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Performance of Smart Grid Based on Data Aggregation Using Wireless Communication Network Technology

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Abstract: With the advancements in technology, electrical energy has become a basic need to support every field of life including Electric Vehicles (EVs), Industry automation, security networks and communication systems. This, in turn, demands a high order of design, protection and measurement setup of power transmission from the energy source to the end users (load) with minimum loss of energy. All types of loads need a nominal supply voltage to operate, which necessary for its safe operation. Usually the nominal-rated voltage allows ±5% variation tolerance in the operation of loads, without affecting the equipment. The transmission lines that connect several smart grids are called as interconnection, by using it the stability and proficiency can be increased. It should provide reliable and secure communication, with a low-cost solution. Hence, in this research paper, an efficient communication system based on wireless sensor networks will be under consideration, to ensure good quality of service for smart grids. The initial two points that are required to be covered include 1) research on optimum network topology to connect several smart grids and 2) interference cancellation to avoid errors in transmission due to the induced field from the power lines. In addition, 3) the wireless sensor network will be used to support efficient data collection, self-organization of the network and data reduction by removing the redundancy. Finally, 4) development of data prediction algorithm to reduce the transmission rate and latency. Overall, these approaches will help in development of smart network to reduce the energy wastage, ensure nominal supply voltage, increased reliability and improved communication network as compared to existing solutions. The presented work includes the two sorts of wind and solar energy in ordinary working environments and illuminates the energy trade between buyers and power Production Company. The expense of power isn't thought about; however, the various buyers can pick the least expensive energy.

Keywords: Control Station (CS), Distributed Energy Resources (DER), Distributed Grid Management (DGM), Key performance indicators (KPI's), Neighborhood Area Network (NAN), Quality of Service (QOS), Smart Grid (SG), Smart meter system (SMS), Town sever (TS), Wide Area Situational Awareness (WASA)

1. Introduction

The standard grid of power is building by power networks to feed the homes, factories, building and other since many years. This connects the main power plant to the sub plant [1-3]. Due to increase in the consumer demand and less availability of power, the standard power grids are no longer efficient

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for consumer. The existing power grid should be well built composed of two-way communication including smart technology like metering and sensing [4-5]. The important and main goal is to increase Smart Grid (SG) and present the intellect by the network of communications and the information technology to the various units of power grid similar to segment consumed (power grid demand) [6]. So, there is need of a well-built communication network that can keep eyes on the grid activities and issues by using an authorized management and control system [7]. Development of SG connects several points of control station (CS) to the different points of SG which is a main role of this technology [8]. The devices present in the gird and control station should have enough capacity for transmission of data [9]. The flow of data can be managed in a system by developing a structure which is the first step for strong and suitable communication [10]. Supply should be equal to the demand which is a common rule. A well developed and suitable communication network control it. The demand and supply of the electricity are managed over a thousand miles using a wide communication network [11]. The old technology in PLC of current communication has no benefit over the advanced technology [12-14]. Thus, due to lack of proper awareness of the situation, it leaves the distribution system [15]. Performance is measured by taking into account multiple KPIs such as dealing with conflicting communication network, typically data rates, security and delay sensitivity. In addition, the use of high modulation schemes that result in high performance cost a certain RAT per joule per hertz per bit increase.

1.1 Problem Statement

A regular electricity grid is more complicated that typically contains different power devices power likewise distribution lines, synchronous machines, transmission lines, transmission substations power transformers distribution substations and kinds of loads [1-2]. Household loads contains machine like water pump, heater, refrigerators, washing machine and air conditioners. Mini generators, induction motor, large electrical system and copying machine are the many forms of industrial loads. The flow of electricity is one dimensional which cannot manage the energy now a day. The fact is that the increment in demand for power by existing consumers is limited due to improper design, poor transmission, poor management system, and inefficient operation, lack of maintenance process and lack of central communication system [4].

In addition, numerous electric energy source, such as electric vehicles, wind grids and photovoltaic, complicate energy management [5].

1.2 Objectives

The purposes of this work are given below:

- To investigate quality of service in SG in positions of less power and harmful network in various uses.
- To propose and investigate the performance of wireless sensor network for data collection
- To compare the existing network topologies and propose a low-cost and low-complexity network model

2. Background and Literature Review

Several of review documents have been issued whose chief material are dedicated toward SG communication nodule needs, effective structure in system field such as little size communication for SG altered node kinds HAN NAN and WAN. In the writings, the absence of a complete communication system model where in various Communication of RATs features appeal worth existence defined for various node kinds of SG dissimilar message needs. The method to select and give the node kinds of SG users between the dissimilar RATs to be able to achieve the SG message needs is quiet an open stuff. There is still a no of exploration tasks ahead like complete system preparation and calculation of functions of the various system as a role of node no. Structures of RATs and types of SG node communications needs. Furthermore, Eb/N0 as a very precarious function has not reflected as a contribution in blend with other statement features to explain a well-organized system proposed idea for backup node message necessities of SG.

2.1 Arrangement of various Node Natures for Communication of Smart Grid

Many readings and documents have been prepared about to present the various SG communication node kinds necessity and the appropriate RATs to achieve these necessities. Abstract of several are certain in this section.B. Karimi et al. Complete learning on AMI structure examining in what way to connect also achieve client information composed by values and handling insufficient communication system resources. Founded on these workings several facts convey points accumulator or aggregators are essential to meet documents created by SMs to direct them through a message to back bone network system of the CS. SMs communication series is problematic to learn in this work and a technique to couple many minor smooth metering info received at statistics collector units in demand to decrease procedure slide. In this effort by suggesting a procedure to range to actual dispatch series is presented in a way that the technique is proficient to decrease over-all facts capacity by 10 to 25 percent for each collector.

