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Examining the Secure Communication Network for the Reliable Use of Micro-Grids in the Power System

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ABSTRACT

In the current study, the investigation of the secure communication network for the reliable use of micro-grids in the power grid has been investigated. Micro grid will have many benefits for both consumers and electricity companies. From the consumer's viewpoint, the micro grid has the ability to provide electricity and heat at the same time, increase reliability, reduce greenhouse gas emissions, improve quality, and from the viewpoint of power companies, the use of micro grids reduces consumption demand and therefore reduces the facilities for the development of transmission lines and in addition to That factor will be the removal of peak consumption points, which will also reduce network losses. On the other hand, the existence of distribution networks that are fed only through these transmission networks always exposes these networks to blackout and instability. One of the upcoming solutions to overcome these problems is the use of scattered energy sources. The limitation of fossil fuels and air pollution is one of the main incentives for the development of this technology. Producing electricity near the place of consumption, in addition to reducing losses in the system, can create more flexibility to provide various services to consumers. One of the methods of aggregating scattered production resources is a new concept called micro grid. During disruption and chaos in the network, the micro grid is separated from the distribution network and the island resulting from the disturbance in the power network is isolated.

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Introduction

Today, the electricity industry is not only faced with providing resources to meet the energy demand of industries, but on the other hand, minimizing and reducing the effects that humans have on the environment in connection with the production of this energy is also another matter of interest. Smart grid (SG) is a solution for this challenge that has a lot of profit and efficiency [1]. For the consumer side, the SG means that they can manage their consumption intelligently, to pay less during peak hours when energy prices are expensive, and for environmental experts, this grid means the use of technology [2]. It is to help solve the bad weather changes and avoid the excessive production of carbon gases, and for the colleagues of the electricity industry, it is a peak and intelligent decision making and providing accurate information about the network situation. Nowadays, with the advancements made in communication technology and measuring devices such as PMUs and various sensors, as well as in order to manage energy consumption and reduce environmental pollution, as well as in order to regularly plan network upgrades, smart networks are expanding [3]. Meanwhile, the design of a secure telecommunication platform is very important in order to maintain and increase reliability. In an intelligent electrical energy distribution system, information, and their transmission are of great importance. Because any intelligent system is not able to make a decision without being aware of the conditions. In a smart system, the information required by the system is collected from various sources such as smart meters, power plants, feeders, substations, and any other components that are related to the network. In this type of network, information transmission is two-way in some cases, that is, for example, not only does the network receive shared data, but it is possible for the network to send information and commands to the subscriber. Information transmission in such networks has certain characteristics. The information sent must have high security and reliability and in addition have a high sending speed [4]. As an example, when a command to disconnect a feeder or enter a unit from a power plant is issued in a smart network, the entire network must ensure that the command is received and executed with complete accuracy and speed [5-7]. Therefore, the communication infrastructure in the smart network, which is considered one of the most important and basic parts of a smart network, must have special features such as speed, security and high reliability. On the other hand, due to the large size of distribution networks and the large number of terminals, it makes the idea of creating a separate network for data transfer next to the distribution network impossible [6-8]. Therefore, this data transmission network must use the capabilities and capacities of the distribution network itself. Smart electrical energy distribution networks were introduced in March 2008, one of the most recent SGs in the world, and the city of Balder, Colorado, USA, was awarded the title of the first city with a smart electricity distribution network [9-11]. The goal of designers is to use smart technology around the three main axes of subscribers, equipment and communication. Smart technology has the ability to make fundamental changes in the production, transmission, distribution, and use of electrical energy along with economic and environmental benefits, which ultimately ends in meeting the needs of customers and the availability of reliable and stable electricity [12]. On the other hand, with the discussion of SGs in traditional power systems, a lot of attention has been paid to the exploitation of renewable resources, electric cars that can be connected to the grid, as well as other types of widespread energy sources such as CHPs [13].

