MPM – Master of Project Management

Assessing stakeholders benefits of a microgrid energy system in Iceland

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ABSTRACT

Past years have shown that occurances such as extreme weather, war, terrorism, seismic activity, and other events have illustrated the lack of resilience the electrical power grid of nations can have and how vulnerable society can be when power grids go out for longer time. There are, further, many barriers which will need to be crossed as to ensure sufficient supply for the increasing demand for electricity around the world. However, an increasing penetration of distributed energy resources that provide electricity into the existing grid has in recent years been developing an interesting scenario for power generation. Example of these developments are, for instance, the solar and wind farms.

It is clear that reliability and resilience of electrical supply has gained its importance in regards to modern living for instance, communication, foodsupply storage and medical device. When a electrical power grid goes out for a longer time, numerous things that play a crucial role to maintain society, security and the economy can get affected. Micro electrical grids with independent power sources and generators might come in handy in such situations.

The main objective of this paper is to spaculate about the potential social and economic benefits by which microgrids may have in countries that can be defined as developed. Microgrids are currently used in many places within the developing world, but the question being asked in this paper is: Could electrical microgrids with independent source energy benefit users in more developed countries as crucial backup when the larger electrical system can not supply?

The microgrid gains are importance due to its ability to provide secure and sustainable electricity as back up, either as a compensation for the main grid or as a sole electrical supply when the main grid fails. In other words, the microgrid can be used both as a supplementary electrical generation at peak hours and as a full back-up when the large grid is down or cut off. Such a function of a microgrid is often referred to as “islanded” from the main utility power grid.

To further analyse the social benefits a micro grid installation project might have, a simple stakeholder and outcome study was done based on Icelandic data. The key elements in such analyses are energy costs, reliability, opportunities and supply expansions. Icelandic energy costs was taken into consideration as to gain knowledge on the energy costs from a country which would be defined as well developed.

This paper provides a brief overview on these topics and how their importance may differently reflect upon significant outcome measures such as cost and security.

In order to gain more in-depth knowledge of the true impacts of the benefits of islanded microgrids, further analysis regarding the social and economic aspect of microgrid implementation is needed. The same hold true when it comes to evaluate the measure of suffcient reliability and resilience as to defining clearly on what aspect of a developed country would need such energy reliability and resilience.

1. INTRODUCTION

Modern society today depends critically on a secure supply of energy. Most of today's power supplies arise from large power grids, hydro, wind, solar, nuclear, coal, etc. (Parag & Ainspan, 2019). Energy demand is rapidly increasing, electrical transmission and distribution networks are increasingly challenging security, reliability and quality of power supply. (Ali et al., 2017). Further, past years have shown that occurances such as extreme weather, war, terrorism, seismic activity and other extreme events have set a bar at what resilience the larger electrical power grid has, and how vulnerable societies can become when power grids are cut off. This can mean downtime of emergency telecom lines, food shortage, lack of lighting, medical equipment and other essential things.

According to the Kyoto protocol the energy sector has a clean sustainable energy goal which must be reached by the year 2030 and it also contains certain milestones to keep it on track till then. The goal is clear and a positive way to make way for a brighter future (European commission, n.d.). These are:

- At least 40% cuts in greenhouse gas emmisions (from 1990 numbers)
- At least 32% share for renewable energy.
- At least 32.5% improvement in energy efficiency.

Nevertheless, how can all countries, especially those less developed, react to such goals? There are many barriers which will need to be crossed in order to ensure safe and clean electrical supply for the increasing demand around the world. However, an increasing penetration of distributed energy resource, for instance the solar and wind farms, into the existing power sector has developed into a promising power scenario for electric power generation (Ali et al., 2017). This increasing penetration might be especially important due to, among other things, to factors such as:

- Potential fossil fuel shortage;
- Political instability in major energy-supplying countries;
- Fossil fuel power generation which causes global warming.

These things might be done to protect the climate and the environment from the impact of fossil fuels, to improve energy reliability, and to meet the growing electricity demand. Microgrids have the ability to provide electrical power that is customized, efficient, reliable, and clean (Ali et al., 2017).

