Chapter 8: SCADA and Smart Energy Grid Control Automation

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01/08/2020

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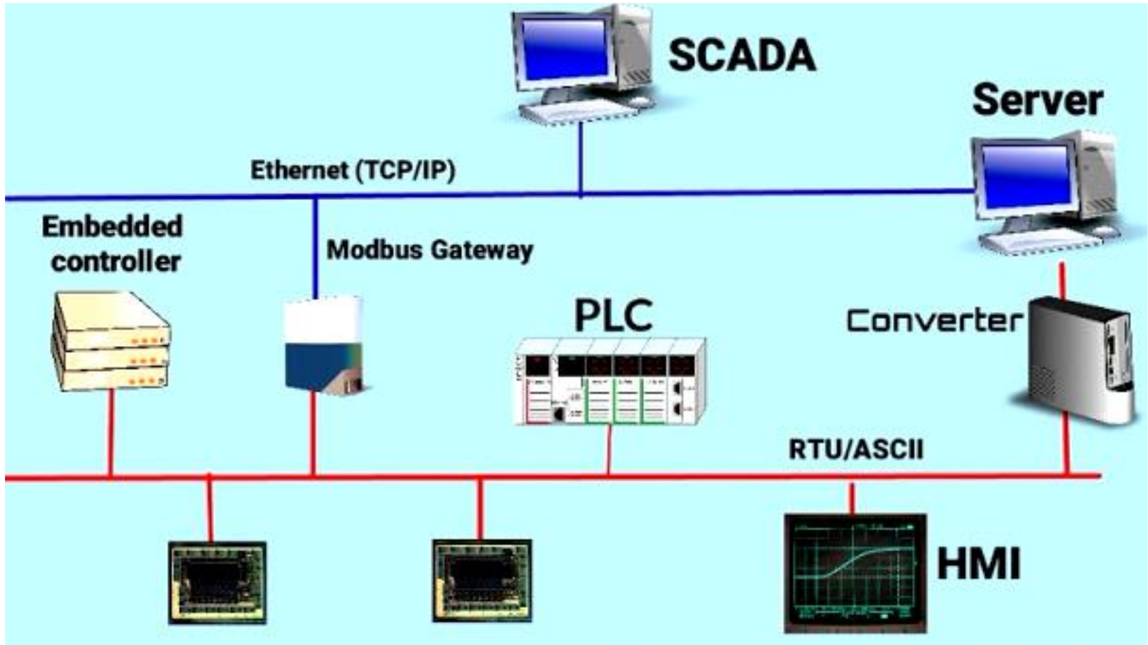
Course material developed in collaboration with Technical University of Sofia, University of Western Macedonia, International Hellenic University, University of Cyprus, Public Power Corporation S.A., K3Y Ltd and Software Company EOOD

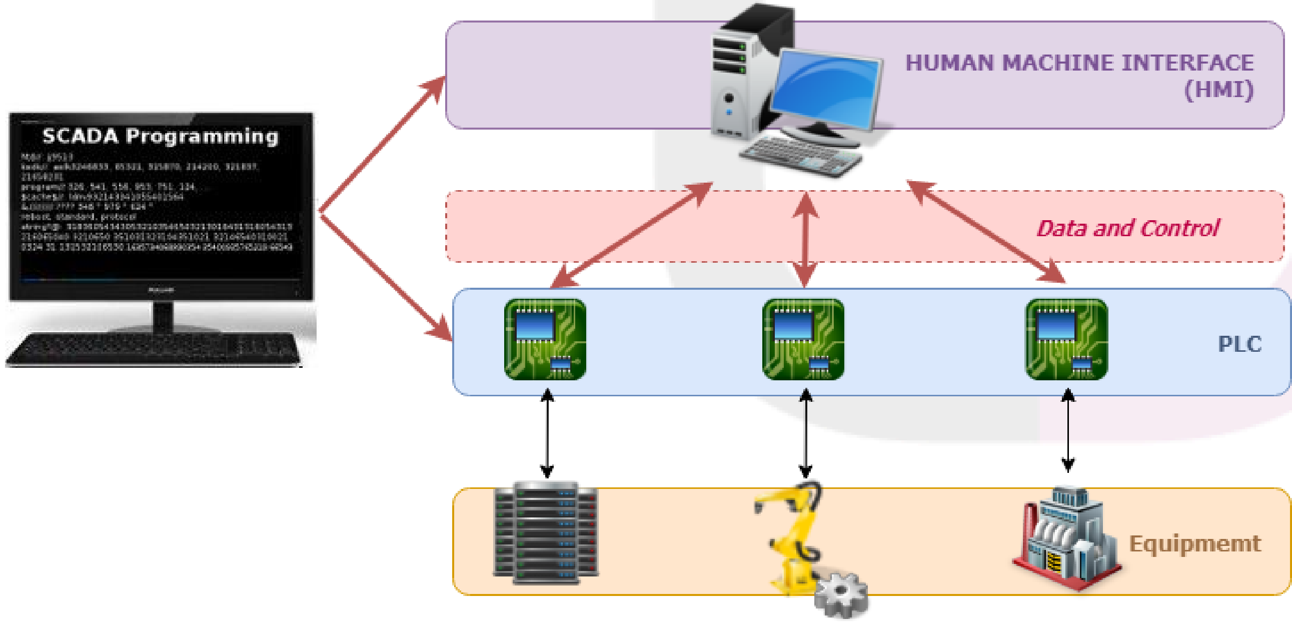
with support from Erasmus +

Content of the lecture

8.1 Introduction

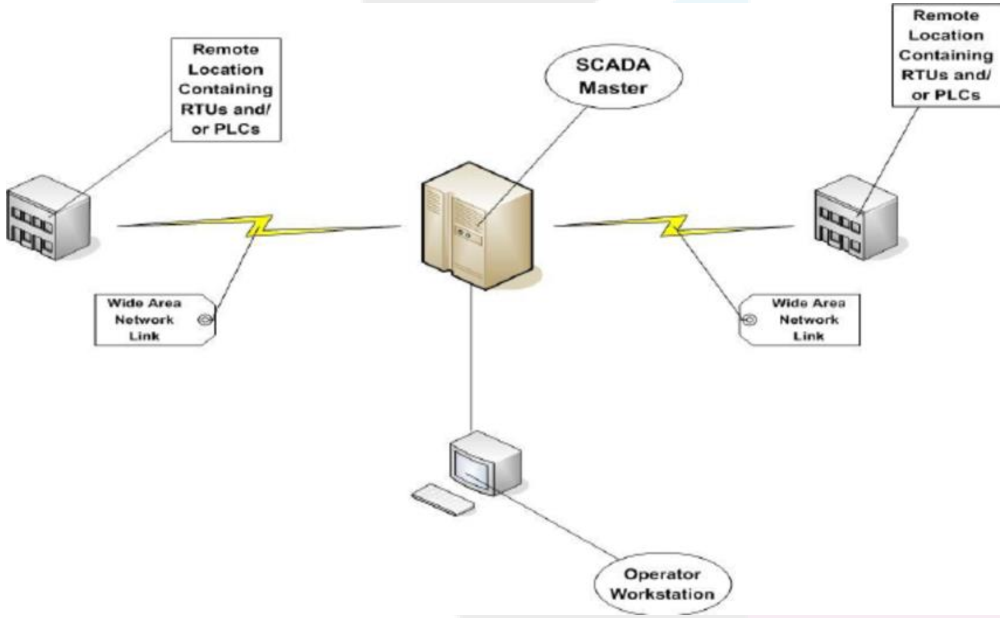
- In this chapter, the SCADA and smart grid are explained to discuss the efficacy and challenges in the integration process.
- The challenges for secure smart grid and automation systems will be discussed.





8.1 Introduction

- Control systems are computer-based systems used within many critical infrastructures and industries (e.g.; electric grid, natural gas, water, and wastewater industries) to monitor and control sensitive process. To deploy the smart grid system, there is a trend toward interconnecting SCADA with data networks.
- Control systems collect field measurement and operational data from the field stations, process and display this information. The relay control commands to local or remote outstations are issued from the control center. Control systems may perform additional control functions such as operating switches and circuit breakers and adjusting valves *to regulate the fuel flow.*



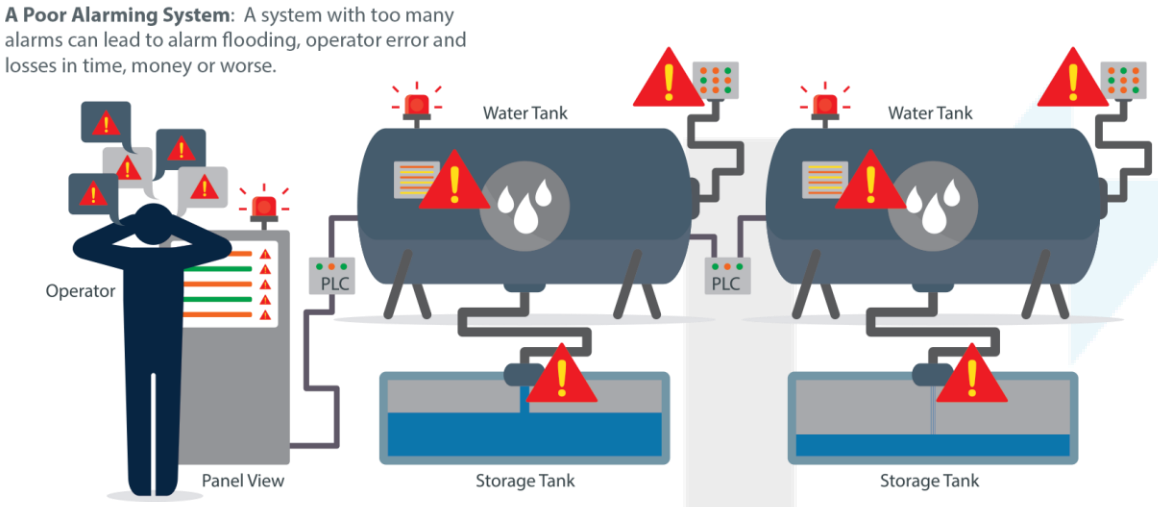
8.1 Introduction

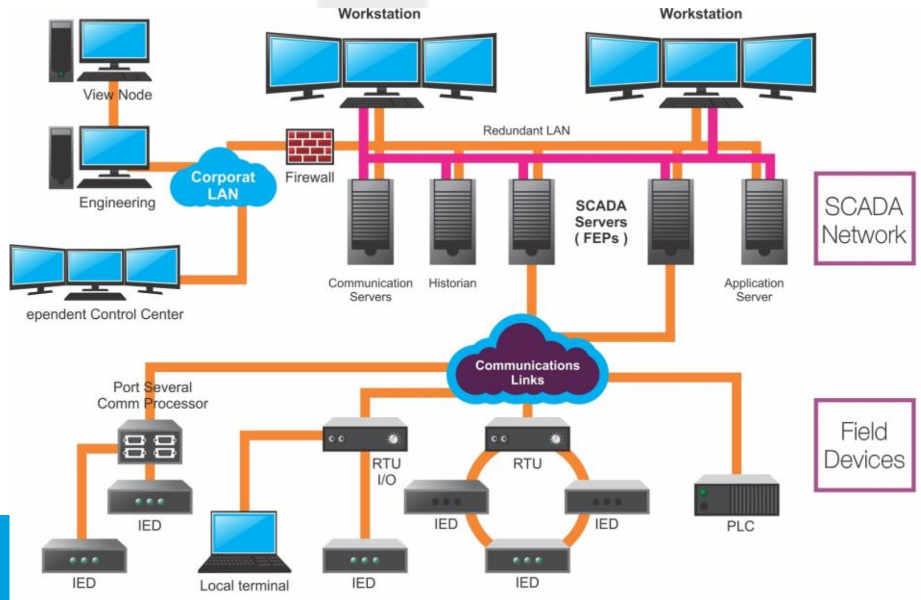
- Control systems have been implemented since the 1930s; there are two primary types of control systems: distributed control systems (DCS) and SCADA (Supervisory Control And Data Acquisition) systems.
- Typically, DCS systems are used within a single processing or generating plant or over a small geographic area [2-7]. SCADA systems usually are used for large, geographically extended electricity distribution or generation operations.
- For example, a utility company may use a DCS to generate power and a SCADA system to distribute it. But nowadays SCADA is applicable in large scales renewable energy systems such as the wind and solar farms.
- We will concentrate on SCADA systems for renewable energy, and our discussion is generally applicable to DCS systems. The resulting computer-aided control center is called the renewable energy management system (EMS).