On the other hand, in the smart power system, not only the resources on the production side are relied on, but in such an environment, the use and efficiency of the capabilities of the subscribers on the consumption side is also very important. This issue is important because the response speed of the resources on the consumption side is much higher than the resources on the production side. Likewise, they do not need investment cost and also increase the ability to use resources with random production, such as scrap cars, as well as renewable resources [14-16].

Among the solutions that are implemented on the consumption side, we can mention productivity or energy response solutions. For the consumer side, the SG means that they can manage their consumption intelligently, to pay less during peak hours when energy prices are expensive. Reducing the power consumption of subscribers during peak hours can also help improve environmental conditions, which is one of the goals of smart networks. Now that the importance of productivity from consumption side resources has been determined, it is necessary to establish a secure communication infrastructure with high reliability in the smart network. In other words, the discussion of intelligent zing the power grid is not only a discussion related to power systems, but issues related to communication, information technology, and intelligent processing should also be considered in it [17-19]. It should be noted that in the smart power network, most of the loads are digital loads that require much higher reliability. Accordingly, the goal of this thesis is to design a suitable telecommunication infrastructure for operation with the desired reliability. For this purpose, a micro grid will be considered as a sample network that has resources such as renewable resources, smart cars that can be connected to the network, and load response resources.

Concept of reliability in power system

The reliability of a system can be defined as the ability of that system to perform assigned tasks and tasks within a certain time frame and under certain conditions [20]. In the case of the power system, reliability can be defined as the ability of the system to supply electric energy to consumers [21-23]. A power system is usually divided into three parts: generation, transmission, and distribution. As expected, the reliability of a consumer should be studied for all three sections. Of course, the complexity of the problem and the number of elements in the real system are so large that it becomes impossible or very difficult to perform these calculations. The reliability of the power system has a wide concept and this concept can be divided into two main parts:

System adequacy

The concept of system adequacy is usually considered to be the existence of suitable and sufficient facilities in the system to deliver the energy needed by the subscribers. These suitable and sufficient facilities include sufficient energy production, the availability of the transmission and distribution network to transfer energy to the load points of the subscribers. Therefore, sufficiency is related to a state of the system that is in static conditions and without disturbances [24-26].

System security

System security shows the ability of the system to respond to sudden shocks and disturbances in the system, such as the sudden exit of production or transmission equipment or short circuit errors. In such conditions, security studies show the ability of the system to survive without chain failures and without loss of stability. In system security studies, security analysis can again be divided into two parts:

A) Transient (dynamic) [27].

B) Permanent state (static) [28].

The evaluation of transient stability examines system fluctuations following the removal of an element or an error, to investigate the possibility of loss of synchronism of generators. The purpose of steady state security evaluation is to investigate the existence of a new and safe steady state operating point after an event occurs, in which the disturbed power system calms down after damping the dynamic fluctuations [29-31].

Characteristics of islanding of electricity distribution network

Electrical islands are delicate and difficult to manage. Their reduced size and isolation means that they are more susceptible to inertial events and support large continental or interconnected systems [32-35]. Isolated system territories are small areas, but their energy requirements are very small. They need to supply industry or population and tourism in summer seasons. Therefore, dealing with peak demand can be a real challenge. They must have a high reserve margin, so that they can handle the fluctuations in demand. On the other hand, their isolation also means that they are not only supplied by renewable energy production and are dependent on uncontrollable external factors. All these limitations mean that fossil fuel technologies must be used, including diesel, fuel oil and gas, all of which are not used in continental systems due to their high cost and polluting effects. These conditions make the operation of isolated electrical systems more complicated and lead to higher production costs than continental systems [36].

Advantages of simulation training

Training simulators are a useful tool for training and educating personnel who operate these isolated systems. They enable the training of different profiles on a unique platform, in a shared environment that encourages team spirit and collective learning. Students are active in developing their knowledge, skills and attitudes through experience and decision-making with immediate visible results [37]. It has also been shown that it is best to remember things that we have direct experience with when learning. Inductive learning model from a specific situation we finally find a goal. It is easier to understand complex phenomena and relationships between systems or causes and effects [38]. It allows to test scenarios and new methods without endangering the actual plant equipment and can also anticipate certain conditions [39].

