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# A review on Energy usage, Smart grid and Development

Musa Yahaya

College of Basic and Applied Science University of Ghana.

ABSTRACT

In the world, energy need is on the increase, the power produced ought to also increase in order to satisfy the needs of the users in their day to day activities. Nevertheless, because the number of consumers are increasing, and also because of the irregularity nature of the electric load, power demand may cause challenges to the electric utilities and system operators. High peak demands have a great probability to occur in many periods and may be a threat to the system functionality. To resolve this issue, the electric utility and system operators have two choices available: Increase the size and dimension of the network which is costly and requires time to implement. Utilize energy management in order to reduce the possibility of high peak demand during peak hours. Investment in electricity grids showed a strong increase of 6% in 2021, with advanced economies accelerating investment to support and enable the electrification of buildings, industry and transport and to accommodate variable renewables on the power system. Despite some recovery from the economic disruption caused by the Covid-19 pandemic, investment in smart grids need to more than double through to 2030 to get on track with the Net Zero Emissions by 2050 Scenario, especially in emerging market and developing economies. Investment in electricity grids needs to average around USD 600 billion annually through to 2030 to get on the Net Zero Scenario trajectory. This is almost double the current investment levels, at around USD 300 billion per year.
Keywords Energy usage, Smart grid and Development.

## Smart grid systems

Smart grids are electricity grids that use information and communication technologies (ICT) from the points of generation to customers in a smart way, as an integral part of the SG, since they can contribute to the balance, automatically, between generation, consumption and distribution [1,2,3,4]. To adjust the flow of electricity exchanged from suppliers to consumers, to improve flexible and reliable grids and to allow the integration of numerous components as RES, distributed micro-processor rooms and electricity storage units. Figure 1 shows the different components of the SG. Another key benefit of SG technology is that real-time, two-way communication permits faster recovery of power service after a blackout. Rotating power outages can cause a damaging domino effect that negatively impacts banking, communications, manufacturing, traffic and security [5,7,8,9]. The system uses digital sensors, smart metering techniques, and intelligent control systems equipped with analytical tools for automating, controlling and monitoring the bi-directional flow of electricity from power outlet to plug during the operation [10].

