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SCADA integration in smart grid: A solar PV plant application

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***Abstract*— Supervisory control and data acquisition (SCADA) systems for a smart power grid presents many challenges in the integration process and the automation systems especially when it integrates renewable energy sources. In fact, SCADA empowers electricity consumers by authorizing them to manage their own demand of energy and control costs. It allows also the grid to be self-healing by responding automatically to power quality issues and power system faults. This paper highlights the difference between a conventional grid and a smart grid concept. Then, presents the integration of SCADA application in a power renewable energy system. Finally, this paper ends by an interpretation of the SCADA application a PV solar plant.**

***Keywords*—Smart grid, SCADA system, renewable energy, conventional grid, solar plant.**

I. *Introduction*

Faced with the depletion and dependence on fossil energy, renewable energy sources remains an inexhaustible energy, reliable, easy to use and especially respects nature and environment. Several researches have been developed to improve the integration of renewable energy sources in the smart grid system. The aim is to a develop opportunities for future investment and economic feasibility. However, despite its great advantages, renewable energy remains unreliable and very sensitive to meteorological fluctuations and load conditions. [1]

This paper focus, in section 1, on characteristics of a conventional grid versus a smart grid system. In section 2, it highlights the integration of renewable energy into a smart grid system and its different challenges. Next, in section 3, SCADA system and its role in a smart grid is presented. Later, in section 4, it highlights SCADA application in a solar PV plant and ends with final conclusion.

A. *Conventional grid*

All over the world, and since few years ago, the electricity delivery system has been operating the same way. In fact,

the conventional electric grid is a network that acts as a link for transmission, distribution and control of electric power from power producers to consumers. [2]

However, because of increase in power demand, complexity in power grid management, the existing power grid does not meet the needs of the twenty-first century. Therefore, there is an immediate need for the development of highly reliable, self-regulating, self-healing and efficient grid system.

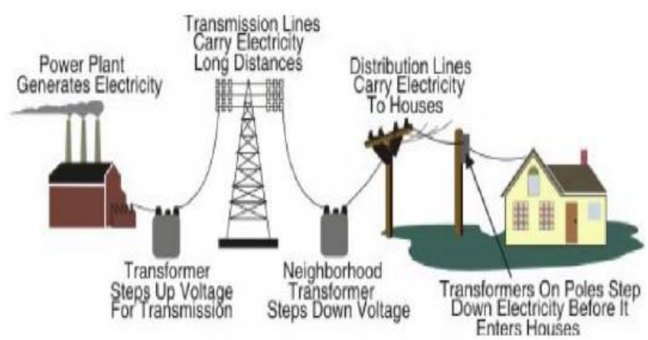

Fig. 1 Example of a conventional grid.

Obviously there is a far difference between the conventional grid and Smart Grid system. The conventional grid has a non-real time and a one way delivery technique. Technologically, it is based on analog or electromechanical signals and it has limited protection, monitoring and control systems which makes it a blind grid since it is not equipped with a self- monitoring system. All these factors can cause deregulations and increase failures of the grid especially during peak load hours. Moreover, when a failure accures, the grid doesn't have a self-healing ability, so a manual restoration have to be done. In addition, the grid predictability is low in a conventional grid since it is based on estimation and not prediction.

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B. *Smart grid*

The advent of the Smart Grid is the combination of a more demanding business environment and new technological possibilities. We can now build systems that would have been unaffordable only a few years ago.

The Smart Grids European Technology Platform has given a definition of Smart grid as “an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supply” [3]

Also, according to the US department of energy, a smart grid uses digital technology to improve reliability, security, and efficiency (both economic and energy) of the electrical system from large generation, through the delivery systems to electricity consumers and a growing number of distributed-generation and storage resources. [4]

The global energy consumption growth can be forecasted from 2007 to 2050 as shown in figure 2:

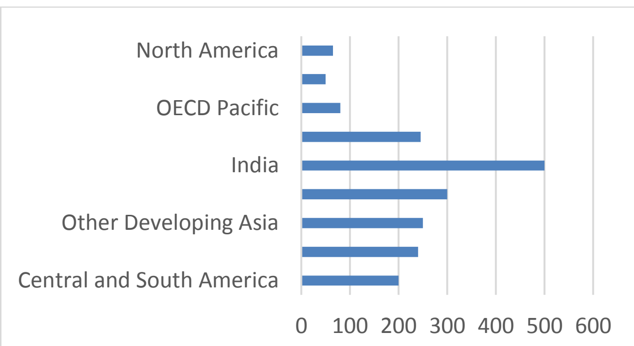

Fig.2 Global energy consumption forecast from 2007 to 2050. [5]

The Smart Grid infrastructure consists essentially on three levels. The first level is made up of sensors and advanced electrical equipments. The median level consists on communication networks and an integration platform. And the higher level brings together the applications and analytical systems required for data presentation and decision-making. It is therefore said that the Smart Grid differs from the traditional network because it is instrumented, interconnected and communicative.

