The Role of Utilities in the Development of the Smart City

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ABSTRACT

A smart city is 'a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses,' according to the EU definition. In this context 'networks' consist of the many related infrastructures such as electricity, gas, heat, water, telecommunications and transportation/mobility; and 'services' are both commercial and public, including policing, waste, transport, commerce, housing and health, among others.

Smart cities build on the concept of advanced energy communities (AECs) and integrate these holistically. These electrically contiguous areas will integrate multiple customer-owned distributed energy resources (DER) such as energy efficiency, demand response, customer storage, photovoltaic (PV) or other local generation, electrification, electric vehicles, combined heat and power (CHP), and district heating and cooling systems. Utility customers will look to these advanced technologies to provide benefits in comfort, convenience, and cost. Such communities also can achieve larger societal and utility goals such as decarbonisation, grid hardening, and grid support. An AEC can either be a new community development or involve reconstruction and retrofit of existing residential, commercial, or industrial communities.

INTRODUCTION

Utilities provide networks and services which are an integral component of a functioning city. The digitization of these is a complex task, requiring integrated planning, consumer engagement, new technology deployments and real-time network management. EPRI research in these areas is developing solutions, insights and pathways to help utilities formalize their smart city role. This paper sets out how the utility role can develop to deliver these functions to city planners and become an integral partner on the smart city journey.

UTILITY PARTICIPATION IN SMART CITY PLANNING AND DEVELOPMENT

Utilities have valuable experience in a number of critical areas that can support cities develop their vision and roadmap, they should be integral to integrated smart city planning. By collaborating with policymakers, technology vendors, community groups and other stakeholders they can provide unique insights, energy perspectives and real-time critical infrastructure operations and planning. Utility capabilities and assets that can benefit the smart city eco-system include:

- Ownership of an infrastructure that can be used by others to enhance city services, useful assets include distribution poles, streetlights, substations and trenches. This infrastructure can be used to deploy communications networks and a new generation of sensors, for example for air quality, security and transport. The communications network can be used by other city utilities, water gas and transport to collect and transmit data saving on the need for separate, costly communications networks.

- Valuable knowledge and experience with deploying and integrating low carbon decentralized generation, for example PV, CHP, Storage, AECs and microgrids. Also, helping Industrial and Commercial (I&C) customers with Building Management Systems (BMSs), including retrofits as well as new build. Those BMSs can be more readily designed to integrate into wider smart city systems to optimize energy usage at peak periods.

- Engagement with IoT companies and system integrators such as IBM, Cisco, Accenture who have all provided utility systems for many decades and are likely to be central to smart city deployments. Utilities have also deployed communications networks on their infrastructure, working with large networks providers such as AT&T, Silver Spring and others).

- Core capabilities around planning and operating real-time critical networks with instantaneous balancing of supply and demand and very high levels of availability (circa 99%). This can be leveraged as cities embrace new digital systems, employ smart management principles of resources and manage more systems in near real-time.

- Expertise with electrification of transport, heat and other industrial process, many of which are at the heart of smart city deployments and environmental targets. Utilities will be able to design and develop electric transportation infrastructure building on the many demonstration programs that utilities have led in urban environments.

- Decades of experience in developing and commercializing energy efficiency programs to help end users understand energy usage rates and options around the adoption of new energy efficiency measures that can dramatically cut energy bills.

Smart cities are complex with a number of layers, some are physical, some are organizations while others relate to the collection and management of data and the activities that bring them together to drive value for citizens. Utilities operate throughout these layers. Figure 1 shows these layers;

Figure 1: Example of advanced energy community architecture

EXAMPLES OF ADVANCED ENERGY COMMUNITIES

Advanced Energy Communities can vary in form and function. Examples (example shown in Figure 2) include solar residential communities and zero net energy (ZNE) communities; campuses with multiple buildings and various modes of local generation including district heating, steam, CHP systems, large commercial buildings with on-site generation, energy efficiency, and thermal storage; multifamily housing with solar and community storage; and microgrids serving critical facilities.