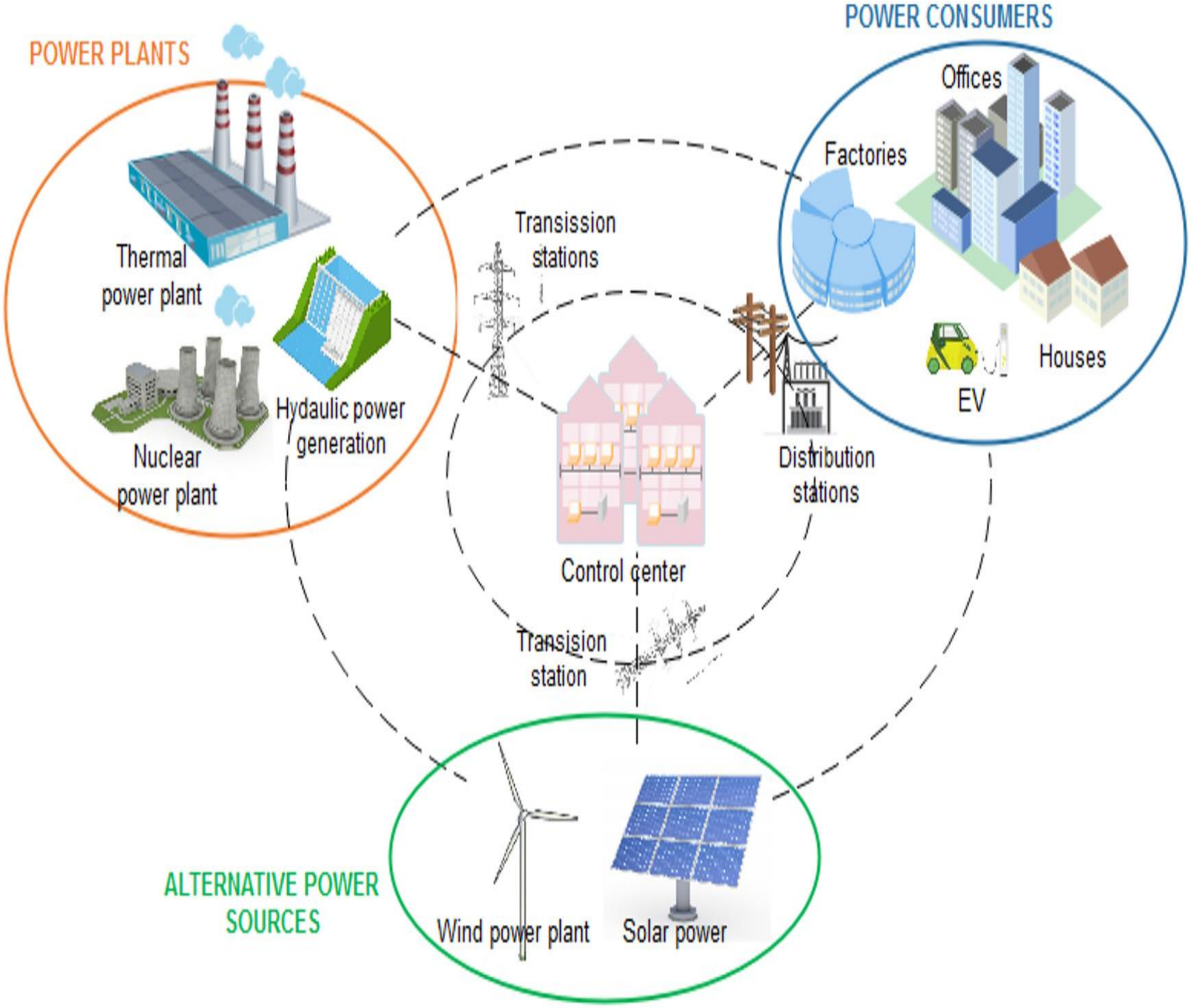
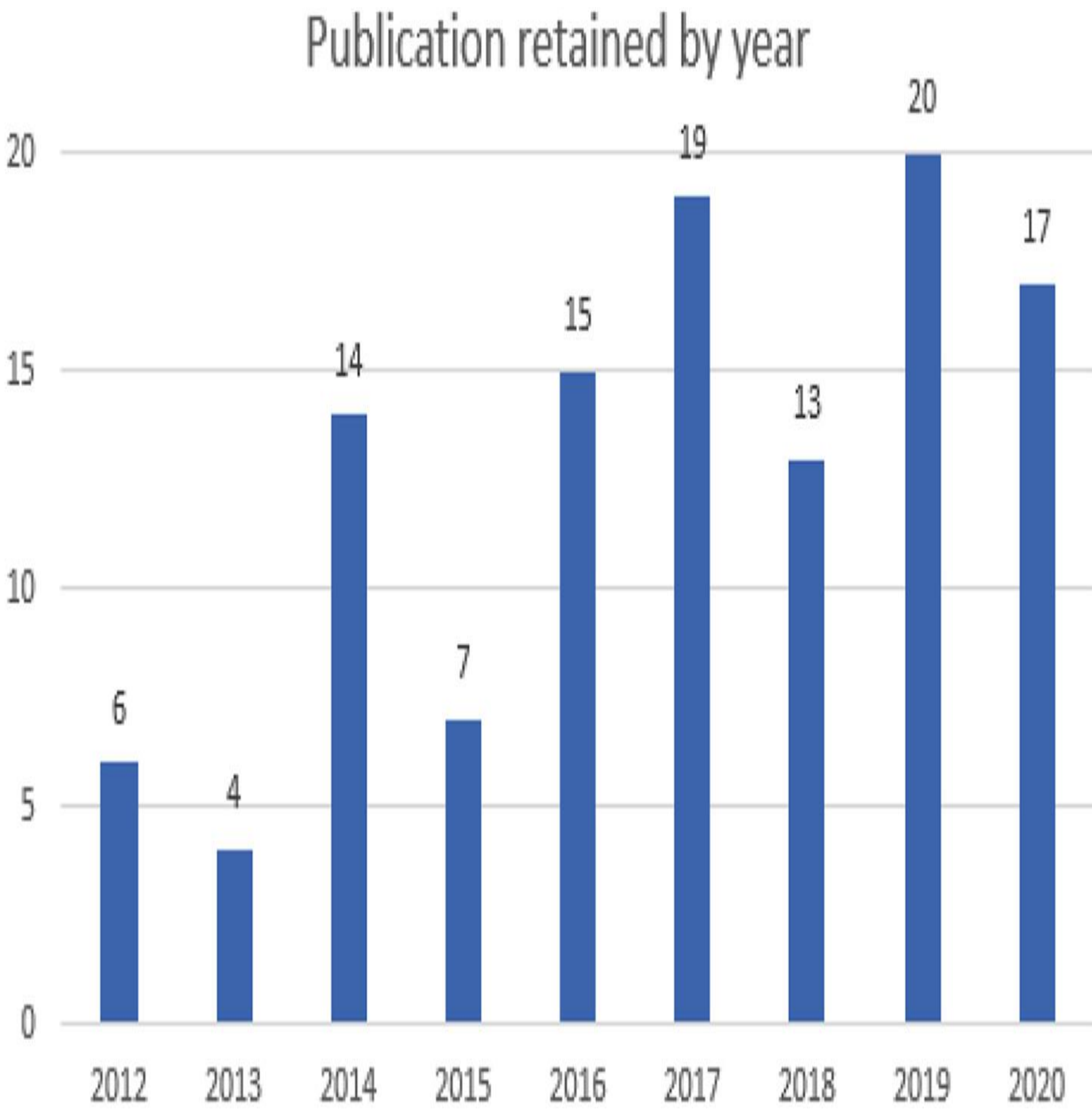