These factors have attracted the attention of the government and industries globally and has given the power sector a push towards more optimaztion in resource utilization and installation of local microgrids at necessary locations. These locations are often linked to remote communities, less developed countries, and electrical equipment located at remote areas.

This paper will point out some of the potential social and economic benefits which microgrids might possibly have in developed countries. The outcome can hopefully be further used as foundation for more thorough feasibility studies in this field.

2. LITERATURE REVIEW

The potentialities of microgrids to serve local communites around the world have been studied quite extensively, especially in light if the increase of power usage has grown and social needs of reliable power.

In order to explore the research topic on potential social advantages of microgrids, past literature and lessons learned need to be taken into notice. The technical barriers and benefits have been the main focus of most literature past years, due to a still rising need for development in the energy sector. It has been noticed that the overall social and economic benefits have been less studied and sometimes even not taken into account when assessing overall benefits of the technology (Santos et al., 2018).

Regarding social and economic perspectives it has been pointed out that microgrids can improve the life of people in isolated communities, increase public awareness and foster incentives for energy saving and green-house gas reduction (Santos et al., 2018). Previous work has also highlighted many of the benefits by implementing microgrids in less developed countries. This means bringing reliable sustainable energy sources to places which have vulnerable power grids due to outfated and old infrastructure. Therefore, developed countries which have their main power source supply from large sustainable power grids might be a good benchmark on investigating the key social and economic benefits which the micro grid systems apply (Soshinskaya et al., 2014).

Importance and role of the microgrid

As to understand the potential importance of microgrids, the needs of users and their applications should be described. Such evaluation needs to take notice of the relative value that the installation might have based on where the systems are distributed and how they might influence the local economical and social situation. Most microgrids are currently treated around the world as developmental projects and the benefits and barriers are researched normally as case studies of past projects. This fits well as to understand the impact of new projects in different environment. Such studies also give indications of the possible barriers teams installing microgrid might face and as to identify some of the common important interests of all parties involved (Soshinskaya et al., 2014).

Functionality of the microgrids

The microgrid gains its importance mainly due to the fact that as it can create sustainable electricity and be connected, or disconnected, to the main power grid based on demand for electricity. Therefore, using both the larger grid and the microgrid production at peak hours, or having the microgrid running on itself while the larger grid is down or cut off is often referred to as the microgrid as being “islanded” from the utility power grid (Zhou et al., 2018).

Microgrids are usually connected to all users in the area where they are installed; commercial, industrial and residential alike. They, therefore, need to serve the different types of electrical loads according to the different needs of the customer in that area and hence the microgrid technology needs to serve principal operating strategies (Soshinskaya et al., 2014) meaning that:

- The power production needs to meet the electricity consumption demand, so that the basic requirements such as power balance, quality, flexibility and electrical safety are taken into account.
- The grid has to have a "plug and play" functionality on two levels: (1) Be a flexible system where additional electrical power generators such as wind turbines or solar panels can be installed; and have the (2) Ability to enter island mode by disconnecting from the main grid at one central point. That way produces enough power to reduce/eliminate power outages and then re-synchronize with the grid when ready.

To achieve these functional and operational conditions, microgrids can have diverse structures, which can be defined by the internal consumer structure and the ownership of the microgrid (Soshinskaya et al., 2014). Moreover, since the goal is to deploy more efficient and cleaner power compared to the main grid, renewable on-site generation options are used; these can, for instance, include solar photovoltaics, micro-wind turbines (<1MW) and fuel cells. Depending on the location, hydro power generation might also be used. (Soshinskaya et al., 2014). Two or more of these could be connected together in order to meet the demand for elecricity as a distributed energy system.

Distributed energy systems might require energy storage since the energy production cannot always meet the demand at a given time. The storage units function as to bridge the intervals between the demand of production capability and energy demand. During time when demand goes down the storage can be recharged by letting the energy system produce energy into the storage system and vice versa. These storages would have to be sized according to the need of each customer (Soshinskaya et al., 2014).