Guaranteed supply to the public

With the overall goal of improving the understanding of the operation of these diesel stations and the operation of the electric generators that they consist of, especially in adverse or emergency situations, Technetium has developed an isolated electrical installation simulator, so that when this happens, the operator trained to deal with them as soon as possible. Using educational simulators in diesel stations in these electrical islands, we have improved the capacity of power plants and, as a result, the supply of electricity to the population and industry in electrical islands.

The advantages of islanding the power distribution network

1- Improving reliability.
2- Reducing the exit rate.
3- Increase in profit [39].

Reliability levels

The power system can be divided into three main areas: generation, transmission, and distribution. Evaluating the adequacy of the power system can be done in each of these main areas and in each of the hierarchical levels [40].

Reliability of HLI level

The first category of studies from the point of view of reliability is the reliability of production level or HLI level. In this section, the problem of reliability is not particularly complicated and it will not take much time as the dimensions of the study system increase. Among the important issues in this section, we can mention the number of outputs of production units at the same time, which can affect the study time. Reliability studies at this level, the ability of power plants to provide all the power demanded by customers is known as system adequacy [41].

Reliability of HLII level

In the studies of transmission level of power networks, equipment's are usually considered together with the tools of the production system and they form a composite network, and these studies are referred to as HLII level reliability. These studies are carried out to determine the reliability indicators of the entire power system or load points. In each region, the reliability of the transmission system is ensured by evaluating the security of transmission performance. The evaluation of transmission security determines whether the power system can supply the peak demand after one or more components of the equipment are cut or not.

Reliability of HLIII level

The third level, which is HLIII, includes production, transmission and distribution, which, of course, mostly in this level, the third part, i.e. distribution networks, reliability studies were conducted separately, and the outputs of HLII level studies are the input form of these studies are considered. Assessing the adequacy of the distribution system includes the calculation of a series of reliability indicators at this level, which are directly related to the end users. The calculation method of distribution systems depends on the structure of the distribution system. In most parts of the power system, the inadequacy of the load point is usually caused by the distribution system. Indicators related to system adequacy in HLII usually have little effect on indicators related to individual load points. From another viewpoint, indices related to HLII and HLI levels are very important. Because damage at these levels affects a large part of the system and, therefore, can have irreparable results. In other words, the HLII level has a small effect in terms of cut-off frequency in the distribution network and load points, but it has a great effect in terms of the amount of load or megawatt cut off. Because an outage at the HLII level can take a large part of the distribution system out of the circuit [42].

Reliability criteria of power systems

The criteria for power system reliability calculations are generally divided into two categories: definite and probabilistic. Certain techniques deal with how errors occur in the system, its consequences on system reliability, and how to achieve a successful system for the reliability analyst. The most famous specific standard that is common in the composite power system and studies most of the security aspects of reliability is the N-1 security standard. Therefore, certain methods, which are often referred to as criteria for engineering judgments, do not evaluate the real reliability of the system [43].

These standards do not include the probabilistic and random nature of the system and the error of the system components. Similarly, this index cannot be used to perform economic analysis and compare the proposed arrangement of equipment. On the other hand, probabilistic criteria can consider important factors that affect system reliability. These techniques use numerical indicators to evaluate the reliability and determine the performance of the system numerically, whether the system is in a favorable condition in terms of reliability, or whether changes should be made to improve the reliability of the system.

