I customers who are also the "subsidizing" customers in the DISCOM network

- **Higher ability to invest upfront:** For C&I customers, investments in decentral energy systems such as rooftop solar represent a long-term capital investment decision. As a result, the investment in rooftop solar should be evaluated over the complete life of the asset. Given the healthy Internal Rate of Return (IRR) associated with these projects, the C&I customers have the ability to raise financing from banks / other lenders to make these investments.

- **Power and fuel being a significant cost:** For many industries, electricity cost is a sizeable fraction of their overall cost base—hence, reducing the electricity cost is often a strategic priority as it can potentially enhance profitability and competitive intensity in their industry.

- **Superior ability to operate and maintain:** Rooftop solar needs periodic maintenance for optimal performance. As the C&I customers have large rooftop projects and typically a large management cadre, they have the option of outsourcing maintenance or, in the case of customers with a large technically competent workforce, perform the maintenance in-house.

Marginal customers remaining on the network

Marginal customers for DISCOMs are typically customers with a high cost to serve (present in remote locations) or customers whose tariffs are highly subsidized.

Despite decentral energy systems becoming highly viable for C&I customers, these marginal customers have limited incentives to move away from conventional centralized electricity supply. This is largely due to the following key factors:

- Low electricity consumption—leading to such customers typically purchasing power at the subsidized lower bands from DISCOMs and not having enough consumption to guarantee high utilization of any potential decentral energy installations

- Limited ability to make upfront investments which might be required in the absence of financing solutions

- Limited feasibility of opex model in small installation sizes for rooftop solar suppliers

This is a major concern for DISCOMs—while lucrative "subsidizing" customers are incentivized to partially offset their dependence on the grid, "subsidized" marginal customers have limited incentive to do the same.

Reduction in tariff due to lowering of consumption slabs

Electricity tariffs across slabs increase rapidly as customers move up each consumption slab—this is designed to subsidize the "low" consumption customers using electricity for basic necessities by charging the "higher" consumption customers for using electricity for their luxury needs or businesses. Rooftop solar reduces the offtake of the customers from the grid by substituting it with in-house generation—thereby, reducing the consumption slab in which the customer is billed. This is likely to affect DISCOMs across all segments of customers—even if the plant size is small or the rooftop solar project is only a fraction of the peak load required by the customer.

Impact of Decentral Energy Systems on Network Operation and Investments

As decentral energy systems increase in scale and penetration, DISCOMs will need to increasingly tackle the complexities that are likely to arise in network planning and operations due to the inherent variability in power generation from these installations.

Challenge in planning network investments

Generation from decentral systems—especially when operating without battery backup—are inherently variable. On the other hand, network investments are planned by the DISCOMs to meet the peak load requirement, through the year. With economic growth and increasing temperatures during summers, there is a high probability that this peak load will keep increasing year on year—thus requiring DISCOMs to further augment the network.

While these investments cater to the peak load in the entire license area, they need to be planned to keep in mind the demand from local markets that constitute the license area. Distributed generation poses a challenge in planning these network investments due to three inherent characteristics:

- Variation in demand vis-a-vis demand assumed in capex planning
- Variation in demand basis the time of day
- Inability to measure true generation with current metering practices

The following sections elaborate on these challenges

- **Variation in demand vis-a-vis demand assumed in capex planning:** Typical investment cases for distribution transformers assume a ~10-year period of operation. However, decentral installations can alter the demand profile of the area catered to by the distribution transformer within that period.

  For commercial and industrial establishments, for whom the DISCOM has made dedicated network investments, there can be a significant drop in revenue (as discussed above) thereby, making it challenging to recoup the investments made for such customers.

- **Variation in demand basis the time of day:** Even if the rated capacity of the decentral system is known, the actual generation depends on the solar irradiation—which varies across days and within time blocks on any given day. For instance, solar irradiation can be impacted by factors such as cloud cover, time of day, time of the year, etc.

  This makes demand prediction complex and extremely difficult to factor into decentral generation capacities in network planning.

- **Inability to measure the true generation from decentral installations:**
  Current net metering technology only allows the DISCOMs to measure the "net" consumption of the customer from the electricity grid. The DISCOMs do not know the actual total consumption and the generation from the rooftop installation. This in turn enhances the variability created by the above two factors and therefore, makes network planning even more challenging.

Challenge in network operations

Network operation is a major challenge for DISCOMs given the variability of generation from decentral installations.

Network operations aim to deliver consistent voltage within the right frequency band with minimal interruptions to the supply—all the while ensuring safety of the network equipment and personnel.

DISCOMs' ability to efficiently operate the network can get diminished due to decentral generation along three dimensions: estimating power purchase requirements, keeping the grid "pollution" free, and ensuring safety during network repair and maintenance.

- **Estimating power purchase requirements:** The DISCOM system control function schedules power purchase from Generating Companies (GENCOs) and the state / national grid in 15 minute intervals. These power inflows into the grid need to match the demand for power on the grid, for consistent voltage to be delivered to the end customers. The GENCOs in turn plan their plant operations to provide adequate power to the DISCOMs. Variability in generation from decentral generation, especially without storage, will make this task more complex, both for DISCOMs and GENCOs.

- **Keeping the grid "pollution" free:** Distributed generation systems generating DC current induce harmonics into the prevailing AC voltage grids. High quality invertors which minimize harmonic distortions are required to safely operate the grid without any fluctuations. The highly fragmented supplier landscape makes it challenging to ensure the quality of the invertors that are installed for distributed generators. In the absence of a robust mechanism to keep harmonics to a minimum, the distortions in the network are likely to increase as the installed capacity for distributed generators increases.

- **Ensuring safety during network repair and maintenance:** DISCOMs currently control the entire flow of electricity in the network and can isolate any required section of the network unilaterally. This ability to isolate is crucial when a specific network segment needs to be repaired or maintained to ensure safety of the personnel. As decentral generation is not under the control of a single entity, DISCOMs will need to develop a mechanism to isolate network elements and coordinate with a much larger number of stakeholders to plan repair and maintenance activities.