As to actively control and operate a microgrid system that is connected to a main power grid, some kind of communication is needed between the two. Controls are installed between the grids as to control the loads, enhance advanced power conversion and all necessary grid management and functionality (Akpolat, 2016).
Figures 1 and 2 illustrate the connection and disconnection from the main grid:

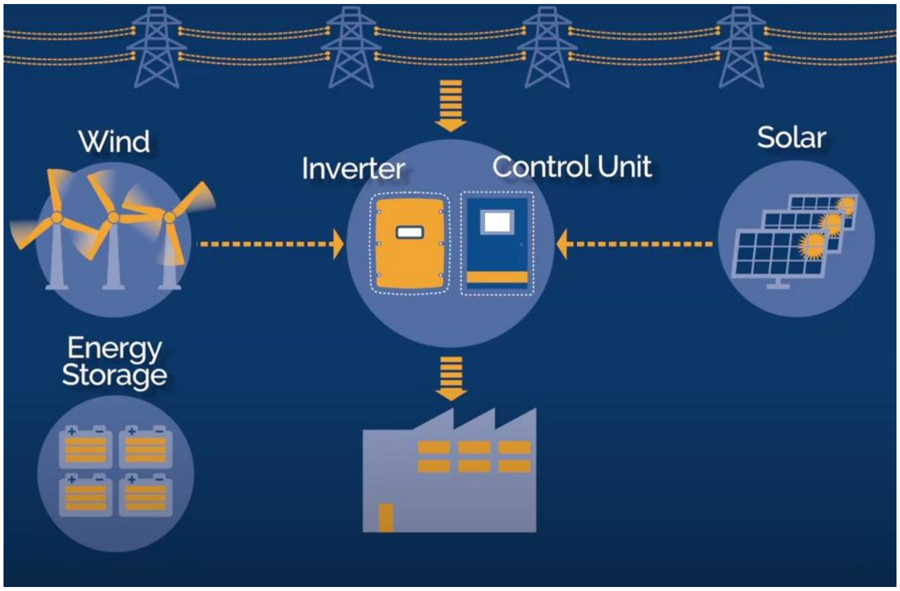

Figure 1 microgrid connection to main grid

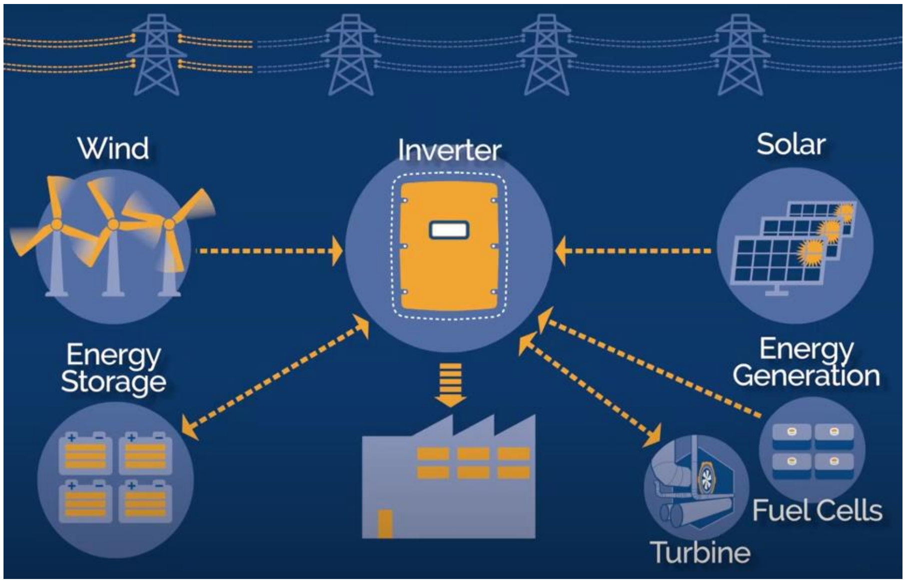

Figure 2 microgrid disconnection to main grid (island mode)

In general, microgrids are not defined by their size. It is rather the function which determines their type and overall definition. The size of the microgrid would ideally depends on the load of the peak power required by the customers (Akpolat, 2016).

