ANALYSIS ON THE STAKEHOLDERS OF MICROGRID BUSINESSES FOR THE DEVELPOMENT OF DISSEMINATION POLICIES

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ABSTRACT

This papers shows a new economic analysis model to able to consider complicated industrial environments related to microgrid hardware and software elements. It is expected that the proposed model could contribute to make a proper decision with the economic feasibility for creating and developing microgrid deployment policies.

INTRODUCTION

When we discuss about the dissemination of any public project, such as renewable energy, high efficient appliances, and so on, the economic feasibility is regarded as one of important decision-making criteria. So, various economic evaluation tools are applied to decide appropriate solutions. California Standard Practice Test is a representative evaluation tool for demand side management programs as well as for other public programs. However, limited stakeholders are considered in this test so that the solutions are used only for policy makers or utilities. In the case of demand side management programs, this test is useful because that there are not many related entities. To disseminate microgrid business models, we should consider so many stakeholders such as various manufacturers for renewable energy facilities, battery systems, diesel turbines, power conditioning systems, etc., operators for microgrids, conventional power supply systems, DSO, TSO, ISO, etc., and various customers who participate in microgrid businesses or do not participate in the businesses. Also, the state and provincial governments have their own viewpoints into the businesses. For example, most of governments have some plans to lower carbon through renewable energy and high efficient appliances. Among these various stakeholders, there are so many economic viewpoints. It is very difficult to find out an optimal solution for all because each satisfaction point is different and various. In this paper, the relationship between various stakeholders of microgrid businesses is analysed considering various industrial constraints to find out cross sections in which are satisfied by the stakeholders. The constraints would be manufacturing capacity and facility replacement times of battery, government's subsidy budget limitation, and so on. Based on this analysis, a new economic analysis method will be proposed and a few business models be analysed.

MICROGRID BUSINESS MODEL TRENDS

According to Navigant Research, ten microgrid business models are identified as shown in Table 1. The Navigant consulting results explain about these models briefly as follow [1][3]: (1) [Owner Financing & Maintenance] The most prevalent and mature business model is owner financing and maintenance model and the representative market segments are campus microgrids and remote microgrids. Some facilities are involved with R&D projects. (2) [Utility Rate Base] A utility could to place the costs of design, construction and maintenance of a microgrid into its rate base. To date, most utility systems based on the rate base approach are public power entities in rural and off-grid markets. (3) [Pure Hardware Component Sales] The least risky business model is to be a supplier or manufacturer of hardware products such as renewable generation, smart meters, inverters or switchgears. A lot of vendors consider microgrids as another marketplace for their products. (4) [Software as a Service] While sales of distribution generation facilities will likely be the biggest portion of microgrid revenue, the most challenging technological task is the networking function. Because there are so many approaches to controlling and optimizing microgrid systems, this is the space where Navigant Research expects the most creativity. (5) [Government Energy Service Contracts] During this industry's nascent stage, many microgrids deployed in the United States for government entities have prescribed contract vehicles that dictate the terms for any viable business model. This is the contracting approach most frequently deployed in the U.S. Department of Defence (DOD) microgrids market. (6) [PPAs] The PPA is a common approach to developing an independent power system project, whether it be a large-scale wind farm or a rooftop solar PV installation. It is, in practice, often pegged to the utility cost of providing an identical energy services, priced at or just below this cost, and then increases by 1%-5% annually over a 20-year term. It is designed for a third party that acts as a virtual utility in terms of delivery of energy services to take advantage of various tax credits and other subsidies. (7) [Non-Synchronous Direct Current] In terms of technology, the most novel of all microgrid business models is developing a non-synchronous DC microgrid. This approach represents a completely different take on the microgrid business model, based on the disruptive technology of grid-tied, DC-based, non-synchronous microgrid architectures. (8) [O&Ms] Operations and maintenance contracts are a common way to ensure microgrid performance. These contracts are often rolled into utility-developed microgrid projects. For microgrids not developed by a utility or under the owner financing and maintenance model, O&M contracts represent opportunities for both utilities and other vendors to capture relatively small revenue streams from microgrid deployments. O&M contracts are designed to maintain optimum performance and are likely to become increasingly popular as microgrids move into the mainstream. (9) [Pay-As-You-Go] Perhaps the most unique business model in terms of

