Smart Grids and The Renewable Energy Component

Omotosho T.V., Abodunrin T.J., Achuka J.A., Olawole O.O.
Physics Department,
Covenant University,
Ota, Ogun-State, Nigeria

Abstract - **A twentieth- first century grid cannot be built on a twentieth century electric grid. Smart grid has undertaken the promise of incredible advances in innovation, provision of jobs, wealth creation, cleaner environment and, consumer empowerment. Smart grid can be defined as the sum of concerted efforts to advance existing technologies; Integrating operations and IT to achieve higher utility, better environment and society. A real smart modern grid would involve concepts of sustainability ; development that meets the needs of present generations yet uncompromising future generations ability to meet their own needs, that influence cost effective and confirmed cleaner technology. This smart grid involves integration of communication and electrical infrastructures with unconventional information and computerization in an already existing grid. This is an enquiry into introduction of solar photovoltaics (PV) and wind energy into the existing Covenant University grid, for the purpose of serving CU community and to serve as a case study for developing wind energy systems in Lagos.**

Index Terms – Smart Grid, Renewable Energy, Sustainability, Solar PV, Wind Energy

I. INTRODUCTION

Charles F. Brush fabricated the world's pioneer automatically operating wind turbine for electricity generation. The turbine was installed in Cleveland, Ohio, in 1887, worked for 20 years with a peak power production of 12 kW. Nikola Tesla in 1888 founded much of the thinking behind today's power grid based on design decisions assumptions like centralized power generation, demand-driven control and unidirectional transmission that are now considered obsolete.

The automatic control system helped the turbine to achieve effective action at 6.6 rpm (330 rpm at the dynamo) such that the dc voltage was maintained in the range of 70 to 90 volts. A laudable project in early wind energy research was the 1.25-MW wind turbine developed by Palmer Putnam [10] in the U.S. The ubiquitous wind turbine, which was 53 m (175 feet) in diameter, was installed in Vermont, Pennsylvania, around 1940 and having two blades with a hydraulic pitch control system.

In the late 1970s, modern wind-driven electricity generators started manifesting. The average power output of a wind turbine unit was about 50 kW with a blade length of 8 m. currently, the size of the machines has increased enormously. At Present, the actual values for power output of the modern turbines distributed around the globe are about 1.5 to 3.5 MW with blade lengths that exceed 40 m for onshore and 60 m for offshore uses. The cost per kilowatt has reduced to barest minimum, which has resulted to an improvement in terms of efficiency, reliability, and availability of the machines. Latest multidisciplinary computer design tools [11, 12], perform simulate, analyse, and redesign in a concurrent engineering way the mechanics, aerodynamics, and electrical and control systems under several conditions and external scenarios [13, 14, 15], have extended the capability to develop more complex and efficient wind turbines. This newest method (Fig. 3), the control system designs, and the designers' understanding of the system's dynamics from the control standpoint, are playing a central role in new engineering achievements. Far better than in the old days, when the design of any machine was carried out under a rigid and sequential strategy, starting from the pure aerodynamics and following with the mechanical, the electrical, and finally the control system design, these technologies have opened opportunity for control engineers.

A smart grid must integrate the characteristics or deliver the performance described below: "self-healing from power disturbance events; enabling active participation by consumers in demand response; operating resiliently against physical and cyber-attacks; providing power quality for 21st century needs;

accommodating all generation and storage options; enabling new products, services, and markets; optimizing assets and operating efficiently" [21]. A progressive change is to build a grid from foundation to finish with capacity for computerization equipment and technology, a digital grid prepared to meet the burgeoning and complex 21st Century needs. The smart grid refers to a network of transmission lines, substations, transformers and every component that delivers electricity from the power plant to your home or business. The smart grid presents a novel chance to move energy industry to an era of unprecedented availability, reliability and efficiency which will translate to our community health and economic wealth. Similar to the internet, the smart grid would be made of computers, automation, controls, new equipment and technologies mutually working together. "Smart" grid must be capable of providing power from multiple and widely distributed sources, e.g., from concentrating solar power systems, wind turbines, photovoltaic panels, perhaps even plug-in hybrid electric vehicles. Furthermore, since all renewable energy sources discovered so far vary greatly with time, a smart grid must therefore be capable of flexibly storing electric power for later use, e.g., in flywheels, batteries, or super-capacitors or even in plug-in hybrid electric vehicles. Finally, to improve power reliability a smart grid must make use of new and very sophisticated adaptive generation and distribution control algorithms.