3. RESEARCH METHOD

As said before, current literature regarding the microgrid topic are most often investigating the technological advantages and barriers of a microgrid system. This paper specutively explores the perspective of the social and economical side of the micro grid.

In order to thouroughly analyse the social benefits of a microgrid project, a careful stakeholder´s benefit analyses would be done and that would require: (1) A clear definition of the stakeholders and their possible features of interest; (2) A method to determine outcomes and impacts (benefits) against which the success/failure of an project is to be evaluated.

In order to have some comparison, this paper will take Iceland as a benchmark. The country is considered a modern and developed country which has most of its energy resources generated from sustainable energy sources. Necessary data such as the electrical cost and current situations of the country or location will be analysed. Once the current situation has to be laid out, a list of potential stakeholders and outcomes is made by speculatively analysing the potential difference between the pre-installing a microgrid situation and potential post-installation situation. These outcomes are then drawn together and analysed by highlighting the main outcomes which are affected by the installation.

4. RESEARCH RESULTS

Identification of outcomes

In order to identify the legimacy of a project or program the justification for taking it on would have to be addressed. Particularly, the outcome measures have to be defined and it laid out how they relate to all the stakeholders involved (Todorov, 2014). The preferred outcomes of installing a microgrid system is listed below along with some key stakeholders (Figure 3):

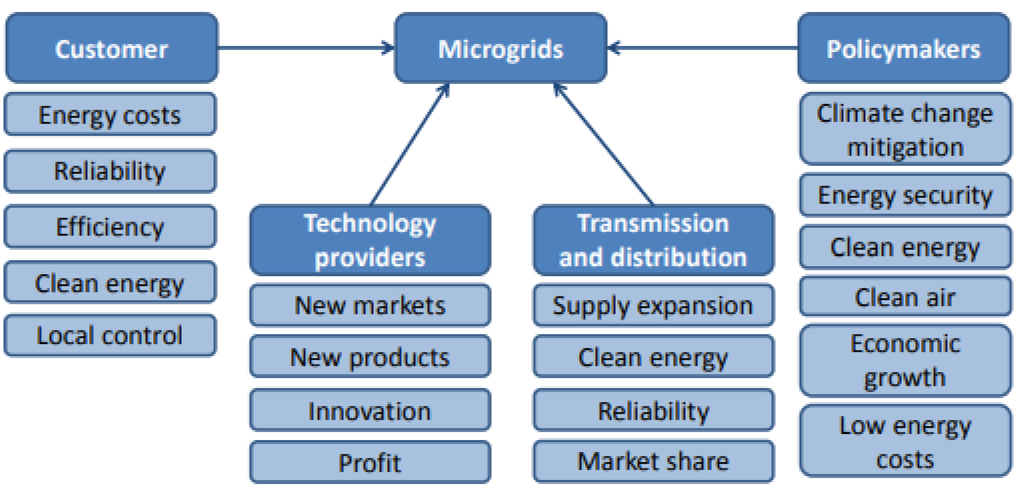

Figure 3 Stakeholders Related to Microgrids (Marnay et al., 2012)

From figure 3 it becomes clear what outcomes refer to which stakeholder (Marnay et al., 2012). This paper will use electrical cost data from Iceland where the country has sufficient electrical power to the customers and generates it from sustainable sources. Stakeholders and their outcomes are listed up and both current conditions and post installation conditions.

