MEASURING THE VALUE OF MICROGRIDS: A BENEFIT-COST FRAMEWORK

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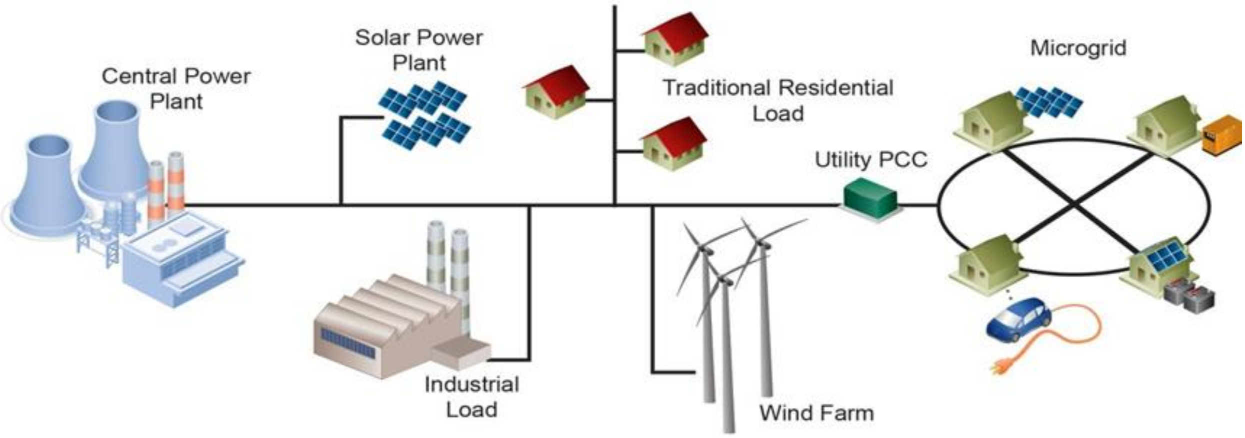

Figure 1. Microgrid as Part of a Traditional Utility System. Source: EPRI, 2016

ABSTRACT

This paper examines the special case of how to value the costs and benefits as applied to microgrids. There are a variety of factors complicating the application of a utility-planning benefit-cost framework to questions concerning microgrids. For the purposes of this paper, a "microgrid" is defined as a group of interconnected resources and loads sharing a (usually) single point of interconnection (POI) with a larger grid and capable of balancing load and resources when disconnected from the grid, through dispatch of resources and demand control and/or response. Economically, a microgrid can be examined from a variety of perspectives, and the picture is more complex than for typical utility investments.

It is EPRI's intent to provide unbiased and independent analysis of technology applications, examining economic questions from the perspectives of electricity end-consumers and society as a whole. Among the first steps of this Benefit-Cost Analysis (BCA) framework is narrowing down the set of economic questions the analysis is intended to answer and determining the point of view the analysis is to assume. A valid economic questions can be as broad as "Do the benefits of a proposed microgrid outweigh its costs?" If so, then perhaps a first hurdle is cleared, but there remain further, penetrating questions. Since the nature and major purpose of a microgrid is presumably to provide its internal customers with enhanced reliability, it is important to ask the question of perspective: For whom is the microgrid an economical choice? A subsequent question might ask "An economical choice compared with what?"

INTRODUCTION

Microgrids pose challenges for economic evaluation because of the variety of forms that are being proposed. Demonstration and exploratory projects may provide data and experience for evaluating proposals for genuine microgrid applications, but challenges appear when considering the business arrangements for serious microgrid proposals.

The first task of economic analysis is to determine the economic question, which includes the point of view to be taken. With microgrids, the task can begin by asking the proposer why they want a microgrid. The proposer might be a utility, but it might be a customer. Alternatively, it might be a third party that is neither a utility nor a customer. The proposer's intent is focused on a set of benefits, whether financial in nature, for reliability, or for other goals. This information can guide the steps of analysis, and it leads directly to the question of the business model.

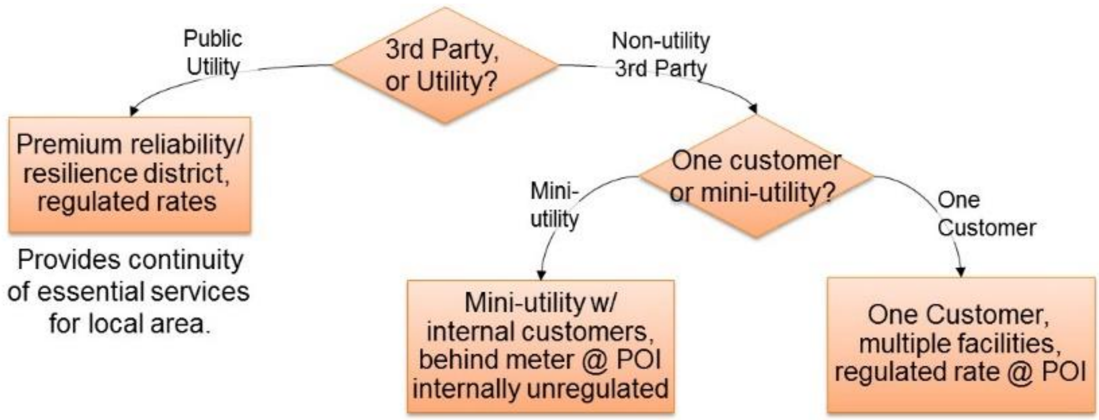

Figure 2. Sample Decision Tree for Determining the Structure Arrangement of a Microgrid. Source: EPRI.

