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Performance Analysis of Small-Scale Micro Grid for Smart Grid Applications

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***Abstract*— Electricity has become an integral part of human life. There are many ways to meet the rise in demand and considering the available resources, and fuels, it is crucial that the method involved be sustainable. One such option is using Smart Grids. Smart Grid uses advanced ICT (Information and Communication Technology) to control next-generation power systems reliably and efficiently. This work presents Matlab simulink simulation of a small scale microgid performance analysis.**

Keywords—Smart Grid, IoT, Microgrid

I. INTRODUCTION

It will be troublesome to imagine life without electricity. Can't it? we discover ourselves enclosed by electricity each day. Electricity is key in trendy society and also the scheme. Anyhow, the current world depends on the Associate in Nursing electricity system that was designed around fifty years ago. This methodology of providing might need to cater to the wants of the population until currently. except for the growing technology, the digitalized era, the increasing international population, and international problems, the present electrical system cannot be economical enough.

Approximately $13 trillion investment is needed in energy infrastructure over the twenty years. This demands an Associate in Nursing approaching want and an opportunity to seem towards a low-carbon, efficient, and clean energy system.

The 3 main sources of energy for electricity generation are unit 1) fossil fuels i.e., coal, fossil fuel, petroleum, 2) atomic energy and 3) renewable energy sources. Most electricity that's created these days is generated with steam turbines victimizing fossil fuels, nuclear, biomass, geothermal, and star thermal energy. Thus, considering the world's population (2022), electricity for seven billion individuals would be not possible to form power property for future generations. close to four-hundredth of worldwide greenhouse emission emissions are units emitted from electricity generation through the combustion of fossil fuels to come up with the warmth required to power steam turbines. Burning these fuels leads to the emission of greenhouse gas (CO2)—the gas that's accountable for warming, alleged the greenhouse emission.

There are many ways to meet the rise in demand and considering the available resources, and fuels, it is crucial that the method involved be sustainable. One such option is using Smart Grids. A smart grid is the leading methodology of mechanisms required to cut back carbon emissions, victimization handles like integration of additional renewable energy, facilitation of PHEV adoption, and energy potency. Hence, we have a tendency to associate with good grids as a result of their additional economics at the transmission of electricity. faster restoration of electricity once power disturbances. Reduced operations and management prices for utilities, and ultimately lowered power prices for customers.

In the modern era, electricity has become an integral part of human life. Yet the production and consumption methods are dated from a few decades ago. These methods are not efficient and eco-friendly. Hence a Smart Grid should be replacing the conventional methods for efficient usage of electricity and sustainability. A Smart grid is the electric supply system where it incorporates the technical part of the electric power system to make it more efficient and of less wastage. Smart Grid integrates telecommunications, digital communications, and wireless communications so that the work can be made easy for the producers, consumers, and as well as to nature. It mainly focuses on distribution networks, interaction between suppliers and consumers, active power flow management, and energy storage.

There are three major systems that run the smart grids:

A. Smart Infrastructure System

Smart Grid uses advanced ICT (Information and Communication Technology) to control next-generation power systems reliably and efficiently. This ICT will extend beyond transmission voltages to distribution networks and consumer-level operation through meters and smart homes. This smart element(infrastructure) enhances the power supply and makes it faster and easier for both producers as well as consumers.

B. Smart Management System

Smart Grids introduce new factors such as smart devices, smart meters, energy management devices, and communication equipment as well as the WSN (Wireless Sensor Networks) construct the grid into a very productive and smart system that involves energy saving.

C. Smart Protection System

It is very important to rectify and isolate the fault as soon as possible. The smart Grids concentrate mainly on over-current protection, transformer protection, and directional overcurrent protection. Smart Grids are designed in such a way that they protect the currents and their own system right from the background to the transformer protection. It is also a self-healing system.

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II. WHAT LED TO SMART GRIDS

Raising the cost of energy, Mass electrification of everyday life, Climate change are the factors. Generating electric power consumes fossil fuels, hydropower, manpower, and a lot. Though the existing electric system that is supplying the energy is efficient enough and productive enough, there has been a demand for something that evaluates the amount of power consumed. In the present era, where the population sees no bounds, it is difficult to supply energy to each and every house. It is mandatory to save power, and keep a record of the power supplied and power consumed. This is an age where technology has been incorporated in such a way that, right from bank transactions to bill payments everything has become digital. The only field where digital communication or the technical part hasn't been used is the electric system. The climate factor also plays a major part in energy consumption. The consumption of energy varies from season to season, place to place, and house to house. In such a case, it is important to track the power supply and power consumed so that the power can be supplied in a calculated manner based on the amount of power consumed. If we see on the other hand where the wires get damaged or there may raise any issue due to any reason like heavy rains leading to wiring damage, or heavy vehicles leading to breakage of wires. There goes a lot of processes and a lot of time to raise a complaint about the issue, for the officials to come and inspect, the problem to be rectified, and then it has to be corrected right from the power station. It may take any amount of time to solve such types of issues. All these are very alarming situations that cannot be left unattended. Therefore, considering all the demands, and raising issues, smart grids have started to be implemented. Smart grids not only conserve energy but also make the resources sustainable for the coming generations.