Momentarily the system application thoughts and tasks in the power scheme surroundings have been intensely considered in which the analysis penalties are clear.

- Home Area System (HAN)
- Neighborhood Area System (NAN)
- Wide Area System (WAN

The Section of Energy Communication Rations of SG tools in the United States has disputed the most important issues in SG by providing the main goal of SG as well as the operator types in SG in general [30]. Furthermore, the communication necessities for a section of SG operator in relations of statistics degree, interval compassion, and safety have been deliberated. Smart Grid Distribution Automation and System Theory is additional learning for system strategy of SG examined by S. Bush et al. Furthermore, the net system is investigated to see if it has the lowest inactivity with the least variance owing to the idealized mesh redundant interconnections. In papers by ZWang and et al., the effectiveness of the SG system control architecture was investigated [13] stated that for scheming effective communication design it is desirable to describe power grid material cause.

3. Research Methodology

A Smart Grid has been developed for Active Power analysis using a MATLAB/SIMULINK method. The range of maximal allowable loads that can be attached to their respective bus bars can be determined using active power analysis. This paper uses limited signal analysis to show how the importance of Active Power changes as the load angle changes. The Smart Grid are the power grids in the upcoming era, creates a globally deployed combined energy circulation network by using bidirectional electricity and knowledge transfer.

3.1 Proposed model

The projected Wind turbine model is dependent on wind speed in contradiction of output generated power characteristics in this report. The wind turbine's output generated power is given by [9]:

$$P_m = C_p\,(\lambda,\beta)\,\rho A V^3_{wind} \tag{1}$$

Here Pm represents the turbine's mechanical power output, Cp represents the turbine's efficiency coefficient, = the rotor blade's tip speed ratio, = the blade pitch angle, = the air density, A is the turbine's swept field, and V wind is the wind speed. The output coefficient model Cp(,) used in this paper is based on [9] and is defined as follows:

$$C\_p\,(\lambda,\beta) = C\_1\,[C\_2/\lambda\_1 - C\_3\,\beta - C\_4\,]\,e\text{^}(-C\_(5/\lambda\_1\,)\,) + C\_6\,\lambda \tag{2}$$

The parameters that determine the configuration of the wind turbine rotor and blades are constants C1 to C6. I is a parameter that is defined in (3):

$$1/\lambda\_1 = 1/(\lambda+0.07\beta)- 0.045/(\beta\text{^}3+1) \tag{3}$$

Equivalence (1) can also be normalized and clarified for special standards of A and, as seen in (4):

$$P\_(m\text{-}pu) = K\_p\ C\_(P\text{-}pu)\ V\_(wind\text{-}pu)\text{^}3 \tag{4}$$

where Pm-pu is equal to the nominal power in milli watts per unit of A, Cppu is equal to the output coefficient Cp, and Kp is equal to the power gain Vwind-pu wind speed base. The mean of the expected wind speed in meters per second is the reliant or dependent wind speed. For the last three decades, the general mathematical model for the solar cell has been investigated [10]. Figure 1 depicts the solar cell model's circuit, which includes a parallel resistor (leakage current) photocurrent, a diode, and a series resistor are all used in this circuit. Using both the PV cell circuit and Kirchhoff's circuit rules, the photovoltaic current may be stated as follows [5]:

$$I\_pv= I\_GC- I\_0\ [\ 〖exp〗\ \text{^}(eV\_(d/(KFT\_C\ ))\ )-1]- V\_d/R\_p \tag{5}$$

where Ipv represents the photovoltaic current, IGC means the light generated current, Io represents the dark saturation current based on cell temperature, and e signifies the electric charge. Tc=the cell's absolute temperature, Vd=the diode voltage, Rp=the parallel resistance, e=1.6*10-19C, K=constant, Boltzmann's K=1.38*10-23 J/K, F=the cell idealizing force, Tc=the cell's absolute temperature, Vd=the diode voltage, Rp=the parallel resistance.

3.2 Description smart grid system

Smart grid users connect in two-way directions using multiple wireless and wired networking protocols such as ZigBee, Wi-Fi, Home plug, power line carrier, GPRS, WiMAX, LET, Lease line, and Fibers [5,6], as smart grid concepts have emerged as a rapidly expanding research and development area in recent years. Several software packages, including the distribution management system (DMS), geographic information systems (GIS), outage management systems (OMS).

3.3 Automatic smart home system

A smart home is a purchaser's home that is armed with smart devices. The addition of a smart wireless card has made the devices smart. The schematic of a smart wireless card is The digital meter, The microcontroller, The sensors and The modest wireless card.

3.4 Smart meter system (SM)

The main and basic aim of SM system are [13] to manage /measure the power. note the unit and price and to build communication. SM is a self-contained system that determines how much electricity smart appliances demand and distributes it from the smart grid/power station appropriately [14]. If both sources of power are insufficient, it will try to satisfy the demand by taking power from RS. SM will send a signal to TS to supply the difference between the necessary and useable power if RS is unable to satisfy the power requirement. So, if the needed power is less than the power provided by the town server, the town server broadcasts to TS that the power provided by TS is more than required, allowing TS to reduce the power provided by TS that is more than required by SH [15].