It is interesting to note that these challenges (profitability and network management) emerge from different sets of customers—threat to profitability stems from relatively larger commercial and industrial customers while the operational challenges germinate from the smaller residential and institutional customers. This further increases the complexity of the situation as it does not provide any easy way out for the DISCOMS to support any segment without taking on at least some of the challenges above.

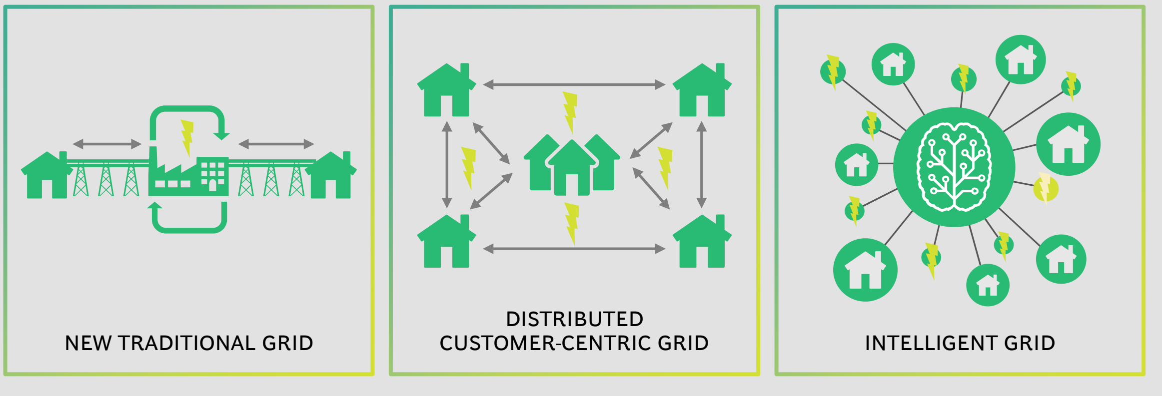
HOW CAN DISCOMS ADAPT?

With the inevitable increase in penetration of decentralized energy systems, the grid itself is likely to evolve. From a traditional grid network with centralized GENCOs supplying power to consumers, the grid will evolve first to "distributed" and eventually an "intelligent" network (Exhibit 13).

The end-state "intelligent" grid is envisaged to involve high levels of analytics and machine learning to identify, predict and correct faults automatically ("self-healing")—with a unidirectional flow of power (GENCOs to consumers) to be replaced by bi-directional flow of power from "prosumers" controlling distributed generation resources to consumers who intermittently draw power from the grid to supplement their in-house generation.

As depicted in Exhibit 14, the grid of the future will thus have 7 functionalities—ranging from reliability, cost efficiency and Distributed Energy Resources (DER) integration to safety and (most importantly) customer centricity.

Exhibit 13 | How the Grids are Likely to Evolve



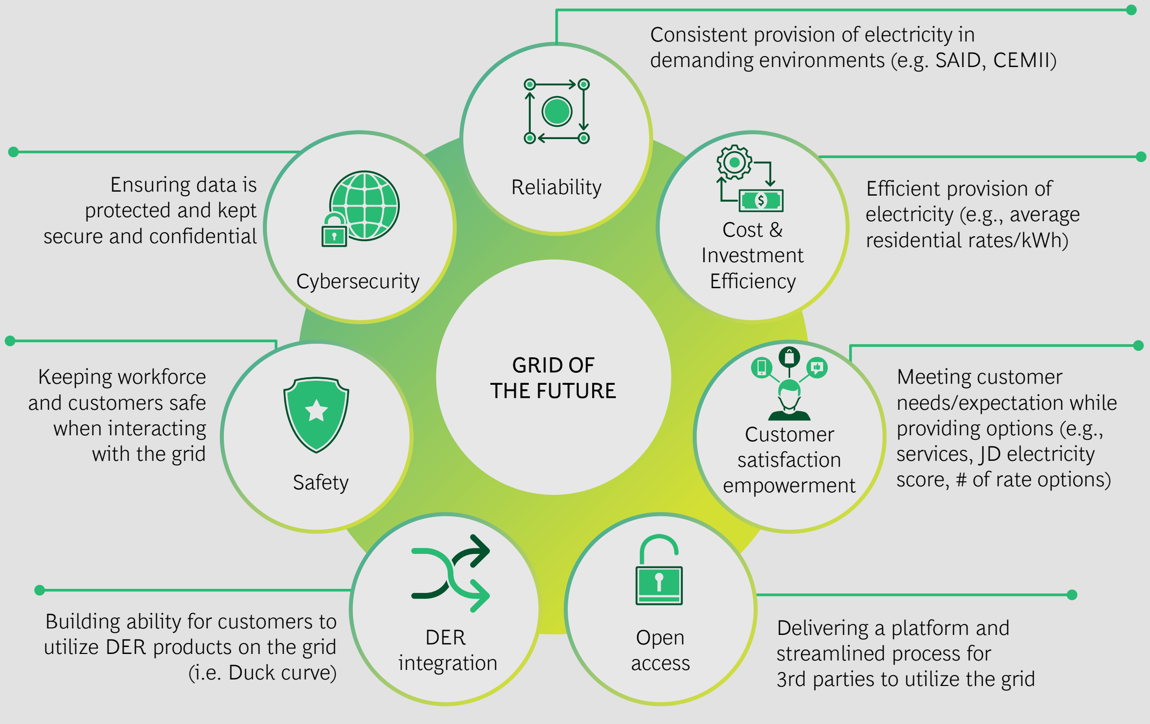
Continued evolution of existing grid, with focus on automation and two-way flow

Decentralized grid, with strong processes and high level of management at customer sites

Self-healing grid with high levels of machine learning and strong analytics communication

Source: BCG Analysis.

Exhibit 14 | Functionality Framework for End State – Grid of the Future



Source: BCG Analysis.

With the increasing penetration of decentralized energy systems, it is imperative to envisage the role that a DISCOM would play in this "intelligent" grid. Distribution companies would need to work on strategies to co-exist and participate in these trends, if not lead them entirely.