Once in place, this infrastructure is going to justify new initiatives that cannot be otherwise such as an acceleration of projects related to tele-driving, remote maintenance and advanced telemetry aiming to realize additional operational costs. The realization of these initiatives is largely based on increasingly complex computer systems.

In addition, realizing the benefits of the Smart Grid relies heavily on the integration of data from its various sources, and not confined information as in a more traditional network. This integration is also pushed to the customer, who, for the first time, can receive real-time indications of his consumption and the cost of energy, thus allowing certain energy appliances to be monitored in response to events in the electricity grid or electricity markets. This integration is also reflected in the business processes and functions that use the Smart Grid, including between companies or divisions. The advent of the Smart Grid therefore leads to a profound transformation of the operational and economic models of companies in this sector. The implementation of an open and standardized architecture is also essential to integrate industry advances and accelerate the deployment of the Smart Grid at the lowest cost.

A practical smart grid requires five main parameters: Technologies, standards, rates and policies, awareness and education, cyber-security and privacy. In fact, the electric power industry provides the platform and the context and

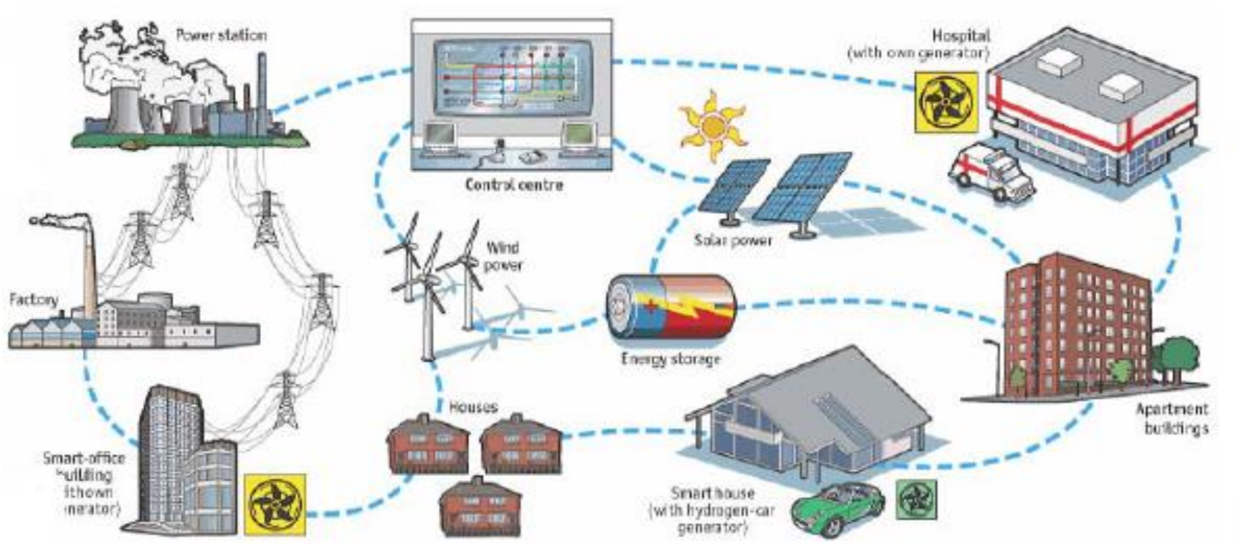

Fig.3 Example of a future smart grid system

requires new generation of engineers who are versatile in different disciplines. And telecommunication, IT and computer industries provide the technology and software to interface with the electric power network.

II. INTEGRATION OF RENEWABLE ENERGY IN SMART GRID

Renewable energy has different types and is so versatile. It regroups biomass, geothermal, sun oriented, wind and more others. Renewable energy sources can be used independently as standalone or islanded (system isolated) power generation. , However their advantages are significantly upgraded when they are coordinated into broader electric power networks.