In academic studies, most of the research to evaluate reliability in engineering systems uses probabilistic methods, not specific methods. This is while there is a significant reluctance to use probabilistic techniques in many fields. This is due to the difficulty of interpreting numerical indicators. Although certain criteria do not consider the random behavior of equipment and system parts, it is easier for programmers, designers and system operators to understand it than numerical risk indicators determined using probabilistic techniques. This problem has been solved by combining the specific criterion N-1 and the probability criterion to produce a new criterion. This solution is proposed under the title of system health standard. For example, to determine the reserve of the power system, a certain criterion specifies that the amount of reserve should be equal to the largest unit of the system [44]. With this definition, if the amount of network reservation is more than the value of the largest unit, the system is in normal mode, and otherwise, the system is in risk mode. By defining the health standard, three states of health, margin and risk can be considered for the system, which are defined as follows:

1- *Health*: according to a certain standard, the system is responsible for supplying the load with the largest unit of the network.

2- *Margin*: The system responds to the load, but if the largest unit of the system goes out, it does not respond to the network load.

3- *Risk*: The system is not responsive to the network load.

Reliability evaluation indicators

The most important indicators for reliability evaluation are LOLE, LOEE, LOLF, and LOLD indicators. The LOLE index shows the expected value of the risk of load interruption for a certain period of time. The scale of the LOLE index depends on the characteristics of the load and the studied interval. If daily peak load per year is used, LOLE will be in terms of day/year, and if hourly load changes are considered, this index will be in terms of hr/year (Equation 1).

$$LOLE= \sum_{i=1}^{Nh} Pi\ (C_i<L_i)\quad (h/year) \tag{1}$$

Where,
C_i: production capacity available in hour i.
L_i: amount of load in the i-th hour.
N_h: total number of hours in the study period.
P_i (C_i < L_i): the probability of not supplying the load in the i-th hour.
The LOEE index shows the average amount of unsupplied energy in kilowatt hours per year that the production cannot supply the load due to the withdrawal of units (Equation 2).

$$LOEE= \sum_{i=1}^{Nh} (L_i-C_i)\times P_i(C_i-L_i)\quad (MWh/year) \tag{2}$$

The LOLF index shows the number of times per year that production cannot supply the load due to outages.
The LOLD index in terms of hours shows, on average, the continuity of the load's definite time in each definite time.
Reliability indices for health criteria, which are usually used in composite power system, are P(H), P(M), LOLP, and LOHE.
P(H) is the probability of the system being in a healthy state, which is defined as a relationship (Equation 3).

$$P(H)=1/8760\sum_{i=1}^{n(H)} T_i(H) \tag{3}$$

Where,
N: total number of years studied.
n(H): the number of times that the system is in a healthy state in the study period.
T_i(H): duration of the healthy state in the *i* th time that the system is in the healthy state.
P(H): The probability of the system being in the marginal state is defined according to the relationship (Equation 4).

$$P(M) = \frac{1}{8760N}\sum_{i=1}^{n(M)} T_i(M) \tag{4}$$

n(M): the number of times that the system is in the marginal state in the study period.
T_i(M): duration of the health state in the i th time when the system is in the marginal state.
LOLP: The possibility of the system being in risk mode.
In this case, the system load is interrupted due to the lack of production. This index is calculated according to the following relationship (Equation 5).

$$LOLP = \frac{1}{8760N}\sum_{i=1}^{n(R)} t_i \tag{5}$$

In this regard:
n(R): the number of times the system is at risk in the study period.
t_i: the duration of the i-th time when the system is in the risk state.
The LOHE index is similar to the LOLE index, which shows the expected duration of system health loss. This index can be defined using the following relationship (Equation 6).

$$LOHE = 8760 - \frac{1}{8760N}\sum_{i=1}^{n(H)} T_i(H)\ hr/year \tag{6}$$

Reliability assessment methods:
Reliability assessment methods can be divided into two main parts:
1- Analytical methods.
2- Simulation methods.