The following paragraphs of the report discuss the potential roles that a DISCOM could play in this emerging environment

Grid Management:

With the potential changes envisaged in the "intelligent" grid, there is a need to significantly ramp up the way DISCOMs think about grid management—with a higher emphasis on demand response and digital technologies:

- Demand response would be critical in smoothening out peaks and troughs, especially with a bi-directional flow of energy. Mid-day spikes in power sold back to the grid from rooftop solar installations coupled with home charging of EV would create a more volatile daily demand pattern.
  - In the Indian market, distributed generation is expected to achieve moderate to high degree of penetration in medium term (5-10 years). Customers would be retaining their grid connection—either to sell surplus power or as a back-up.
  - In this scenario, DISCOMs would need to become system stabilizers. To enable this, DISCOMs would need to develop the following capabilities:
    - Customer Indexation and Data Analytics to track network metrics (for example, faults, System Average Interruption Duration Index (SAIDI), Transmission & Distribution (T&D) loss, phase loading etc.) at granular levels (such as distribution transformers), enabling highly specific corrective action
    - Distribution automation to enable the grid to respond automatically to fault or fault-like events through self-switching and routing

- Field force automation to improve effectiveness of fault-handling crews, cable laying and Repair & Maintenance (R&M) teams—all through automated processes and richer data and analytical support

- Predictive maintenance models for pre-issue identification

- Smart metering to allow bi-directional grid communication

- Demand response programs which seek to curb consumption during peak periods without significant investment, leveraging energy use information

- Investments in a wide variety of technologies, including advanced inverters, grid management and dispatch, and distribution-level energy storage to address issues like overvoltage

In the long term, block-chain technologies can be used in automating demand response and DER activity in real time—leveraging smart contracts and allowing for a greater degree of flexibility in the grid, facilitating grid balancing processes. This technology can be used in automating selections of balancing and re-dispatching bids accordingly. Smart contracts can be used for grid balancing settlement.

- Demand prediction and scheduling which utilize digital technologies: This would entail granular demand forecasting, for example, prediction at the neighborhood / household level, leveraging intra-house smart plugs for accurate decision making on load switching and maintenance planning. Additionally, an array of grid sensors and smart meters would collect data about consumption spikes and patterns which would be fed into a demand prediction and scheduling model

- Managing overloading of select transmission / distribution sub-stations / lines and issues planning and maintenance: DER creates unique challenges for utilities when a large number of solar installations or other distributed resources are connected to a specific circuit or feeder. In these situations, investment may be needed to increase feeder capacity. Transformer upgrades and other measures may also be necessary to ensure that the voltage and frequency are kept within acceptable ranges. DISCOMs might also need to invest in protective devices for avoiding overloads. At the same time, with accurate measurement of distributed energy generation and ready availability of this information to DISCOMs, capital expenditure required by the DISCOMs in augmenting network capacity can be planned better and can even be deferred. This can be further enhanced once battery costs reduce and distributed generation can be used in conjunction with energy storage.

- As we move to DC mini-grids / DC systems to tackle harmonics, utilities might be expected to develop infrastructure to accommodate both AC and DC networks in parallel, especially in the case of mini-grids

- Safety standards for grid disconnection would also need to be established to avoid energizing parts of system under repair

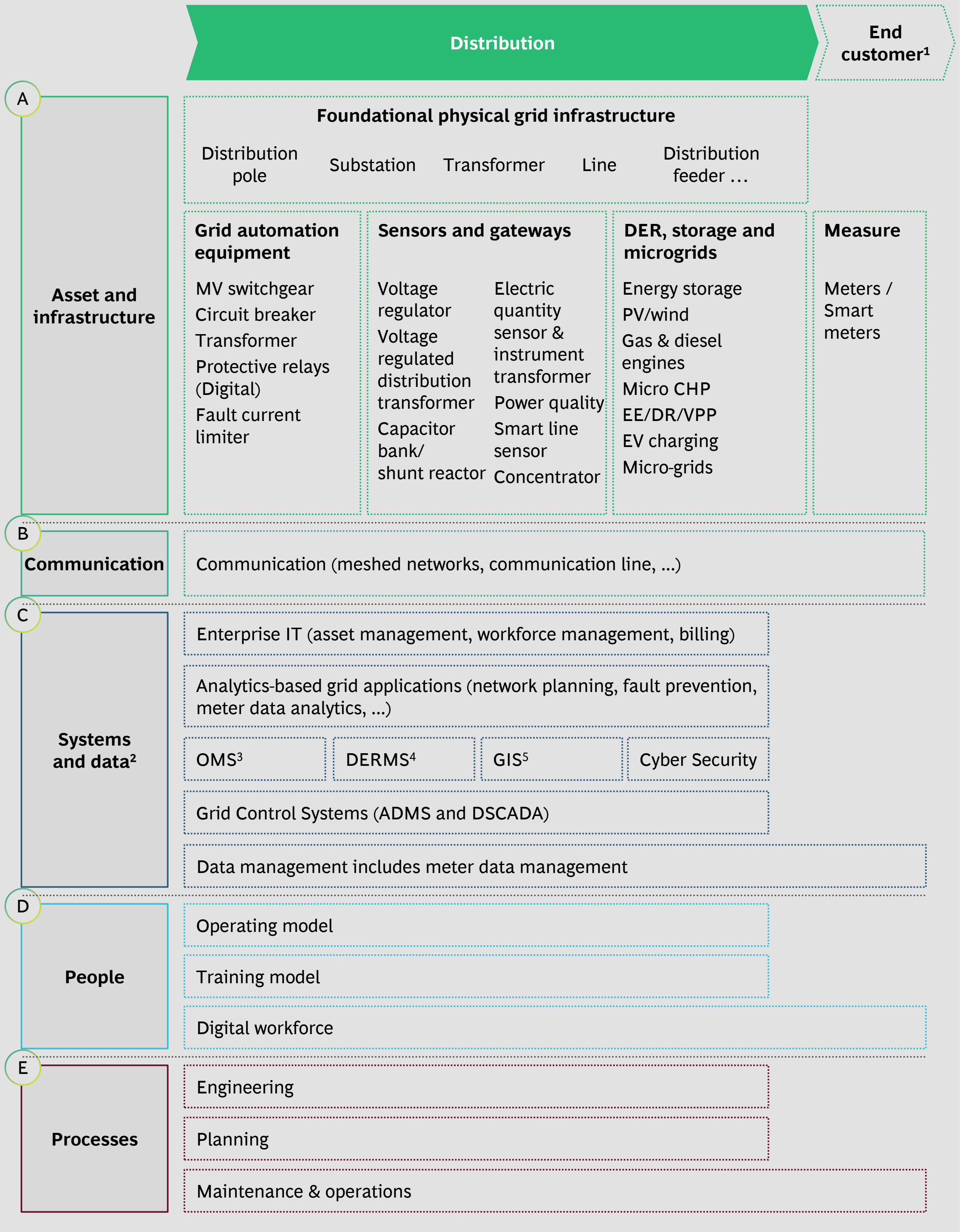
Exhibit 15 depicts the BCG framework on how a grid optimized for DER will look like. This would entail not just physical grid infrastructure, data and communication systems but also a mindset shift in people and processes for enablement.