A. Uses, Advantages, and Need of Smart Grids

In this evolving generation, it is very advantageous to incorporate technology into the electricity distribution grid. That would bring a lot of global economic and natural benefits.

- The major advantage of the Smart grid is that it reduces carbon emissions, and reduces the usage of fossil fuels, which can be made sustainable for future generations.
- Smart grids can be used to avoid the large investment to build up additional capacity for distribution generation, they can manage available capacities which leads to the saving of energy.
- The new system of the power grid is helpful for both end-users.
- It makes the power supply more efficient, faster, and easier.
- It transforms the conventional electric system into an advanced version, where a lot of time and energy is saved.
- As the smart grid involves smart meters which can calculate the amount of power consumed by each individual consumer, this enables the power stations to know the exact amount of power to be generated. That validates the power producers to generate suitably sufficient amounts of energy based on each individual consumer so that the wastage is reduced.
- The multi-level advancement in the grid such as

  Smart Infrastructure System

  Smart Management System and

  Smart Protection System

Improves reliability and explores the security and privacy issues in the smart grids.

- This move will not only benefit the business process but also their organization and technologies.
- It cuts down the power supply to only how much ever required. This reduces the wastage of power.
- A lot of benefits can be observed even in terms of the economy. When it reduces the usage of fossil fuels and reduces the power supply, then financially too a lot can be saved.
- As it is a two-way flow of production, it makes consumers also the producers and controllers.
- One can manage his electricity bill, inspect their power usage, and even know at what times the power rates are low i.e., non-peak times so that he can control his power bill and can even save electricity.
- This enhances a brighter future with a healthy environment, and sufficient natural resources, and reduces the workload.

B. What makes the Smart Grids 'Smart'?

Smart grids are very advanced, useful, and complex when compared to the conventional electricity supply grid. They are self-sufficient systems that find solutions to any problem very quickly. That reduces the work and then this can concentrate on making the resources sustainable, reliable, and safe. It also ensures quality electricity to the customers. Primarily, it incorporates technology into the system. Technologies mean-wireless sensor communications, and digital communication systems that build the grid into a very efficient and reliable system. It creates a widely distributed automated energy delivery network. Secondly, the conventional method of power supply needs a radical transformation in order to decarbonize the electricity power supply. Whereas the smart grid replaces the aging assets with new ICT (Information and Communication Technology). The third main aspect that makes it smart is including digital technologies and long transmission networks to optimize energy consumption. This system improves reliability, efficiency, and safety for both producers as well as consumers. It increases the flexibility for power consumption, for example - if there's any popular T.V. show being telecasted, those times will be the times where the load increases as everybody turns on their T.V.e.g., are at the same time. This may lead to overload and it takes more time to

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isolate this problem in the case of the conventional power supply method when compared to the smart grids. Smart grids, in this case, can firstly see to it that there won't be any heavy loads through the flexible power consumption method, and secondly, even if it leads to heavy loads, it can isolate and correct the problem within no time. Smart grids even allow consumers to act as electrical energy clients. The power planning is designed according to predictions for Photo Voltaic power production and load forecasting. The central and local management systems exchange data and order through a communication network. This enables the consumer to control and keep a track of their usage of electricity.

C. Fields in which Smart Grids are used:

- Integrated communications
- Substation automation
- Demand Response
- Distribution automation
- Supervisory control
- Super Control and Data Acquisition (SCADA)
- Energy Management Systems
- Wireless Sensor Networks and other technologies
- Power Line Carriers Communications
- Fiber Optics

D. Major Stakeholders:

- Consumers
- Utilities
- Government
- Policymaker
- Regulators
- Technology vendors
- Environmental groups
- Employees' and
- Societies as a whole

III. SMART GRIDS AND IOT (INTERNET OF THINGS)

A. What is IoT?

As the name suggests, IoT is the system of interconnection between the "things". Things mean computing devices, mechanical and digital machines, objects, people, or animals. But in order for these things to be connected, they should be provided with unique identifiers (UIDs) and should be able to transfer data over a network without any need for human-to-human or human-to-computer interaction. It connects to any device in any manner at any time. This can also be called the network of things embedded with sensors, software, and other technologies so that the connection can be made easy and exchanging data with other devices and systems over the internet is made efficient. The rapidly growing network of connected objects is IoT. A few examples of IoT are thermostats, cars, lights, refrigerators, and more appliances that can all be connected to the IoT.