3.5 The Town sever (TS)

The most fundamental component of a smart management system is the town server (TS). It's essentially a central computer and a complete server that can make decisions on behalf of the whole user base. For communication, the TS is exclusively connected to the MS through PSTN. All data is kept at MS, but TS only keeps data for the current month, because the town server delivers measured power units to MS each hour up until that time. TS loses data as long as the current month passes since MS holds all of the data from the previous month and the new month up to that time. The hourly data sending is meant to avoid the risk of network misuse and reduce bandwidth use to a fraction of what it was in earlier smart systems. The TS is controlled by a real-time multitasking operating system and real-time software that is configured to switch the mode of the TS to administrative mode whenever the MS is in connection down mode. In this mode, TS works as a stand-alone MS and remains attached to data until the MS is disconnected. Although TSs are connected via PSTNs and power lines, these two connections are the only way for TSs to communicate with one another, making them incredibly important. One of the most compelling reasons to use PSTN, as we said in the opening, is the possibility for unbounded bandwidth capacity. The bandwidth equation is given below by the Shannon theorem:

$$BPS = BW \log2(1+ n/s) \quad (6)$$

BPS stands for bits per second, BW for channel bandwidth, and s/n stands for signal to noise ratio. This is not a db ratio, but rather a true power ratio. The equation for bit per second is:

$$BPS = RS \log 2NS \quad (7)$$

TS will receive those notifications from all of its SMs in this manner. TS will be notified if SH's necessary power decreases or increases. If this is the case, ASM must decrease its power while the other SM must raise its power, both send a message signal to TS, and TS decreases the indicated power of the first one while assigning the necessary power to the other. If it is necessary for the second one's requirements, TS will look for another SH whose power can be allocated; otherwise, TS will look for another SH whose power can be assigned. If the power shortage persists, TS will search its SHs and see if they can supply power from their regenerative sources to make up for the shortfall. If no SH can supply power or if the power of the SH is insufficient, it sends a request to the nearest TS to provide power (see Figure 2). If the closest TS does not have enough electricity to donate from its own circle/ grid, it can borrow from the next TS. If a problem occurs at MS or one or more TSs, all other TSs will continue to work normally.

3.5. Main server

The main server (MS) is the core computer that the whole machine revolves around. For its town servers, it holds measurements, bills, data, consumer records, and the topology of division of all the capacity of smart grid/power stations. Any TS is only linked to the MS via PSTN. MS is controlled centrally by the service provider's headquarters. And MS may use commands or passwords to start or interrupt all of the features and operations of a given SH / TS. If several delivery providers are operating under a single smart machine umbrella, the service provider corporation will shut down any TS under extreme circumstances for any reason.MS now generates a concise overview for each SM and TS at the end of each month

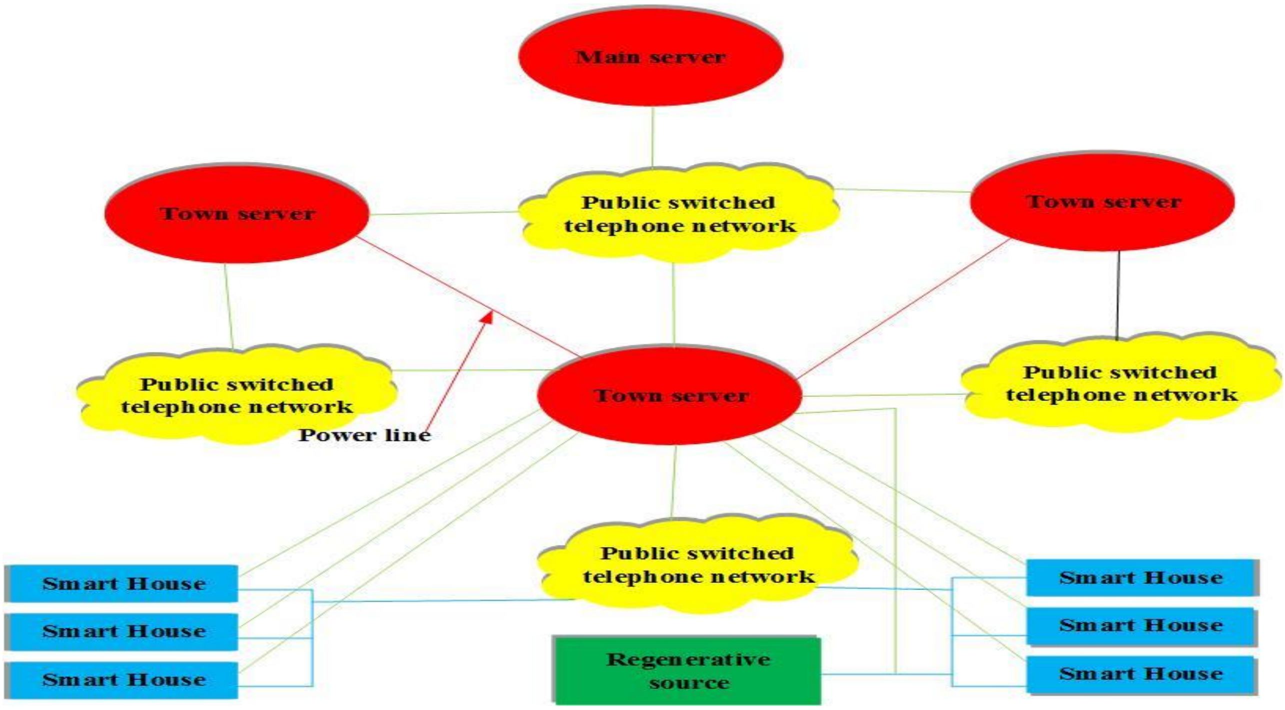

Fig. 1 -The Topology of smart system; upper part shows way of connection between TS and also with MS while lower part shows the way of connection of SH to TS through local PNST.