While most of these scenarios and applications seem futuristic and infeasible in the near future, given the current financial health of DISCOMS, it is useful to keep an eye out for the changing nature of the grid and hence preparedness of utility for the same.

Re-look at Power Sourcing and Generation Capacities

Most of the DISCOMs utilize integrated generation plants and legacy Power Purchase Agreements (PPAs) with high costs of power generation. This increases the cost of supply for consumers, making DISCOMs less attrac-

Exhibit 15 | Grid Of The Future – BCG Functionality Framework



Note: Numerous combinations of capabilities can deliver the same level of functionality; Above list represents a sample set of assets, systems, etc. and is not exhaustive.
1. Elements directly related to DEP only 2. EMS is being addressed in a separate but interconnected effort. 3. Outage management system 4. Distributed energy resource management system. 5. Geographic information system

tive for customers vis-à-vis alternative sources. This is also indicated in the merit order where some of the thermal plants have a cost of supply as high as Rs. 11 / unit. (Exhibit 16).

Given this scenario, utilities would need to relook at their power sourcing and generation capacities—and evaluate options such as retiring old capacities and / or exploring alternate low-cost sources of power

As variable generation from renewables increases further, utilities will need to replace these conventional sources with flexible generation sources—such as combined-cycle natural gas plants and storage. These would require new types of PPAs with Independent Power Producers (IPPs), as utilities purchase not just power but also require the flexibility to ramp-up or ramp-down said resources based on grid needs.

In-addition, DISCOMs need to look at their power mix to meet the Renewable Purchase Obligations (RPO) (Exhibit 17). Venturing into decentral power can help in meeting a portion of these obligations.

Emerging Business Models:

With the envisaged changes in the role of DISCOMs, revenue generation from power sale would no longer be the only potential income option for these companies. DISCOMs would need to explore partaking in the complete electricity value pool and leveraging innovative business models to capture value from this trend.

Alternate business models and revenue streams

Value chain integration and portfolio expansion to energy services:

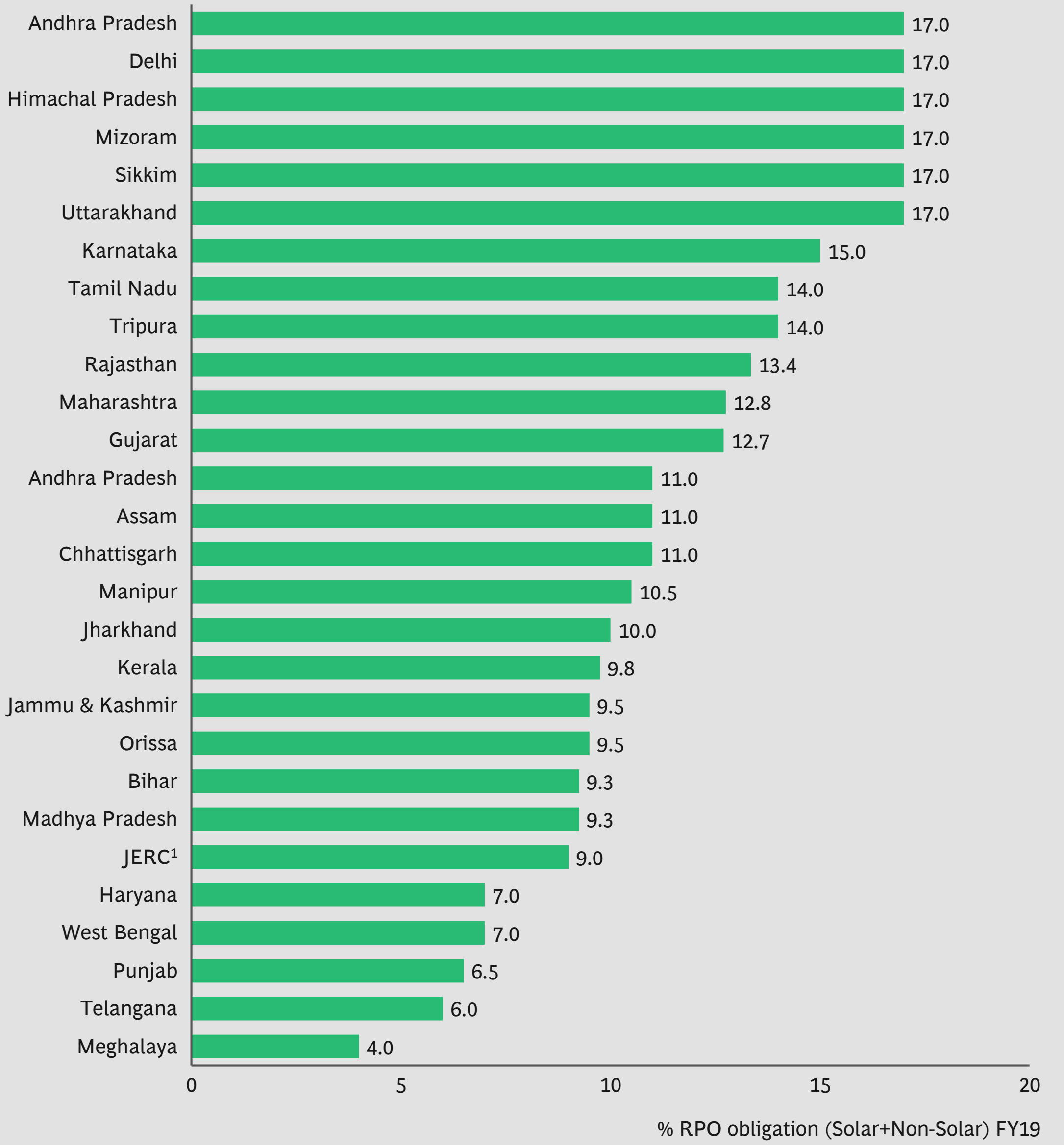
Currently, DISCOMs are restricted to the front-end of the value chain—predominantly in being the supplier of power. However, they can play a much larger role in the power ecosystem by becoming an **energy services player** (Exhibit 18).