Analytical methods

In the analytical method, the mathematical model of the system is presented and the reliability indicators are calculated using mathematical formulas. In this method, for a simple unit, two healthy and damaged states are considered. In this Equations, λ and μ are the failure rate and the repair rate of the unit, respectively, and these parameters are obtained according to the historical information obtained from the performance of that unit or a unit similar to it. The time m and r are, respectively, the average waiting time for unit failure and the average waiting time for unit repair during several times of unit failure and repair. The relationship between m and r with the rate of damage and repair is as Equations 7,8:

$$m = \frac{1}{\lambda} \quad (7)$$

$$r = \frac{1}{\mu} \quad (8)$$

According to these parameters, the probability of system availability (A) and the probability of system unavailability (U) or FOR can be calculated. These probabilities are defined by the following Equations 9,10:

$$A = \frac{m}{m+r} \quad (9)$$

$$U = FOR = \frac{r}{m+r} \quad (10)$$

To calculate the reliability indices with an analytical method at the HLI level, the probabilistic model of all units (FOR) is needed. By using FOR units, first, the capacity exit probability table (COPT) is formed to evaluate the production capacity probabilities. Using this COPT table, reliability indices such as LOLE, LOEE, LOLF, and LOLD can be calculated. For example, for a system that has two units C1 and C2 with FOR1 and FOR2 and the LDC load continuity curve shown in Figure 1, the COPT table can be formed as the following table. According to this table, it is possible to calculate the indicators of load interruption and energy interruption [45]. The sum of the product of the column related to the probability of exiting the units with the exit duration column of Table 1 gives the LOLE of the network. In the case that the load continuity curve is based on daily peak load, the scale of this index is days per year (day/year) and if the load continuity curve is based on hourly load, the scale of this index is in hours per year (hr/year). is The LOEE of the network is obtained in terms of megawatt hours per year from the total product of the column related to the probability of outage, outage duration and interrupted load in Table 1. This index shows the amount of energy cut off in the year or in the studied time period. An important point that is noteworthy in this regard is the load continuity curve, so that if this curve is in terms of daily peak load, it cannot be used to calculate LOEE.

Simulation methods

As mentioned above, one of the methods of evaluating the reliability of engineering systems is simulation methods. In this method, the performance process and behavior of the system is simulated naturally or artificially. One of the advantages of the simulation method is the application of these methods in systems with complex working conditions and also systems that consist of a large number of parameters. While one of the limitations of the analytical method is the evaluation of systems with wide and complex dimensions.

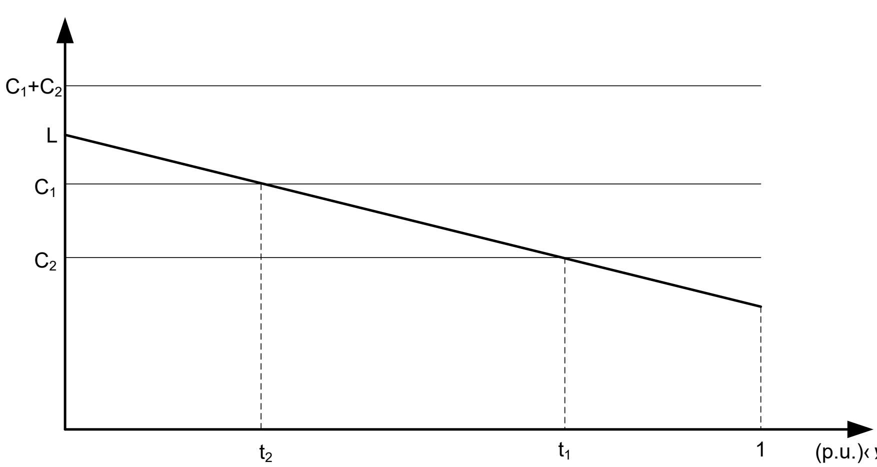

Figure 1: Load continuity curve

Table 1: Table of probability of capacity withdrawal (COPT)

The capacity is out	Possibility of exit	Departure time	The load is disconnected
0	(1-FOR1)(1-FOR2)	0	0
C1	(FOR1)(1-FOR2)	t1	L-C2
C2	(1-FOR1)(FOR2)	t2	L- C1
C1+C2	(FOR1)(FOR2)	1	L

From the simulation method, the system can be divided into several sub-systems and each of these sub-systems can be modeled and analyzed separately. Monte Carlo method is one of the most widely used simulation methods for reliability evaluation. The basis of the Monte Carlo method is the generation of random numbers and the use of probabilistic relationships to model the behavior of the system. The Monte Carlo method can be divided into two chain and non-chain methods.