8.1 Introduction

- A smart grid SCADA system’s main function is:

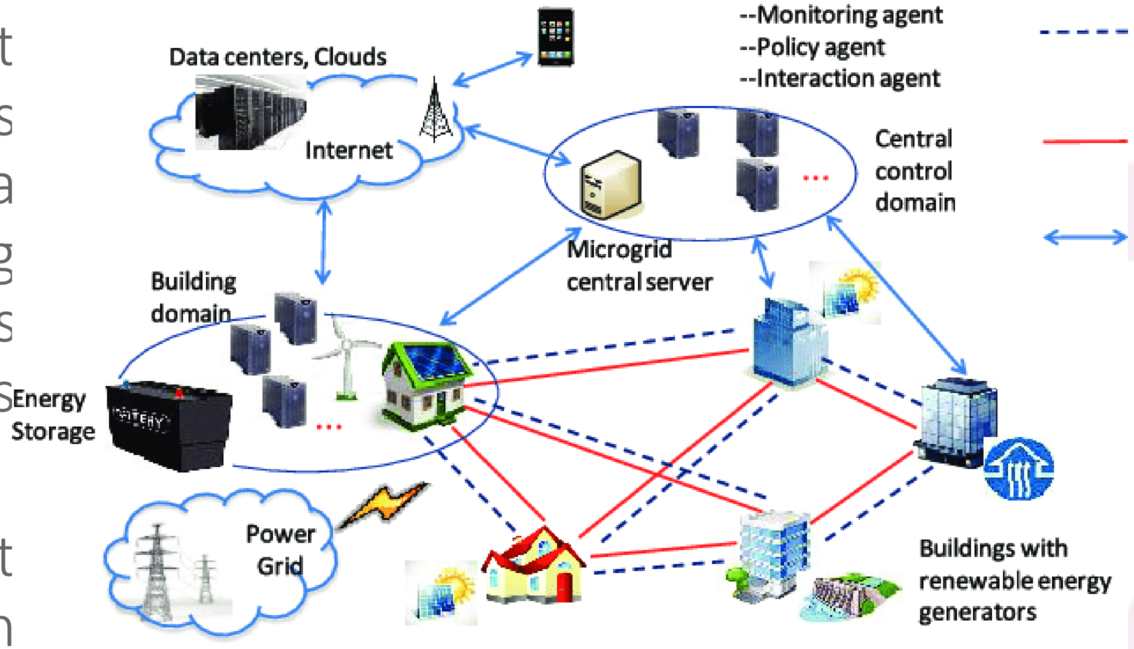
1. assisting of distributed generation operations,
2. alarming,
3. telemetry,
4. event logging recording,
5. remote control of outstation field equipment





8.1 Introduction

- A modern SCADA system must be able to support the engineering planning and budgeting functions by providing access to power system data without an operational workstation. The evolving changes in recent power system operational needs demand a distributed control center that is ***decentralized, flexible, integrated, and opened***.
- Present-day control centers are moving in that direction with varying degrees of success [2-7. In the internet age, the trend in information and communication technologies is moving toward microgrid and grid computing and web services, or microgrid services.



Microgrid networking

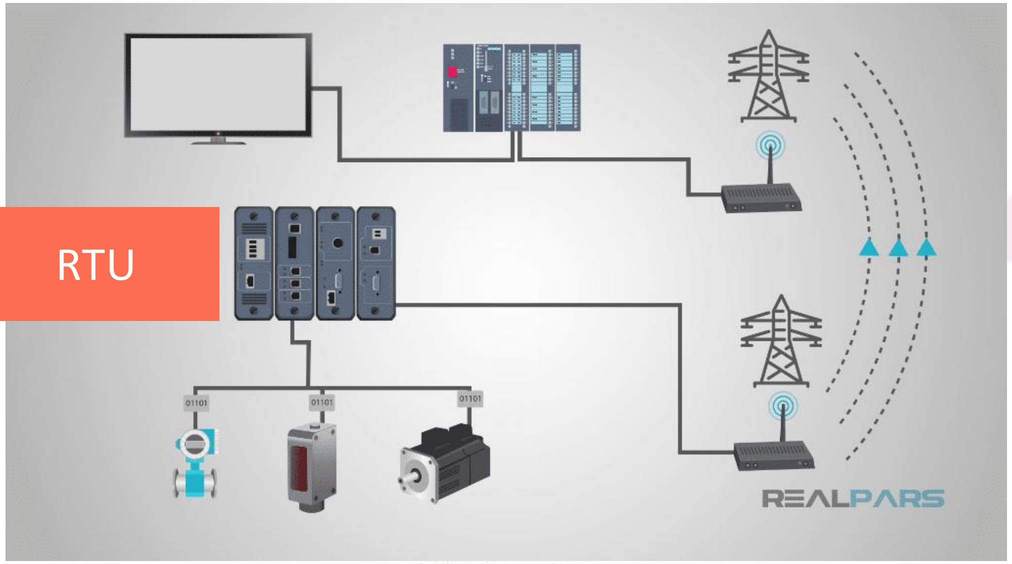
8.1 Introduction

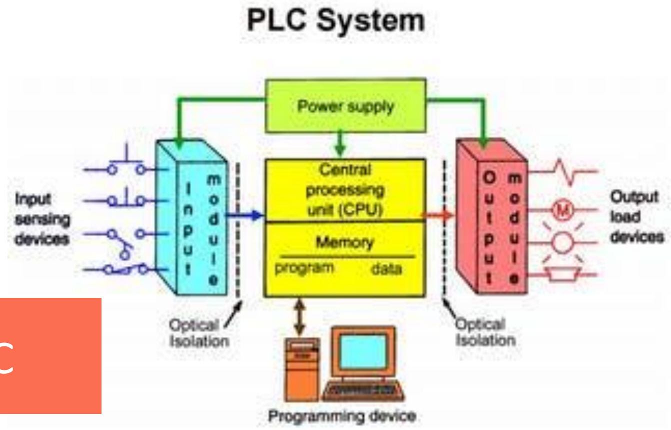
- Renewable energy systems have gained tremendous popularity nowadays because of the need to cut CO_2 emissions and the rising costs of fossil fuel sources. Renewable energy forms a major source of energy in distributed generation systems; their energy can be integrated into the existing power grid or it can be used for domestic microgrid consumption.
- Even though renewable sources are in abundance and are inexhaustible, they are *intermittent* because of variations in the weather conditions, thereby jeopardizing the chances of relying on them as the only source of energy.

8.1 Introduction

- SCADA systems are actually Process Control Systems (PCS) that are used for gathering, monitoring, and analyzing real-time environmental data from a simple residential building or a complex large scale PV or wind far power plant.
- PCSs are designed for microgrid automation or power distribution systems based on a predetermined set of data and conditions, such as generated/consumed energy or power grid management.
- Some PCSs consist of one or more remote terminal units (RTUs) and/or Programmable Logic Controllers (PLC) connected to any number of actuators and sensors, which relay data to a master data collective device for analysis.

RTU





PLC

8.1 Introduction

SCADA systems are composed of the following components:

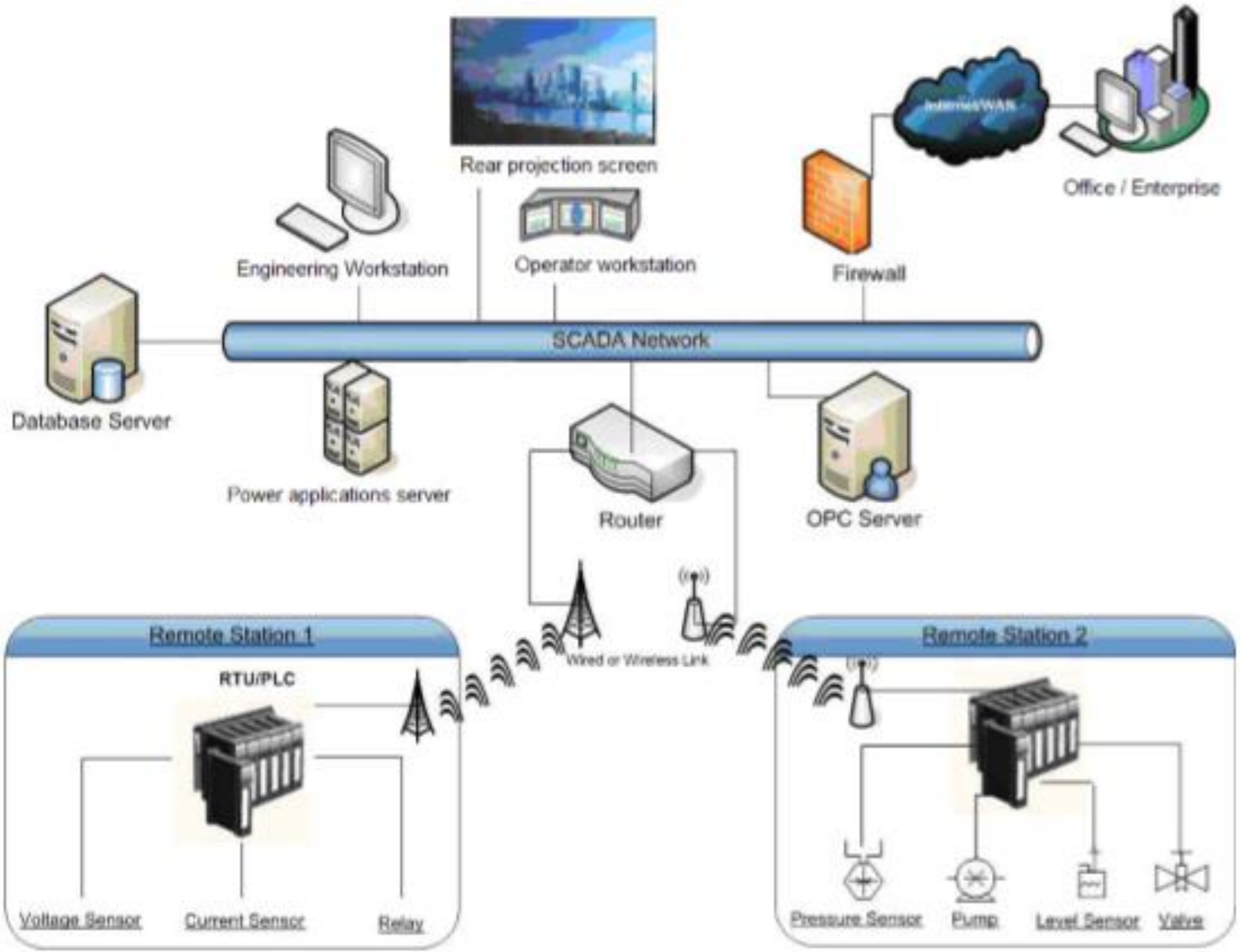
1. **Outstations hardware:** state of charge (SOC), Current transformer CT, Voltage transformer VT, fuel valves, conveyors, and Circuit breakers CB that can be controlled locally or remotely.