II. COMPARISON OF SMART GRID WITH TRADITIONAL GRID

A graphic diagram of the origin of smart grids from conventional power grids is illustrated in Fig. 1. Important components are shown in the schematic diagram. The transformation evades modernization in the domain of electricity generation, power grid monitoring, power flow control, and the system protection centre (SPC). In the electricity generation sector, conventional power plants are augmented with DGs and MGs. Monitoring of Power grid has been aided with global position and system (GPS) smart meters based synchrophasor measurement units with phasor data concentrators (PDCs) for real-time security evaluation at the main control centre (MCC). Real-time power flow control, demand response, alongside with local load control is manoeuvred by MCC based on the intelligent energy management system (IEMS) [1–9].

Characteristic components of a smart grid include: Intelligent appliances capable of deciding when to consume power based on pre-set customer preferences. This can go a long way toward reducing peak loads which has a major impact on electricity generation costs - alleviating the need for new power plants and cutting down on damaging greenhouse emissions. Early hypothesis with smart grids have shown that consumers can save up to 25% on their energy usage by simply providing them with information on that usage and the tools to manage it. Smart power meters featuring two-way communications between consumers and power providers to automate billing data collection, detect outages and dispatch repair crews to the correct location faster.

Wind turbines comprise: constant-speed and variable-speed machines. Constant-speed concept has been gaining higher demand in the market. But just of recent variable-speed designs also came to the market as the latest technology [12, 15-17].

TABLE I: DIFFERENCES BETWEEN TRADITIONAL POWER GRIDS AND SMART GRIDS

Traditional power grid	Smart grids
Radial topology	Network Topology
Manual recovery	Semi-automatic and automatic recovery
Handling emergencies through staff and telephone	Decision support system and reliable prediction
Limited pricing information	Complete pricing information
Fewer user options	More user options
One-way communication	Two-way communication
Mechanization	Digitization
Pay attention to failures and disruptions	Adaptive protection measures
Finite control	Pervasive and intensive control system

Source: [20]

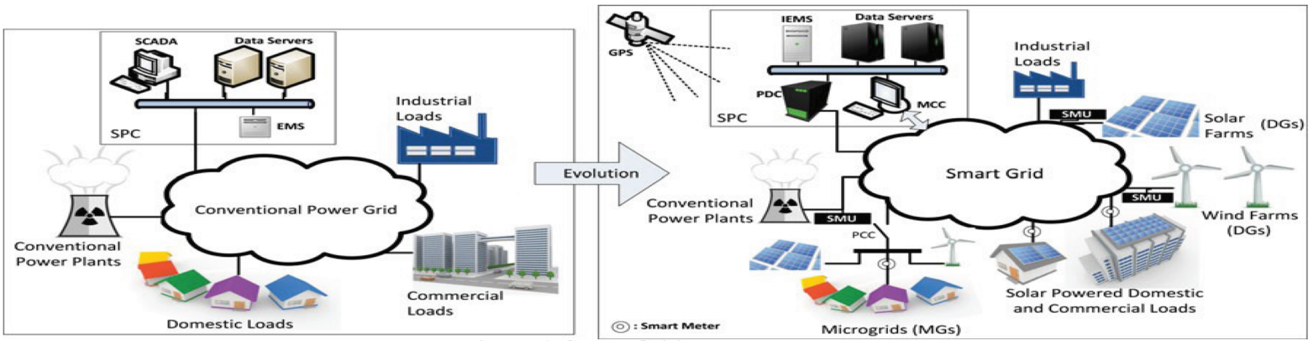

Fig. 1. A Smart Grid [18]

III. OPERATION OF THE SMART GRID

To regulate the amount of power captured by the rotor these three alternative ways can be employed: passive stall control or fixed pitch, variable pitch control, and active stall control. Till date none of these alternative ways is superior to one another. As machines get larger and power production increases, the trend is toward pitch control and active stall control [12, 15-17].

The configuration of a fixed-speed wind turbine is based on a gearbox and an asynchronous generator, which is usually a squirrel-cage induction generator to reduce costs. The gearbox links the wind turbine shaft with the rotor of a fixed-speed generator, providing the high rotational speed required by the generator. The generator produces electricity through a direct grid connection, and a set of capacitors is used to compensate reactive power. Because of a frequency converter, the generator speed is controlled by the grid frequency. The shortcoming of fixed-speed operation is low aerodynamic efficiency, particularly at partial-load operation. The generator can function at any rotational speed, making operation to track the optimal speed for each wind condition. The advantages of this approach are low maintenance costs, high reliability because of omission of the gearbox, the ability to assist grid voltage control and improved aerodynamic efficiency. Consider the power curve for a variable-speed pitch-controlled wind turbine is shown in Fig. 4. Four zones and two areas are highlighted in the figure [12]. The rated power Pr of the wind turbine (that is, the actual power supplied to the grid at wind speed greater than V_r) divides the graph into two major areas. Below rated power, the wind turbine yields only a fraction of its total design power, and therefore an optimization control strategy needs to be done. Conversely, above rated power, a limitation control strategy is needed.