4. Proposed Framework

In this research work the proposed framework is basically consisting of three parts, the power generation from solar energy system, the power generation from wind turbine plant and finally these two generated power systems are linked with the main grid system. Where then the power is transformed to the consumers. There are 66 parallel strings are connected and each string includes 5 solar panels connected series. Figure 3 and Figure 4 presents the outcomes generated of solar system in terms of irradiance (w/m2), temperature, power in kw, voltage and duty cycle.

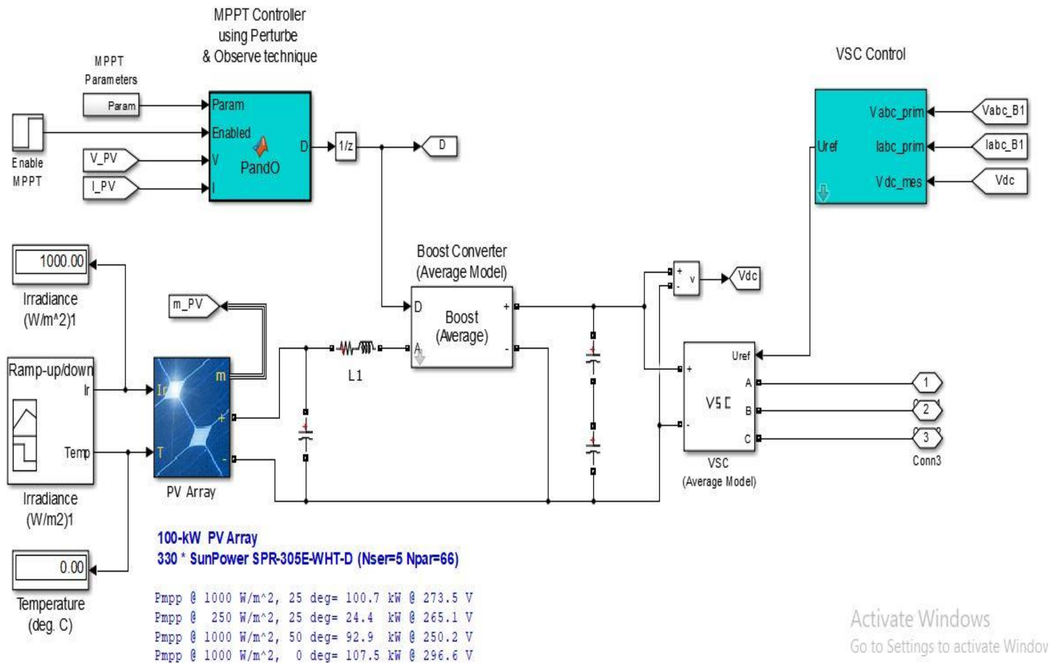

Fig. 2 - Internal Structure of MPPT based PV system.

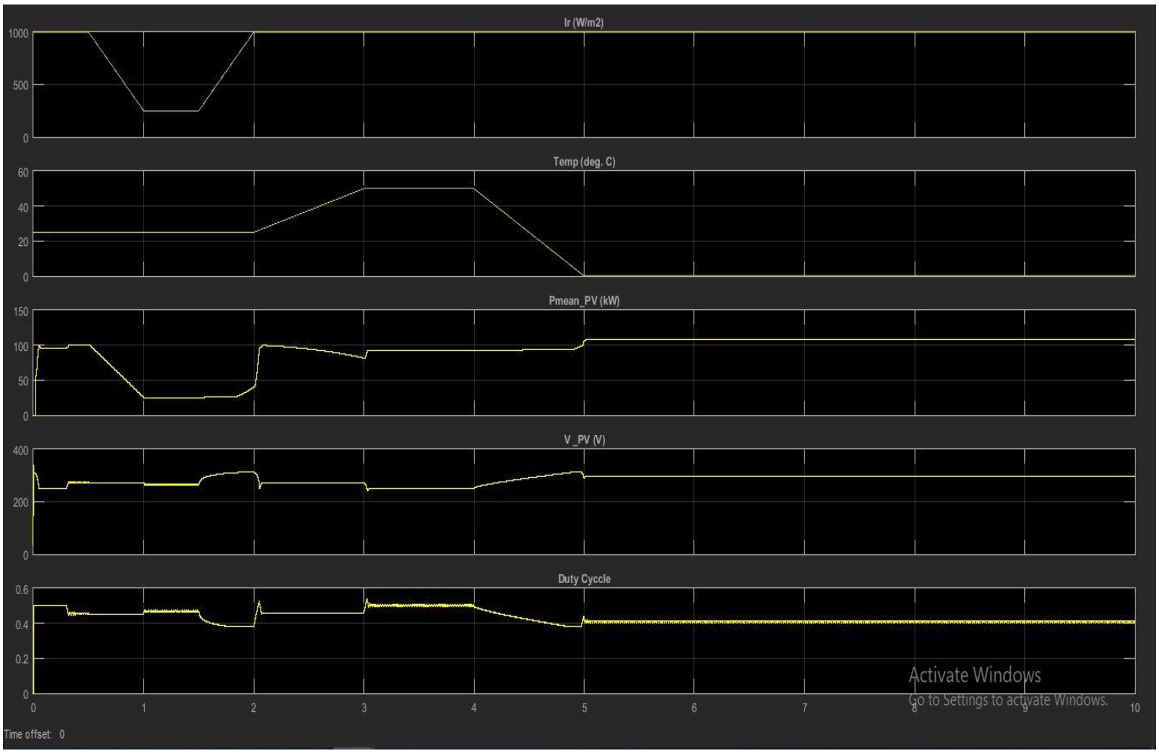

Fig. 3 - Results outcomes from solar system.