This would entail venturing into segments across the cross-section of the electricity value chain—including distributed energy services, energy efficiency, providing integrated solutions (virtual power plant, energy management systems) or adjacencies like e-mobility and storage.

Exhibit 16 | Select Thermal Plants – National Merit Order

Source: Merit order dispatch data, National Load Dispatch Centre (NLDC).

Exhibit 17 | RPO Obligations



Source: MNRE.
1. JERC = Joint Electricity Regulatory Commission (For The State Of Goa And Union Territories, Government Of India).

Ownership of solar rooftop offerings by partnering with local installers can help defend overall sales volumes. Providing end-to-end solutions (via partnerships) can help DISCOMs benefit from synergies and opportunities for cross—selling (for instance, leveraging Smart meters for data analytics).

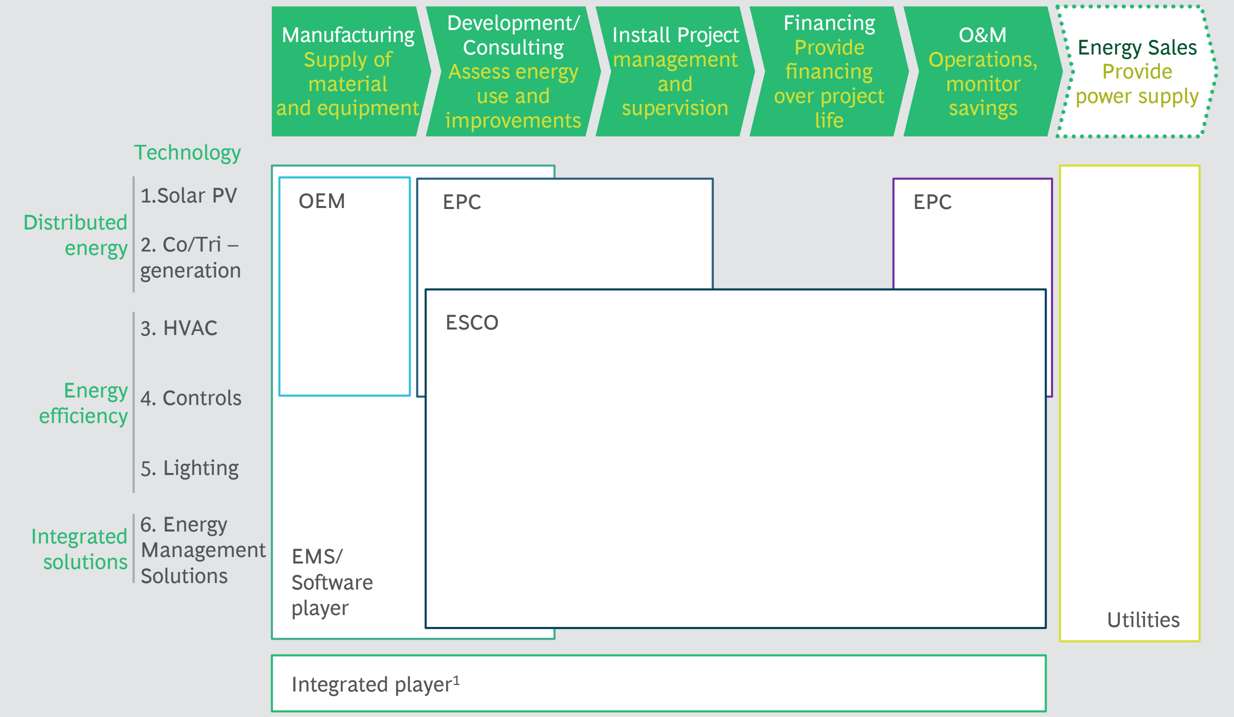
DISCOMs have a competitive advantage in market entry due to better consumer access and the existence of a standing sales force. In addition to these, utilities can also use legacy data collected from the grid to offer new value-added services—including the tracking of solar rooftop production. These value-added services are likely to be of interest to other distributed-energy companies.

Globally, large utilities are already providing most of these services (Exhibit 19)—indicating that a similar move in the Indian power market is imminent.

Playing the role of a distributor or aggregator:

DISCOMs can explore emerging models such

Exhibit 18 | Utilities can Play a Broader Role in the Power Sector Landscape



1. Integrated players cover most or all steps of the value chain in each solution.
Source: BCG Analysis.

Exhibit 19 | Globally, Utilities Provide a Wide Range of Technologies

		EWE	RWE	E.on	Vattenfall	Centrica	Vattenfall	Eneco
Distributed energy	Decentralized assets	✓	✓					
	• Solar panels to consumers	✓				✓		✓
	• Micro—co/tri generation					✓		✓
	• Micro—wind							✓
Energy efficiency	Air Conditioning							
	Equipment and appliances						✓	✓
	• Heat pumps		✓	✓		✓	✓	✓
	• Boiler inst. and services	✓				✓		
	Energy monitoring/controls	✓	✓	✓	✓	✓	✓	
	Lighting			✓		✓	✓	
	Building insulation						✓	
Integrated solutions	Energy management systems	✓			✓			
	Smart city concepts		✓		✓	✓	✓	✓
	VPP (virtual power plant)	✓	✓	✓		✓		
	Smart home system		✓	✓		✓		
Others	Management of CO_2 certificates	✓			✓			
	E-mobility	✓	✓	✓	✓	✓	✓	
	Storage	✓	✓	✓	✓		✓	✓

Source: BCG Research

as community solar, financing on-bill etc. In a community solar model led by utilities, a common roof in the complex serves as the platform for rooftop solar.