B. Relation between IoT and Smart Grids

One of the most important, useful, and productive applications of IoT is the Smart Grid technology.

In an annual report published by the International Telecom Union (ITU) on the subject of IoT in 2005, there are 4 key drivers that drive the IoT:

1. Tagging things:

This means tracking equipment, assets, tools, inventory, people, or other objects by tagging RFID (Radio Frequency Identification) to the things.

2. Feeling things:

Inclusion of WSN or Sensor technologies in order to feel things without touching them.

3. Shrinking things:

Using nanotechnology to make products smaller and smaller.

4. Thinking things:

Smart materials, smart homes, robotics, etc.

In the case of Smart Grids, they deal with all these applications of the IoT:

- SMS's are the key enablers that run the whole system of smart grids.
- RFID technology is the main source to track the problems that are arisen in power transmission.
- Smart grids use a lot of nanotechnologies to reduce the size of devices, and meters of the power grid.
- The key application of the IoT used in Smart Grids is smart homes, smart materials, and robotics. The main motto or the principle behind the implementation of the smart grids is to convert the existing power grid into a smart grid, homes into smart homes, and to promote a smarter generation.

Smart grids and IoT almost share the same vision. The three main visions of IoT are (1) comprehensive sense which means using sensors to collect information from any source to any receiver. (2) Intelligent processing uses cloud computing to analyze huge amounts of data to control objects. (3) Reliable transmission which means accurate and real-time data transmission via communications networks and the internet. Whereas smart grid's visions involve (1) Communication networks (2) Cybersecurity (3) Distributed energy sources. (4) Distributed grid management. (5) Advanced metering infrastructure. Hence, as IoT is observed as a key factor for greater development in society, many countries invest in fully funded IoT projects. Every government will want its city to be smarter, and a smart grid is a prime factor in making a smart city. And for the smart grids to run well a major role is played by the IoT. Without IoT, there is no smart grid and without a smart grid, there is no smart city. Society benefits a lot from the smart grid and this is possible only through the active participation of the IoT.

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IV. SMART GRIDS FOR AGRICULTURE

Rural power grids directly relate to the farmer's Living Standards, the level of agricultural production, and rural prosperity. An intelligent rural power grid has played an important role in promoting green development in many countries. When it comes to the field of agriculture, a little more modern technology has to be integrated into conventional agricultural techniques. Gathering information, reading the information, and demand-side management are the few steps to be followed to make an intelligent rural power grid.

The information regarding the field can be perceived by using various sensors such as soil moisture sensors, humidity sensors, rain sensors, etc. These sensors come in handy to determine the seasonal trends of the field. For example, if there is excessive humidity in the soil, this denotes that either the day was cloudy or the season is rainy. This leads to switching on the dehumidification equipment to avoid degradation of equipment due to humidity and saves crops if the crop is sensitive to the humidity. Now all the information collected by various sensors placed in the fields and machinery warehouses is transmitted using the very recent invention of 5G technology. The 5g technology is wireless and provides plug-and-play communication network architecture which makes it efficient ata reasonable cost. It also provides universal standards and protocols to enable seamless communication. A ZigBee is also used based on the site conditions and sensors being used on the field. Demand management is what differentiates the smart grid from others.

A. Challenges for the Smart Grids to be implemented:

To implement smart grids, major 3 challenges can be observed. They are:

- Communication systems
- Including interaction between the devices
- Intelligible access to unlicensed cyber security and radio spectra

Obtaining a well-developed communication infrastructure, requires synchronization, reliability, suspension, the necessity of data delivery, and support for multitasking. And also, a major issue in networking communications is that a smart grid has to build up interaction between the producer and the consumer. The heavy amount of data generated by the technology involved in the smart grid also could pose a technical problem. As this system deals with complete technology and it requires the data of the consumers and generators too, there may be a threat to the data which can be called the cyber threat. There is also another concern where the people don't want to be inundated with telemarketing calls regarding the behavior of their usage.

