DEVELOPING MICROGRID CRITERIAS AND PROPER DATA PACKAGE FOR CENTRALIZED MANAGEMENT OF MULTI MICROGRIDS

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Abstract: In this study, Microgrid (MG) Characteristics are defined for perform an effective and fair management of multi microgrids system. A research study has been conducted in order to establish data package for description of MGs. Criteria of MG characteristics for determining an approach not only protects the interests of the energy grid, both the interests of energy grid and microgrid are mutually used an approach that protects. In this paper, the justification of selected criteria discussed and the data package for these criteria were analyzed how much data length is needed in data package. Also the appropriateness of the communication technology of the generated sample data package is examined. The work is expected to be made an important contribution to the creation of microgrid standards.

Keywords: Microgrid, fair-management, microgrid-characteristics, multi-microgrid.

Introduction

Microgrid (MG) concept was first proposed in 2002 and the concept is that the charges are a set and micro sources provide electric and heat to the system. This concept arises from the need of the integration of many micro sources to the main energy grid (Lasseter R. H., (2002)) .Since 2002, renewable energy sources can be achieved through optimal adaptation to the energy grid by MG concept has now become a widely accepted idea (Lasseter R. H., (2011), Guerrero J.M. (2010)) .Worldwide growth of MGs also support this idea. For example, the increase in small and medium-sized MGs was a rate of 267% in the last five years according to information from the United States. However, this increase is not controlled by certain centers of MGs also brought up the fact that they should (Tsikalakis A.G. (2011), Lasseter R.H., Akhil A. (2002)).

If it is providing fast and reliable communication infrastructure, a large number of MGs when checking in specific locations, is expected to contribute to the solution of many important problems. For example, the most frequently encountered problem within the scope of the adaption of MG and the renewable energy sources to the interconnected system is the problems related to the change of the current direction. These problems have a negative influence on system protection structure and energy quality (Long M. (2016)). Communication is very important for the MG to run steady and stability after the integration of power and communication of MGs and the communication protocol has a massive role for handling the control latency that may occur during the transition from island mode and connected mode (Mao R. (2013)).

Generally, within the scope of MG, there are several studies about communication infrastructure, control optimization algorithms, protection, energy management, micro source management and autonomous control of MG components (Nthontho M. P. (2012), Gallina M. (2012), Shukla S. (2014), Siow L. K. (2011), Weimer J. (2012)). Also Intelligent Distributed Autonomous Power Systems (IDAPS) was examined in detail which it aims at intelligently managing customer-owned distributed energy resources such that these assets can be shared in an autonomous grid both during normal and outage operations (Rahman S. (2007)). In addition to these studies, controlling MGs and monitoring their status from a center is required to reach the goals of MGs such as reliability and continuous and good quality electricity flow. With the increase of renewable energy sources will be needed in this case the control centers and fair and efficient energy purchase / sale is necessary to standardize the information to be able to microgrid. The information to be sent and the command should be determined by what is MG status. In this study, the display of MG status and controlled from a center that allows for the creation of a data package according to MG information and gives detailed information about this data package.

What is the criterion for generally MGs, these criteria may be used in accordance with proper justification and communication technology is necessary to prepare the data package. These criteria are generally a MG's the characteristic denotes type and working values. Efficient use of a communication network for the specified degree of importance also in defining each criterion and is aimed to accelerate the data transmission. Smart grids under the MGs energy exchanges / markets after the creation of the distribution companies or smart grids will make bilateral agreements with the center (protocols) are also considered to be added to the reserved area in the data package. Fair benefits can be obtained as result of the study of energy trading, high energy quality; the aim is to prepare the ground transition to reduce the risk of collapse and smart grid network. Also these data package correspond to a resilient flexible management system is aimed to improve the data package which different systems for example IDAPS or another systems.

The subject was examined in three sections. The second section is determined by the description of Microgrid Characteristics. In the third the necessary information and a data package samples are presented. In the fourth section of communication system architecture for monitoring MGs are assumed.