2. **Local substations processors:** which collect data from the site's instruments and hardware equipment. This includes the Remote Terminal Unit (RTU), Programmable Logic Controller (PLC). Intelligent Electronic Device (IED) such as digital relays and digital meters. The local processor will be responsible for dozens of analog and digital inputs/outputs from IEDs and switchgear equipment.

3. **Digital Instrument:** It is usually installed in the field or in a facility that sense conditions such as current, voltage, irradiance, temperature, pressure, wind speed, and flow rate.

4. **Communications devices:** (short-range or long-range) The short-range communications are installed between local RTUs, instruments, and operating equipment. These are relatively short distance cables or wireless connections carry digital and analog signals using electrical properties such as voltage and current or using other settled industrial communications protocols. The Long-range communications are installed between local processors RTU/PLC and host serves. This communication typically are using methods such as leased telephone lines, microwave, satellite, frame relay network, and cellular packet data.

5. **Host computers/servers:** Host computers, like Data acquisition server DAC, engineering/operation workstations. It acts as the central point of monitoring and control. They will be in the control room or master station. The operation workstation is where an engineer or operator can supervise the process, as well as receive system alarms, review data, and exercise remote control.



.1 Introduction

A SCADA system network

High-level overview of SCADA architecture, where the Remote Stations might be an Electric Substation, the SCADA network on one network segment, with another organization network on differing network segments

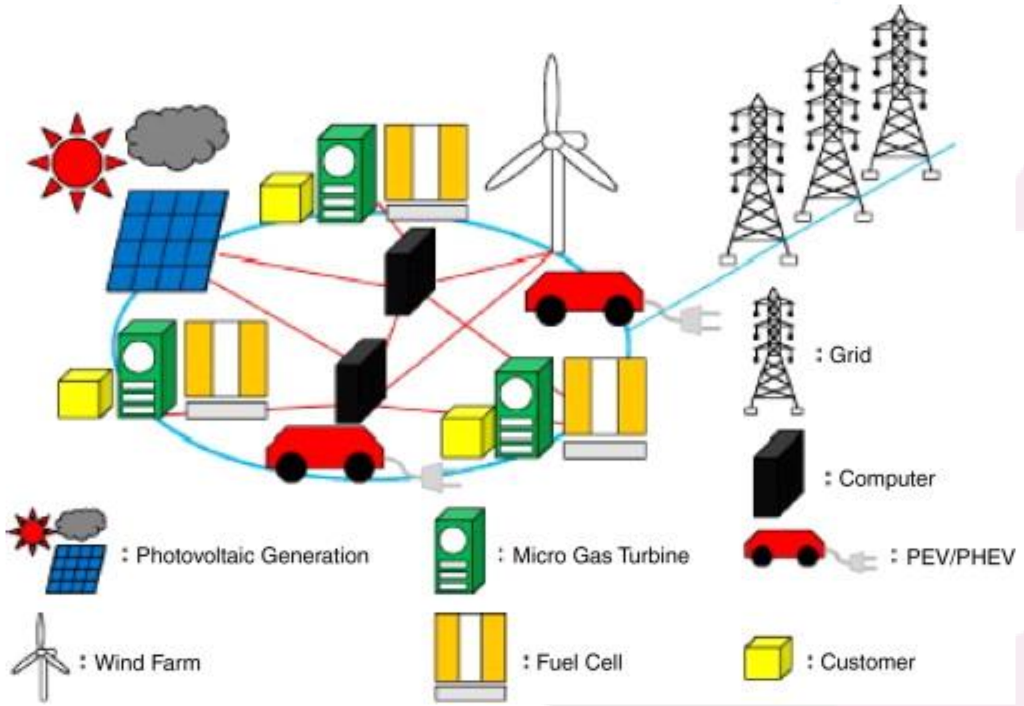
8.2 The Smart-Grid concept

- The Smart Grid framework is composed of and concerned with distributed intelligence including data decentralization, renewable distributed generation (and energy storage), and distribution system automation.
- It regards customer partnership and interaction, micro-grids, and high-demand electric devices.
- The Smart Grid is by definition about real-time data monitoring and active microgrid management via rapid two-way digital communications through the implementation of technological solutions to the power delivery infrastructure.

Renewable energy and storage

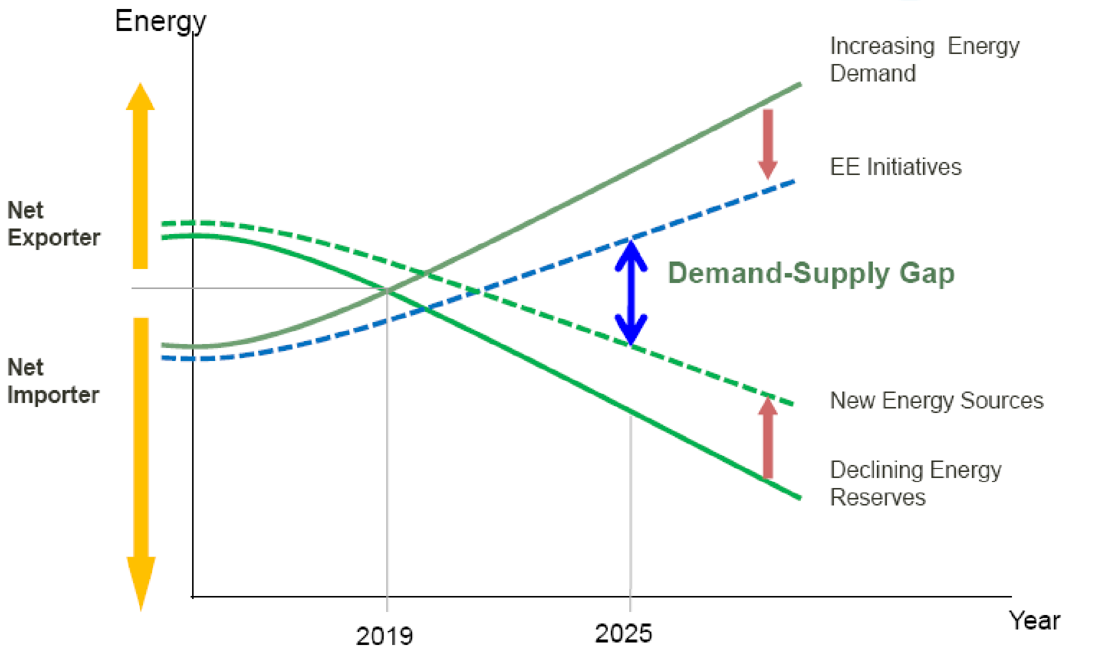
8.2 The Smart-Grid concept

- Microgrids and the electric utility, renewable power generating devices, consumer loads devices, and third-party entities either as consumers, vendors, or regulatory organizations are all interconnected.
- Smart Grid comprise an intelligent monitoring system that observes the flow of electrical energy throughout the power network and incorporates the use of cables or transmission lines to manage power fluctuations, losses, and co-generation integration from solar, fuel cell and the wind.



8.2 The Smart-Grid concept

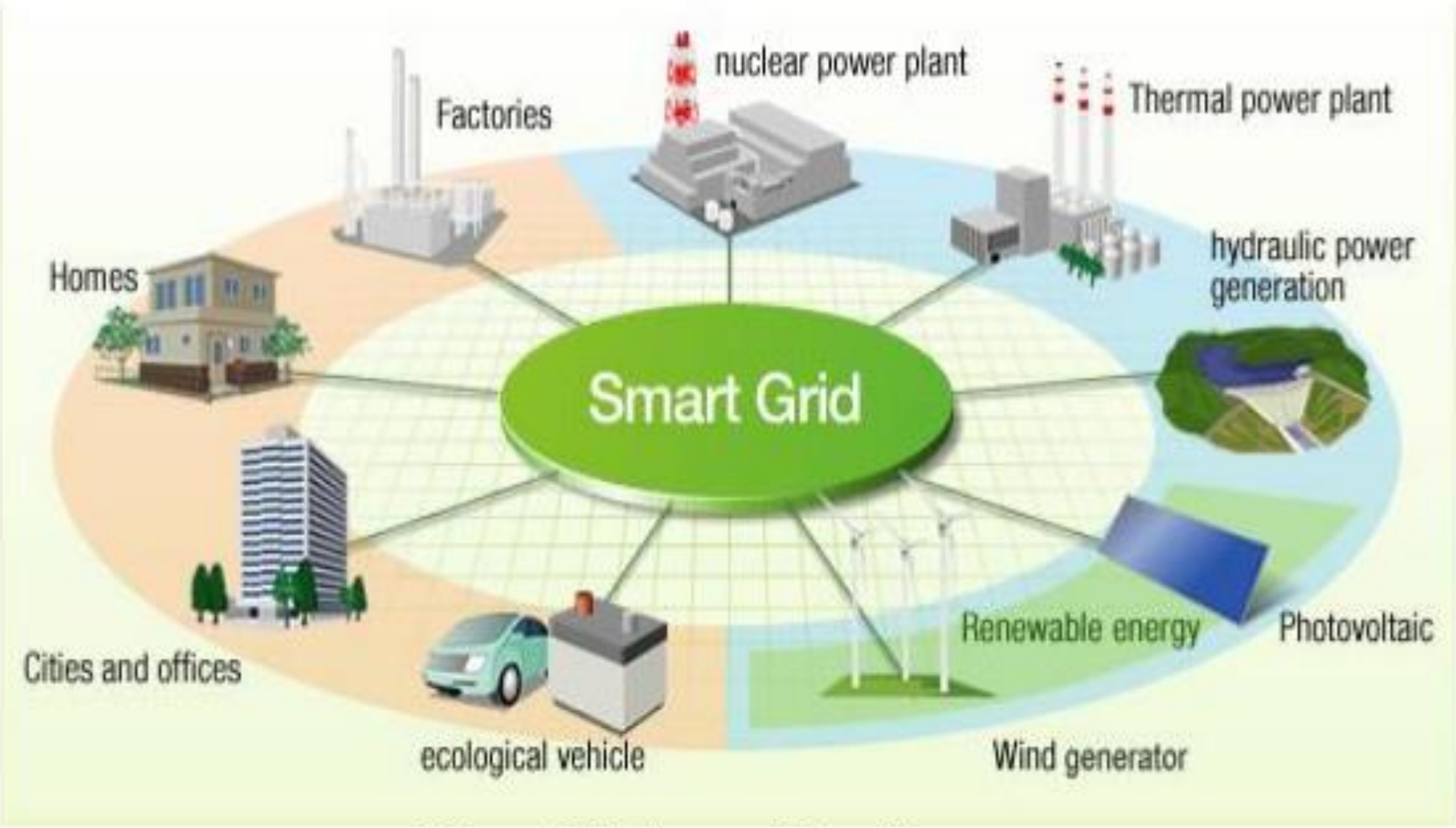
- Generally, the most effective Smart Grid can monitor/control residential home devices that are non-critical during peak power consumption times to reduce power demand, and restore their function during non-peak hours.
- Proposals for optimization include smart microgrids, smart power grid, and intelligent grid.
- In addition to minimizing electric demand, the management of power consumption peaks can help avoid brown-outs and black-outs when power demand exceeds supply, and help maintain critical loads and devices under such conditions.



- Energy demand is projected to increase from 2,000 PJ in 2009 to 4,013 PJ in 2030
- Average rate of 3.6% p.a.

