Smart Grids in Emerging Markets—Private Sector Perspectives

Background

A smart grid is a modernized version of a traditional electricity transmission and distribution network that includes two-way communication systems and enables the integration of decentralized technologies to improve the grid's efficiency, reliability, sustainability, and security (U.S. Department of Commerce 2019).

The exact role of a smart grid is determined by the policy and regulatory requirements in which it functions, and the goals for which it was constructed. Smart grids can support power system reliability, enable demand response efforts, and provide alternative and cost-effective solutions to transmission or grid upgrades.

As countries look to include higher levels of renewable energy onto their power systems, smart grid technologies (e.g., inverters, power electronics, smart appliances, and integrated storage solutions) can help mitigate variability issues that might arise with high levels of renewable energy penetration. Smart grid technologies can help better balance supply and demand during both generation scarcity and surplus by enabling more accurate forecasting, as well as real-time system awareness and management. In addition, energy storage integrated in a smart grid can help smooth renewable energy output variations and manage mismatches in supply and demand (Speer et al. 2015).

Smart Grid Definition

"A concept and a vision that captures a range of advanced information, sensing, communications, control and energy technologies. Taken together, these result in an electric power system that can intelligently integrate the actions of all connected users—from power generators to electricity consumers to those that both produce and consume electricity—to efficiently deliver sustainable, economic, and secure electricity supplies" (Speer et al. 2015). Smart grid technologies could include smart meters (a device that records and transmits information including consumption of electricity, voltage levels, and current) and sensors, energy storage, electric vehicle charging stations, smart appliances, building automation and control systems, and two-way communications.

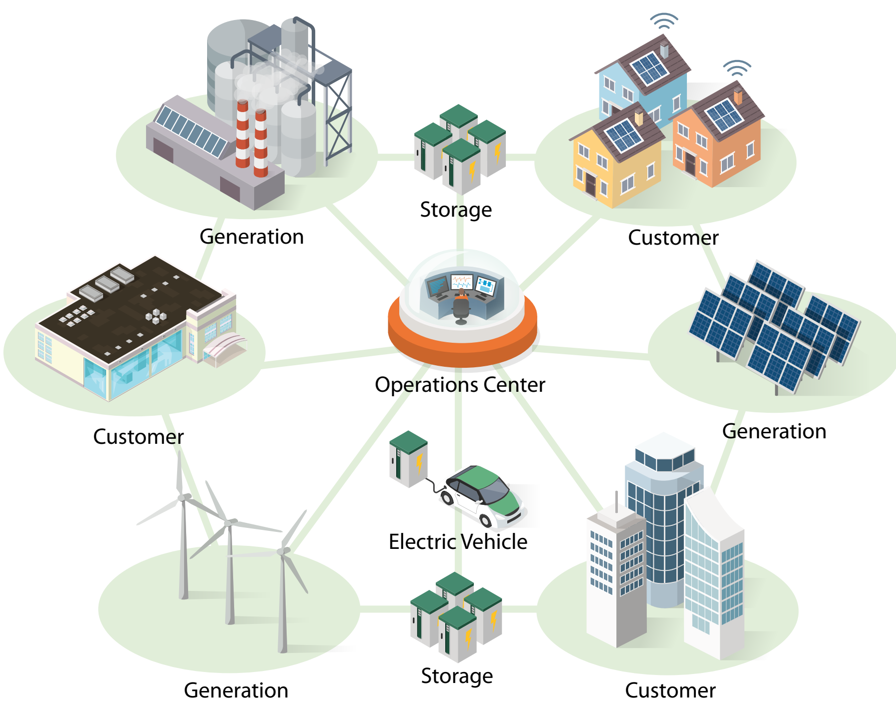

Figure 1: Conceptual model of a smart grid

Emerging economies could benefit from the implementation of smart grid technologies. Global energy consumption is projected to increase by 50% between 2018 and 2050, and much of that demand growth is expected to be in emerging economies (Kahan 2019). Smart grid technologies could help meet this growing electricity demand by optimizing the utilization of electricity transmission and distribution assets (EPA 2018). In addition, smart grid technologies can also help improve energy access by enabling countries to leapfrog components of the traditional, centralized electrification system (Bazilian et al. 2013). Leapfrogging allows an emerging economy to expand infrastructure and go from little or no electricity access to having renewable energy access, potentially bypassing fossil fuel use. This can be done in part by using smart grid technologies that can help integrate new and improving distributed generation and storage technologies (Bazilian et al. 2013).