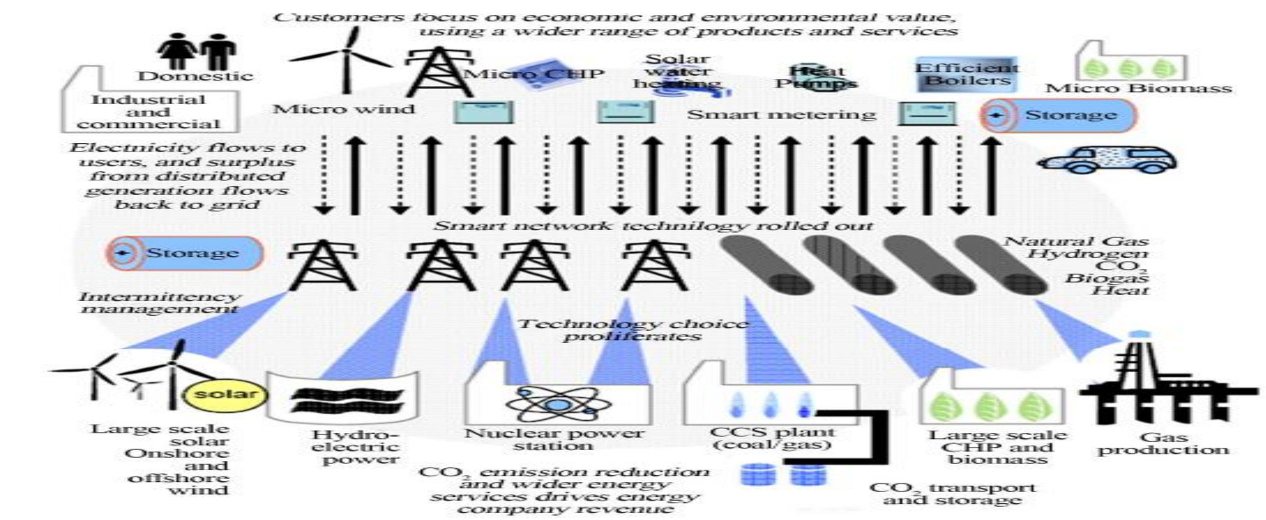

Fig. 4 Impact of renewable energy interactions with smart grid system. [7]

With more prominent utilization of smart grid technologies, higher degrees and rates of infiltration can be obliged. Every source is different regarding the grid perspective and some are simpler to coordinate than others.
Expanding renewable energy sources is a basic segment in developing renewable energies worldwide. Such development is in fact possible, however is going to require upgrades of the grid system and new creative solutions to follow the distinctive expansion of renewable energy sources. [6]
The national grid of USA has proposed a scenario model on the impact of renewable energy interactions with smart grid. [7]

Solar energy is an intermittent resource. It means that the availability of the resource varies without control since sunlight is only available during daylight hours. Solar energy can be viewed as an aggregate resource from the point of view of a power grid, with levels that vary within a 10 minute to 1 hour time frame.

Solar forecasting is already in use by utilities that have large PV plants, but because most solar power variation is due to visible clouds, satellite imagery can be used in addition to traditional weather prediction methods.
However, forecasting has not yet been applied commercially to distributed PV because its penetrations are typically low, but there will be value in forecasting distributed PV power if penetrations become higher.

III. SCADA SYSTEM IN SMART GRID

The supervisory control and data acquisition system (SCADA), is an automation computer based system that can assure control, monitoring and additional automation functions. The main objective is to support the engineering plan by providing power data system without affecting the normal operation of the workstation. SCADA system is not only used in electric systems but also in other diverse systems such as natural gas pipelines and energy grids. SCADA system also informs the operator or the management level on the current functioning state of equipment and process.
The communication network must be reliable, and must meet international standards in the industrial control systems.
Communication within a local network should make it possible to collect information from various devices such as frequency, starters, digital relays, chargers, inverters, etc.
SCADA system is composed of three network levels: control network, information network and communication network.

First, the information network should be able to assure following functions:

- Connect the processing system and the pilot position.
- Connect to host computers for multiple users.
- Transfer a large amount of data.
- Use standard network management and diagnostic tools.

Then, the control network shall permit the following operations:

- Allow real-time operation.
- Be deterministic and repeatable.
- Accept all messages as equal.
- Connect PLCs, computers, man-machine interfacing devices.
- Electronic devices, I / O, etc.
- Allow programming and configuration.