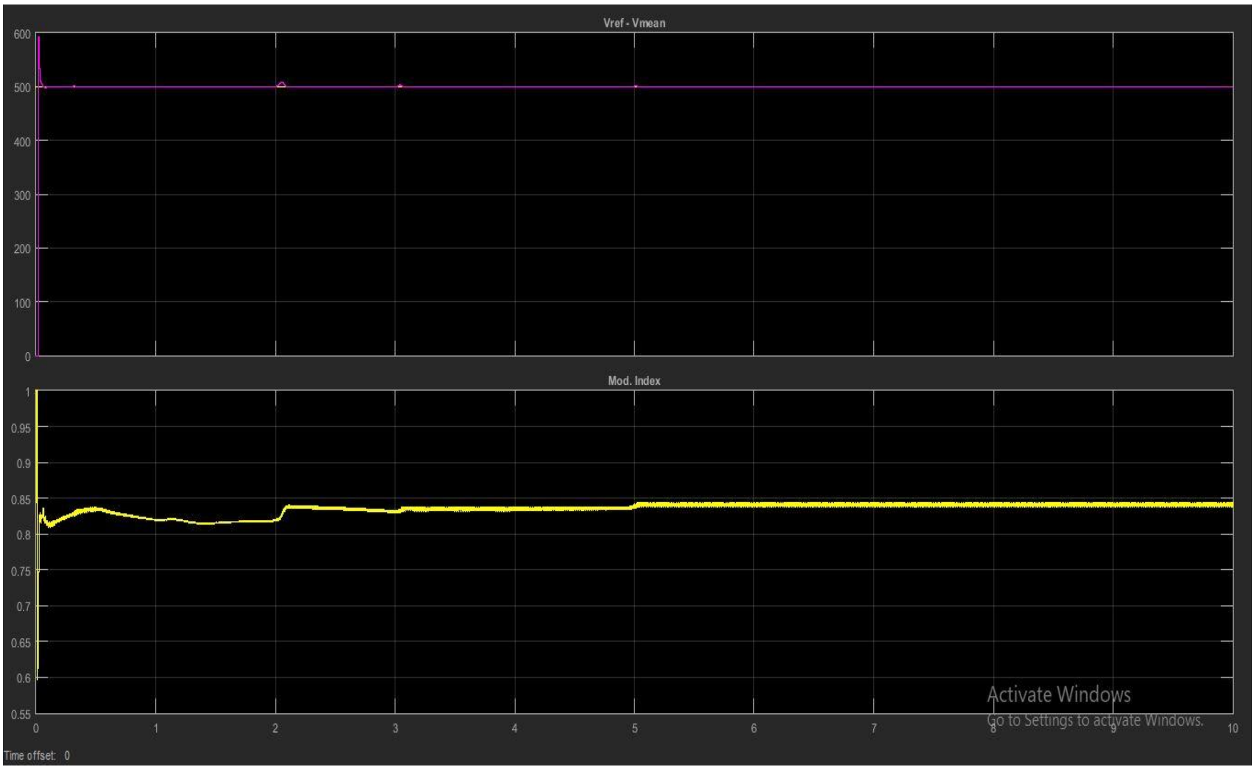

Fig. 4 - Mode Index and mean results of solar system.

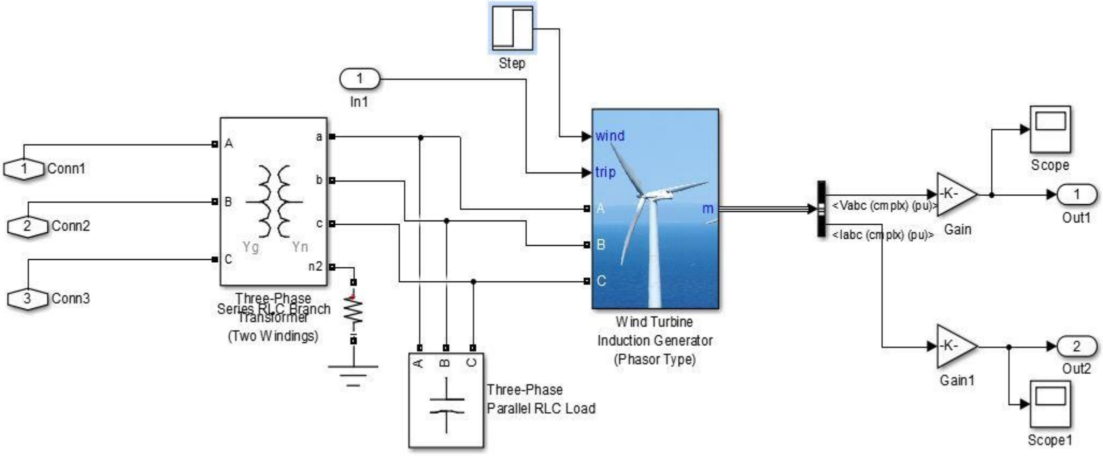

Fig. 5 - Basic model of Wind power plant system, proving power to Main grid.