IV. HEALTH PERSPECTIVES OF A SMART GRID

The advantages of renewable energy cannot be over emphasized considering the damage done to our environment from non-renewable sources. However, no technology comes without its own risks. It is therefore paramount to consider the risks associated with a particular technology and find a solution around them before we employ it. In view of this, we shall enumerate some environmental impacts of renewable energy and possible solutions to them that will make it suitable for use in Covenant University. The following are some challenges associated with the use of renewable energy;

1. *The Effect on Buildings*

Solar thermal heating on buildings can lead to increase fire risk and water intrusion into the roof [23], this can lead to electrocution in such a building. The weight of solar panels can sometimes act as excess load and undue stress on building since it was not incorporated during the construction stage. The solar panel's weight should be put into consideration as part of building fabric during the construction of new building while newly manufactured panel with light weight material [22], should be used in old buildings where this alternative energy is sourced for. The beauty of building are sometimes compromised when solar panel are installed. In order to eliminate this challenge, [23] reported that solar elements should be used as architectural elements in an attractive and visible ways such that it will be appealing to clients.

2. *The Effect on Humans*

Study has shown that the inverter and battery of a solar system emit radiofrequency radiation [22]. The wires connected to the inverter act as antennas, transmitting the radiation hundreds of metres (m) away from the source (solar EMF hazards). This can lead [25] to electromagnetic hypersensitivity (EHS) in allergic people. More researches are ongoing on the improvement of materials used for the construction of renewable components [27]. Human safety measures are to be employed in handling laptops, cell phone and other gadgets that emit electromagnetic radiation to keep a distance from these components in their vicinity.

3. *Visual Intrusion*

Visual impact of solar panels does not pose major risk like wind turbines. However, consumers should go for designs which fit closely to their existing roofline such that it will produce little glare [23], while making a choice for solar panel installations in their home. In wind farms, this effect can be minimized by citing it in an isolated area [22], as we have proposed in Covenant University. Also, our ability to cope with the installation of TV antennas, cable disc, will make the effect not a challenge.

4. *Noise Pollution*

This is about the only challenge of wind energy. Wind turbines are noisy and as a result they cause noise pollution and discomfort to people. When mounted on a house, it magnifies the vibrational noise of the building (www.eiwellspring.org). Windmill also uses inverter which generates radiofrequency radiation. All these effect can be reduced or averted by sitting the farm at a recommended distance, using current engineering materials [27] and imbibing good working practice [23], geared towards noise suppression.

5. *Impact on Archaeological Sites*

Harnessing the benefits of renewable energy in our society today demands that building with archaeological interests and land with archaeological history should be avoided.

6. *Effect on Ecosystem*

The impact of renewable energy on ecosystem depends on location [26]**.** Installation of solar power plant changes the ecosystem drastically by; limiting the movement of animals, destroying of vegetation, microclimate change due to shadow cast by panels, destruction of wildlife, etc. Wind farms are also not left out in this menace. However, reports have it that appropriately sited and well-designed renewable energy developments are generally not a threat to biodiversity.

7. *Impact on Climate*

The development of renewal energy sometimes requires that some trees and bulrushes must be removed to enhance its installation. Research has shown that climate can be effected when large power plant are constructed [24]. But, when located in true deserts, and other locations where solar insolation is intense and wildlife is absent, they have the most beneficial environmental impact.

All these challenges are enumerated in order to alienate the fear people have towards embracing new technology. Hence, the cumulative effects of renewable energy on man and its environment are generally small and insignificant making it the best option suited for the world we crave for.

CONCLUSION AND RECOMMENDATION

The average wind speed measured from the Davis data logger located on the roof (about 5m) of School of Natural and Applied Science (SNAS) building has 0.4m/s as its least reading and the highest for 2014 was 5.8m/s per minute (Table 2). Higher values of wind speed would be recorded (wind shear) at higher heights where there is no obstruction from buildings, topography of land, trees. The wind direction varies diurnally while wind speed is constant for maximum of 4 minutes, data for years have been logged on; this shows the availability of wind resource in the river valley between SNAS and the female hall could be used by siting some wind turbines in this green belt valley.