financial innovation is the pay-as-you-go (PAYG) model, aimed at accelerating the progress on the energy access front being championed by organizations such as the United Nations, World Bank, and various philanthropic foundations. In this model, the microgrid may be financed by several mechanisms but customers pay for energy as they use it. A PAYG strategy for critical infrastructure, such as power supplies, is growing in popularity. This is especially the case when applied to small, remote microgrids in the developing world. (10) [DBOOM] The final example of a microgrid business model is reliance upon one entity to handle everything associated with upfront microgrid design and planning, construction, and ongoing operations. The advantage of this approach for the customer is that it represents one-stop shopping. For the vendor—whether a private company or public utility—it theoretically captures all potential revenue derived from a microgrid project, from upfront engineering and permitting to full-scale development, and then ongoing O&M.

Table 1 Microgrid business models by Navigant [1]

Business Model	Prevalence	Market Segment
(1) Owner Financing & Maintenance	High	Campus, Remote
(2) Utility Rate Base	Low	Utility, Community Resilience, Remote
(3) Pure Component Sales	High	Campus, Military, DC
(4) Software as a Service	Low	Military, Utility, Remote
(5) Government Energy Service Contracts	Low	Campus, Military
(6) Power Purchase Agreements (PPAs)	Medium	Campus, Commercial & Industrial, Military, Community Resilience, Remote, DC
(7) Direct Current	Low	Commercial & Industrial, Remote
(8) Operation & Maintenance	Low	Campus, Utility, Community Resilience
(9) Pay-As-You-Go (PAYG)	High	Military, Remote, DC
(10) Design, Build, Operate, Own and Maintain (DBOOM)	Low	Campus, Commercial & Industrial, Utility, Remote

STAKEHOLDERS OF MICROGRID

Although there are so many stakeholders related to the microgrid business, essential entities should be identified to analyse economic effects by and on microgrid effectively. Firstly, the stakeholders in the California Test which has used globally to analyse and evaluate demand side management programs. In the next place, more various stakeholders are considered to propose a new economic analysis model comparing with the stakeholders of the California Test.

Stakeholders in California Standard Practice Test

There are just three stakeholders, which are utility, participant and nonparticipant, in the California Standard Practices test. The economic feasibility of most of demand side management programs is analysed and evaluated with this simple configuration because it is assumed that only these three parties would effect by the programs and each other. The benefit and cost element of the test as shown in Table 2. The benefits of participants are the bill reduction by application of the program and the subsidy incentive paid by utility or government. The costs of participants are equipment purchasing cost and installation cost including operation and maintenance. The benefits of non-participants are the savings form avoided costs. The costs of non-participants are the program costs incurred by the utility, the incentives paid to the participants, decreased revenues for load reduction periods and increased supply costs for load increasing periods. The benefits of utility are the savings from avoided costs, the reduction in generation, transmission, distribution, and capacity valued at marginal costs for the load reduction periods. The costs of utility are the program cost incurred by the administrator, the incentives paid to the participants, and the increased supply costs for the load increasing periods [2].

Table 2 Benefit and cost elements of California test

Stakeholders	Benefits	Costs
Participant	Bill reduction Incentive Tax credit	Equipment cost
Non-participant	Avoided cost	Program cost Sales reduction
Utility	Avoided cost	Program cost Incentive Sales reduction

Expanding Stakeholders for a New Economic Analysis Model

In a proposed new economic analysis model, more various stakeholders are considered as well as three stakeholders in the California Test because the industrial environment concerning microgrid is so complicated. In demand side management programs, the essential problem is the subsidy incentive level for customers paid by utility or government. To decide appropriate subsidy levels, it is sufficient to consider only viewpoints of participants, non-participants and utilities evaluating the peak reduction or energy saving. However, in microgrid deployment programs, there are various parties such as microgrid aggregators, microgrid with diesel generator, microgrid with renewable energy, microgrid with demand response, system providers, constructors, and so on. Table 3 shows benefit and cost elements of these stakeholders.