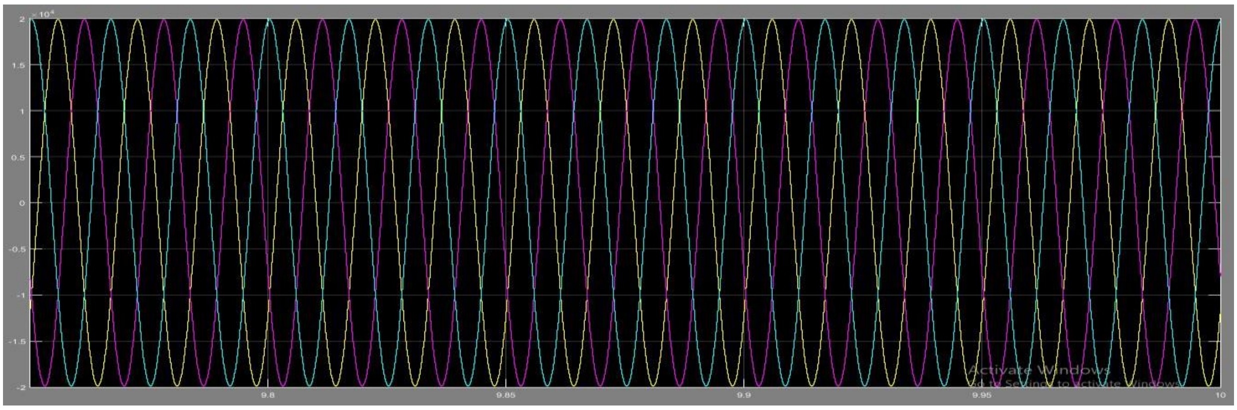

Fig. 7 - Sine wave of 3-phase induction generator installed in wind turbine

The internal model of the proposed wind is mentioned in Figure 5, which clarifies that power of the wind turbine in linked to transformer where then it is provided to the load and utility grid as in. Figure 6 explains the sine wave generation of the generator installed inside wind turbine.

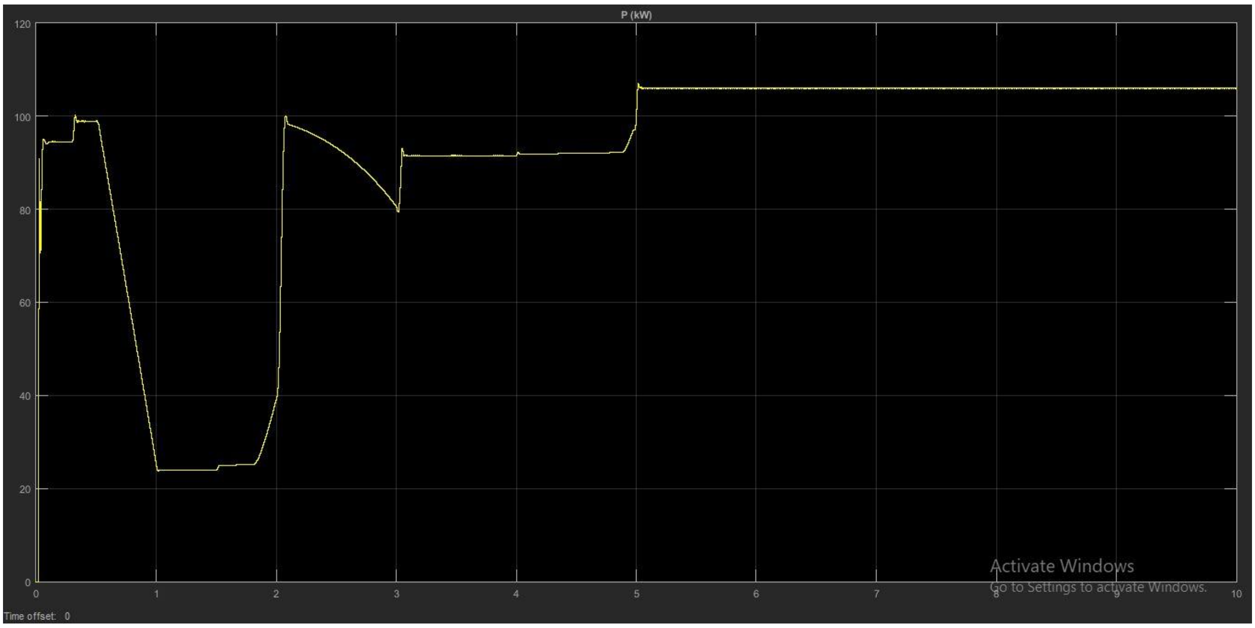

Fig. 7 - Graphical representation of output power.

The output generation of the wind turbine is shown in Figure 7, which explains that at starting the wind turbine induces irregular power.

5. Results and Discussion

The suggested model's study is based on different residential and industrial users to recognize how the smart network works. Table 5.1 presents the list of used elements for simulation analysis of the proposed model. The first residential load, presented by Figure 8, is powered by two sources of energy: 4KW of wind energy and the general electricity grid (GEN). The following software describes its load curve: The house absorbs a steady electric power of 1KW provided by the wind turbine from 0:00 to 7:00 a.m. At 7:00 a.m., the load peaks at 3 KW, which is also provided by the wind turbine. In that case, the house is cut off from the GEN until 7 p.m., when a second 5 KW power surge is observed, which would last until 23 p.m. GEN steps in to fill the void at this period.