Figure 1; Energy management system

In 1960, the evolution of the Energy Management System (EMS) began as a control center and became known as the Energy Control Centre (ECC) in 1970. It was also renamed Supervisory Control and Data Acquisition (SCADA-EMS) when advanced computerized SCADA appeared in 1990, then it eventually developed to a system in real time called EMS that encompasses different techniques of control such as Demand Side Management (DSM), Load Control (LC), and Distribution Management System (DMS) [11,12,13]. The EMS's goal is to distribute the different energy sources optimally among consumers, while introducing sustainable energy supplies in a way that does not affect the reliable, safe and secure operation of the network. In addition, it is also able of monitoring, supervising, controlling and optimizing consumers, as well as transmitting, distributing and generating facilities [14,15,16,17,18]. This system is suitable for SCADA real-time applications, controlling, power dispatching, and programming, as well as transmitting safety management. EMS is getting more complex as the grid evolves with the integration of Plug-in Electric Vehicles (PEVs), Energy Storage System (ESS), RES, high energy buildings, and many other factors. Figure 2 illustrates the annual publication growth, marked by an increase in the rate of publications over the period from 2012 to 2020. We note that there is an upward trend in the number of publications, even if this number is more or less constant over some years, as well as an improvement and development toward a common programming of different modes of management and control aimed at improving the efficiency and quality of the network [3].



An EMS has many objectives: technical, economic, techno-economic, environmental, and social-economic. Most EMS research contributions focus on economic objectives. These objectives concern the total cost of operating energy, royalties, profit maximization for aggregators, and so forth. If economic objectives are set, technical aspects are also taken into account, because if we1 do not consider any of these technical constraints, the optimization of the EMS may give an optimal result in terms of economic performance, at the risk of causing a power outage, a power failure, or damage to appliances operating in a distribution network. The technical focuses of the EMS comprise energy quality, transformer degradation and equipment performance; and addressing them leads to better system performance, improved life expectancy, improved power quality, and reduced maintenance and down-time. However, uncoordinated integration of RES, PEV, and ESS can divert the system off its expected performance; e.g. charging and discharging PEV in an uncoordinated supply line can cause heat stress to the distribution system and transformer, while uncoordinated implementation of RES can produce problem in reactive power which causes deviations in voltage and other problems [8,9]. In another hand, the environmental objectives cover the reduction of greenhouse gas (GHG) emissions, where different modes of fossil fuel and renewable sources have been planned, in order to reach a lower carbon emission impact. Socioeconomic goals are regarded when social processes form the economic activity that comprises various programs where aggregators, agents, network operators and end-users are involved in order to reach better economical results [12].