A developer or utility can build a larger-scale facility than retail customers. They can, thereafter, either sell electricity from the solar farm at a differentiated rate or sell ownership interests in the solar farm itself. Payment from the customers can be a combination of upfront fee and adjustments to their monthly electricity bills. Variations of this model are indicated in Exhibit 20.

Provide reliability and grid backup as a service:

Taking a step further in community models, DISCOMs can look at a more evolved model for value-added services. To further achieve the goal of reliability and 24X7 power, they can explore offering grid back-up **as a service.**

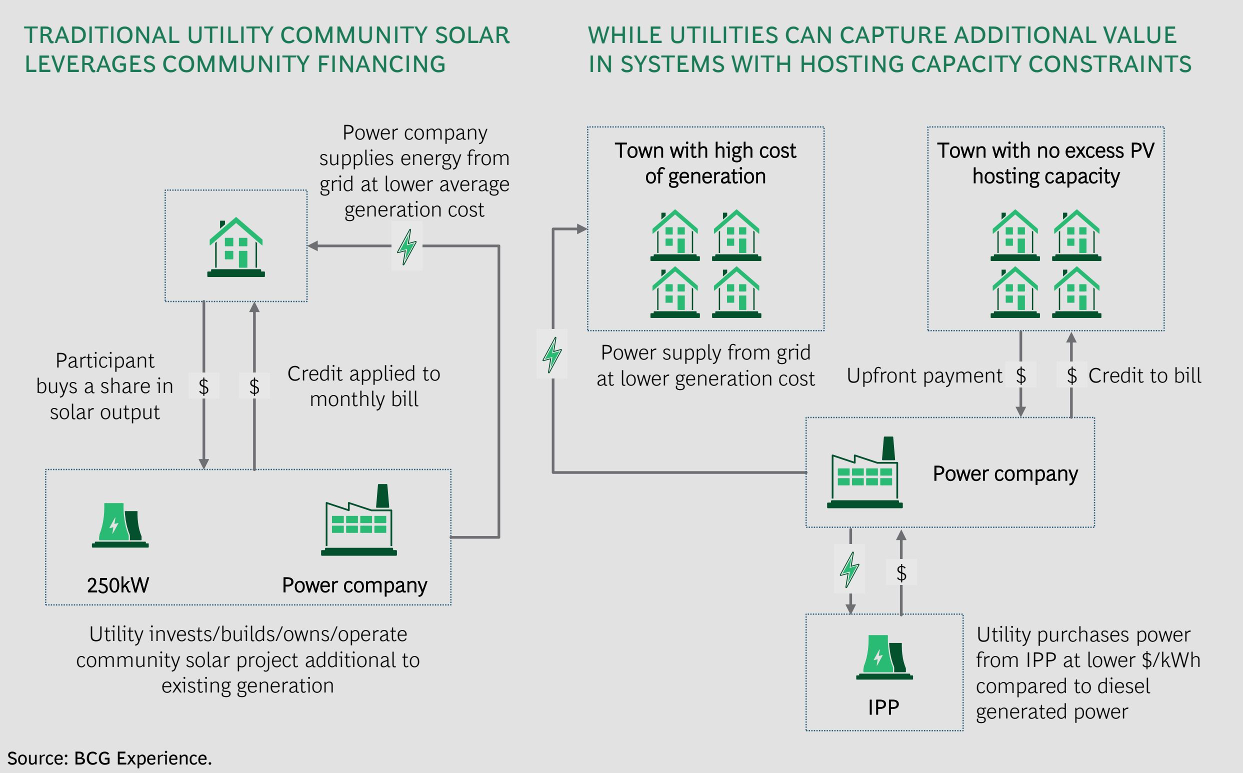
Such a model would be of particular interest to mini-grids with renewable based generating resources and no / or limited storage facilities. In such a model, a community would be powered by a mini-grid and connected with the main grid as a back-up. The distributed storage solution would be used to even out supply-demand imbalances.

The members—prosumers can be supported by a blockchain platform to enable P2P trading (Exhibit 21). DISCOMs can extend support in setting up the mini-grid, providing storage and offering grid backup. Not only would such a model enable DISCOMs to directly participate in the decentral energy system market, it could also potentially enable them to command a premium for these services. Ancillary benefits could potentially include incentivizing marginal high-cost customers to explore decentral solutions and move away from the centralized grid—reducing their subsidy burden.

Create micro-markets and customer segmentation where DISCOMs push this actively

DISCOMs can look to segment the market by customer types, application and geography to customize their offerings. Two segment archetypes can be as follows:

EXHIBIT 20 | Different Variations of a Utility Sponsored Community Solar Project



Source: BCG Experience.

- There are urban customers (including the C&I segment) who need reliability and quality of service and are willing to pay a premium for it. Here, DISCOMs can offer grid as a back-up service through a combination of mini-grids connected to the central grid and storage installations

- In the case of rural customers where access to electricity is a challenge, DISCOMs can play an active role by developing customized solutions for last-mile power access with improved unit economics. Some of the options include PPP models for franchisees, micro-grid-based solutions and innovative business models—for example, water + utility supply. DISCOMs can also adopt web / cloud-based metering and collection solution like what micro finance organizations do—make use of prepaid wallets and reduce the cost to serve and collect for customers. This can be made it akin to telecom where people are able to consume based on need and refill accordingly.

The key question that DISCOMs would need to answer would be on how to build a compelling case for regulators that accounts for the "functionalities" that they want to achieve—open access, reliability and universal 24X7 power provision—without compromising on potential developer interest.