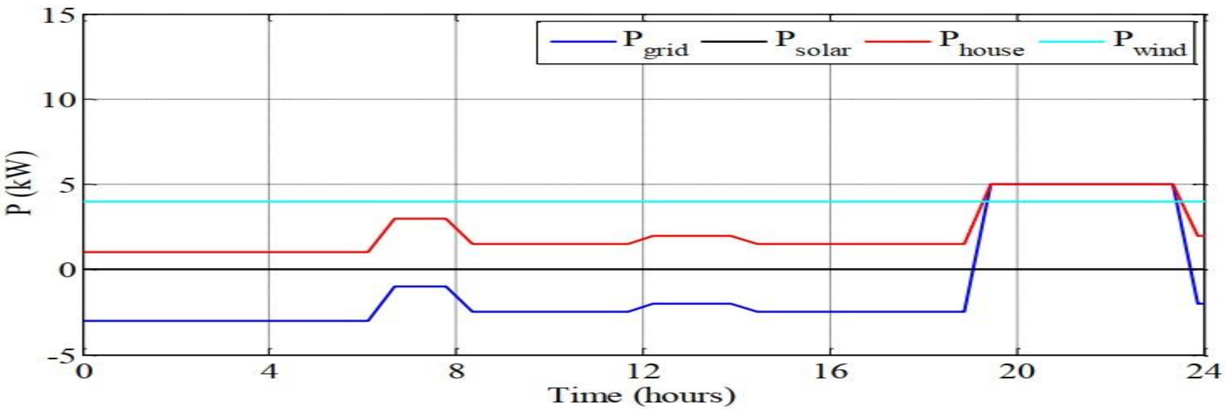

Fig. 8 - Simulation analysis of first home user.

The load curve for the second house, as seen in Figure 9, is as follows: from 00h to 06:00, it absorbs 1KW of power provided by the GEN. 3KW power peak demand that should last 1h30mn. This electricity is still provided by the generator, and when the sun comes up, the consumption is reduced to 1.5KW. As a result, before 19:00, the GEN will be free of this gap. As a result, before 24:00, the GEN is responsible for the use of the second house.

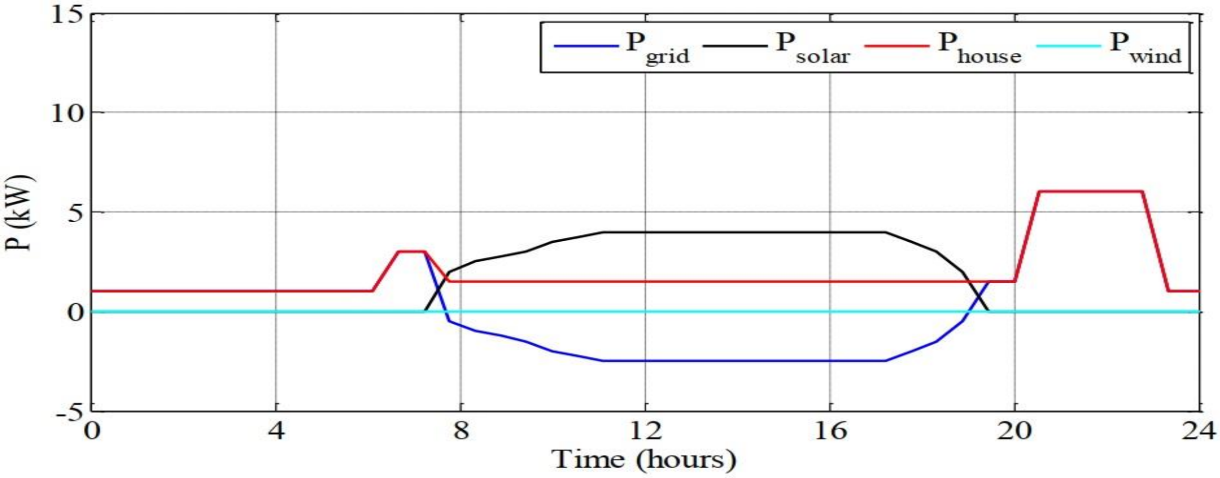

Fig. 9 - Simulation analysis of first home user.

In contrast to homes, factories have significant manufacturing and consumption poles. Figure 10 depicts the first industry, which includes a 5MW wind turbine and is associated to the GEN, allowing it to be driven by both bases of energy. The following distribution describes its load curve: From 00h00 to 7h00, it utilizes a constant electricity of 2MW provided by the wind turbine. The arrival of the personnel and the start-up of industry equipment results in the first peak of power consumption, which reaches 7MW at 7:30 a.m. The above can only be met with GEN support before 10 a.m., after which the load is limited to 5MW. In contrast to homes, factories have significant manufacturing and consumption poles. Figure 10 depicts the first industry, which includes a 5MW wind turbine and is linked to the GEN, allowing it to be powered by both energy sources. The following distribution describes its load curve: It devour a steady power of 2MW given by the wind turbine from 00h00 to 7h00. The arrival of the workforce and the start-up of the industry's equipment causes a first peak of power demand, which hits a value of 7MW at 7:30 a.m. The above can only be met with GEN support before 10 a.m., after which the load is limited to 5MW.

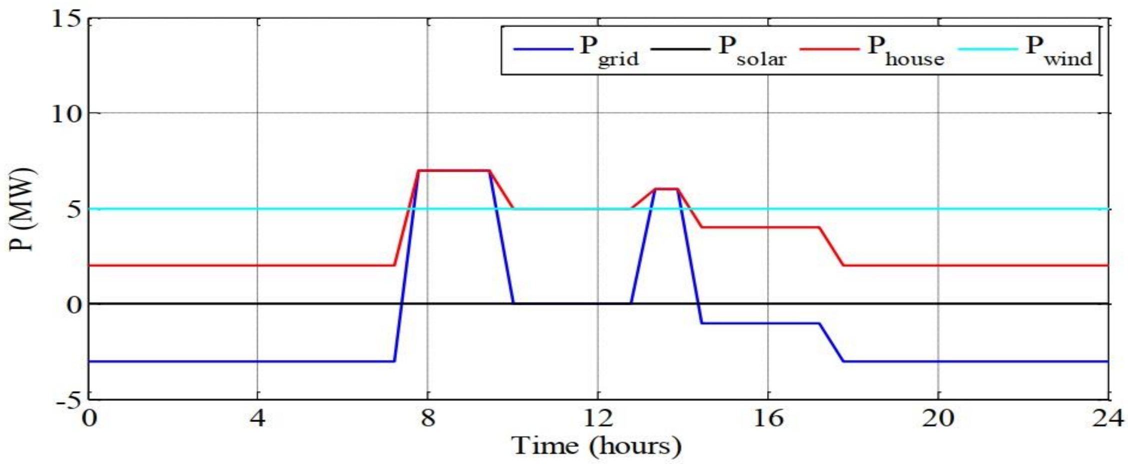

Fig. 10 - Simulation analysis of Industrial user.