Description of Microgrid Characteristics

In this section, first of all which criteria for microgrid will be used for MG characteristics in multi MG system and what has been determined that the justification for these criteria. In generally these criteria:

- Special adress for MG,
- Generation type (photovoltaic, wind, natural gas etc.) and generation power,
- Whether with an energy storage system, storage type and how much power storage energy,
- Ability to run island mode, energy demand (buying / selling) and the amount of demand,
- Load characteristics and priority load metrics (hospital, school etc.)

information is what is designated as such. Also,

- Special protocols with MG and smart grid system,
- Whether with advanced metering infrastructure (AMI) system,
- Failure and maintenance information

This information should be added to the MG data package as private data. These criteria and the criteria as justification and availability frequency of the messages to be sent:

A. Address

This information is defined to integrate MG to the system. The data package has been sent to the Microgrid Management System (MGMS) which comes from the MG. This information is high-frequency coefficients of the criteria should be available in all messages.

B. Time Stamp

It represents the time of the generated data package. This information is high-frequency coefficients of these criteria and it is very important due to the control of MG time criteria should be available in all messages.

C. Energy Conversion Method

MG has several types of renewable energy sources which are photovoltaic, wind, natural gas, and cogeneration and so on. General characteristics of the types of these energy sources have production, stability, quality, in addition to electricity generation, heating other factors in the slightly improve and production conditions (weather, petrol / gas stocks, etc.) must be passed this information since it depends. Due to the change of frequency coefficients can’t be sustained these criteria is low and is expected to be sent once a day.

D. Generation Power

This information refers to how much energy produce in MG. The amount of the generation and should be sent this information to determine how much energy could be given to the system. This high-frequency coefficient of the criteria should be available in all messages.

E. Storage Type

Small-scale energy storage systems use pad-mounted energy storage units distributed along residential feeders at the edge of the power grid. It refers to the type of storage system have different properties which are lead-acid, lithium ion, electrical vehicles and so on. These battery-based units permit the integration of the community’s intermittent renewable generation resources ¾ such as rooftop photovoltaic panels and wind turbines ¾ into the grid, where these increasingly popular resources can be dispatched when needed.

These parts have different life of the storage system, how much time due to the presence of factors such as the effect of type and generation power to provide energy to the system must be delivered to these criteria. The battery-based energy storage units can be aggregated to collectively provide peak shaving, improve power quality, and/or improve local voltage control to reduce losses and thus improve distribution feeder efficiencies. This aggregation of energy storage units can eliminate the need for costly, time-consuming infrastructure build-outs. Due to the change of frequency coefficients can't be sustained these criteria is low and is expected to be sent once a day (Zeng A. (2015), (Palızban O. (2016)).

F. Storage Capacity

This information refers the instant that represents how many kilowatts storage of MG and when and how to have the stored energy should be used in determining how many of the necessary energy is required for this information. Distributed energy storage can be a means for peak shaving since it doesn't require customer involvement. The mesh communication system used to link the energy storage units can help the utility quickly find the site of a problem on the distribution system without first dispatching a crew to locate it.

The energy storage units offer reliable, local backup power for consumers as well. The close proximity of the energy storage units to consumers helps ensure the availability of supplemental power in the event of an outage. A typical 25-kVA energy storage unit can offer supplemental power to several homes for up to three hours more than sufficient for the duration of many outages. They can also be deployed at traffic signals and used for emergency lighting, emergency communications, and more.

A fleet of larger-capacity energy storage units ¾ typically rated 250 kVA ¾ distributed throughout the grid can support hundreds of homes, small businesses, and critical infrastructure during an outage. When combined with the community's renewable generation resources, the resultant microgrid is capable of operating for many hours or even days. Groups of these larger-capacity energy storage units can be arranged as "virtual power plants" and suitably planned to be storm-ready in anticipation of an outage. With the deployment of virtual power plants, utility crews can concentrate on service restoration elsewhere on the system.

The distribution grid, transformed into microgrids, offers an additional benefit: increased resilience to potential cybersecurity attacks. This high-frequency coefficient of the criteria should be available in all messages (Rajesha K.S. (2017), Nosratabadi S.M. (2017), Kaur A. (2016)).

G. Mode

This information refers to take the overall energy demand / sell energy and the ability to operate in island mode of MG. This It can increase the stability of the system to operate in island mode of MG that a general network problem and can reduce overall production costs from riding too much load and transmitting energy demand is a critical role for the determination of the fairness and efficiency. This high-frequency coefficient of the criteria should be available in all messages.

Microgrid is designed to seamlessly connect or disconnect from the distribution system. When connected to the grid, the phase, voltage, frequency, and phase angles of the renewable energy generation sources, batteries and system loads are synchronized to the grid.