Table 3 Benefit and cost elements of a new analysis model

Stakeholders	Benefits	Costs
Participant	Bill reduction Incentive Tax credit	Equipment cost
Non-participant	Avoided cost	Program cost Sales reduction
Aggregator	Commission fee	Administration cost
Utility	Avoided cost	Program cost Incentive Sales reduction Reliability cost
Government	Tax CDM revenue	Incentive
Manufacturer	Sales revenue (Incentive)	Installation cost for facilities
Constructor	Sales revenue	Construction cost

PROPOSED ECONOMIC ANALYSIS MODEL

It is difficult to consider and compare the economic features of all the stakeholders because their economic viewpoints and purposes clash each other in their own economic activities. That is to say, we should treat multiple objectives and subjects in the decision making of public programs. Firstly, policy makers must consider major interest parties which are governments, utilities, microgrid facility providers or manufactures, constructors, fuel providers or importers, microgrid program participants and non-participants, microgrid aggregators, free-riders, and free-riders as shown in Figure 1[4]. What is remarkable is that the fuel providers are located in the overseas because Korea depends on the import to provide most of natural resources. And the microgrid facility providers and manufacturers lie on the border between overseas side and domestic side because facilities and appliances are manufactured domestically as well as imported from foreign countries.

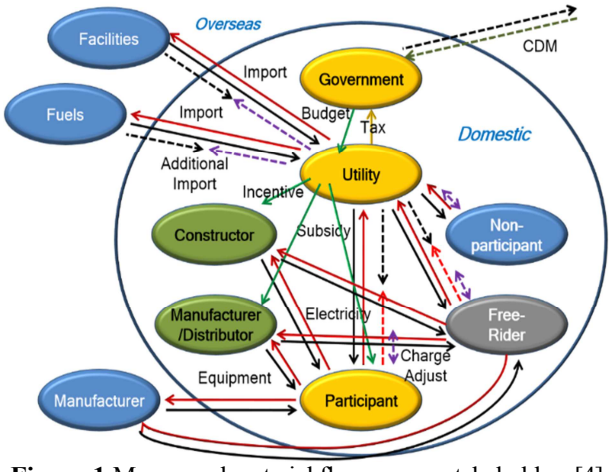

Figure 1 Money and material flow among stakeholders [4]

Formulation of a new economic analysis model

The evaluation of benefit-cost ratio is a conventional and simple economic analysis method to explain easily the economic feasibility of any social policy. In the California Test, benefit-cost ratios of participants, non-participants and utilities are considered. In addition to these stakeholders, microgrid aggregator, government, manufacturer and constructor are included as follow:

$$BCR_U = \frac{AC+TC}{OC+IC+UH} \quad (1)$$

$$BCR_P = \frac{IC+RR}{PH} \quad (2)$$

$$BCR_{NP} = \frac{AC}{OC+IC+UH+RR} \quad (3)$$

$$BCR_{AG} = \frac{CF}{AD} \quad (4)$$

$$BCR_G = \frac{TR+CD}{IC} \quad (5)$$

$$BCR_M = \frac{SM+IC}{FC} \quad (6)$$

$$BCR_C = \frac{SC+IC}{CC} \quad (7)$$

where

BCR_U : Benefit-Cost Ratio of Utility
BCR_P : Benefit-Cost Ratio of Participant
BCR_{NP} : Benefit-Cost Ratio of Non-participant
BCR_{AG} : Benefit-Cost Ratio of Aggregator
BCR_G : Benefit-Cost Ratio of Government
BCR_M : Benefit-Cost Ratio of Manufacturer
BCR_C : Benefit-Cost Ratio of Constructor
AC : Avoided Cost
TC : Tax Credit
OC : Program Operation Cost
UH : Utility Equipment Cost
PH : Participant Equipment Cost
IC : Incentive
RR : Revenue Reduction of Utility
CF : Commission Fee
AD : Administration Cost
TR : Tax Revenue
CD : Revenue from CDM
SM : Sales Revenue of Manufacturer
FC : Installation Cost for Facilities
SC : Sales Revenue of Constructor
CC : Construction Cost.

Consideration of industrial environment

Although the equity is a very important element in the decision-making process, it has not been considered in the economic analysis models. For example, diesel generator set is a main electricity supplier in standalone islands of Korea. If microgrid systems without diesel generators would be deployed rapidly, diesel generator manufacturers and providers could be eliminated in the microgrid industry because of unprofitable products. To prevent this situation, a gradual deployment policy should be designed and the replacement opportunities and periods to adopt to new industry environment are provided for conventional facility manufacturers. Figure 2 and equation (8) show this concept. The gradual

reduction of old equipment such as diesel generators is expressed as a linear pattern to understand easily. And policy makers may adjust the replacement period of old facilities to produce new equipment such as renewable energy with parameter k considering the facility life [13].