The second industry, depicted in Figure 11, includes a 5MW solar park that is connected to the GEN, allowing it to be powered by both energy sources. The following distribution describes its load curve: from 00h00 to 6h00, it absorbs a constant power of 2MW given by the GEN. With the arrival of the workforce and the start-up of the industry's equipment, a total of 7MW power is observed, which is handled solely by the GEN. All energy sources are active at 8:00 a.m., when solar energy emerges and starts to supply energy, but solar energy alone cannot meet the demand, and the peak will last until 10:00 a.m. The GEN is turned off after a 5MW power cut, and the plant is still fed by the solar park. A second high of 6MW occurs at 15h00 and lasts until 16h00, involving the GEN once more. With the industry shut down at 5 p.m., demand is limited to 2 MW. The latter is supplied by the solar park before sunset at 19:00, during which the GEN is used until the end of the day.

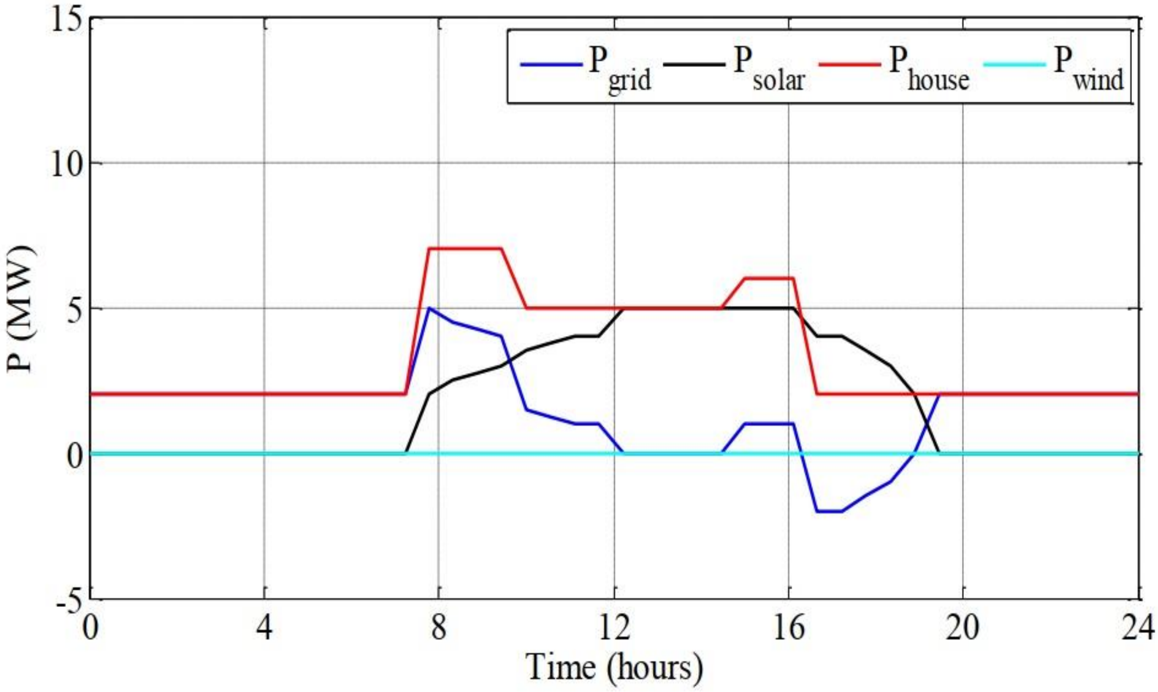

Fig. 11 - Simulation analysis of second industrial user.

6. Conclusion

The electricity demands are increased rapidly from last decade, and the current set up has increased complexity to analyze the power consumption and load management. The problems in current electrical power system are investigated and the methods to resolve current matters are conferred in detail. The investigation among regular power grids and proposed smart are discussed briefly. Finally, the organization of thesis is explored in this work. To the finest of our information, the other approaches planned in the works are not well-organized supply delivery approaches regarding the SGCN supplies with the assumed restraints. Furthermore, a technique to associate entire RATs whose provision is different to node communication of SG necessities and selecting finest maximum well-organized one in this matter of logic communication and competence has not been offered to this point. Lastly a well-organized technique to mark a HET and NET for SG system and transfer the various node kinds of SG to different RATs founded over message standards in cooperation of operators and RATs expounded deliberately. Furthermore, as developed phantom competence SE consequences in dropping power productivity and spectral effectiveness reasons the increase of per bit energy

7. Future Work

The theoretical model under standard operating conditions includes all forms of solar and wind energy and describes the energy exchange between customers and GEN. The price of power is not taken into account. Thus, in the future, the cost-benefit study of the new model as well as advanced transmission systems such as satellite systems should be investigated in command to increase the competence of the electricity delivery system and provide customers with the cheapest energy supply.

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