1. Supply to Grid: Microgrid is connected to the distribution system and is supplying energy to the grid using renewable solar or wind power. Stored electricity from the Sodium Nickel Chloride, Lithium Ion Battery and Lead Acid Battery Systems can also be used to supply energy to the grid. During the Supply to Grid operating mode, the natural gas generator will not be operated.

2. Supply from Grid: Microgrid is connected to the distribution system and is taking energy from the grid to power its load. Electricity can also be stored in the Sodium Nickel Chloride, Lithium Ion Battery and Lead Acid

Battery Systems for future consumption. During the Supply from Grid operating mode, the solar photovoltaic system and wind turbine system may also be powering the load and charging the batteries, but the natural gas generator will not be operated.

3. Island (Generator): Microgrid is designed to operate in isolation from the distribution grid with the Island (Generator) operating mode. During this mode, the natural gas generator will be the primary source of electricity with the renewable solar and wind generators providing supplementary power. Electricity stored in the Lead Acid, Sodium Nickel Chloride and Lithium Ion Battery Systems can also be used at this time.

4. Island (No Generator): Microgrid is designed to operate in isolation from the distribution grid with the Island (No Generator) operating mode. During this mode renewable solar and wind generators will be primary source of power. Electricity stored in the Lead Acid, Sodium Nickel Chloride and Lithium Ion Battery Systems can also be used at this time. Since all generation sources are intermittent with this operating mode, low priority Microgrid loads may be disconnected depending on the amount of generation available.

5. Black Start: Microgrid is designed to have black start capability that involves using backup systems to help launch the Microgrid's generation sources. During this mode, the Microgrid is not connected to the distribution system and does not have electricity serving its load. The Microgrid will use the backup systems to initiate the renewable generation sources and connect the battery systems to help restore power to system loads.

6. Unintentional Grid Outage (Generator): Microgrid is designed to operate in the event of an outage on the distribution system and provide seamless service to its loads. In this scenario, the Microgrid will automatically disconnect from the grid and start drawing electricity from the natural gas generator, renewable energy sources and battery systems.

7. Unintentional Grid Outage (No Generator): Microgrid is designed to operate in the event of an outage on the distribution system and provide seamless service to its loads. In this scenario, the Microgrid will automatically disconnect from the grid and start drawing electricity from renewable energy sources and battery systems. Since only intermittent generation sources are available, low priority Microgrid loads may be disconnected depending on the amount of generation available.

8. Intentional Grid Outage (Generator): Microgrid is designed to operate in the event of an outage of the distribution system and provide seamless service to its loads. Utilities from time-to-time have planned outages to allow for maintenance and servicing. In this scenario, the Microgrid will automatically disconnect from the grid and start drawing electricity from the natural gas generator, renewable energy sources and battery systems. Since this operating mode involves a planned outage, the battery systems can be fully charged ahead of time to maximize the amount of power for loads during the outage.

9. Intentional Grid Outage (No Generator): Microgrid is designed to operate in the event of an outage on the distribution system and provide seamless service to its loads. Utilities from time-to-time have planned outages to allow for maintenance and servicing. In this scenario, the Microgrid will automatically disconnect from the grid and start drawing electricity from renewable energy sources and battery systems. This operating mode involves a planned outage and hence the battery systems can be fully charged ahead of time to maximize the amount of power for loads during the outage. However, since only intermittent generation sources are available, low priority Microgrid loads may be disconnected depending on the amount of generation available (Yang P. (2017), Mahmood H. (2017), Han Y. (2017), Karavasa C.S. (2018)).

H. Amount of Demand

This information refers to how many kilowatts of energy to get the MG and how much energy wants to sell. MGMS will be decided in terms of fair trading in energy and energy efficiency will play an active role to be taken by using this information. This high-frequency coefficient of the criteria should be available in all messages.

I. Load Type

This information refers priority load information of MG (hospital / school, etc.) and indicate the severity. Removed from the system and some of the burden when it is necessary to increase the stability of the overall system must be transmitted this information. Due to the change of frequency coefficients can't be sustained these criteria is low and is expected to be sent once a day.

J. Special Information

After using energy market in smart grid concept, distribution companies or intelligent networks of bilateral agreements (protocols) could do with a center will take in terms of equitable energy trading and energy efficiency to be taken by the organization will play an active role in determining decisions. Whether with advanced metering infrastructure system gives detailed information on how to communicate MGMS with MGs belonging to the counter information. Failure and maintenance information should also be communicated to increase the stability of the overall system. Due to the change of frequency coefficients can't be sustained these criteria is low and is expected to be sent once a day.