B. Simulation Results

Here is the simulation of a small-scale microgrid Matlab Simulink. This model shows the behavior of a simplified model of a small-scale microgrid during a 24hour typical day. The model uses the Phasor solution provided by Specialized Power Systems in order to accelerate simulation speed as in Fig.1.

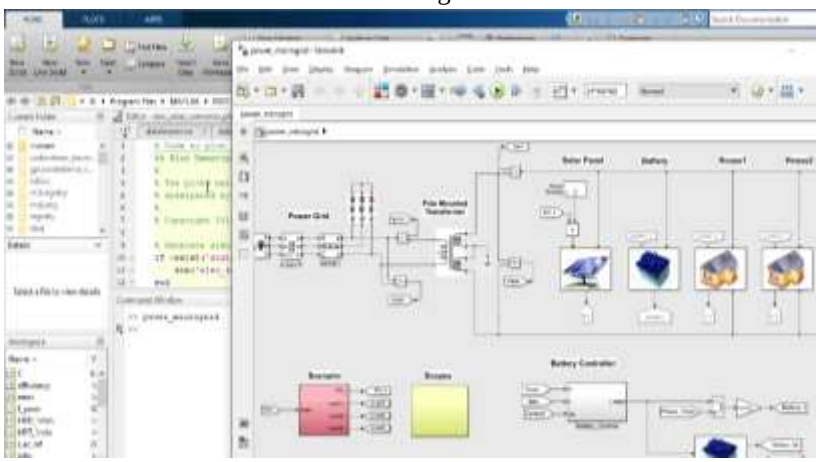

Fig.1.Phasor solution provided by Specialized Power Systems in order to accelerate simulation speed

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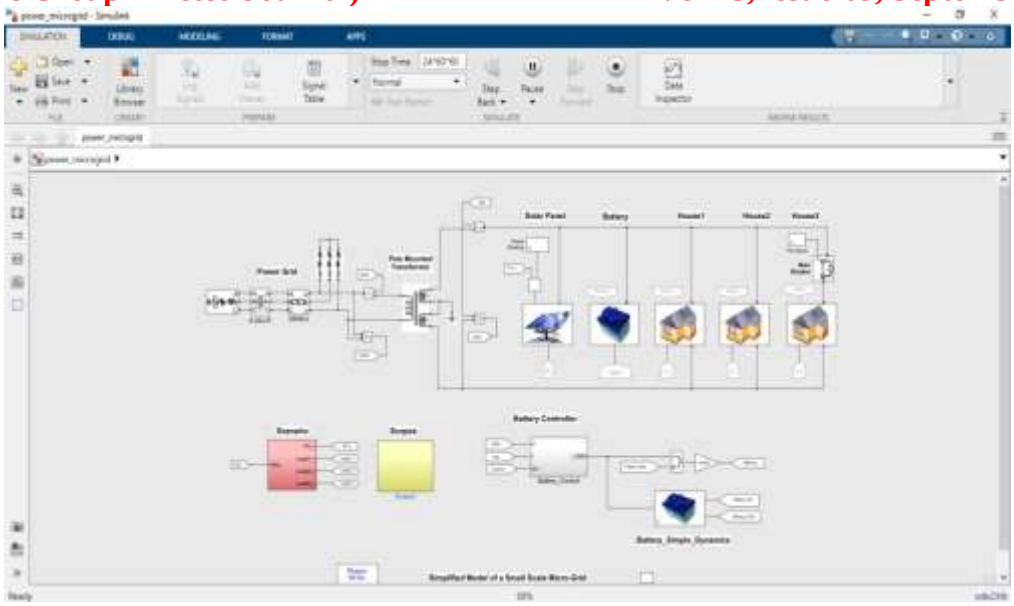