Energy management field contains some interesting topics, which may be classified under the following categories: the intelligent transmission system, and the intelligent distribution system and the demand side. Energy management of transmission system central optimization remains an important approach. An EMS's centralized structure can be described as a central controller comprising a highly efficient computing system along with secure, dedicated network communication for managing energy use [6,7,8]. This controller can either be an aggregator or an utility, that gathers all information, like energy consumption pattern of the load/consumer, energy production of the DER, and so forth, of each node to run optimization programs toward achieving their goals, for an effective operation. In this area, contributions focus on how solar and wind energy could contribute to the large-scale use, and also on the potential of demand-responsive flexible loads (DR). As an example, for energy systems including large-scale wind energy, a new optimal planning method considering DR is proposed. This methodology allows the joint allocation of demand resources and energy so that fluctuations in wind energy loading and production can be limited. Moreover, a study was done on the effect of EVs and RES integration in SG. A binary version of the fireworks algorithm is used to efficiently engage and program thermal units and EVs and RES.

The integration of highly fluctuated distributed generations (such as PVs, wind turbines, electric vehicles, and energy storage systems) threatens the stability of the power and distribution systems. The main cause is that the power ratio between the supply and demand may not be balanced. An excess/shortage in the generation or consumption of power may perturb the network and create severe problems such as voltage drop/rise and in severe conditions, blackouts. To increase the balance between the supply and the demand in an efficient way, and to reduce the peak load during unexpected periods, energy management systems are utilized. Energy management can be divided into two main categories. The first one is on the side of the supplier such as electric utility, in which some generators are turned ON or OFF to follow the fluctuation of the load demand. The second category is on the consumer side and it is called demand-side management. In demand-side management, the consumers manage their energy consumption in order to meet the available power from the generation side. The main goal of using energy management is to reduce the cost of operation and consumption, reduce the energy losses and increase the reliability of the network. Energy management has many barriers and limitations. However, it has a prominent future in which most of the current research is focused on developing sophisticated algorithms and models to better manage the energy on the grid [9,10,11].

## Where is Energy Management Applicable

Energy management can be divided into two major categories. The first one is from the electricity supplier's viewpoint, while the second one is from the electricity consumer's viewpoint.

- The electricity supplier (such as electric utility, power plant operators and production units) can use the energy management to control its generation units in an efficient way. For example, to meet a certain power demand of the consumers, using energy management, the electric utility can turn on some generators, which may have the least operation cost, while the generators with high operation cost are left to supply extra load demand in specific peak periods. In this way, the electric utility is trying to minimize the operation cost of its generation units
- The system operator (such as transmission and distribution systems) can use energy management to regulate the power flow in a way to minimize the energy losses on the network and increase the penetration level of renewable energy sources (such as PV and wind farms) in an efficient way
- The end-users (such as householders, residential and commercial buildings, industries, faculties, etc.) use energy management to minimize their electricity bill and schedule their load demand in an efficient way.

## Electricity Tariff System

The main goal of applying energy management is to minimize the economic cost and losses. For this purpose, the management cannot be efficient without changing the electricity tariff system. In most of the countries, the traditional fixed tariff is mostly used, in which the tariff of a kWh is fixed in different hours of the day. A progressive tariff system is also common in many countries and regions in which the tariff of energy increases with the increase in consumption. The increase is decomposed into many slices and each slice is for certain energy consumption. For example, a tariff of 0.1$/kWh is for slice 1 (0-100kWh of energy consumption), 0.2$/kWh is for slice 2 (101-200kWh), etc. However, the traditional tariff system is not sufficient to improve energy management and reduce the electricity bill. For this reason, many sophisticated tariff systems of electricity are proposed such as Demand Response Programs (DRPs) in which the electricity tariff becomes variable in time. Moreover, the users are penalized if they consume more than a certain limit or rewarded if they respect a certain limit.