Investments in Smart Grids

Investment in smart grid technology makes up a small, but growing, portion of overall grid investments. In 2017, global investment in smart grid technologies was $13 billion, accounting for 11% of total network investments (IEA 2018).

Emerging economies with high electricity demand growth are considered strong potential smart grid markets due to the future projected electricity consumption (U.S. Department of Commerce 2019). In 2017, investment in smart distribution networks for China, India, and other emerging markets combined was about $8 billion. From 2015–2017, investment in these emerging markets increased by about 10% (IEA 2018). Approximately 430 million smart meters will be deployed across emerging markets from 2020–2025. China is expected to install approximately half of those meters (Nhede 2020a). In Africa, anticipated metering investment from 2016–2026 is $8 billion (Nhede 2020b). Overall, emerging markets are expected to invest $40.7 billion in advanced metering infrastructure and up to $47.9 billion in additional smart grid infrastructure between 2020 and 2024 (Nhede 2020a). This expected investment in smart grid technology, especially in emerging markets, in the near future demonstrates that there are opportunities for the involvement of private sector players in the smart grid sector. Implementing regulatory frameworks and supportive policy measures that recognize and compensate benefits and services provided by these smart grid technologies are needed to bolster private sector investment (IEA 2019).

Opportunities for Smart Grid Technologies in Emerging Markets

Private sector investment can play a critical role in scaling up the deployment of clean energy technology in emerging markets. Though the potential in the smart grid market is high due to growing global electricity demand and for the benefits that smart grids can provide, the private sector faces several uncertainties. Figure 3 shows how private sector representatives ranked various barriers to market entry in emerging markets. The representatives highlighted off-taker ability to pay, access to finance, political instability, and a lack of renewable energy policies and incentives as the top barriers to market entry in emerging markets.

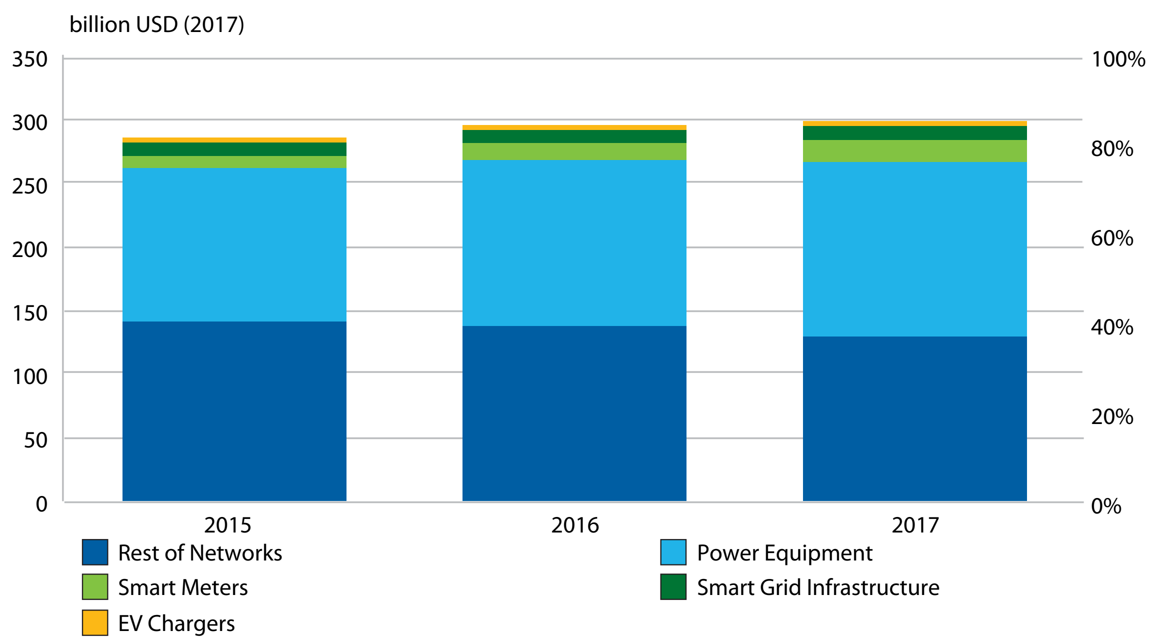

Figure 2: Share of spending on electricity network equipment by type. *Adapted from IEA 2018.*