Fig.2 System Model

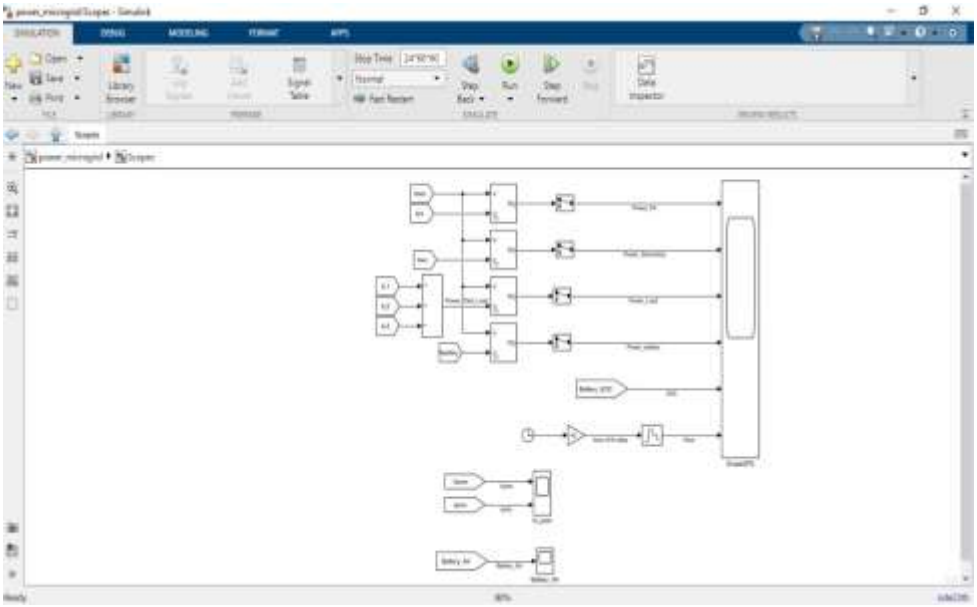

Fig.3. Detailed Model

Giving the command [power_microgrid] the below model can be obtained as in Fig.2. It has a battery controller, power grid and pole mounted transformer section. It also has battery and 3 houses as load. Clicking on scopes window it opens to a detailed explanation as in Fig.3 of the power consumption.

This simulation depicts the power consumed by the load i.e., the three houses, the battery and the secondary section. Here are the output graphs of the simulation shown in Fig.4.

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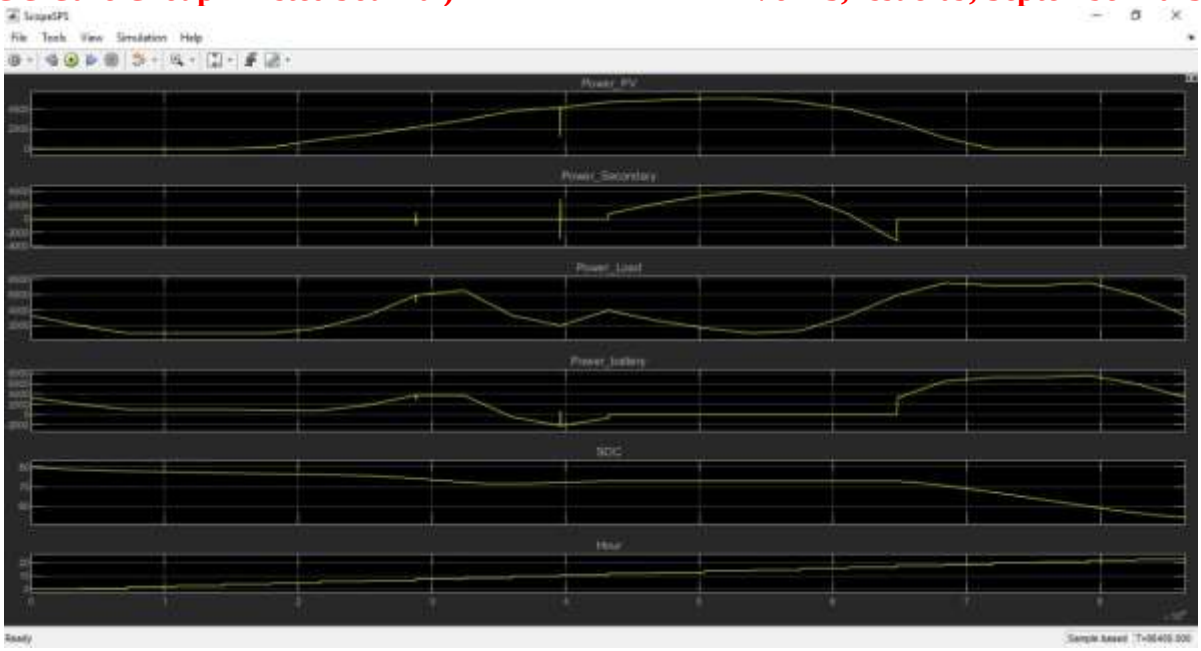

Fig.4. Simulation Results

It shows the peak values at the PV generator, secondary values, battery, and load. The output graphs also give information about the state of charge and the hours where the power consumed is at its peak.

V. CONCLUSION

Simulation of a small-scale microgrid with Matlab Simulink is presented and this model shows the behavior of a simplified model of a small-scale microgrid during a 24 hour typical day. The model uses the Phasor solution provided by Specialized Power Systems in order to accelerate simulation speed.

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