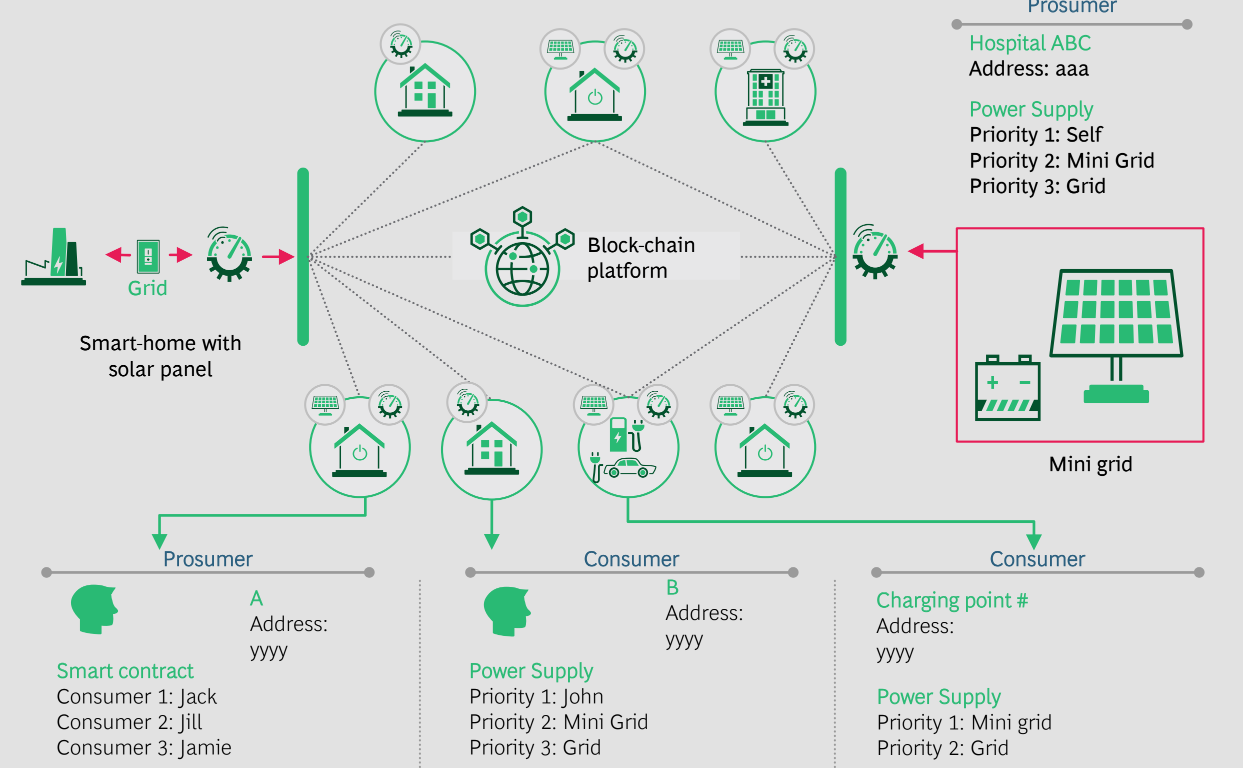
Look at advancing the trend and taking leadership in emerging segments such as e-mobility, reliability as a service and technologies such as blockchain

Indian DISCOMs stand to gain significantly by emulating their global peers. Markets where distributed energy forms a significant part of the system are a compelling test case on the emerging business models proposed above. Utilities in such markets have also co-evolved, in-line with these emerging market trends.

For instance, in the field of e-charging, utilities have capitalized on their "right-to-play" given their network infrastructure. Utilities around the globe are partnering with OEMs to provide readily accessible EV charging infrastructure (Exhibit 22).

Blockchain is seeing increasing adoption in various facets of power markets across the

EXHIBIT 21 | Energy as a Service



Source: BCG Analysis.

EXHIBIT 22 | Utilities Around the Globe are Partnering with OEMs to Provide EV Charging Infrastructure

	E-CAR PARTNERSHIPS BETWEEN UTILITIES AND OEMS		CONTENT OF PARTNERSHIPS	COUNTRIES
Utilities	EDF Energy	Toyota	• Toyota PHEV (plug-in hybrid) tested in EDF fleet • Development and set-up of an innovative charging and billing system fore-vehicle/PHEVs	
	EDF Energy	Zap, Transport for London	• Free parking and charging in the city of London for Zap! Xebra e-car (savings of ca. US$83 per day)	
	EDF Energy	Smart, BT	• Pilot of Smart EV in Greater London (~100 units) • Discount parking and free charging at charging spots	
	Vattenfall	Swedish Energy Agency, Volvo, Saab, ETC	• Investment in Plug-in hybrids to build, demonstrate and evaluate vehicles • Development and testing of electricity infrastructure and various charging alternatives	
	Southern California Edison	Ford	• Equipping single garages with charging stations for plug-in hybrids and electric cars	
	RWE	Smart/Daimler	• Pilot of Smart EV in Berlin (~100 units)—500 charging sites	
	Vattenfall	Mini	• Pilot of 50 MINI E with accessible charging stations in Berlin	
	E.ON	Mini, Volkswagen	• Pilot of Mini E in Munich • E.ON is to set up public charging stations • Project "Flottenversuch Elektromobiliat" (Golf TwinDrive)	
	ESB Energy	Renault Nissan	• Alliance with the Irish government to foster electric vehicles introduction in Ireland	
	PG&E	BMW	• Pilot to test the ability of EV to provide demand response value trough a minimum of 100 kW demand from EV	
	Enel	Nissan	• First ever vehicle-to-grid (V2G) trials in the UK • Trial comprises of 100 V2G units	

Source: Press; BCG Analysis.

world. Multiple use cases of the same can be seen in Singapore—one of the most liberalized power markets in Asia.