- Who owns and controls the microgrid and its component resources?
- Does it interface with a wholesale market or is it tied to a vertically-integrated utility?
- Is it connected to a distribution-only utility? Is the entity a full- or partial-requirements customer of another utility?
- Does the microgrid serve a single customer or many customers?
- What technologies comprise the microgrid?

It is important to understand the values that are driving a microgrid proposal, especially if there are strong non-financial drivers. For instance, a university may envision competitive benefits in reputation and image associated with use of renewable energy resources to reduce campus carbon footprint, or it may see renewables as consistent with their mission. How these are valued and monetized are clearly the province of the decision-making entity, but it may also be important to determine whether the islanding capability of a microgrid is really necessary to achieve such goals. A campus can be self-sufficient in the same sense that a zero-net-energy home is self-sufficient, but it may use its grid connection constantly to achieve its goals. For this reason, EPRI's framework opens the possibility of evaluating the costs and benefits of the resources apart from the costs and benefits of islanding capability that provides reliability and resilience benefits. This is not a necessary step, but it provides a breakdown of the costs and benefits of a project in a way that may be meaningful to some decision-makers.

The business model establishes who is investing in the microgrid and how its costs are to be recovered. Societal economic analysis or utility-planning analysis is appropriate for some business models, but for others such analysis may be moot. In the prior example, a campus considering a microgrid for its various buildings may be interested in its own reliability or its image as a self-reliant user of renewable resources. Its interests are parochial, and the value may reside in the eye of the proposer. The decision-makers may be interested to know whether the reliability and environmental benefits can justify the cost of a microgrid, but they may have sources of value that fall outside of such analysis.

The business-model landscape can be simplified by generalizing into three categories: an integrated-utility model, a third-party model, and a hybrid or unbundled model. However, there are variations on each of these models, and many of the details will be determined by the structure of the surrounding market or utilities and the regulatory environment.

UTILITY-OWNED MICROGRID INCORPORATING EXTANT CUSTOMERS

Perhaps the most straightforward business model is a vertically integrated utility establishing a microgrid within its service territory, supplied with its own resources. The overall economics of such a microgrid might be rooted in the services provided to a broad area by customer facilities within the microgrid. For instance, hospitals, police stations, grocery and gasoline retailers in a microgrid could provide services over a wide area in the event of a broad grid outage.

The cost of a utility-owned microgrid clearly includes the microgrid controller, but the cost of the distributed energy resources—generation, storage, or demand-response assets—can be considered in a broader context. Because the utility would have the resources as part of its resource plan, the entire cost of the microgrid resources is not necessarily chargeable to the microgrid. Rather, the microgrid resource cost is the increment of cost that the microgrid arrangement and resource selection adds to the utility's overall resource plan, that is, the overcost. The microgrid resource overcost is most likely not zero, but it is likely somewhat less than the full cost of the resources that serve the microgrid when it is isolated.

Naturally, the microgrid will be fully interconnected and optimized as part of the utility's broader system almost all of the time, and it will provide services as called for by the system operators. This approach is straightforward because no special arrangements need be in place to price and transact the various services that the microgrid resources can perform. It is also straightforward if customers within the microgrid can continue with the service plans that they have before the microgrid project. These customers may receive premium reliability, and while this is valuable, their inclusion in the microgrid is more a matter of coincidence. It is also possible to shed non-critical loads when microgrid resources are needed for critical loads. Not all customers of a utility receive identical reliability under normal circumstances, and the resilience benefits of continuity of services from the beneficial loads may outweigh the microgrid's overcost.

The operating cost of the microgrid resources can be considered in the context of the total resource stack for the utility, and measured as the incremental cost of the microgrid plan compared with a non-microgrid plan. The services that the microgrid resources provide to the system are part of this mix; they would be provided by other resources in the non-microgrid plan. The microgrid resource selection and location may impose an over-cost as compared with a fully optimized non-microgrid resource plan, but these costs would be incremental, and only the over-cost should be considered as the cost of the microgrid proper.

Note that environmental benefits of the microgrid's renewable resources are not necessarily included here if the resources are part of the utility's plan, whether or not under the need to comply with a renewable portfolio standard. There might be some differences in the resource mix to account for, but the presence of a microgrid does not by itself enable favorable environmental decisions on the part of the utility; the possibilities are there already. What the microgrid may provide is better integration of resources because of their proximity to each other and the ability to control then with a single controller. These benefits are listed below in the incremental net system operating cost savings (or costs). Microgrid owned and operated by a utility in its territory:

Incurred cost:

- Resource selection and location overcosts
- (compared with a non-microgrid resource plan)
- Incremental change in net system operating cost
- (compared with the optimized system of a non-microgrid plan)
- Microgrid controller
- Additional infrastructure costs (e.g. protection devices, communications network)

Benefits:

- Reliability benefits for enclosed loads (dependent on base-case reliability)
- Resilience benefits for enclosed loads and broader area.