Data Package

In this study, it is desired to develop a data package with relevant data that will be used for the MG in the system. While developing the data package, the criteria of MG is established. It is also considered that the data package must be flexible and open to insert additional fields reserved area in the future. In addition, the packing process data in terms of the communication speed is important, therefore some of these criteria of MG are provided for continuously, while others are planned to be sent out within days. As the length of 24 bytes of data packets (low + high importance) and 16 bytes (high importance) information about the shows in Table 1.

Table 1. Data Package

Information	Length (# bytes)	Importance
Address	2	High
Time	5	High
Energy Conversion Method	1	Low
Generation Power	2	High
Storage Type	1	Low
Storage Capacity	2	High
Mode	1	High
Amount of Demand	2	High
Load Type	1	High
Reserved Area	6	Low
Checksum	1	High

As values can be received by the address information represents 1-65536 MG connected to the system. Time information is in "hhmmssddmmyy" format of this information (the number) is a binary response. Generation type, storage type, mode and load characteristics information is shown Table 2 in below. A microgrid for example in terms of flexibility of the data package in the table below both the photovoltaic and the wind is also allowed various combinations can produce the sum of the indicated value. These combinations generation type, storage type, load type and can be applied to mode. Power generation, power storage, amount of demand response is a binary value of the information in kW. Reserved Area for a "0" value is used. The checksum value is the sum of all the mod operation of 256 bytes in the data packet until checksums.

Table 2. Format for Energy Conversion Method, Storage Type, Load Type and Mode

Energy Conversion Method	Storage Type	Load Type	Mode	Binary Equal
Null	Null	Null	Null	00000000
Photovoltaic	Lead-acid	Hospital	Sell	00000001
Wind	Hydrogen	School	Purchase	00000010
Natural Gas Gen.	Lithium-Ion	Factory	Island Mode	00000100
Diesel Generator	Electrical Veh.	Reserved Area	Grid Mode	00001000
Cogeneration	Mechanical	Reserved Area	Reserved Area	00010000
Biofuels Generator	Reserved Area	Reserved Area	Reserved Area	00100000
Reserved Area	Reserved Area	Reserved Area	Reserved Area	01000000
Reserved Area	Reserved Area	Users	Island Mode Cap.	10000000

According to the sample scenario (Scenario #1) data package to be transmitted one time in days is shown in Figure 1. In data package, the address of MG is 1 (0x00 0x01), with the time stamp of creation of the data packet is 12:03 18.02.2016 (0x00 0x47 0xb7 0x12 0xb8), MG has the energy conversion method both solar and wind (0x03), generation power is 256 kW (0x01 0x00,) storage-type is lithium ion battery (0x04), and the storage capacity of 100 kW (0x00 0x64), where the ability of the energy purchase requisition to operate in island mode (0x81), receiving energy demand is 1 MW (0x03 0xe8), MG has several types of load which are end users and school load (0x82).

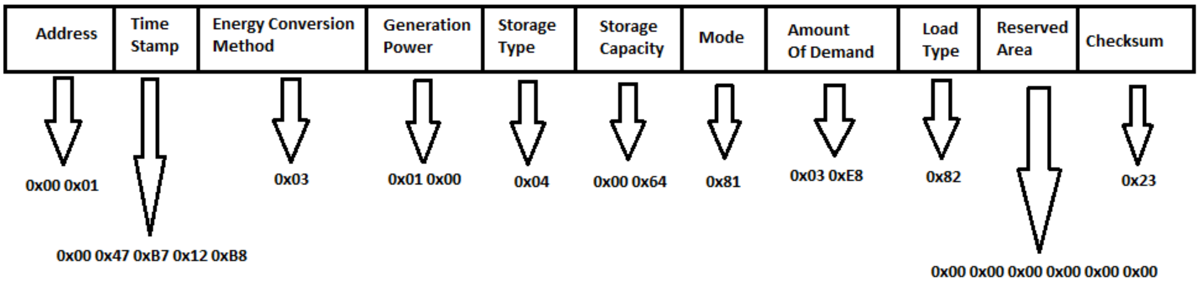

Figure 1. Data Package for Sample Scenario #1

According to another scenario (Scenario #2), during the day continuous data package to be sent is shown in Figure 2. The address of MG is 1 (0x00 0x01), with the time stamp of creation of the data package 12:15 18.02.2016 (0x00 0x48 0x6 to 0x2D 0xb8), the generation power is 256 kW (0x01 0x00), and the storage reserves of MG is 100 kW (0x00 0x64), where the ability of the energy purchase requisition to operate in island mode (0x81), receiving energy demand of MG is 1 MW (0x03 0xe8), MG has several types of load which are end users and school (0x82).