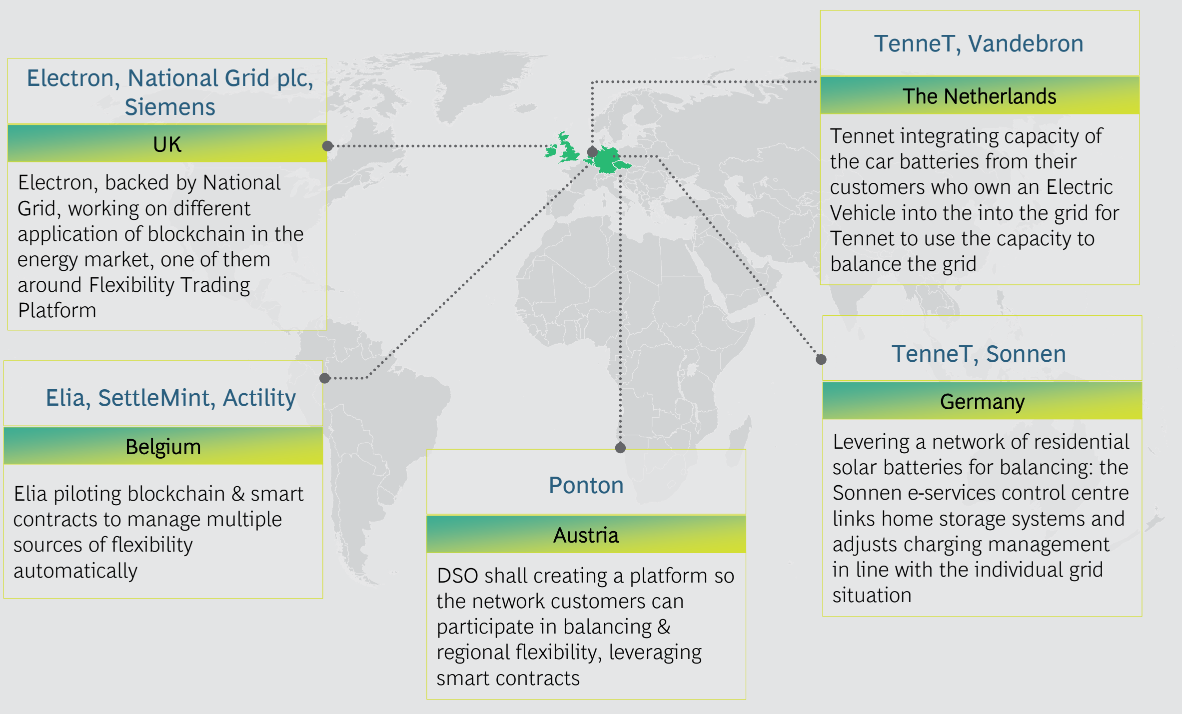
The Singapore government-owned electricity & gas DISCOM SP Group, introduced a blockchain-based platform to trade in renewable energy certificates. The presence of the blockchain platform eliminates the need for a centralized verification authority. In addition, the DISCOM believes that the platform can eventually also facilitate cross-border trading in energy credits.

Separately, ElectrifyAsia, a privately-owned energy technology company, was one of the first few companies from South East Asia to organize an ICO (an initial coin offering) for its P2P energy trading platform, Synergy. The key objective behind Synergy was to develop a blockchain-based decentralized energy market. The company has concluded a pilot of the same in November 2018 with encouraging results.

Other utilities from around the globe have explored similar pilots. Axpo—the Switzerland based energy utility explored a similar blockchain model for P2P renewable energy trading in 2017. Enerchain—another European trading platform has launched the first commercial version of its blockchain based trading platform for decentralized energy resources as of May 2019, after extensive pilots in 2017 and 2018 with 40+ energy utilities.

Blockchain is also being leveraged around the globe for network balancing—with multiple pilots in progress (Exhibit 23)

EXHIBIT 23 | Examples of Projects Exploring the Use of Block Chain for Network Balancing Around the World



Source: Press Search.

In yet another example, a US-based utility undertook multiple measures to tackle increasing penetration of DER. This utility provided inputs to the public utilities commission to develop two different tariffs for DER customers: Grid supply and Self-supply. It also created multiple distributed generation programs which are sustainable for customers—while at the same time preserving system reliability. Basis consumer research, the utility then expanded into community-based renewable energy and electric vehicles and is working with its largest customers to develop customizable solutions.

In some of the more matured markets such as the US, regulators are also shifting from a cost-plus model for utilities towards a rewards model based on efficiency and innovation. Some are redefining the role of utilities and using compensation structures that encourage the provision of new products and services. For example, the New York State's regulator has announced a new model that will reward grid companies that facilitate a competitive market in distributed energy.

CONCLUSION

Given the emerging priorities of the Indian power sector, the role that various stakeholders play in the electricity value chain is highly likely to change soon.

The falling prices for renewable generation and its increased mind-space in the end consumer is likely to convert these end consumers from passive "recipients" of power from large DISCOMs to active "prosumers"—who are moving towards self-sufficiency for their power needs. Correspondingly, DISCOMs would no longer be the unidirectional suppliers of power for these consumers—a role that they have enjoyed for decades.

Multiple examples from the developed world would also indicate that this trend for decentral energy systems is here to stay and shall endure in the future.

As a result, DISCOMs would need to holistically rethink their involvement in this new trend. While DISCOMs' fears of shrinking profitability are not unfounded, decentral energy systems are also likely to lead to the creation of multiple new value pools that DISCOMs could shape and partake in.

Such a transition would, however, necessitate a shift in the mindsets of DISCOMs—from suppliers of energy as a "commodity"—to providers of various facets of the complete energy value chain as a "service".

This would involve DISCOMs becoming increasingly involved in new segments of the energy value chain—from supporting the establishment of mini-grids and rooftop solar projects, to the provision of critical grid services such as storage, back-up and network operations as a service.

This transition would require DISCOMs to develop a high technology layer to integrate the different elements of "grid of the future"—be it traditional stakeholders such as GENCOs and regular consumers, self-sufficient "prosumers" or new third-party developers in emerging applications such as mini-grids, EV charging etc.

While such a transition is likely to be fraught with its own set of challenges, the inevitability of decentral energy systems necessitates that DISCOMs evolve along with these emerging trends to both survive, as well as, thrive.

NOTE TO THE READER

Acknowledgments

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FOR FURTHER READING

Boston Consulting Group published other reports and articles on related topics that may be of interest to senior executives. Recent examples include:

Digital in Power
(Aug 2018)

The Digital Energy Retailer
(April 20, 2018)

How the Wind Industry Can Harness Gale-Force Change
(Dec 20, 2018)

Finding the Sweet Spot in Distributed Energy
(May 25, 2017)

Will Your Offshore Wind Strategy Sink or Swim
(Jan 24, 2018)

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