Stakeholder outcomes		Pre-microgrid installation	Post installation
Customer	Energy costs	Energy cost is low	Chance of cost increase
	Reliability	Reliability is okay (52.2 min. per year, *Landsnet, Iceland, 2018*)	Reliability increases due to back up storage and production from the Island mode
	Efficiency	Mainly hydropower used (>90%)	Overall efficiency will lower.
	Clean energy	Sustainable (hydro, geo-thermal & wind)	Sustainable (hydro, geo-thermal, wind & solar)
	Local control	None	Local control of the microgrids will open up
Technology Providers	New markets	N/A	Creates opportunity
	New Products	N/A	Creates income
	Innovation	N/A	Creates new products
	Profit	N/A	Creates new jobs
Transmission and distribution	Supply expansion	Needed in relation to usage, Large power station installed.	Smaller modular and expandable solutions installed.
	Clean energy	Yes	Similar status
	Reliability	Good	Will increase
	Market share	Competition between distributors is healthy	New competitors arrive to the market.
Policy makers	Climate change mitigation	Good efforts are being made today towards climate change.	Would support Climate change mitigation.
	Energy security	Not a problem, enough energy resources available and price low.	Would increase the resources. However price might change. Due to capital cost.
	Clean energy	Not a problem.	Not a problem
	Clean air	Not a problem	Not a problem
	Economic growth	N/A	Would support economic growth.
	Low energy costs	Today the cost is relatively low	A chance that price per MW might increase.

Table 1 Potential stakeholders and outcomes form the installation of electrical microgrids

In order to explore this futher a realistic scenario an example from Iceland was looked at, but Iceland has almost all its energy resource from sustainable energy.

As to identify the potential benefits, outcomes were analysed in order to see where they might stand out as to have the most substantial benefits. However, it is also possible that some factors could counteract against some of the benefits. (Parag & Ainspan, 2019). These outcomes where then pulled together and analysed according to the above project design.

The analyses of the stakeholders and their outcomes shows that few factors do need to be investigated further based on the potential change that occurs when a microgrid energy generator is installed. Here the outcomes which are barely affected will not be analysed further. For instance, there will be little change in clean energy production as it was mostly clean energy before. There are also factors which will counteract potential benefits today. The main possible changes relate to energy costs, reliability, opportunities and supply expansions.

Installing a microgrid plant, reliability is known to increase due to its backup generator function for the larger grid (Marnay et al., 2012). At the same time, it can also maintain a full charge status on its internal back up energy storage as well. Usually increased reliability doesn't come without a cost. The increasing energy cost would increase reliability. However, the energy costs to customers in Iceland is the lowest of all Nordic countries (Figure 4).

The reliability in Iceland is high or just 52 minutes/year in downtime on average. These 52 minutes are made of minutes where the main supply grid is down and also where backup generators supply electricity because of the grid loss. Therefore, the actual time a customer is without power is usually much less (Landsnet, n.d.). In order to evaluate the quantitative size for this benefit/factor one needs to understand the cost of losing 52 minutes of power per year (Landsnet, n.d.). According to landsnet, the average price for a kW which is used to calculate total cost of loss is around 0.2 euros as shown in the picture below. (Statistics Iceland, 2019)

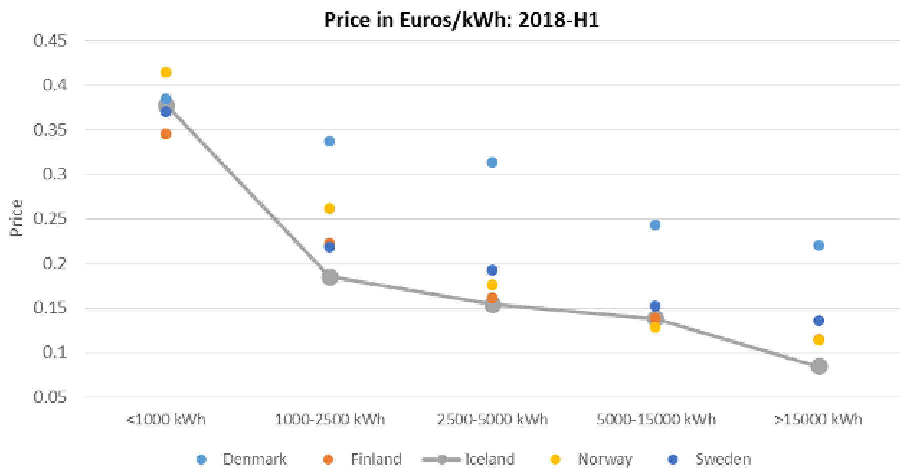

Figure 4 Price per kWh in the Nordic countries (Statistics Iceland, 2019)

The total downtime is 1800 MWhr. Which sums up to be 1.8 million kWhr. Therefore, the total cost of downtime that last for 52 minutes is approx. 360.000 euros.