Finally, the communication network must:

- Have high-speed transfer of critical data over time between devices and I / O controllers.
- Send deterministic and repeatable data.
- Have a maintenance program.
- Use redundant media.
- Have intrinsic safety.
- Integrate into a redundant automation architecture.

The figure 5 illustrates a typical control SCADA system architecture.
The software chosen for any SCADA system application including its environment is a supervisory that:

- Is interactive and easy-to-use software.
- Assure development and implementation of integrated operators reproducing the functions of control and visualization of dynamic variables.
- Assure interoperability with other software installations.
- Include modification of automation programs over the entire network.
- Monitor the evolution of online programs without interrupting other programs.
- Supervise, control and assure maintenance of network equipment.
- Edit alarm log files for example.

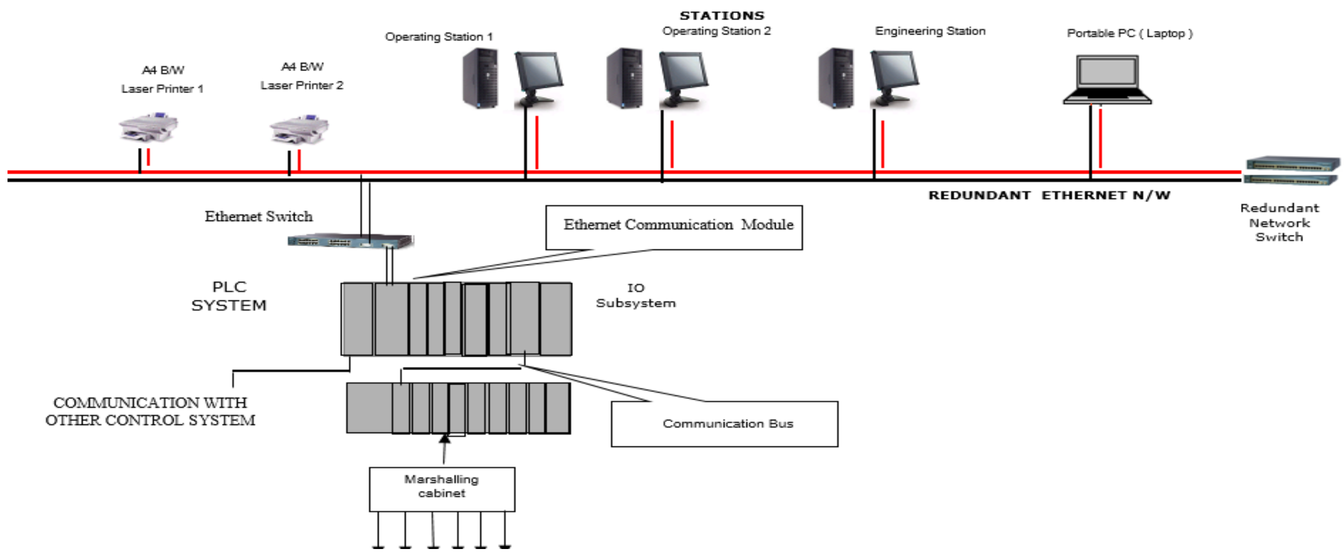

Fig. 5 A typical control SCADA system architecture

IV. SCADA APPLICATION IN A PV SOLAR PLANT

When contemplating the use of a solar electric photovoltaic system, it is important to assess how much energy in theory the system can produce according to location, orientation and plant conversion efficiency. Using a performance monitoring system is an absolute necessity for being able to represent the energy delivered by a system continuously, and to guarantee the efficient forecast conversion throughout all its life service.

Most electric utilities in the U.S. have adopted standard criteria and guidelines for interconnection of distributed generation (DG) into their electric distribution systems. During minimum loading conditions, sunlight based PV installations viably diminish the consumer load and may even export energy back to the utility grid.