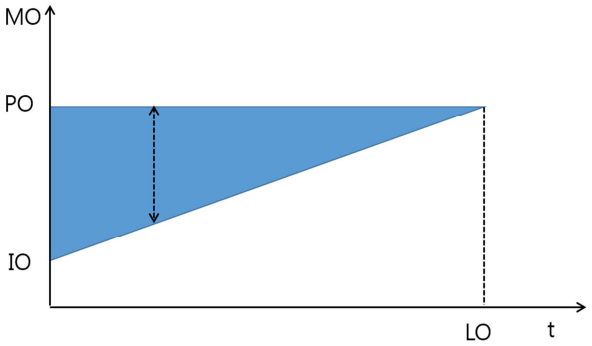

Figure 2 Max. replacement constraint of old facility [13]

$$\text{MO} \leq \frac{PO-IO}{kLO} + IO \qquad (8)$$

where

MO : Annual Max. Diffusion of Old Equipment
PO : Production Capacity of Old Facility
IO : Initial Diffusion of Old Equipment
LO : Life of Old Facility
k : Life Span Parameter (Integer).

CONCLUSIONS

In this paper, the relationship among various stakeholders of microgrid businesses is analysed considering various industrial constraints to find out cross sections in which are satisfied by the stakeholders. The constraints would be manufacturing capacity and facility replacement times of battery, government's subsidy budget limitation, and so on. Based on this analysis, a new economic analysis method will be proposed and a few business models be analysed in this paper. As future studies, the formulation of the proposed method will be developed in detail and case studies will be carried out to verify the method considering real conditions.

ACKNOWLEDGEMENT

This work is supported by KEPCO Research Institute grant funded by Korea Electric Power Corporation (R16DA11).

REFERENCES

[1] Peter Asmus and Mackinnon Lawrence, 2016, *Emerging Microgrid Business Models,* Navigant Consulting Inc., Boulder, USA, 4-11.
[2] Gray Davis, 2002, *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects*, Governor's Office of Planning and Research, California, USA.
[3] Peter Asmus and Adam Forni, 2017, *Market Data: Microgrid O&M Revenue Opportunities*, Navigant Consluting Inc., Boulder, USA.
[4] S. W. Hwang, et. al., 2013, "A Study on the Economic Analysis and Optimal Budget Decision Methods for DSM Programs Including Load Creation", *Proceedings of 2013 the International Conference on Electrical Engineering (ICEE)*, Xiamen, China
[5] J. J. Park, 2009, *A Study on the Investment Optimization for the Portfolio of DSM Programs,* Dissertation for PhD., Hanyang University, Seoul, Korea.
[6] S. W. Hwang, et. al, 2010, "Analysis on the Benefit & Cost Elements and the Interested Relations for Optimal Apportionment of DSM Budget", *Proceedings of KIEE PES Spring Meeting*, Incheon, Korea.
[7] H. S. Nah, et al., 2009, "Future Development and Proto Type of Electrified House", *KPIC2009*, Seoul, Korea.
[8] KEPCO, *Guide to KEPCO's Demand-Side Management*, KEPCO DSM internet web page (www.kepco.co.kr/DSM).
[9] Industrial Technology Institute, 1983, *A Study on the Development of Power System Planning*, Seoul National University, Seoul, Korea.
[10] J. S. Ryu, 1996, *A Study on Establishing Short-term based DSM Screening Model, Estimating Optimal Investments and Pervading Plan in Nation-wide Perspective*, Dissertation for Master, Hongik University, Seoul, Korea.
[11] S. I. Kim, 1997, *A Study on Developing Methodology of DSM Monitoring System*, Dissertation for Master, Hongik University, Seoul, Korea.
[12] S. C. Chang, 1999, *A Study on the Probabilistic Production Simulation in Electricity Resource Planning Considering DSM Impacts*, PhD Dissertation, Hongik University, Seoul, Korea.
[13] S. W. Hwang, 2012, *A Study on an Optimal Budget Allocation Method for Demand Side Management Programs and the Impact Analysis Considering Related Industrial Environments*, PhD Dissertation, Hongik University, Seoul, Korea.
[14] Korea Power Exchange, 2009, *Survey on the Diffusion Rate of Home Appliances and the Electricity Consumption Behaviour*, KPX, Seoul, Korea.