AECs can provide grid services such as demand response to the larger grid without islanding. In many cases, the principal purpose of an AEC may be to reduce the cost of energy or infrastructure to end users. In contrast to a DER management system (DERMS) or other utility-managed controls, AECs may be managed not with a central controller, but with aggregation of local controls—enabled through data acquisition and controls operation.

Figure 2: Example of advanced energy community architecture

Microgrids are a popular example of AECs and potentially share many DER technologies and controls (see Figure 3). Microgrids are not a replacement for traditional utility infrastructure, but instead form a self-contained organization of distributed generation and demand management that is capable of self-balancing when necessary. The U.S. Department of Energy (DOE) defines microgrids as a group of interconnected loads and distributed energy resources (DER) within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected and island mode. Individual microgrids are expected to spend most of the time operating in a grid-tied mode, with power flowing both ways between the microgrid and the surrounding system. A bi-directional connection help achieve operational goals, such as improved reliability, cost reduction, and diversification of energy sources.

The ability to to separate from the grid adds the resiliency values and provides a backup or emergency operation mode. The primary objective of a microgrid is to guarantee resiliency; therefore, the DER operations and infrastructure upgrade needs might be different from those of other types of AEC.

Microgrids and AECs leverage clustering of loads and generation to enable facilitation of system-level planning while minimizing the number of local control points. They aim to provide balance between load and the portfolio of DER while adding precise control of local power flow that enables scalable "blocks" of DER solutions, while at the same time maximizing the hosting capacity at each node in the system. While the resiliency benefit of microgrids has commanded the most attention in the past, many investigators have pointed out that the control infrastructure required for microgrids brings many additional benefits even while operating with the grid. In particular, microgrid controllers can bring together diverse DER systems and allow them to act in concert, potentially improving asset utilization, optimizing energy consumption, reducing energy losses, and ultimately reducing overall energy costs. In this way, microgrids act as an extension of existing distribution system operations.

Many customers, on the other hand, may not need the high level of resiliency, reliability, or power quality a microgrid can provide—and may not be willing to pay the higher cost of creating a microgrid. For such customers, local controllers can be used to create AECs in a way that minimizes the net power draw on the grid without eliminating it entirely.

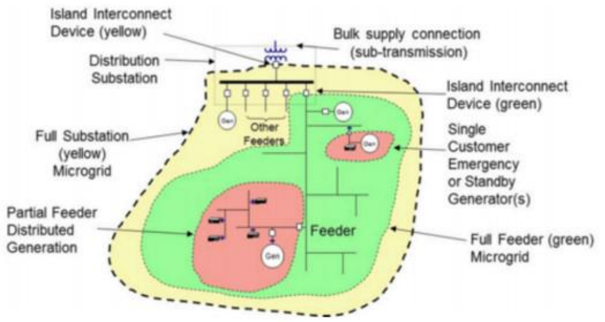

Figure 2: Example of a Microgrid Structure

INTEGRATING UTILITY CAPABILITIES INTO THE SMART CITY ENVIRONMENT

A number of core utility processes lend themselves well to the smart city environment. City planners already carry out many of these process, but they are not as technical and integrated as a utility does. In many ways city planner will need to develop core capabilities for the design and operation of critical real-time networks echoing those already at utilities. There is the opportunity to integrate utility systems into wider city planning systems and for city planners to learn from core utility processes, such as:

- Detailed network planning over the short and long term.
- Network operations and data integration.
- Infrastructure design and development.
- Provision of ICT network and services (for critical real-time network management).
- Ensuring data privacy and security.
- Supporting policies for sustainability, clean air and the environment throughout business operations.

BUSINESS MODELS AND REGULATORY FRAMEWORKS TO SUPPORT UTILITIES IN SMART CITY ENVIRONMENTS

The accepted role of the utility needs to evolve to acknowledge the greater part they play in the transition to smarter cities. This will provide them with the broader remit to become more central to many city development programs. Regulation needs to encourage and support utilities working with cities, in order to be successful, the relationship will have a number of facets:

- Information exchange
- Collaboration on projects
- Integrated strategic direction
- Aligned governance mechanisms

More broadly, regulation models are changing to acknowledge the changing nature of the power sector. They need to accommodate:

- the changing role of the customer (towards a prosumer with choice and flexible energy needs).
- the trend towards a more decentralized energy system
- community energy systems, microgrids and private networks.
- fair and equitable socialization of system costs to meet carbon reduction targets.
- new market entrants with innovative products and services built on new technologies.
- integration across energy vectors.
- appropriate long term investment with adequate risk / reward profiles, whilst minimizing stranded asset scenarios.