Due to this requirement, an industrial supervisory control and data acquisition (SCADA) environment has been developed. In fact, PV designers could oversee information streams for few thousand measures every second and to

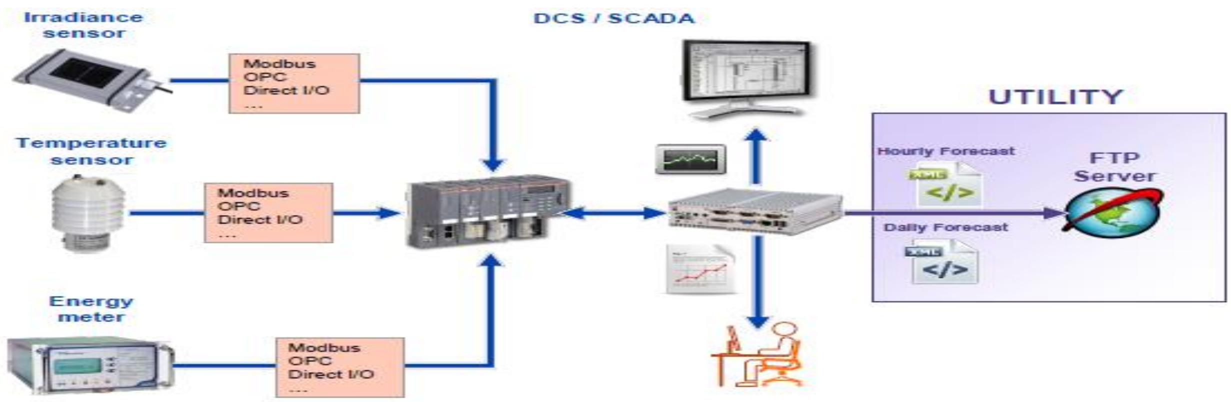

Fig. 6 An example of SCADA solar power automation

proof the efficiency system, they have accomplished many system tests in order to meet PV application requirements. SCADA system gave flexibility in monitoring and controlling the different plant part and operations, including trackers, meters and inverters. The system has demonstrated being able of overseeing enormous PV plants, and additionally some bigger multi-tenant and multi-site systems.

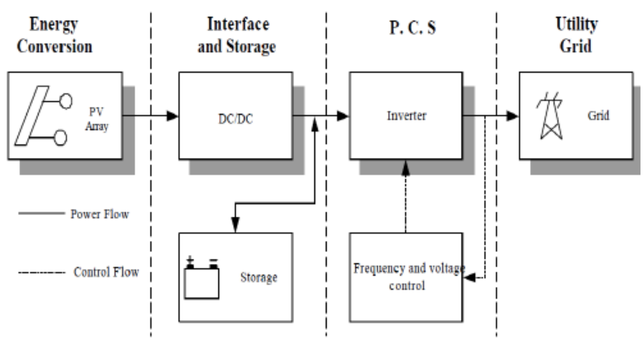

Fig.7 A typical PV utility grid interconnection

Additionally, the SCADA application enables dynamic configuration, stand-alone and client-server configurations, redundancy for data protection, and historical and real-time trends analysis, as well as advanced alarm management. Looking further at compliance, the support of such protocols as IEC 61850 and DNP3 are considered an asset if you have to communicate with various electric substation devices, for example. [8]

Figure 8 shows a program execution in SCADA for process control.

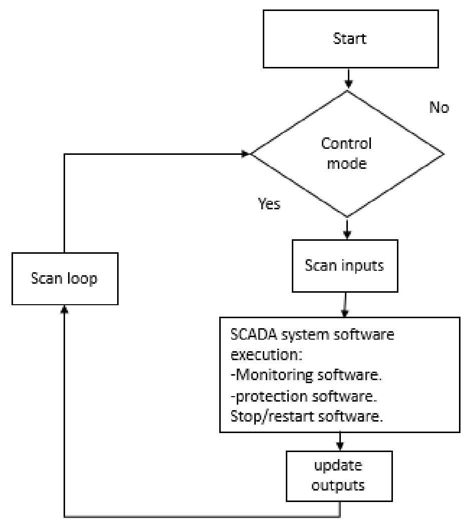

Fig. 8 A typical SCADA execution program

SCADA system for solar plant implementation can assure following functions:

- Uses historical data for training and real time plant data to improve the forecasts accuracy.
- Makes use of weather forecasts in the area where the plants are located.
- Hourly values for a horizon of 6 hours.
- Daily values for a horizon of 7 days.

V. CONCLUSION

SCADA is a platform used to administrate industrial networking for supervising different electrical grid parameters. System normal operation and reliability can be closely controlled thanks to the control of these parameters. In addition, SCADA information and communication system assure more coordination, more protection and security making the electrical grid much more efficient and operative. The main aim is to make the progress toward the modernization and growth of the electric utility more significant.

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