Energy-demand supply balance

8.2 The Smart-Grid concept



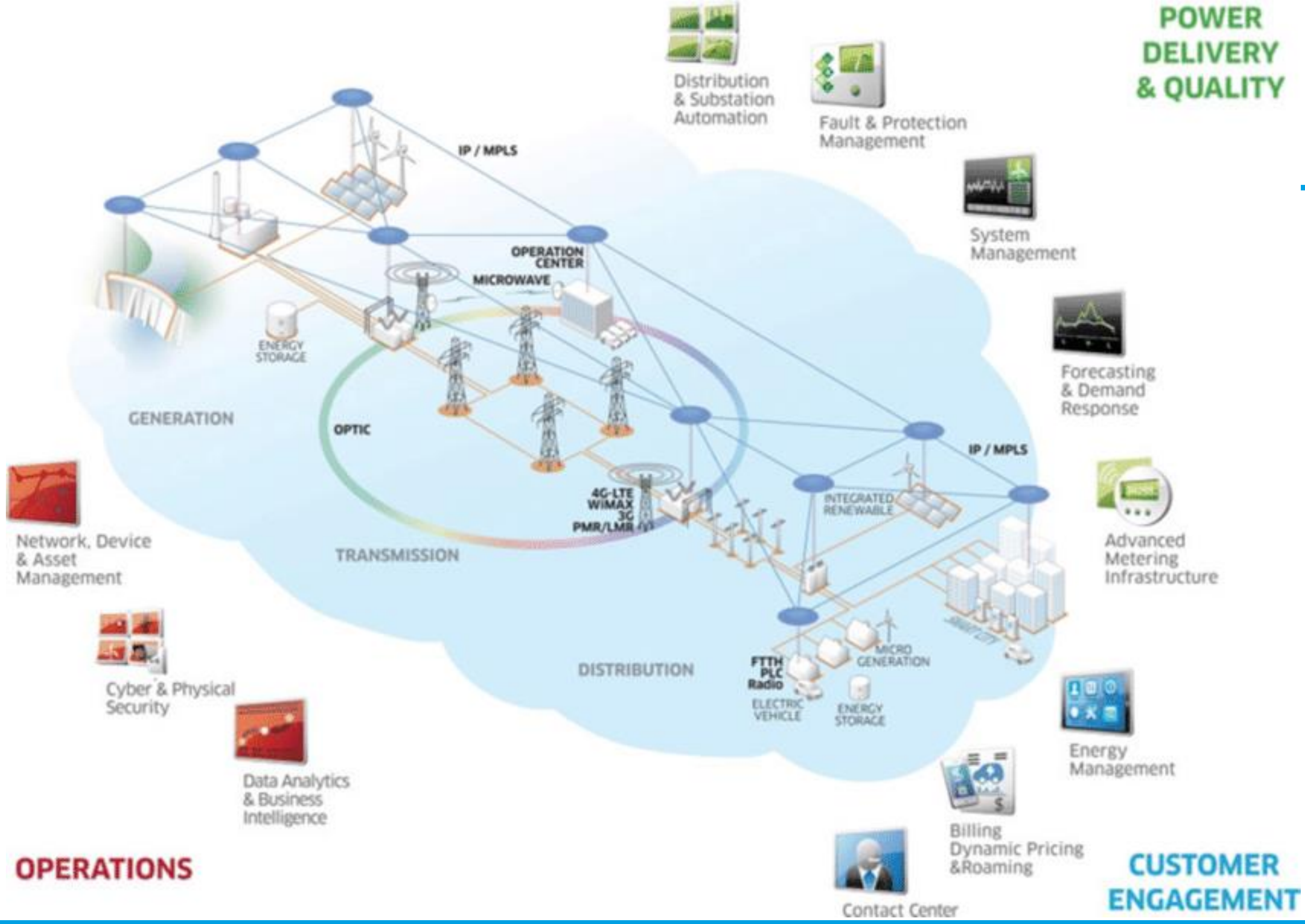
The Smart Grid architecture

8.3 Smart Grid / SCADA Integration

- Incorporating SCADA into the Smart Grid is challenging. SCADA can be connected by electrical, communications and data networks. It allows for distributed and central aggregation of information and control over the entire electrical utility network.
- SCADA helps the electricity consumer by interconnecting energy management systems to enable the customer to manage their own demand of energy and control costs.
- In addition, SCADA allows the grid to be self-healing by automatically responding to power quality issues, power outages, and power system faults. SCADA optimizes the grid assets by monitoring and optimizing those assets while minimizing operations and maintenance costs. The Smart Grid, intelligence and control need to exist along the entire power supply chain. This includes the electricity generation and transmission from beginning to delivery end-points at the customer's side and includes both fixed and mobile devices in the SG architecture.

8.3 Smart Grid / SCADA Integration

SCADA/Smart Grid Integration



8.4 SCADA Applications in Power System

- SCADA system is used in a power system to collect, analyze and observe the power system data effectively.
- The power system is associated with power generation, transmission, distribution, and renewable energy. Monitor and control are the main issues in all these areas.
- Thus, SCADA improves the overall efficiency of the system, by saving costs and time. This can be achieved by an optimizing operation, loss minimization, supervising and controlling the generation and transmission systems.
- SCADA function in the power system network provides greater system reliability and stability for integrated grid operation. The power system automation system offers contingency based fast Load Shedding, Power Control and SCADA functionality for the electrical system.

8.4 SCADA Applications in Power System

- These applications may be supplied by different vendors and applications such as:
  - Generation/Transmission/Distribution Monitoring and Control System
  - Generation/Transmission/Distribution Control System
  - Generation/Transmission/Distribution Integrated Control System
  - Generation/Transmission/Distribution Protection and Control System
  - Power Management System
  - Switching management System
  - Load Management System

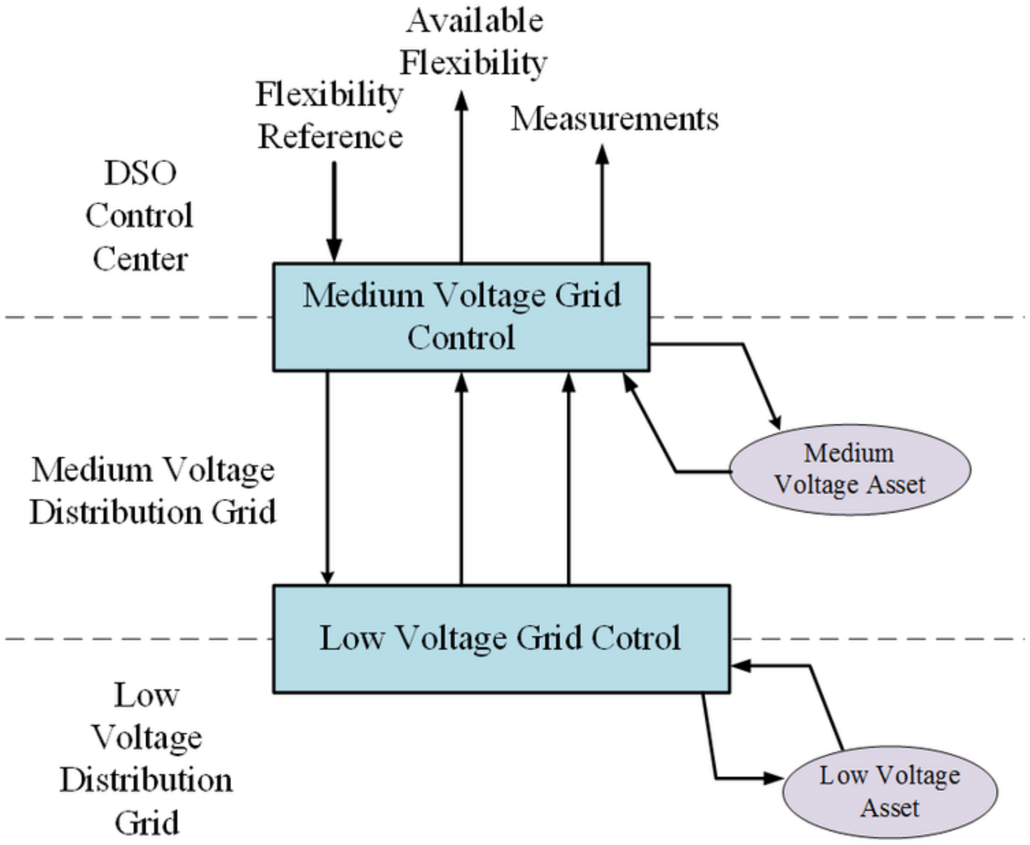
8.4.1 SCADA for Power Generating Stations

The functions of SCADA in power generation include

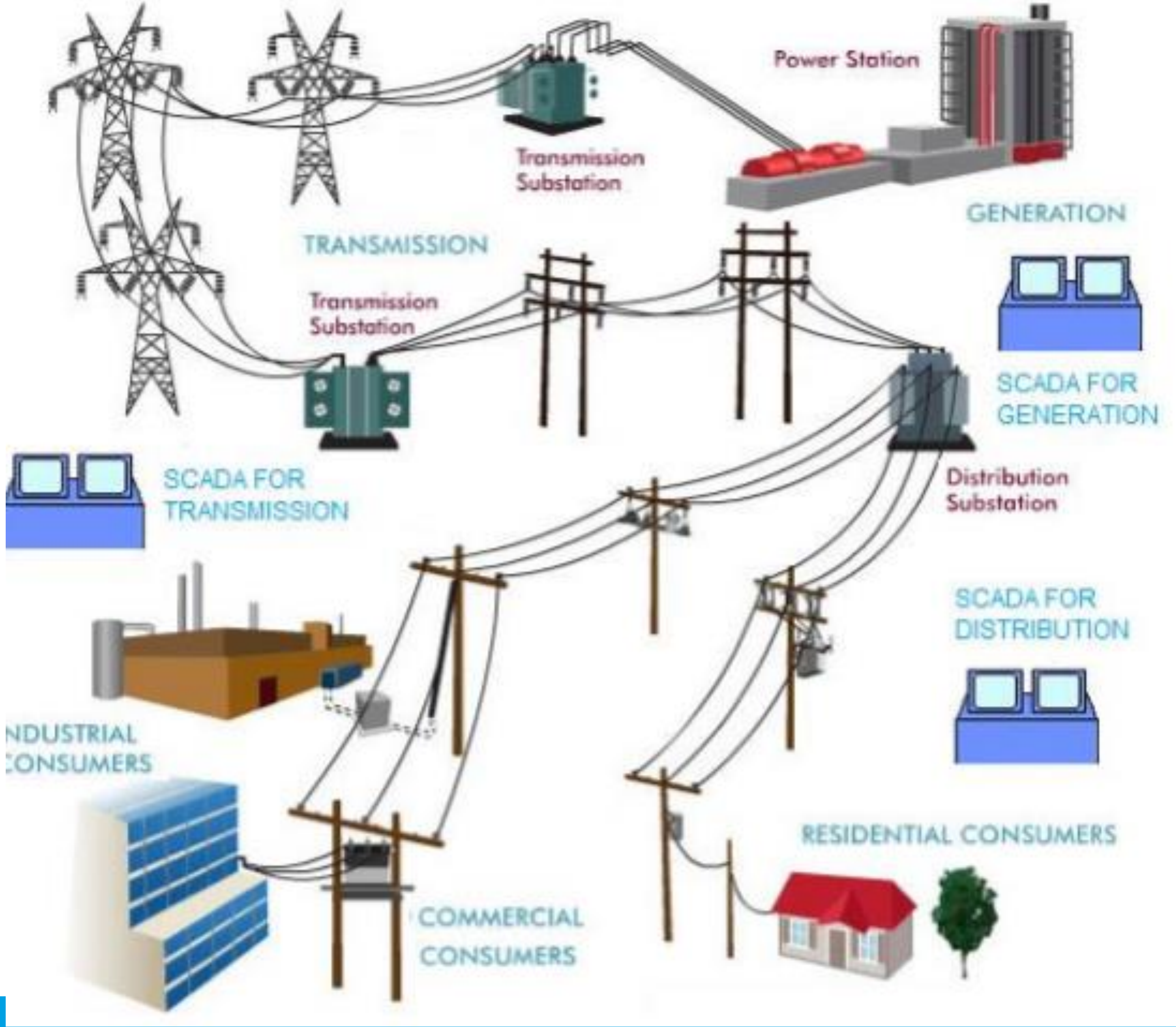
- Continuous monitoring of Speed and Frequency
- Geographical monitoring of coal delivery and water treatment processes
- Supervising the status of circuit breakers, protective relays and other safety related operations
- Generation operations planning
- Active and reactive power control
- Turbine protection
- Load scheduling
- Historical data processing of all generation related parameters

8.4.1 SCADA for Power Generating Stations

- With the use of Programmable Logic Controllers (PLC) hardware and advanced communication links along with SCADA software and hardware in power generating stations, delivering an optimum solution for each and every operation with flexible and advanced control structures.
- The figure in next slide shows the SCADA structure in power generation where it supervises several operations, including protection, controlling and monitoring.