There is no exact data on how much downtime a microgrid can cover up for the main grid to a minimum, therefore the cost of downtime which can be saved in Iceland is, in the current situation, at a maximum of approx. 360.000 euros (might change due to currency fluctuations). Nevertheless, although the overall reliability might be overstated in some cases, the benefits of resilience are often understated if addressed at all. These "resiliency benefits" are mainly the microgrid's ability to maintain system reliability and resilience during extreme events affecting the centralized grid (Parag & Ainspan, 2019).

The main outcome measures looked at have been identified as new markets and future work in research and development within the energy sector. In Iceland, with the price the lowest in the Nordic country´s and reliability measure of 52 minutes per year on average of main power grid downtime, is exceedingly good. This means that the cost of installation of new microgrids, with the associated capital cost and the necessary maintance work, would most likely result in the consumers possibly paying for these changes.

The estimate the economic benefits can also be a reflection of the additional employment generated and on the taskforce needed to construct and maintain the microgrid (Parag & Ainspan, 2019). This paper will not evaluate these benefits as the economic analysis requires data gathering from within the specific field and could be gathered as a part of, for instance, an environmental impact report; that could give a better view of both indirect and direct economic benefits.

Many societies are taking various positive steps as to improve the environmental impact of the electricity supply by increasing the ability to expand the supply grid with microgrids. The microgrid systems are easily expandable and can take notice of the necessity of constantly finding new energy resources to meet the increase in energy demand. Therefore, the size of the microgrid systems installed would have a direct link to the demand and at the same time keeping environmental impacts as low as possible (Parag & Ainspan, 2019).

5. DISCUSSION

When looking at a well-developed country such as Iceland and its need for microgrid energy system, few important benefits can be highlighted. These are the key success factors which all of the benefits of installing microgrids would arise from. In fact, some of these key success factors would apply regardless of the developmental status of the country in question. There is, for instance, a strong indication that reliability and resilience are the key motivators for installing a microgrid system in any country. This would hold true in a country like Iceland also, and as a matter of fact, in any other well-developed country even with good energy resources.

Increase in reliability and resilience, however, comes with a price which the community will need to pay, as to gain increased energy security.

The average downtime of the powergrid in a place like Iceland is 52 minutes per year. This is a very low number and meets by far their target which is around 50 minutes. Therefore, overall the need for increased reliability is not a main issue and the need in additional resilience is not critical. Though the normal household might not be in need for such reliability or resilience, certain communites and industries might be in larger need for a back-up from a microgrid. Those would possibly be the telecommunication devices, medical facilities, weather stations, industrial plants, airports, farms and other technical devices located at remote locations.

The next steps as to determine the feasibility of this sort of project would be to conduct a full feasibility report, which builds on the environmental assessment and on a full social and economic analysis. It is, however, also interesting to see that researches have pointed out numerous papers which have overestimated the total benefits of installing a microgrid system. Therefore, during the next steps in analysis, a careful and realistic estimate must be made in evaluating the needs of stakeholders and by that decrease the chance of overstating expectations.

6. Conclusion

Most current studies on microgrids have focused on the technical barriers and only recently have the social, economical and stakeholder studies been evaluated. However, evidence is lacking when it comes to reflecting upon the stakeholders accountability and profitability with regards to microgrids in well developed countries. Thus, more work is needed to identify the true economic benefits and barriers of the microgrid energy system. Along with an increase in energy demand the importance of many electrical devices such as telecommunication have grown substantially. It is clear that reliability and resilience of electrical supply will contine to gain importance and the microgrid technology is one way to meet that demand.

In order to gain more in-depth knowledge of its true impact, further analysis regarding the social and economic aspect of microgrid implementation in well developed countries and communities is needed.

The overview this paper shows that all benefits come with a cost, and society needs to take a stance on what is enough in regard to security, resilience and reliability when it comes to electricity supply and demand; and based on that make decisions if the benefits of installing microgrids outweights the cost of doing so.

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