Non-sequential (non-chain) Monte Carlo method

In this method, the time order of system events is not observed and the status of system elements is determined by generating random numbers. In this way, a two-state or multi-state model is considered for each element of the system, and then the state of the elements is determined by generating a uniform random number between zero and one. The way to determine the state is that according to the previous information about the performance of each element, the probability of each state is calculated. For example, if the system consists of m states, the probability vector of these states is defined as by forming the cumulative probability vector from this probability vector according to the following relationship and matching the generated uniform random number with the cumulative probability vector, the state of the element is determined.

Sequential Monte Carlo simulation method

In this method, the behavior of the system is modeled according to the probability distribution of the system's performance. The continuity of each element in each state is sampled according to the probability distribution of its performance in time order. For an element with a two-state model, a sample is taken from the condition of the operation time and the repair time of the element, and this sample is combined with the samples of other elements of the system and the load model in chronological order. Sequential Monte Carlo is useful for time-dependent analyses. This method is suitable for evaluating the production of water units due to the limited amount of their production and the use of these units for storing and reserving the system. Among the other advantages of this method, load modeling with time order in all tires can be mentioned.

SG

Smart electrical energy distribution networks are one of the newest technologies in the world and the result of the efforts of specialists to modernize distribution networks and enter the digital age. The main goal is to provide reliable electricity and respond to the growing needs of customers with the least damage to the environment. The world's first smart network was introduced in March 2008, and the city of Balder, Colorado, USA, was awarded the title of the first city with a smart electricity distribution network. The goal of designers by using smart technology is around the three main axes of subscribers, equipment and communication. Smart technology has the ability to create fundamental changes in the production, transmission, distribution, and use of electric energy along with economic and environmental benefits, which ultimately ends in meeting the needs of customers and the availability of reliable and sustainable electricity. The SG is actually a general term to describe a set of elements connected to the electricity distribution network that are connected by a communication infrastructure and share information with each other, which brings benefits to the power seller and subscribers. In other words, the SG is a smart electrical system that connects all the components of the network to each other through a smart communication system. On the other hand, the system can collect information and make decisions in critical situations and prevent unwanted shutdowns. The main components of a SG are given below.

Advantages of smart networks

In short, the advantages of smart networks are as follows:
1) Pik Sai, which is the main result of using the smart network along with advanced technologies in distribution posts and subscribers' homes.
2) Reducing the consumption of fossil fuels, which is obtained as a result of reducing peak and energy losses along with reducing the voltage drop of distribution lines.
3) Reduction in the number of subscribers who have blackouts, this is an important result of the ability to predict or potentially prevent power outages and effective response in case of power outages to fix the fault.
4) The reduction of investment needed for distribution and transmission lines to improve load balance and reduce peak load due to advanced management.
5) Reducing costs that result from disconnecting and connecting subscribers remotely.
6) Reducing the downtime of subscribers.

Preventing power cuts of customers is the main factor of customer satisfaction. The intelligent distribution network quickly identifies and disconnects the devices that are likely to cause errors in the distribution network, and also quickly identifies the leakage current and quickly announces the places that require the presence of force to correct the network. The use of advanced measurement software quickly identifies subscribers who are out of service. Providing such information to incident personnel who are in the shutdown area is very valuable and increases efficiency. Smart distribution networks reduce the downtime of subscribers by using the following solutions:

1) Resetting the system with the help of smart automatic switches that are compatible with smart posts.
2) Remote diagnosis of defects.
3) Determining the size and location of the load out of the circuit remotely in real time.
4) Remote control of scattered energy products and their collection for use in the network.
5) Remote diagnosis of disconnection and connection of the network.