These barriers are discussed further in *Utility Scale Wind and Solar in Emerging Markets—Private Sector Perspectives*, which was also part of this research effort (Gokhale-Welch and Watson 2019). A series of webinars by the U.S. Agency for International Development (USAID) and the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) focused on various clean energy system topics also supported these findings (USAID and NREL 2018).

This section presents the potential opportunities associated with the implementation of smart grid technologies, broadly divided into grid level services and consumer level services provided by smart grid technologies (certain opportunities can benefit both the grid and the consumer). The following section reviews the key considerations that can help support private sector investment in this market.

Douglas Shuster, Principal, Tuatara Group LLC

"Based on our experience, the decision by utilities in emerging markets to invest in smart grids is no longer driven by the availability of proven technologies that will deliver favorable economic returns based on benefits like improved efficiency and reliability. It rather comes down to three questions: What is the policy and regulatory framework and what is the institutional framework for the electric power sector in the country? And do these frameworks incentivize, support and compel smart grid investment?"

Grid Support

As discussed previously, smart grid technologies can help increase the amount of renewable energy in the system by managing the inherent variability in renewable energy. This can be done through improved communication between the smart grid system components, a better balance of supply and demand, and better forecasting of the variable renewable energy (Speer et al. 2015). At high variable renewable energy penetrations, smart grid technologies can support smoother and more efficient integration of energy from small, distributed, renewable energy generators into the grid (Yeager et al. 2010). In addition, storage technologies can help a system manage the variability of renewable energy by smoothing out short-term variations and managing mismatches in supply and demand by using real-time information sharing for load-shaving or meeting peak demand (He et al. 2020).

Damages to the grid, and resulting electricity outages, can be repaired more quickly when smart grid technologies are implemented (DOE 2014). Control room technologies coupled with smart meters can provide real-time data about electric grid and customer outages during a restoration process. With this real-time information, field personnel do not rely just on customers reporting outages, and, therefore, the system can be repaired more efficiently (DOE 2014).

Smart grid technologies can also improve efficiency of the grid. Conservation voltage reduction (CVR) reduces the voltage level of an electrical system, which leads to reduced energy consumption by final consumers. In a smart grid, the voltage profile of the grid can be evaluated continuously and optimized with proper automated CVR, minimizing unnecessary losses in a system (Ferreira 2016, Roehr 2010).

Methodology

Information presented in this paper is based on qualitative and quantitative data collection and analysis methods to provide an empirical understanding of barriers to private sector clean energy investment in emerging markets. Through literature review, a survey, and a series of webinar dialogues, USAID and NREL solicited input from private sector actors, including developers, project financiers, manufacturers, and technical assistance service providers on the challenges they face to market entry in developing and emerging markets, and their suggestions for improving market competitiveness.

Consumer-Side Opportunities

Smart metering technologies provide consumers with the information and tools required to make choices about energy use. This includes opportunities to participate in utility-run demand response programs that allow consumers to reduce electricity usage during periods of high power prices, as well as opportunities for self-generating consumers to sell electricity back to the grid (Zafar et al. 2018).

Consumers tend to save energy when they are more aware of consumption (Yeager et al. 2010). With smart grid technologies, consumers have increased capability, opportunity, and motivation to reduce consumption (Yeager et al. 2010). Smart grid technologies make information about energy availability, pricing, and incentives readily available to the consumer, helping to promote adoption of energy saving measures among households. While smart appliances may not be available in many emerging markets, when available, they too can help consumers reduce their overall energy use as well as reduce their peak-demand time energy use by shifting use to non-peak pricing periods (Yeager et al. 2010).