8.3.1 SCADA for Power Generating Stations



SCADA for the electrical power industry

8.4.1 SCADA for Power Generating Stations

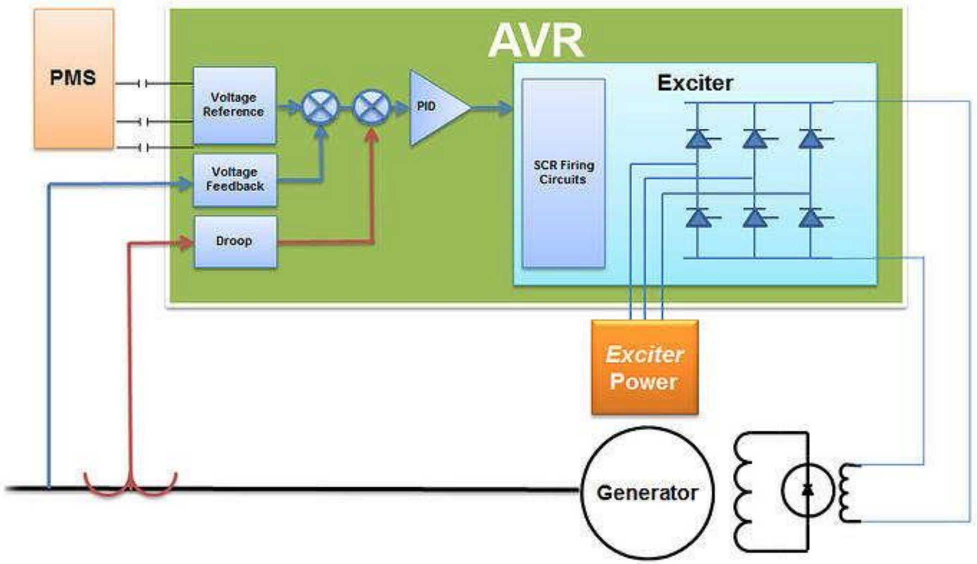
- The SCADA provides an integrated set of control, supervision and management functions for power generation stations. These functions include:

► Generator control including integration with the governor and excitation controller.

► Circuit breaker control including integration with protection relays.

► Synchronization function between generators.

► Transformer and tap-changer control according to the status of the electrical network

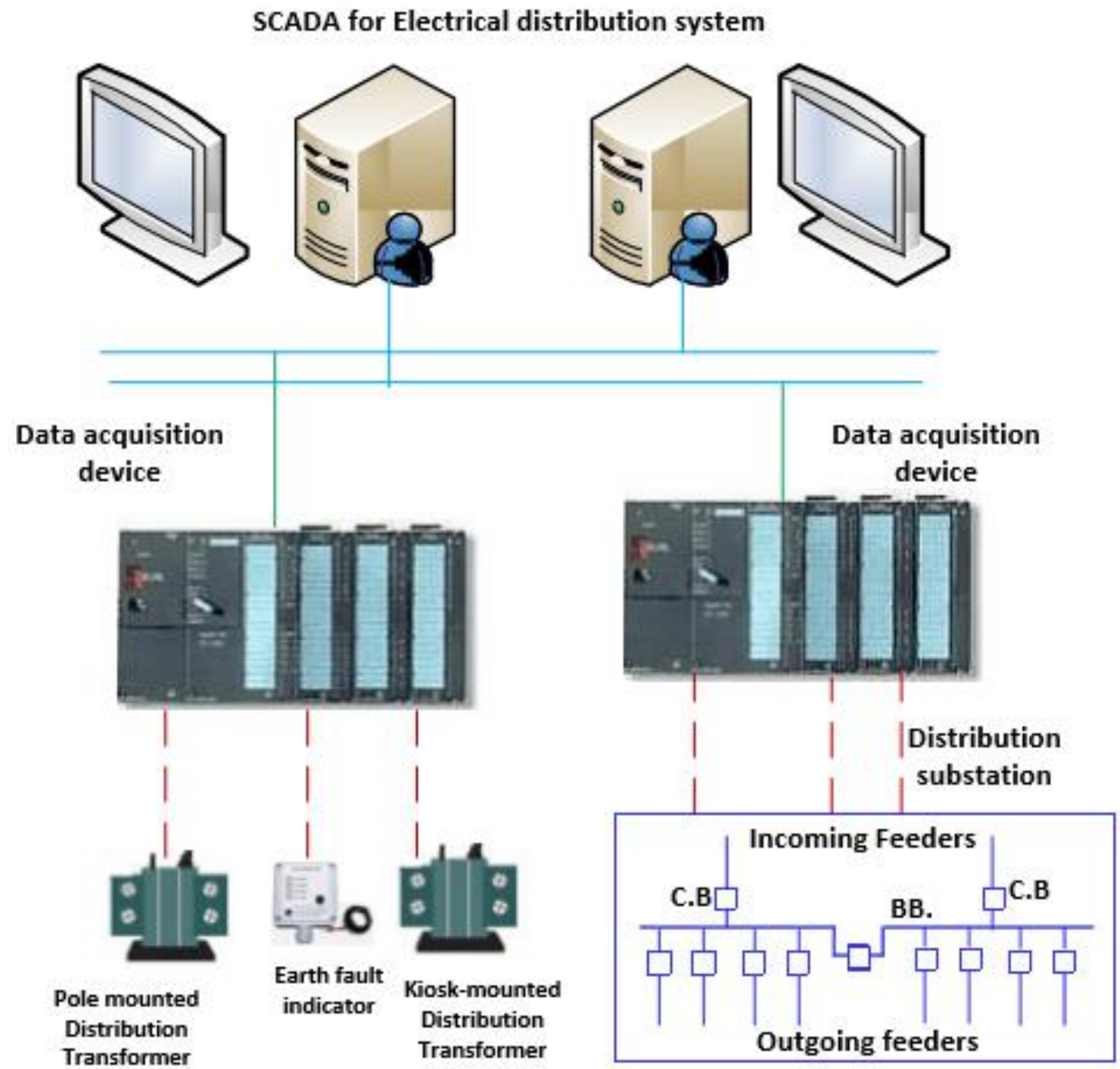


8.4.2 SCADA for Power Distribution System

- Distribution management systems control electric power from distribution substation to the different loads with the use of medium and low voltage cables and transmission lines.
- Most of the power distribution or utility companies are based on manual labor to perform the distribution tasks like interrupting the power to loads, all the parameter hourly checking, fault diagnosis, etc.
- The implementing SCADA to the power distribution not only reduces the manual labor operation but also facilitates smooth automatic operations with minimizing disturbance from various electrical substations, even at remote locations, and does the corresponding data and status processing.

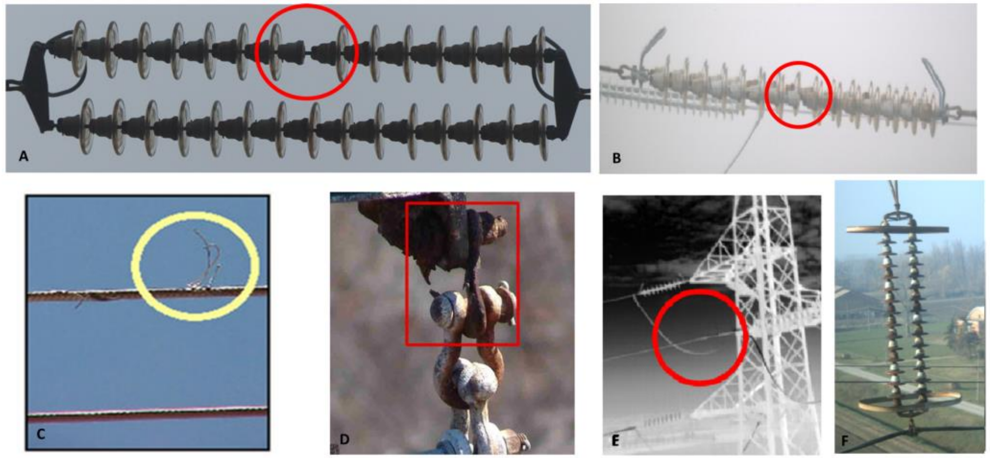
8.4.2 SCADA for Power Distribution System

SCADA for Power Distribution System



8.4.2 SCADA for Power Distribution System

- Programmable logic controllers in electrical substations continuously monitor the substation components and corresponding transfer that to centralized PC-based SCADA system.
- In case of any power outages or failures, this SCADA allows detecting the fault type and location, therefore without waiting for the calls from customers.
- SCADA gives an alarm or event to the operators for identifying and analyzing it. The SCADA in substations automatically controls the circuit breakers and switches for exceeding parameter limits, thereby continuous inspection of network status and parameters are performed regularly without a line worker.



Faults in power equipment

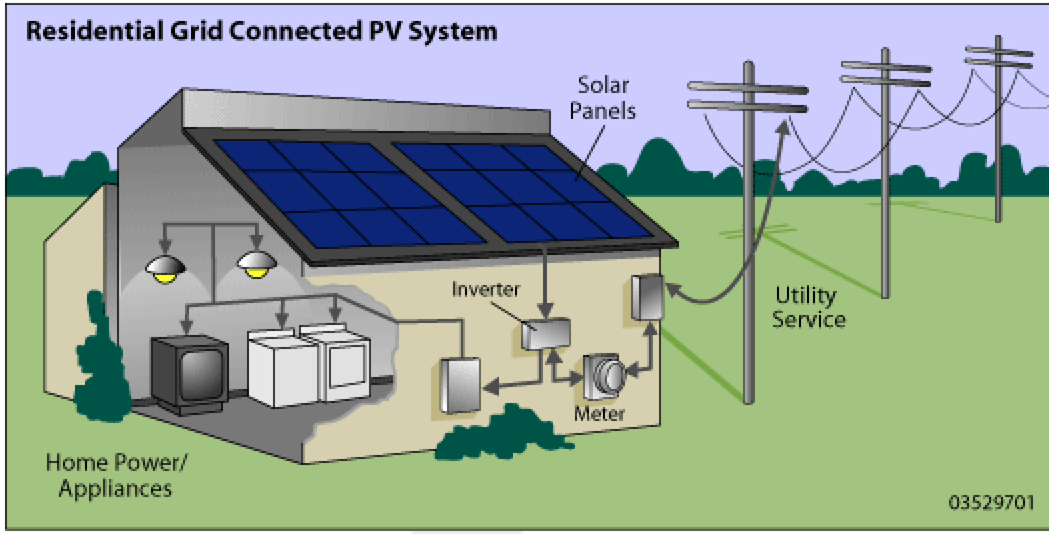
8.4.2 SCADA for Power Distribution System