As cities become more dependent on integrated technology to function, the reliability of its electricity will become more critical. This increased reliability and resiliency needs to be built into utility models to ensure their investment plans reflect this level of service. Regulation will have a role to play in ensuring this is achieved.

There are many synergies between utility and smart city goals; namely around delivering cleaner energy, supporting energy efficiency measures, enabling customer engagement and improving reliability and resilience. Formalizing these into city programs is a key challenge for utility planners and city policymakers. Appropriate places in their respective governance structures need to be identified where city and utility plans come together.

Regulatory models can be updated to reflect this broader role and can include performance measures to incentivize utilities to play and integral part in smart city development. These could follow the carrot and stick approach to provide sufficient upside for utility participation where the longer-term business benefits may not currently be sufficiently clear. This enhanced planning activity comes at a cost that may not be readily recoverable through the traditional business model of socializing the costs. A number of options exist:

- It is procured from the utility and other 3rd parties from city finances (and ultimately local city taxes).
- A regulatory allowance is made for the utilities to recover the costs from existing or future programs.
- Utilities are allowed to develop non-regulated businesses that are operated on a commercial basis to help support the city development and work directly with other vendors.
- Creation of an enhanced city energy planning function that works closely with their partner utilities.

BENEFITS TO UTILITIES OF ACTIVE SMART CITY PARTICIPATION

Active engagement with smart city programs offers a number of benefits to utilities: An opportunity to continue to rebrand themselves from commodity suppliers through to integral organizations that deliver a smarter, more sustainable future for all and a leadership role in the design and development of energy components of a smart city infrastructure. Other benefits include:

- Potential for other city services and new technology vendors to use their physical infrastructure to host a range of new sensors and applications creating a new source of regulatory revenue (eg sensors on poles and streetlights).
- Other new business models that create new sources of revenue and new markets to enter. Some may be regulatory; others may need utilities to become more commercially focused, for example the provision of an ICT network for other city service providers to use. Collaboration with leading edge technology vendors to adopt new technologies in the utility business model for smart cities and export to other more established areas of utility service provision (suburban, I&C etc.).
- Access to new sources of open data that may improve the efficiency of utility operations and planning.
- New infrastructure needs that provides utilities with the opportunity to consider integrated energy options. Solutions that maximize electricity, gas and water networks to provide more optimal solutions to city environments. All underpinned by and utilizing an ICT strategy that serves their needs.

SUMMARY AND RECOMMENDATION FOR ELECTRIC UTILITIES

Electric utilities have an integral role to play in supporting city planners and communities design and implement smart cities as energy provision and usage is core to most smart city programs. In particular, the electric utility's physical infrastructure and communications network offers great potential to host the deployment of additional sensors and equipment to provide valuable data for advanced analytics.

There are many benefits for electric utilities in taking an active role in smart cities; it provides the opportunity to rebrand from a commodity provider to an energy partner, provides new sources of revenue, creates new uses for their infrastructure and the opportunity to provide the ICT backbone for the city environment.

EPRI recommends that electric utilities:

- Begin the engagement with city planners, communities and other stakeholders to develop the vision of future energy needs of the city.
- Consider the design and development of communications networks (ICT) to be able to provide the communications backbone for other network providers, such as gas, water and heat to minimize new ICT needs.
- Work with city planners and technology vendors to review what data will become available and consider how that may be of use to electric utility planning and operations.
- Consider how physical assets such as poles, streetlights, substations, and trenches can be used to host a number of sensors as part of an integrated city approach to deploying hardware.
- Engage with regulators to ensure regulatory frameworks and business models promote an active utility role in meeting the needs of citizens as they embrace smart city technologies.