Smart grid technologies also present opportunities for prosumers, customers who both generate and consume energy. Smart grids provide a bidirectional flow of data and power, which allows consumers to sell surplus energy easily back into the grid (Zafar et al. 2018). Prosumers may also store excess energy for future use with smart grid storage technologies or transfer excess energy to other consumers.

An entire household can be completely and efficiently integrated into the smart grid with household energy management systems, energy storage systems, electric vehicles, and vehicle-to-grid systems (Espe, Potdar, and Chang 2018).

Electric vehicles matched with smart grid technologies also provide benefits for consumers. There are currently over 5 million electric vehicles on the road today, and electric vehicle use is expected to increase. By 2040, 30% of the passenger vehicle fleet is likely to be electric (BNEF 2019). Charging millions of electric vehicles is likely to strain the grid, but smart grid technologies such as dynamic load forecasting and intelligent charging scheduling can enable the expected electric vehicle increase (Venayagamoorthy 2009). Electric vehicles can also provide storage services to the grid with two-way charging control. In the future, utilizing electric vehicle batteries can potentially help mitigate renewable energy variability issues by charging during non-peak hours or hours of high renewable energy and providing power back to the grid during peak hours or hours without high renewable energy production (Coignard et al. 2018). In addition, smart grid technologies may charge electric vehicles at off-peak times, to ensure that electricity bills do not skyrocket (a concern of some consumers). Smart grid technologies enable fast communication between a home charging station and a utility. This can reduce charging station repair times for consumers because system issues can be more easily and quickly diagnosed (SilverSpring Networks 2013).

Key Considerations

The following policy and technical support considerations could help improve private sector investment in smart grids in emerging markets. These solutions could be implemented by policymakers or supported by members of the donor community.

Figure 3: Top barriers to smart grid market entry in emerging markets based on feedback from private sector representatives

Enabling Policies

- Establish standard grid interconnection processes to better integrate distributed energy and utilize smart grid technologies.
- Consider retail tariff design strategies like the implementation of time-of-use rates to drive system efficiencies and customer economics.
- Adopt universal standards that establish and define how different components communicate and connect. Standards can help provide for more market certainty, encouraging more private sector players to get involved in the smart grid sector.
- Encourage project bidding processes to focus on reliability and performance criteria, rather than just least-cost criteria.

Information Exchange

- Strengthen technical understanding for policymakers, utilities, regulators, laborers, and financial institutions to hasten and improve project development processes.
- Educate consumers on the benefits of smart grids to encourage community engagement, as consumer engagement with smart technologies is key to deployment.
- Provide access to private sector players to market and business information, as well as renewable energy resource data.
- Promote peer-learning and sharing of best practices, modeling and design support, study tours, and utility exchanges to learn from other smart grid projects and decision makers.
- Encourage local involvement and provide ongoing training.

Regional Example

The town of Brčko in Bosnia and Herzegovina dealt with frequent extended power outages and power cuts due to storms. To make repairs, utility personnel had to visually identify the outage source, a slow and arduous process (USAID 2017).

From September 2015 to September 2016, USAID partnered with the United States Energy Association (USEA), Schweitzer Engineering Laboratories (SEL), and Brčko's electric utility, Brčko Komunalna, to support a smart grid technology pilot project. The smart grid technology, Distribution Network Automation (DNA), provided by SEL can immediately identify the location of an outage source, reducing repair times (Schweitzer Engineering Laboratories 2017).

The project reduced the number, frequency, and duration of electricity outages. During the year-long pilot project, customers experienced a 51% reduction in the number of outages and 58% reduction in the duration of outages. Reliability for electricity customers in Brčko improved primarily because the smart grid technology enabled faster repair times of critical grid infrastructure (USAID 2017).

Financing

- Improve financial incentives by allowing for a greater rate of return on technology investments. This may include enacting more favorable depreciation rules.
- Develop power purchase agreements and long-term contracts that will decrease uncertainty to encourage investments.
- Enact time-based rates to incentivize the involvement of electricity customers and utilization of smart grid technologies.

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