Project Title:

Investigating the effect of smartening, distributed energy resources, microgrids, and storage devices on electrical energy losses of distribution networks

Department:	Plan of Strategic studies to reduce electrical energy losses in power distribution networks	***Employer:***	NRI
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Project Necessity:

In recent years, smart grids, microgrids, and active distribution networks development considered by many studies. In some cases, these concepts overlap, but the distinction between each of them is clear. Reducing the power system losses is one of the goals achieved by these modern networks, Although there are different motivations for developing these.

The installation of distributed energy resources near consumers and the utilization of smart grid infrastructure will reduce technical and non-technical losses both.

The existing measurement infrastructures facilitate losses calculation more accurately in different areas of a network. In addition, new tools are accessible to reduce network losses. In this project, evaluate the capacities of smart grids, microgrids, automation, and distributed generations to the reduction of network losses. In the end, the necessary actions to use these capacities suggest.

Project Goals:

Investigating the various effects of creating and developing smart grids, microgrids, and distributed energy sources on electrical losses in the distribution network

- Investigate the infrastructure and mechanisms needed to take advantage of the potential of developing smart grids, microgrids, and distributed energy sources to reduce electrical losses in the distribution network

- Develop and propose technical and non-technical solutions and policies to use the opportunity of smartening, creation of microgrids, and development of automation and distributed generation resources to reduce distribution network losses.

Abstract:

The term "smart grid" refers to the modernization of the electrical distribution system. Essentially, the smart grid vision is to provide greater clarity and awareness for low voltage (downstream) networks to allow consumers to be more involved in power system performance, primarily through smart gauges and smart homes. The operational data collected by the smart grid and its subsystems allow system operators and network operators to quickly enter and act on the best course of action to defend and protect the grid against the risks of various events.

The vision of these next-generation distribution systems considers in Many studies and researches. Various studies and investigations on their concept and characteristics can be summarized as follows:

- Reduce costs in terms of investment, operation, and maintenance services
- Enhance safety
- Reduction of electrical losses
- Development of market concepts at the level of distribution and local networks
- Growth of reliability indicators
- Increasing power quality indicators
- Development of infrastructure to provide ancillary services at the local level
- Creating the infrastructure to develop the presence of new technologies
- Increasing the indicators of technical and economic stability
- Increase availability
- Development of competitiveness characteristics
- Develop resilience and flexibility
- Development of concepts of smart electrical networks

Losses of power grids are an indicator to measure the scientific progress of countries. Organizations such as the World Bank cited that. Fewer losses accelerate the economic growth of nations and make electricity distribution companies more flexible to compete in competitive markets.

On the other hand, the electricity industry in various sectors needs significant and long-term investment therefore, very important to plan electricity industry facilities to operate optimally. In addition to causing billions of dollars in losses per year, the losses in electricity networks also waste a large amount of capacity of the country's power plants.

Based on the results obtained from the simulation on 33 balanced buses and 25 unbalanced buses of IEEE test distribution networks and to investigate the effect of solutions such as using distributed generation source, reactive power compensation, energy storage, and performing measures such as network reconfiguration and load balancing can result such as the following:

- The most important cause of losses in networks is due to active electricity. Using distributed generation resources in the network is the most effective way to reduce losses by reducing the gap between production and consumption and reducing the flow of active power in the network.In networks with industrial and motor loads that have low power coefficients (if reactive power is not compensated locally at the load site) or in networks with high inductive reactance lines, the use of reactive power compensators after distributed generation will be an effective solution by reducing the reactive power across the lines and reducing the current.
- In low load networks where the difference between peak and non-peak load times is huge, using solutions to reduce network losses by smoothing the load (such as using a load shift program or storage devices) will reduce losses.

- In the future, due to the numerous benefits of microgrids for stakeholders, we will face the fantastic spread of these technologies in distribution networks, which will change the nature of distribution companies and frameworks of their decision-making and asset management.

This project suggests regulatory frameworks for developing these technologies considering all the benefits of microgrids.

Of course, to encourage more stakeholders and consumers in the development of microgrids, we can emphasize the role of microgrids in reducing losses by considering coefficients and encouraging institutions and actors that work towards this goal to continue their activities by providing incentives.

Steps and Methodologies:

The project was implemented in five phases.

In the first stage, the concepts of smart distribution networks, microgrids, and active distribution networks are explained. The technical information is collected for the following stages of the project. This step is ended by reviewing legal documents, articles, and technical reports.

In the second stage, the reduction opportunities of network losses by the development of smart distribution networks, microgrids, and distributed generation are explained. The investigations on the impact of microgrids.

In the third stage, appropriate policies and measures take to acquire the advantages of smart grids, microgrids, and distributed energy resources for network losses reduction. Then all the technical specifications are proposed to the usage of losses reduction potentials from the development of smart grids, microgrids, and distributed energy resources. In addition, policies and legal procedures review and propose adequately using the benefits of smart grids, microgrids, and distributed energy resources to reduce losses in the distribution network.

In the fourth step, the results of the solutions presented in the previous phase are validated. The results validate by selecting the appropriate standard network and implementing the proposed solutions and observing their reducing losses impact.

In the final stage, to observe the impacts of technical and institutional dimensions of microgrids development on distribution network losses, investigate various issues include the effects of the retail market in the microgrid and its role in reducing electrical energy losses.

Main Results (technical outputs, patents, papers, books, reports, etc.):

The most important outcomes of the project are:

The most important cause of losses in the network is the active power flow. Distributed generation resources are the most effective way to reduce losses by preventing active power from flowing in the network.

Distributed generation resources reduce the distance between production and consumption and decrease the overall active power flowing in the network.

In networks with industrial and motor loads that have low power coefficients (if reactive power is not compensated locally) or in networks with high inductive reactance lines, the use of reactive power compensators after distribution resources will be an effective solution. That reduces reactive power from flowing across the network.

In low load networks where the difference between peak and non-peak load is considerable, Reduce losses by smoothing the load (such as energy storage devices).

It is essential to consider realistic goals to develop reduction losses and increase energy efficiency programs. If goals are easy to achieve, the design of incentives will be meaningless. On the other hand, if the set goals are hard to achieve, the risk of failure is predicted high, and the actors do not engage in implementing those programs.

- The regulator or other stakeholders benefiting from increased energy efficiency should support reduction losses plans.

- To design and provide a regulatory framework for the development of microgrids, it is not possible to focus solely on the losses reduction of that technology. If other benefits and revenues are ignored the economic feasibility of microgrid development faces many challenges.
- To further encourage actors in microgrid development, the role of a microgrid in reducing losses can be emphasized by considering incentives coefficients. The institutions and stakeholders that work towards this goal encourage them to continue their activities by providing incentives.