UTILITY-OWNED MICROGRID ON A BROWNFIELD SITE

Utility-owned greenfield or brownfield[1] microgrid projects share some of the characteristics with utility-owned projects that encircle existing customers, but they are more challenging to assess I a societal framework. Brownfield projects may have only a few existing customers, but have the space to accommodate more customers over time. Like the extant-load projects, these microgrids can accommodate resources that the utility would build anyway, except that these microgrid projects are clearly intended to attract new customers, presumably by selling them on the premium reliability service available within the microgrid. Critical loads can move in, or the microgrid may be created to accommodate a new facility that was already scheduled to be built, and it is not associated directly with the microgrid, in which case there is no new load. But to the extent that projects attract new customers for the utility, there are competitive

1 Unlike greenfield sites, brownfield sites have been developed in the past, and any buildings are either abandoned or have been razed.

issues that are difficult to address in a societal analysis. New loads most likely would not come into being as a result of the microgrid, rather, they are either moving from another utility's territory or making a location decision for a new facility, perhaps influenced by the offerings of a microgrid. In a broad analysis, one utility's gains are another utility's losses, so the benefits that any utility would see from such competitive economic development are parochial in nature. Manu utilities normally compete by various means for economic growth within their territories, and competition may have broad benefits, but these efforts are not usually accounted for in a societal framework.

THIRD-PARTY MICROGRIDS

Third-party microgrids are more challenging to analyse than utility-owned microgrids. Regardless of whether the microgrid is a mini-utility or a single large consumer, presumably there are transactions for energy and services that must take place at the POI. Here, the market/system context is important to understand the nature of possible transactions.

A microgrid in a structured spot market context might be able to function much like a combination of a distributor and a generator, buying and selling energy and services under normal conditions. The microgrid would either dispatch its resources in accord with expected prices, or it could bid them into the market like any other generator. Except for the need to maintain readiness for islanded operation (assuming that is necessary), the microgrid could be fully optimized within and by the market.

A microgrid within a bilateral market area might not have real-time marginal prices to use for dispatch. The microgrid owner will likely be paying a price to the local utility for power at the POI, and may be optimizing the dispatch of its resources around the particular rate structure. Whether this encourages economic operation of the microgrid (relative to the surrounding system) depends on the design of the rate and the prices of the various products that may be transacted at the POI. The rate design might even affect the design of the microgrid in terms of the kinds of resources that it incorporates and the customers it encompasses. If the rate or rate design changes, the underlying financials assumed for the microgrid may no longer hold true. Third-party microgrids inherently involve more parties (e.g. customer, third-party, utility) to negotiate the conditions of interconnection and transactions. In this case, defining the perspective becomes ever more important for conducting the economic analysis.

HYBRID MODELS

The norms for microgrid business models have not been firmly established; norms will be established as unique circumstances are encountered and dealt with in various regulatory and market situations. There may be a number of valid business models that fall between the extremes of integrated utility or third-party ownership and operation.

There is, for instance, a class of microgrids specific to a single large electricity-using entity. Examples are campuses and military bases. These installations may have one or two delivery points that supply a distribution system that may or may not be the property of the entity, and may or may not be exclusive to the entity. The entity may have one meter or many meters, but it is one single business entity that can make decisions that affect the entire entity's electric service. These entities take either bundled or delivery service from their distribution utility. Their microgrid interest is presumably premium reliability or resilience service. Interestingly, these microgrids can take a variety of forms.

The local utility may own the distribution system on the customer's property, and if so it can easily install resources within the campus or base to create a microgrid. Except for the single-customer nature, this microgrid can be much the same as the integrated-utility microgrid. The resources can be treated as part of the utility's resource stack that it uses and optimizes to serve all of its customers. The utility could own and operate the microgrid controller, providing premium reliability service to the purchasing entity. The entity and the utility could ostensibly agree on a rate plan that covers the overcost of the microgrid in addition to its normal service cost, holding other utility customers at least indifferent to the presence of the microgrid.

Alternatively, the entity could own the resources and the distribution system, and install its own microgrid controller to optimize its resources. The utility and the customer would transact at the point of interconnection under a negotiated rate. Presumably the class of service would be different from a standard commercial class, however, since its net-load profile and demand for grid services would be far off the norm.

Other combinations of ownership and operation of microgrids are possible, but each may present challenges for the various stakeholders. Where a utility connects to a third-party microgrid, an interconnection agreement must specify all of the various technical conditions, and pricing of services and energy must be worked out in both directions.

CONCLUSION

Business models for microgrids are appearing and taking shape. There are many varieties of business models, however, owing to the variety of utility types and market contexts, as well as the possible combinations of ownership and operation. The industry will be monitoring closely to categorize, catalog, and evaluate the various models as they progress from proposals to reality.