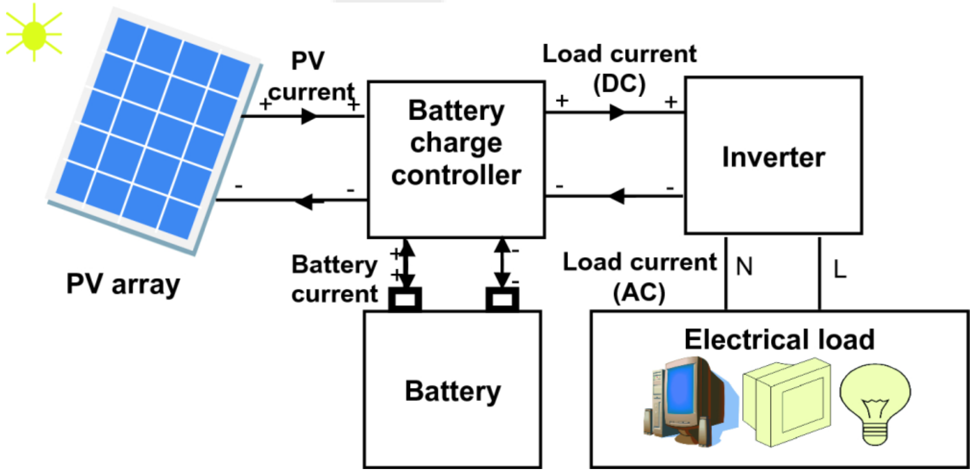
Some of the SCADA functions in power distribution system are given as follows:

- Improving power system quality by maintaining an acceptable range of power factor and harmonics contents
- Limiting peak power demand
- Continuous monitoring and controlling of various electrical components in both normal and abnormal conditions
- Trending and alarming to enable operators to fix outage problems
- Historian data and viewing that from remote locations
- Quick response to customer service interruptions
- Motor control including integration with motor control centers.
- Power Control including tie-line control, peak shaving and load sharing.
- Load Shedding including both fast, slow and frequency based.

8.5 SCADA in solar PV plants

- Photovoltaic power generation system can be divided into stand-alone PV system and grid-connected PV system. Grid-connected PV power plants consist of PV array, inverter, energy management system (EMS), storage etc.
- SCADA system can be employed to be a sub-system of Energy Management System EMS in PV power plants. Its core part is Remote Terminal Unit (RTU). In this way, PV system could be managed using data streams in the range of several thousand measurements per second. SCADA provides flexibility in controlling and monitoring the different PV plant components, including inverters, trackers, circuit breakers substations and meters.





8.5 SCADA in solar PV plants

- In the case of a small scale solar photovoltaic system, it is important to assess how much energy, the system can produce according to a specific location, orientation, and plant power conversion efficiency.
- Employing an efficient monitoring system is important for being able to account for the amount of energy produced by a PV system in real time, and to guarantee the forecast conversion efficiency will stay right over the PV panel’s service life. A digital meter is also used to measure the energy produced. The energy recording frequency requires more advanced data loggers than the meters installed for residential systems.
- Data loggers supply data into SCADA database that can be stored for use at a later time. The meters have communication interfaces through serial ports (RS485/RS232) or Ethernet that allow PC to access the data. Most electric utilities in the world have adopted standard criteria and guidelines for interconnecting distributed energy resources into their electric distribution systems.

8.5 SCADA in solar PV plants

- Solar PV installations efficiently reduce the customer load and, during minimum loading conditions, may export energy back to the grid in a net energy metering transaction.
- The industrial SCADA software should meet its PV application requirements. This SCADA software should provide flexibility in monitoring and controlling the various PV plant component and operations, including MPP (maximum power point) trackers, inverters, substations, circuit breakers, and meters.
- Designed for monitoring performance, the system logs any event and triggers alarms so that the engineering staff can order switching action or change the process of plant operation.

8.5 SCADA in solar PV plants

SCADA in solar PV plants

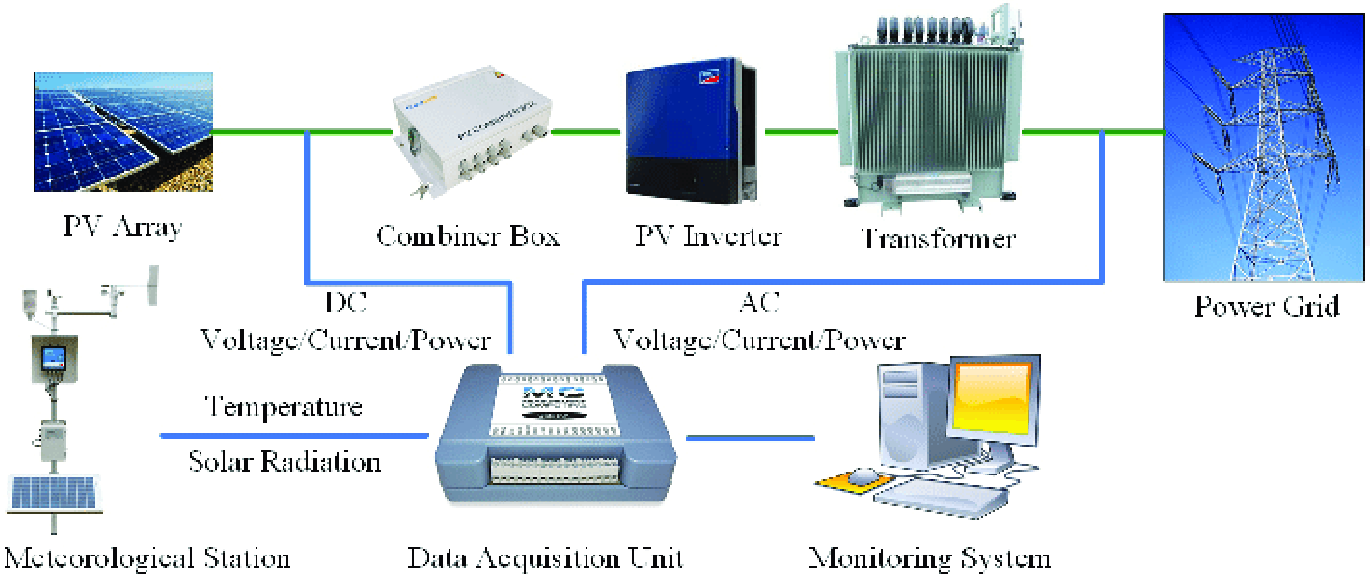
8.5 SCADA in solar PV plants

- The SCADA system monitors PV plant performance by comparing it with a mathematical model initialized at installation with PV plant design data such as PV panels maximum power, inverter specifications, manufacturer-provided electric parameters, the number of strings, strings length, etc.
- The PV model is continuously fed with local weather data and real-time calculates the energy production at full plant rating.
- A comparison is made automatically between the calculated and the real production figures (supplied by the data logger) will give an accurate indication of the plant performance or plant health check every minute or less.

Solar PV station

8.5 SCADA in solar PV plants

- Recent monitoring and performance analysis of solar PV plants has become extremely vital due to the increasing cost of operation and maintenance as well as reducing production due to aging degradation during the lifecycle of the plant equipment.
- This means that the use of a monitoring system can be essential to ensure high performance, less downtime, and fault detection of a solar PV power plant during the entire lifecycle.



Structure of PV monitoring

8.5 SCADA in solar PV plants

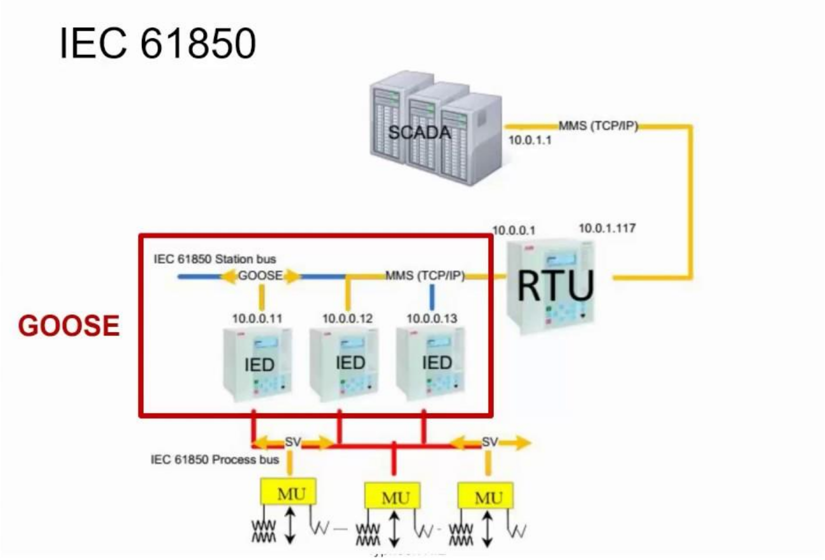
- From a technical point of view, it is interesting to know how the overall data acquisition in PV system is performed starting from the panel output. Here, string combiner boxes designed for PV installations have built-in string probe units that measure the analog values of DC current and voltage then calculate the power.
- The remote terminal units (RTU) makes the data available through a serial RS485 port (different methods or wireless can be used) for communication to the SCADA via ModBus. Some RTUs are installed at the field substation that connects to multiple string junction boxes on the multi-drop loops RS485.
- At the AC level, DC/AC inverters expose RS485 ports to allow an easy interface connection. The communication drivers collect data from control boxes and RTUs with a time stamp for processing, alarming, storage, reporting, and displaying at real-time.

8.5 SCADA in solar PV plants

- The SCADA capabilities are further used in the monitoring of digital protection relays, digital energy meters, weather monitoring station/sensors, low tension (LT), and high tension HT, control panels, DC switches, transformers, and in general any devices installed in the PV plant.
- In order to make PV applications more efficient, scalable, and sustainable as possible, it’s important to take into account other aspects of the SCADA platform.
- These include dynamic configuration, redundancy for data protection, stand-alone and client-server configurations, historical and real-time trends analysis, as well as advanced alarm management.