Comparison of smart network with traditional network

In this section, traditional distribution networks are compared with smart distribution networks. Table 2 compares the smart network with the traditional network.

Table 2: Comparison of smart network and traditional network

Row	Specifications	Existing network (traditional)	Smart network
1	Information flow	One sided	Bilateral
2	Electricity generation	Concentrated	Distributed
3	Network topology	Radial	Network
4	Integration (DER)	Rarely	Often
5	Sensors	Low sensor	Many sensors
6	Ability to monitor	Usually unsupervised	Self-monitoring
7	Definite recovery	Manually	Self-recovery
8	Test	Manual testing	Remote test
9	Ability to control	Limited control	Comprehensive control
10	Control type	Passive control	Active control
11	Overall efficiency	Low	Up
12	Environmental pollution	Up	Low

The old electricity system, which included production, transmission, and distribution, has been replaced by new actors including: production, transmission, distribution, subscribers, and three regulatory areas including regional system operator, energy service providers, and the electricity market. Their connections are marked with arrows. In the Figure 2, whenever a demand arises, the customer exchanges information with the electricity market, system operator, service providers, and distribution areas. The electricity market includes: buying, selling energy, and exchanging information with all areas to balance supply and demand.

Service providers provide services to support the business activities of electricity generation, distributors, and customers. The system operator exchanges information with all domains to provide uniform operation throughout the system. The market and the information operator, the production area, the transmission area and the distribution area work together to provide electricity to the customers [46].

The required infrastructures of the smart network

Communication and measurement devices

The initial step in the development of the intelligent distribution network is establishing high-speed communication between the measurement devices and the control center. There are various solutions to create this connection, of course, concerning the sensitivity and extent of the distribution networks, the least expensive one should be chosen. One of the main measuring devices used in smart networks are smart meters, which are system tools for receiving consumer information and applying network policies to consumers. These contours are available in different types and brands in the market, each of which has its own advantages and services, and the type used is selected according to the network architecture.

Distributed power monitoring infrastructures

One of the goals of smart distribution networks is to monitor distributed power, automation and system components using transmission lines connected from distribution posts to measuring devices. Smart posts, infrastructure optimization allows us to better monitor posts and adapt to common needs.

Smart feeders

In the section of feeders, there is a need for intelligent re-closers and controllable switches that give us system power information and other functions, by spending and improving feeders, the network has the ability to monitor power flow, cut off current, and measure overvoltage. It can disconnect and connect remotely if necessary to prevent damage to the equipment. Figure 2 shows the schematic architecture of the smart network.

Communication in smart networks

In general, the communication infrastructure used in the smart network can be evaluated in several ways, which include:
1) Performance: high performance with the feature of providing two-way communication in real time.
2) Scalability: the ability to provide a high amount of bandwidth for current affairs and high traffic of the smart network and the possibility of easy development and increase of bandwidth due to the rapid development of the network.
3) Complete compatibility with distributed Thomasion systems and advanced measurement infrastructures.
4) Having self-recovery mechanisms in order to return to the desired state in times of breakdown and emergency.
5) Having valid communication standards to establish secure communication, such as point-to-point communication where each subscriber has an identification code or IP.
6) The cost of setting up and maintaining is low and proportional to the extent and expandability of distribution networks [47].