In the construction of new buildings, dual wiring could be done. One could be connected to solar panels just for lightning to reduce the present astronomical cost of electricity. While constructing, allowances should be made in the roof space and weight for the installation and maintenance of solar panels and use of DC energy bulbs to conserve energy eliminate the use of inverters as this is one component that makes renewable energy installation costly.

The Wind speed and other parameters measured with the DAVIS data logger for Jan. 2014 are shown in Table II.

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TABLE II: WIND SPEED AND OTHER PARAMETERS MEASUREMENTS

Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt	Wind Speed	Wind Dir
16/01/14	16:26	31.4	31.4	31.4	74	26.2	3.1	WSW
16/01/14	16:27	31.4	31.4	31.4	74	26.2	2.7	WSW
16/01/14	16:28	31.4	31.4	31.4	74	26.2	3.1	W
16/01/14	16:29	31.4	31.4	31.4	74	26.2	3.6	W
16/01/14	16:30	31.4	31.4	31.4	74	26.2	3.6	W
16/01/14	16:31	31.3	31.4	31.3	74	26.1	2.7	SSW
16/01/14	16:32	31.3	31.3	31.3	74	26.1	0.9	SW
16/01/14	16:33	31.3	31.3	31.3	75	26.4	1.8	W
16/01/14	16:34	31.3	31.3	31.3	75	26.4	3.1	SW
16/01/14	16:35	31.3	31.3	31.3	74	26.1	2.2	SW
16/01/14	16:36	31.3	31.3	31.3	75	26.4	2.2	W
16/01/14	16:37	31.3	31.3	31.3	74	26.1	1.8	W
16/01/14	16:38	31.3	31.3	31.3	74	26.1	3.6	W
16/01/14	16:39	31.3	31.3	31.3	74	26.1	4.9	WSW
16/01/14	16:40	31.3	31.3	31.3	74	26.1	3.6	WSW
16/01/14	16:41	31.2	31.3	31.2	74	26	2.7	WSW
16/01/14	16:42	31.2	31.2	31.2	74	26	3.1	WSW
16/01/14	16:43	31.2	31.2	31.2	74	26	3.6	WSW
16/01/14	16:44	31.1	31.2	31.1	75	26.2	4	WSW
16/01/14	16:45	31.1	31.1	31.1	75	26.1	1.8	W
16/01/14	16:46	31.1	31.1	31.1	75	26.1	4.5	WSW
16/01/14	16:47	31	31.1	31	75	26	4.5	WSW
16/01/14	16:48	30.9	31	30.9	75	26	3.6	WSW
16/01/14	16:49	30.9	30.9	30.9	75	26	4	WSW
16/01/14	16:50	30.9	30.9	30.9	75	25.9	2.2	WSW
16/01/14	16:51	30.9	30.9	30.9	75	25.9	4	W
16/01/14	16:52	30.8	30.8	30.8	76	26.1	4	WSW
16/01/14	16:53	30.8	30.8	30.8	76	26.1	5.8	W
16/01/14	16:54	30.7	30.8	30.7	76	26	4.5	W
16/01/14	16:55	30.7	30.7	30.7	76	25.9	4.9	WSW
16/01/14	16:56	30.6	30.7	30.6	76	25.9	4	WSW
16/01/	16:5	30.6	30.6	30.6	76	25.	4	SW

14	7					8		
16/01/14	16:58	30.6	30.6	30.6	76	25.8	5.4	W
16/01/14	16:59	30.5	30.6	30.5	76	25.8	5.4	W
16/01/14	17:00	30.4	30.5	30.4	77	26	4	WSW
16/01/14	17:01	30.4	30.4	30.4	77	25.9	2.2	SW
16/01/14	17:02	30.4	30.4	30.4	77	25.9	2.2	W
16/01/14	17:03	30.4	30.4	30.4	77	25.9	3.1	W
16/01/14	17:04	30.4	30.4	30.4	77	25.9	3.6	W
16/01/14	17:05	30.4	30.4	30.4	77	25.9	4.5	WSW
16/01/14	17:06	30.4	30.4	30.4	77	26	3.6	WSW
16/01/14	17:07	30.4	30.4	30.4	77	26	4	W
16/01/14	17:08	30.4	30.4	30.4	77	26	4	W
16/01/14	17:09	30.4	30.4	30.4	77	25.9	4	W

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