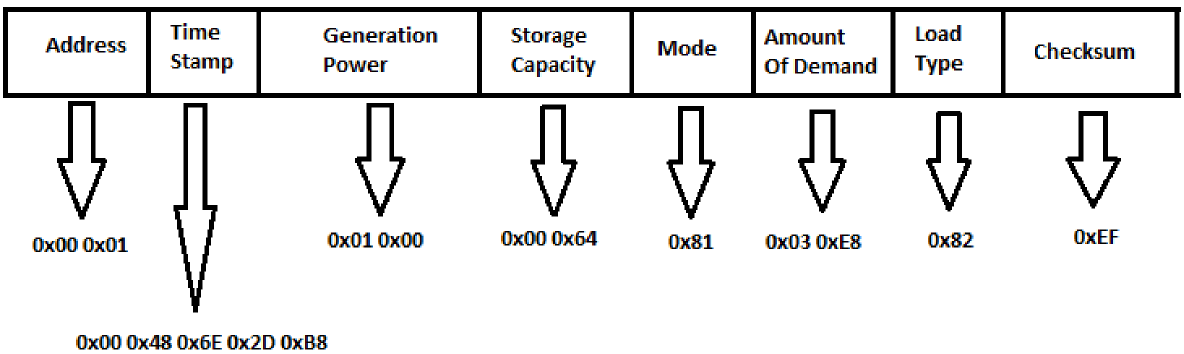

Figure 2. Data Package for Sample Scenario #2

Communication Architecture Section

In this section, necessary communication architecture to control and monitor MG was examined. The system architecture is presented in Figure 3. The data, which are important for a MG, is gathered by an answer-question communication with the EMS (Energy Management System) located in the MG via a hardware and software integrated to the MG. These information are converted to a data package and can be instantaneously and periodically sent to MGMS with necessary protection level. MGMS must merge the grid information, meteorological information, smart grid central control center, and MG status data and then control the MGs and run decision mechanisms to market main grid to run stably.