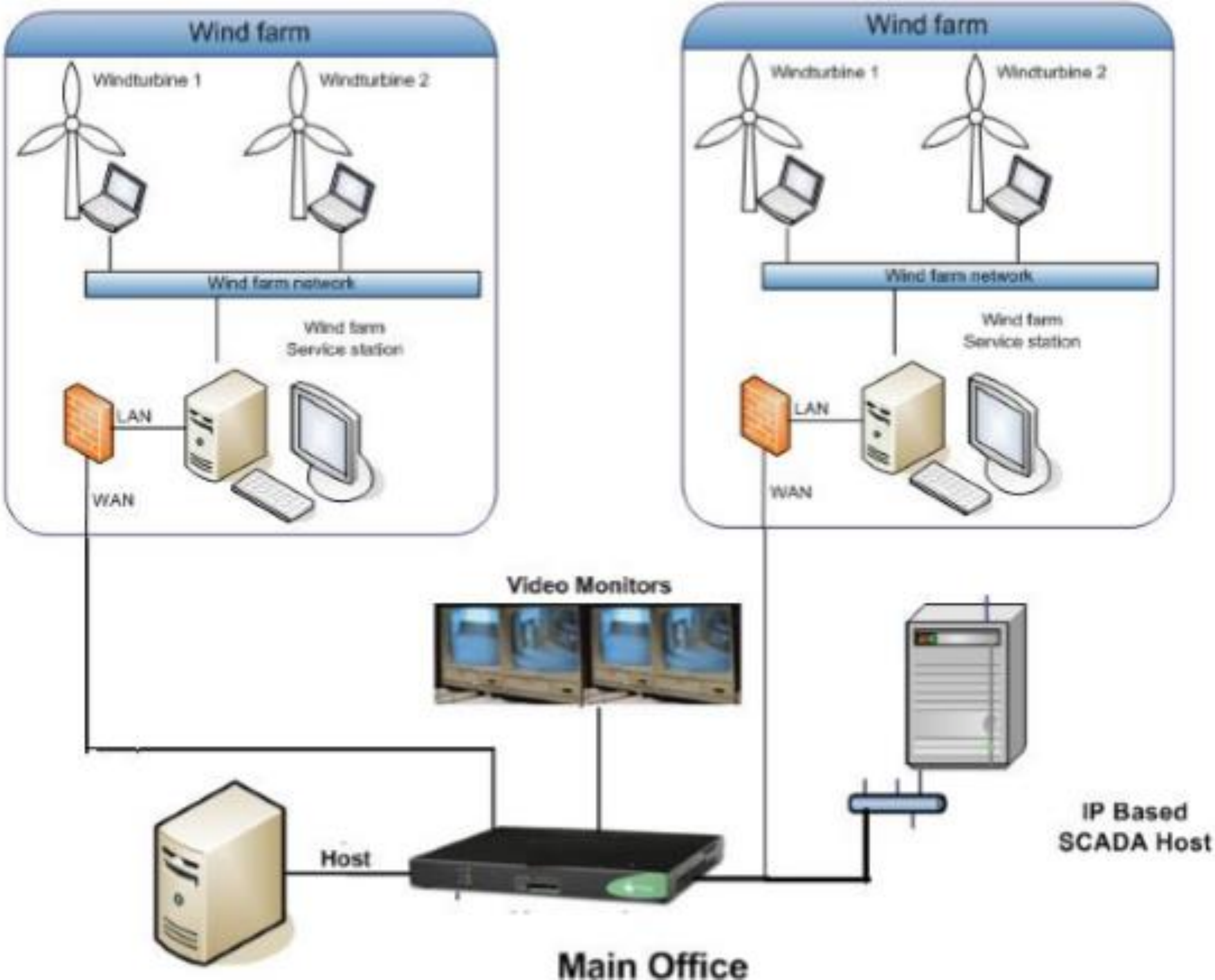
8.5 SCADA in solar PV plants

- Looking further at standards compliance, the support of such protocols as IEC 618560 and DNP3 is considered an asset if required to communicate with several electric substation devices.
- To access all data points, user-friendly graphical user interfaces GUI, report generator, switching management, scheduler, and an event-driven engine all make the process much smoother. Web-access functionality provides all kinds of capabilities and access to remote SCADA devices the application may need.



8.5 SCADA in solar PV plants

- In addition to above, SCADA software also allows monitoring of wind turbines.
- Turbines may be accessed via telephone modem or TCP/IP depending on available communication connection in the individual wind turbine or wind farm.
- SCADA software provides full control and monitoring of each wind turbine and the whole wind park.
- The wind park overview provides a graphical overview of the wind farm showing the status of each individual turbine. Furthermore, current wind and production data are shown.
- The turbine specifications gives a full overview of all relevant parameters of the used wind turbine, for instance rated wind speed, temperatures, pitch angle, generator and rotor speed, electrical parameters, yaw control system, etc.

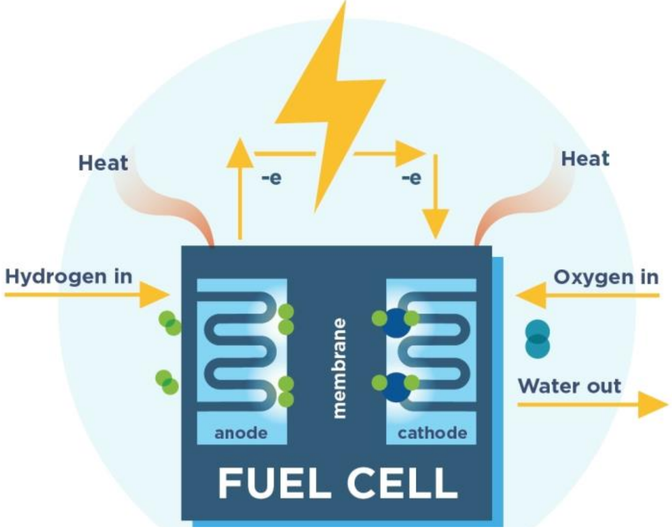


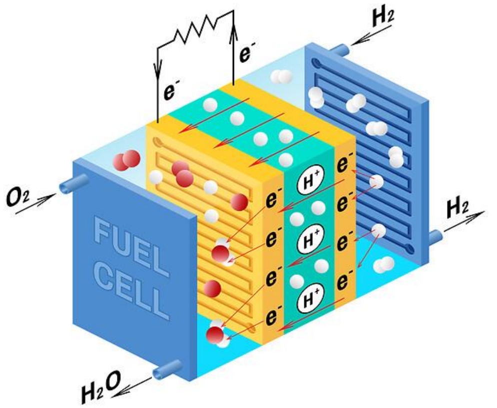
8.6 SCADA in Wind Farms

SCADA software allows to monitor wind turbines. The software should be easy to install, and allows to monitor both individual turbines and wind parks/sites. SCADA products divided into three functions which covers all aspects of a complete SCADA solution: ► Online monitoring and operation of turbines. ► Alarm Handling of incoming alarms from turbines. ► SCADA server which collect Data and reporting events.

8.7 Fuel cell system control and monitoring

- A fuel cell is a dc power generator that converts the fuel chemical energy (hydrogen, natural gas, methane, methanol, etc.) and an oxidant such as air or oxygen directly into electrical energy.
- While there are several available fuel cell technologies, the most popular and practical technology for small to medium-sized standby power supply is the proton exchange membrane (PEM) fuel cell that produces electricity through an electrochemical reaction using hydrogen and oxygen. This electrochemical reaction happens without any combustion process.
- A fuel cell operates electrochemically meanwhile the use of an electrolyte. This is similar to a generator that it operates as long as the fuel is supplied.

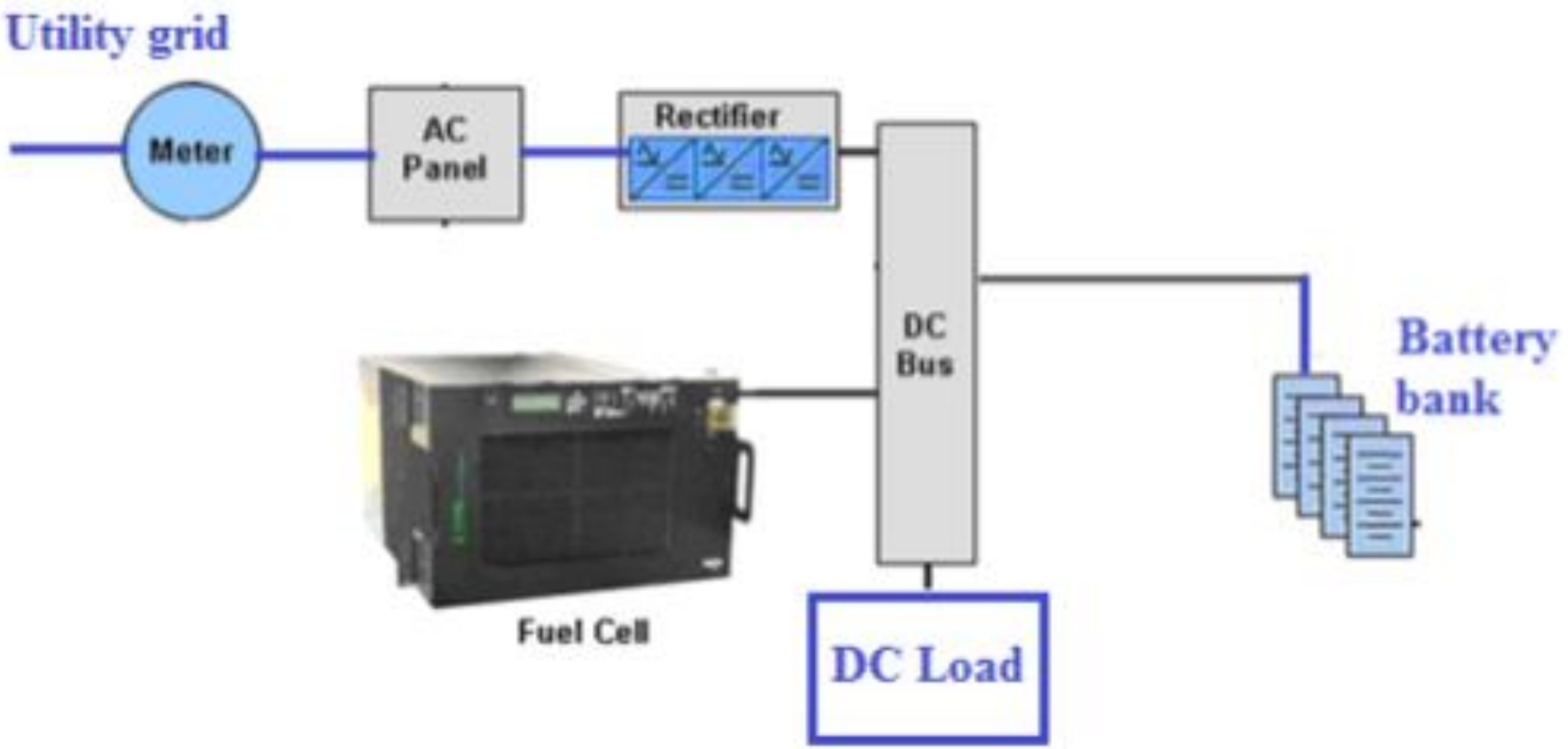




8.7 Fuel cell system control and monitoring

- Fuel cell is designed to provide stable electrical power while operating over a wide range of power and environmental conditions.
- The fuel cell advantages include high efficiency, simple, quiet and clean, low maintenance and noise with few moving parts, null harmful emissions, and economical cost for stationary standby power generation [8-10].
- The fuel cell systems are load-following because fuel consumption depends on the load. The FC power systems are designed for a wide range of customers, including hospitals, hotels, universities, utilities, and water treatment facilities.
- The applications of next generation high temperature fuel cell products, such as a diesel fueled marine ship fuel cells, combined-cycle FC power plants, and next generation solid oxide fuel cells (SOFC). The higher efficiency, environmental friendliness, and modularity have made PEM fuel cell systems to be one of the most attractive candidate for both transportation application and stationary standby power generation.