SMART GRID TECHNOLOGIES SGT AND ITS BASIC REQUIREMENT Technologies in the conventional grid are relatively outmoded when compared to developments experienced in locality like ICT. Smart grid concepts encompass a wide range of technologies [5] as in figure 4. The technology will operate in a duplex communication system, encouraging better efficiency. It has been reported as a win-win situation for stakeholders. Consumers will get involved in power management decisions with the aid of household devices which will also profit Utilities in the long run. Initial cost estimates are huge but with returns on better efficiency and improved billing systems alongside many other improvements.[6]. Wide Area Monitoring and Control WAMC is a reproving component of the smart grid that opens the door for energy consumers to become directly involved in monitoring and controlling energy use [14]. When these sensory device such as, phasor measurement units (PMU), accelerometers, infrared sensors, strain gauge and magnetic sensors, are connected in the Nigerian grid System, it can be monitored properly and this will help to allow the system to automatically adapt and respond to changing conditions within. This will also enable the distribution devices to become intelligent remote agents on communication networks thereby providing data collected through these sensors back to the operator at the control centers. The present technology on the conventional grid cannot monitor power flows throughout the distribution grid since measurements are only accessible at the distribution substations. Sensors and the smart metres located throughout the network will enable the collection of information [9]. Smart grid technology will enhance Real-time monitoring and display of utility components and performance, across interconnections and over large geographic areas. This will help system operators to understand and optimize power system components, behavior and performance. The Advanced system operation tools will help to avoid blackouts and facilitate the integration of variable renewable energy resources. Some monitoring and control technologies and advanced system analytics such as wide area situational awareness (WASA), wide-area monitoring systems (WAMS), and wide-area adaptive Protection, control and automation (WAAPCA) contributes to the generation of data to inform decision making, lessen wide area disturbances, and therefore improve transmission capacity and reliability [6]. Transmission and Enhancement Technology Most Equipment mostly found in PHCN substations include: switch gears, high rupturing capacity fuses (HRC), air-cored ring shielded reactors, lightening arresters, circuit breakers, power transformers, isolators, and bus bars, among other items, while the network components include power lines, cables, circuit breakers, switches, transformers, large size conductors, steel lattice towers, steel tubular poles, wooden poles, earthing equipment. In Nigeria the conventional grid, transmission power system, will become important to fully utilize the existing transmission facilities instead of raising new power plants and transmission lines that are expensive to implement and takes long construction time. The Flexible Alternating Current Transmission Systems (FACTS) and High voltage DC (HVDC) controllers' transmission technologies can be introduced into power systems to solve the above problems. FACTS make it achievable to control the voltage magnitude of a bus, active and reactive power flows through transmission line of a power system hence help to improve the control and transmission optimization. While HVDC is more efficient for long distance transmission, thus providing the platform for transmission of off-shore wind and solar farms to load centers. The smart grid allow for various concept and system that actually brings about it actualization. These concepts serve as the intelligent features of the grids and may integrate various technologies to help achieve the conclusive smartness [9]. With Line sensors used by Dynamic line rating (DLR), real time situations of the Network can also be monitored without the risk of causing overloads. [9] High-temperature superconductors (HTS) can remarkably reduce transmission losses and enable economical fault current limiting with higher performance, though there is a discussion over the market preparedness of the technology. Advance Metering Infrastructure Advanced metering infrastructure (AMI) technology is used in describing combination of a number of technologies which comprises of data management systems, smart meters that enable two-way flow of information, thereby providing consumers and utilities with data on electricity price and consumption, including the time and amount of electricity consumed. AMI will dispense a wide range of purpose which will include; distant consumer price signals, it has ability to collect, store and report customer energy consumption data for any required time intervals or near real time, it improved energy diagnostics from more detailed load profiles, it also has ability to identify location and the extent of outages remotely through a metering function that will sends a signal when the meter goes out and when power is reinstated, remote connection and disconnection, losses and theft detection, it has ability for a retail energy service provider to manage its revenues via more effective cash collection and debt management Technology Road Map on Smart Grids. International Energy Agency [2, 4, 8, 9]. Customer-Side System Customer-side systems, which are used to help manage electricity consumption at the industrial, service and residential level, these include energy management systems, energy storage devices, smart appliances and distributed generation. This part of the smart grid involves Energy efficiency gains and peak demand reduction which can be accelerated with in-home displays/ energy dashboards, smart appliances and local storage. The Demand response involves both manual customer response and automated customers, price-responsive appliances and all thermostats that are connected to an energy management system or controlled with a signal from the utility operator [1] Smart Meters A smart meter in a smart grid replaces analogue mechanical meters with digital ones that records usage in real time. Smart meters are like the advanced metering infrastructure meters that provides a communication path extending from generation plans to electrical outlets (smart sockets) and other smart grid-enabled devices. Through smart meters, the utility companies able to get ever increasing amounts of information on how customers are using electricity.

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