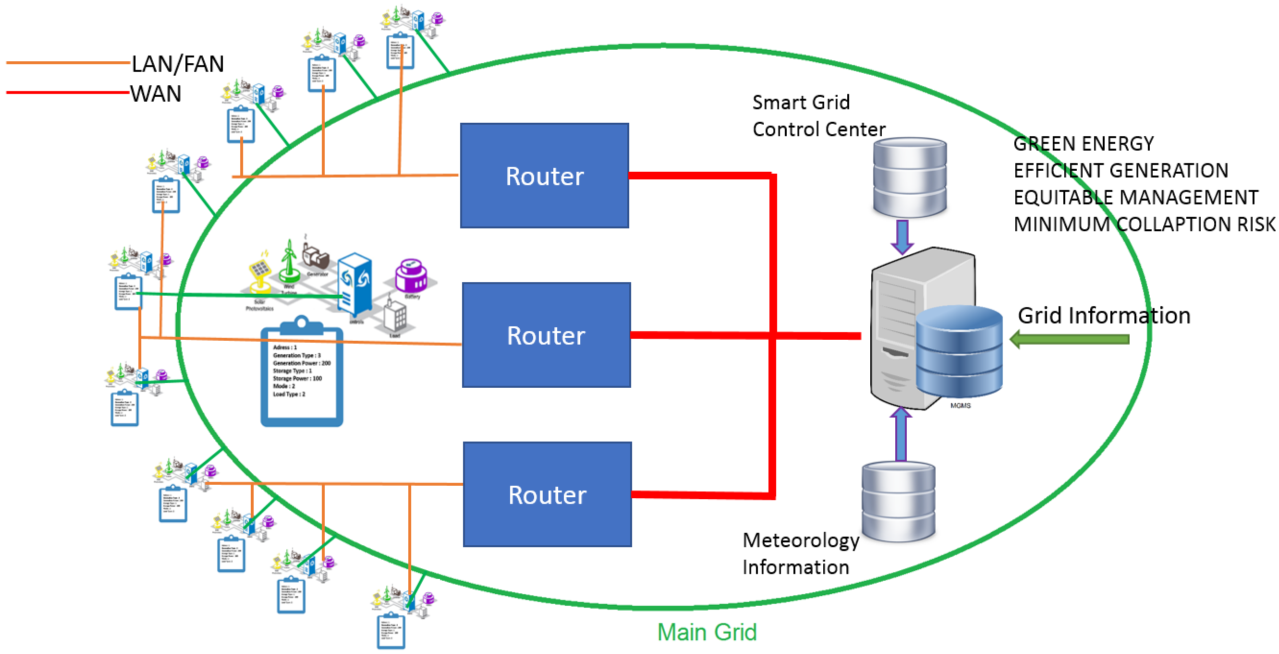

Figure 3. Communication System Architecture

In smart grid used in domestic and smart meter communication between is HAN, overall user communication between the distribution networks is LAN / FAN, generally provide communication with the generation and transformation centers with centers with WAN (Mehra T. (2013)). If not up to any standard this time according to academically study, WAN communications are used to plan Cellular, WiMax, Fiber communication technologies, LAN / FAN communications are used to plan WiMAX RF, DSL communication technologies, HAN communications are used to plan Zigbee, Wi-Fi, stands out the use of PLC communication technology. Supports intelligent in studies on communication for smart grid HAN network coverage in the literature, LAN / WAN networks and FAN and general requirements to be used in smart grid applications are indicated (Yan Y. (2012)). In addition to these studies, different sections of the communications technologies and work on limits and coverage of this communication technology is made for smart grids (Melvin H.(2014)). Wi-Fi availability for MG information of communication technology, but they also envisage making improvements in the security requirements of this technology. In addition, data from the receiving profile and the actual system requirements and safety problems for manufacturers to package the results are sought (Shukla S. (2014), Nthontho M. P. (2012)). Fixed WiMAX for MG as an enabling rapid deployment and cost-effectiveness showed higher can be used for data transmission. Thus, both set up wireless networks may be more practical and reliable in rural and remote areas (Weimer J. (2012)).In this study, the MG information is displayed, and although there is no standard for communication required to be controlled from a central restricts geographical between MGMS with MG, data speed, accuracy and time delay issues considering the LAN / FAN and WAN networks are planned. Wi-Fi technology for their communication systems, DSL and 3G / 4G the use of technology is considered.

Conclusions

Numerous orders to make effective control of certain centers of the MG is very well identifying information will be taken from MGs information, a known evaluation and should be forwarded to MG the most appropriate communications technology is real. In this study, it conducted a study to determine the information to be received from different type MG characteristics.

In this study; unlike other studies, production type, load priority metric, the ability to work the island mode, made between general system and MG are specific protocols, whether or not having a system of advanced metering infrastructure, the introduction of the failure and maintenance information considered and this information is added to the data package. Second, a study on what can be placed in a data package identification information made and criteria then converted into numerical metric, respectively, Address, Time, Generation Type, Generation Power, Storage Type, Storage Power, Mode, Amount of Demand, Load Type, Reserved area (special information) and agreed that it would be appropriate to use a structure in the form of checksum.

In addition, intelligent networks that can be used within the scope of communications technologies examined, communication technologies used by the generated data packets which conducted a review of the need for it. According to this investigation Wi-Fi, DSL and 3G / 4G of communications technology has been determined to be appropriate. In conclusion, this study will contribute very significantly to the standards development work carried out in MG, MG information are among the fair and will pave the provision of effective management, and however, is expected to serve as an example in the selection of appropriate communication technologies should be used.

The future studies presented in this article is planned to be expanded taking into account the following issues and these studies on this issue are ongoing.

- After the data acquisition related to the MG energy management system hardware integration with selection the proper equipment to perform casual work is planned to develop embedded software.
- Control and commands will be created and will be produced by MGMS
- Consideration of the similarities between AMI systems with existing building is planned to be enhanced and improved the structure of the debate to be taken up and combined with the AMI in the group that prepared this paper.
- The electrical network system flexibility on the demand side of the issue is one of the issues that need to be developed and make them flexible choice of MG information allows eligible consumers connected to the data packages generated in this study was a planned operation will slightly improve.
- A study on how to use can be made of flexible structure and packet data networks using the data package MG relationships with service providers is planned.

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