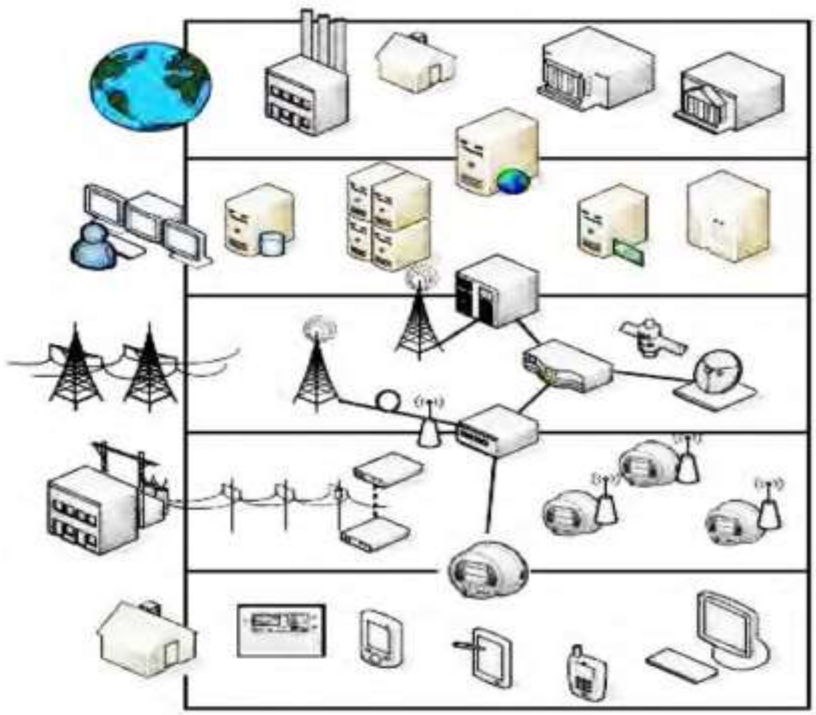

Figure 2: Smart feeders

Until today, various communication methods have been proposed for use in smart networks, and the advantages and disadvantages of each one have been examined and discussed separately. Therefore, in the table below, a comparison has been made based on the most prominent communication infrastructures that can be used in smart networks that have been noticed in the last few years. It is necessary to mention; these four infrastructures have been compared based on the six characteristics mentioned earlier [48].

Conclusion

As it is clear from the presented results, the presence of distributed production sources has improved the reliability. Therefore, although these sources are random in nature, they can ultimately increase the reliability of the power system. It has analyzed this issue by using mixed integer programming. In this reference, the aim is to calculate the optimal size of energy storage resources to improve the reliability of the power system. As previously shown, the investment to upgrade energy storage elements in the power system increases proportionally to the amount of this upgrade, but this investment reduces the amount of network maintenance costs. Micro grids bring many benefits to consumers, including improving reliability by providing reliable power by the island itself during blackouts and improving power quality. In addition, micro grids reduce losses by shortening the generation and consumption interval and blackout management, and make the maintenance process very easy. Likewise, by using renewable energy sources and new and clean energy and energy storage technologies, many benefits are given to the society. The control system of micro grids is designed in such a way that it controls and supports the activities of the system with great safety and security in two modes of working as an island and working as part of the distribution network of an electric power distribution company. This control system can be formed on the basis of a central control system or it can be created in a scattered manner in each island forming the micro grid. When the island is disconnected from the main grid, the control system must control the local voltage level and production frequency and calculate the difference between the production and consumption of active and reactive power in the island and take the necessary measures for the stability of the network and protect the micro grid against errors , events, blackouts and accidents and keep the consumption of subscribers in the most optimal state, but for some reasons, electricity distribution companies do not consider moving towards micro-grids right now, some of these reasons are mentioned below:

Issues and problems related to quality control, such as the presence of unusual voltage levels or the presence of a frequency outside the tolerable range of the equipment.

Preventing the reconnection of the micro grid to the grid in a situation where there is a different voltage phase between the distribution network and the distributed generation sources in the micro grid.

The occurrence of interference when reconnecting the island to the distribution network. Preventing accidents and threats threatening the employees of electricity distribution companies when working with lines that should be without electricity, but have been electrified due to the existence of micro grids. Due to safety and protection issues in solving errors that may not be revealed and identified by the systems in the micro grid. Preventing electricity distribution companies from being condemned in matters and conditions that were beyond their control.

ORCID

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