QUASI-MARKET DESIGN FOR COMMUNITY MICROGRIDS

Emi Gui, +61 44 928 75 15, e.gui@student.unsw.edu.au
Dr. Mark Diesendorf, +61 40 294 08 92 , m.diesendorf@unsw.edu.au
School of Biological, Earth and Environmental Sciences and Interdisciplinary Environmental Studies, UNSW Australia

Overview

Microgrids have been suggested to be an effective option for the integration of a large number of distributed energy resources in the modern electricity grids. In Australia, community microgrids, embracing clusters of residential and commercial PV, have been conceptualised to provide competitive alternative energy supply and to create zero net energy communities, particularly in remote regions. Benefits of microgrids include hedging against future electricity price rises, reduced requirements for transmission and distribution (T&D) asset investments, less distribution loss, increased power quality and reliability of power supply, reduction in greenhouse gas emissions, creation of local employment, etc (Morris, Abbey, Joos and Marnay 2012).

For the purpose of our study, we extend the definition of a Community Microgrid as "*a coordinated local grid area comprising residential, commercial and other electric loads, including interruptible and uninterruptible loads, served by one or more distribution substations and can be supported by high penetrations of local renewables and other distributed energy resources*". Its key objectives are to achieve economic, social and environmental efficiency in community electricity supply and distribution.

Academic research on institutional design and business models of community microgrids is limited so far. Many research questions remain for this new type of community energy architecture: Would central planning or market mechanisms better serve its objectives? How can pricing and incentive schemes be structured to encourage investments and to reduce peak demand? How can cost and revenue be fairly distributed to benefit the whole community and other stakeholders? Who would be responsible and accountable for its performance and risks?

Methods

Community microgrids, as an integrated part of decentralised energy solutions, are facing major challenges in its institutional organisation, revenue adequacy, community acceptance and fair distribution of benefits, which must be satisfactorily resolved before they can be successfully deployed and integrated into the electric power industry worldwide. A quasi-market design, applied widely in public sectors and infrastructure planning, is explored here as a market-like mechanism for community microgrids to improve efficiency and effectiveness, and to increase the responsiveness of the providers (Le Grand and Bartlett 1993). Its key design elements and principles, based on simplicity, low transaction costs and fair benefit distribution to community and all actors, are discussed. Several building blocks in a quasi-market paradigm are envisaged, including governance, supply-side, demand-side, and transactional management to address the above challenges. Each has its own objective, but they complement one another to support the overall objectives of community microgrids.

Results

The quasi-market design addresses the "revenue sufficiency problem" by providing investment incentives via long-term contracts between the community and providers, and tackles supply shortage via investment incentives for new capacity, energy efficiency and dynamic pricing solutions to encourage demand response (DR). Transparency on governing rules and pricing, and the community as a key stakeholder participating in decision-making, are other salient features of its design elements.

Community microgrids can incorporate smart energy management platform to perform system-wide optimisation that supports the microgrid internal retail function (Mancarella and Pudjianto 2009). Microgrid operators or energy management aggregators, can perform the financial transaction between demand-side and supply-side that may include independent generation units, storage units, prosumers with generation capacity, DR resources and consumers with loads only, either in the form of power purchase agreement, private contracts, or real-time pricing mechanisms etc. Integration to the main grid may be necessary depending on institutional setting and its operational setup when community microgrids are allowed for full participation at wholesale electricity market or participation at ancillary services market or DR market only.

Governance structure

Governance structure in a quasi-market is central to form the control system and the rules of collective decision-making among all actors that may include the local government, the community, financiers, asset owners and service providers. One single governing entity, in the form of a committee or a board structure can represent and accommodate interests of all actors, to provide stakeholders and the community opportunities for control and consent through defined processes. This entity is required to play several functions of rule-making, contract negotiation and formulation, compliance and dispute resolution, and can perform community voting and community consultation.

Principal-agent problems can present when multiple actors act to each maximise their own utility, especially when the ownership of the microgrid assets does not sit within the community. The alignment of interests among actors can be enhanced through mechanisms such as, performance-based contract design, risk and reward sharing, and effective incentive structures to encourage certain actions and outcomes, so that the objectives of the local community and external parties, can be harmonised. Clear outcomes, accountability and obligations should be legitimized through the governing entity, and enforced through legal contracts. It is important that vital interests of minority groups are also safeguarded, so the goal of fairness and equitable sharing of benefits, costs and risks among all actors will not be compromised.

Incentive mechanism and pricing

Incentive mechanisms need to be put in place to address key barriers in the development of community microgrids in institutional and community support, investments, service/product development and innovation, system and market optimisation, to achieve long term viability and efficiency. Initial seeding payment, either from government funding as in many microgrid demonstration projects or community contribution, is vital to provide confidence to investors and service providers to develop community microgrids. Other incentives may include some community ownership, a premium for economic and operational efficiency, a share of the user payment for long-term investment adequacy, to reduce investment risks for the provider.

Pricing structures on the demand-side are often associated with ownership models, business models, and contracting strategies, and may include two-part tariff, real-time pricing, and benchmark pricing etc. A long-term bilateral contract or service agreement contract can be constructed, that may include a two-part tariff of a fixed fee component and a variable fee component based on output and performance. Real-time pricing reflects the imbalance between the real-time demand and supply, when high frequency of supply interruption or emergency load shedding signals the need for new generation investments. Benchmark pricing arrangement can be structured to index to the wholesale spot market or critical fuel-prices in the community. Take-or-pay contracts may provide extra incentives for investments when facing customers with options to opt out microgrid contracts.

Competition, transaction costs and risks

Competion in a community microgrid at both capacity provision and retail level is naturally limited due to the small number of consumers and actors it can host. Suboptimal investments may not be avoided when contract prices guaranteed prior to commissioning are based on cost of generation or service provided. Unlike typical high transaction costs associated with a traditional quasi-market in the public sector or a hierachical electricity market, in a community microgrid lower transaction costs can be achieved through transparent pricing and information provision, which can be further reduced by vertical integration, standardised or group contracts.

Consumers in the community microgrid will ultimately bear most of economic and operational risks, particularly in an off-grid application. Transparency in market rules, community involvement from the early stage of the project development and the collective bargaining power of the community as a whole, can help minimise asymmetry information risks where trust between consumers and investors or facility owners is fragile. Investment risks are the largest when consumers have choice over alternative suppliers outside of microgrids while market-wide optimisation under wholesale market full participation may provide means to hedge against these risks.

Conclusions

A theoretical framework of a quasi-market design for community micrgrids is presented to foster investments and to achieve economic efficiency and fairness for all stakeholders. Institutional adequacy and community acceptance are most important to ensure their successful developments. Its ownership structure and operational business model will greatly affect competition, efficiency and benefit distribution within community microgrids. For benefit maximisation and risk control, the design and pricing of community microgrids should be evaluated within the context of the national electricity market.

References

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