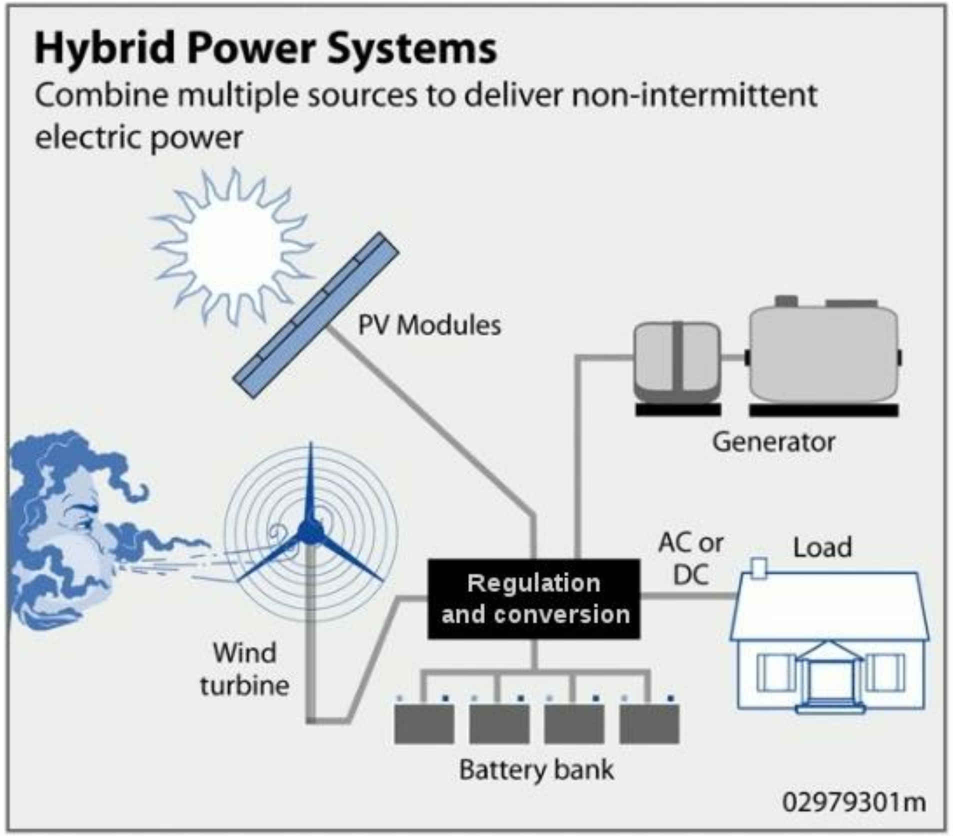
8.7 Fuel cell system control and monitoring



Fuel cells to provide backup to their communications equipment

8.8 Using SCADA in Hybrid Power Systems

- Combining two or more different of renewable energy sources will form the system called “Hybrid Power system”.
- The reliability of the HPS mainly relies on the dynamic behavior of the renewable energy sources. Hence, it is important to analyze the dynamic characteristics of these units in real time for long-time periods.
- A major challenge lies in the development of the real-time control scheme for the HPS. In order to test the HPS controllers, it requires, a controller that can interface with a hardware simulator and the inputs and outputs can be processed at the real time. This provides an excellent platform to implement and test the solutions in real time.



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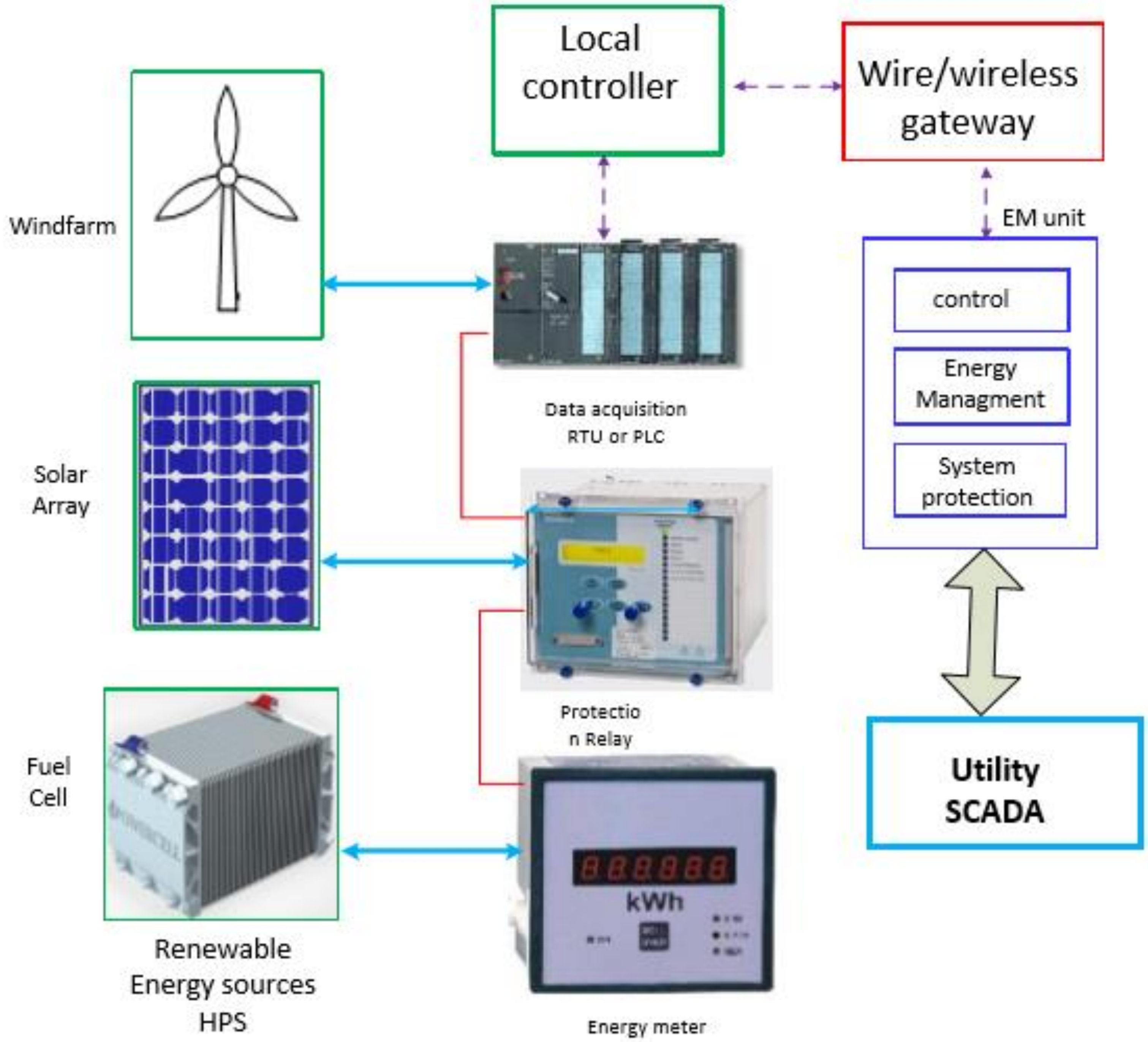
- Today, the improvements in communications system have prompt the implementation of the HPS using PLCs and RTU control schemes by a centralized supervisory control platform which is commonly known as SCADA system. All the Modules should be modeled in the PLC environment. PLC and SCADA system communicate with each other over a dedicated protocol which can be transmitted over serial port or Ethernet.

8.8 Using SCADA in Hybrid Power Systems

Schematic diagram of Renewable Energy based Hybrid Power System



8.8 Using SCADA in Hybrid Power Systems

- Since the monitoring of PV cell and Fuel cell had done in PLC and is interfaced to SCADA/Energy management systems. So that the operator could be able to observe the parameters easily and control the parameters according to the changes in system requirements.
- The data of HPS is collected through PLC and connected to control room through communication protocol. The detailed connection of renewable energy sources as HPS is shown in previous Figure. The PLC is interfaced to energy management control unit to get control actions according to the respective microgrid loads and environmental conditions.
- The entire system is connected to SCADA for supervision and control. The control room contains various I/O consoles such as engineering console and operator console.
- The Engineering console is responsible for adding new points or new IED devices to the system.

8.9 SCADA System Elements

- The data collected at real-time by the SCADA system is passed to the planning engineers for consideration in the radial distribution line development studies. As the electricity distribution industry continues to grow, the utilities make annual investments to improve the electric distribution system to maintain appropriate facilities to satisfy the increasing load requirements.
- Using the real-time data enable the planning engineers *to optimize the annual capital expenditures* requested to meet the needs of the growing electric distribution system.
- The power quality issues include reduction of harmonic content to the 15th harmonic and recording the Total Harmonic Distortion (%THD). This information is used to monitor the performance of the electric distribution system.

8.9 SCADA System Elements

- The components of a distribution automation system can be divided into four major areas:

1. SCADA application and database servers
2. DMS applications and server(s)
3. Trouble management applications servers
4. Front end processors or communication server

8.9.1 Host Computer system

- A central host computer server is usually known as a master station or simply control room, an SCADA control center, or a master terminal unit (MTU). The central host computer is usually a single computer or a computer server network.
- This computer network provides process control remotely or locally for all SCADA system devices, supporting requested control strategy and a remote method of acquiring data and events /alarms for monitoring these processes. The SCADA Host platforms also provide functions for dynamic graphical displays, alarming, logging, trending and historical storage of data.

8.9.1 Host Computer system

- The essential elements of a distribution SCADA host are:

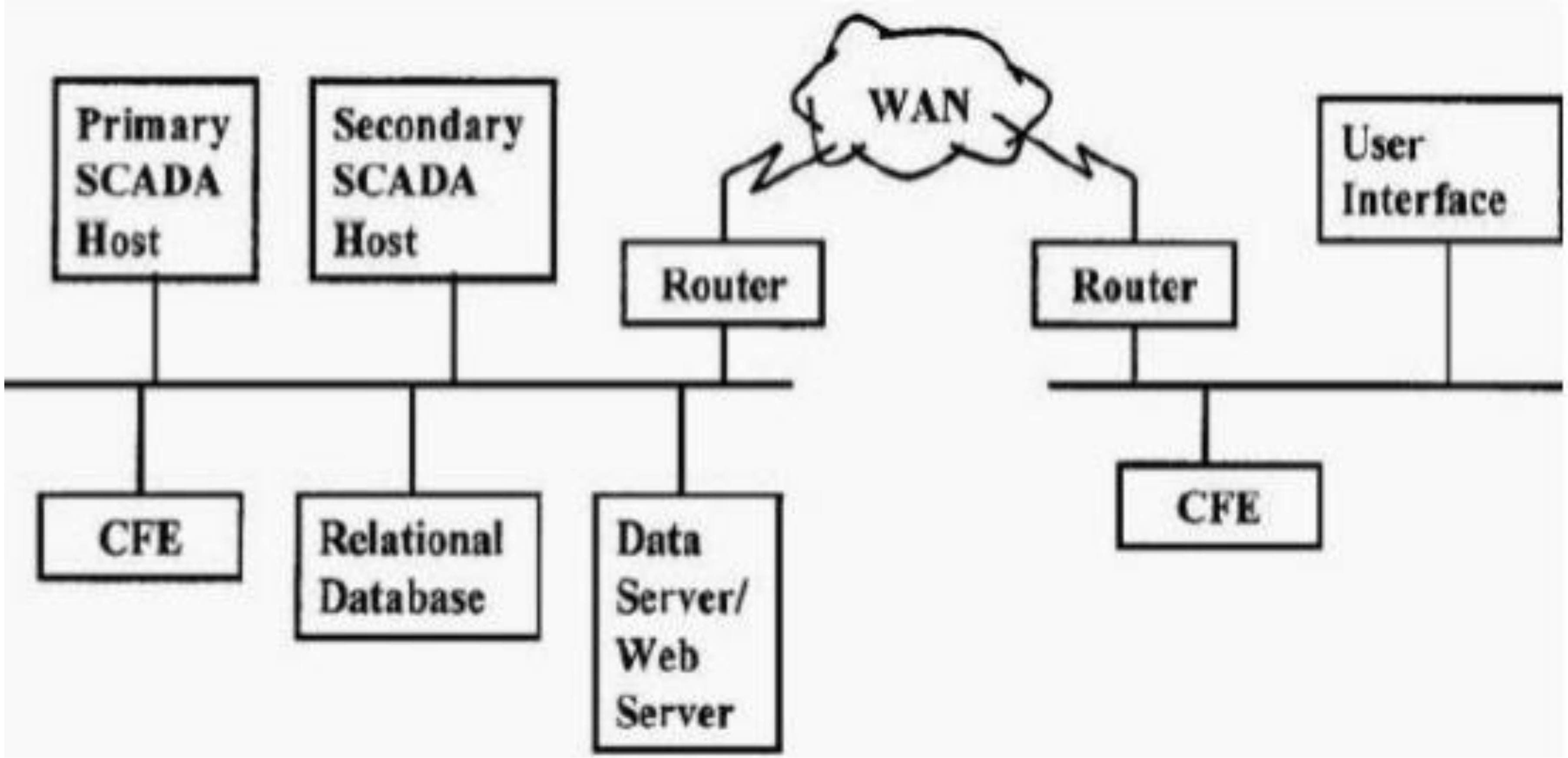
1. Host servers (redundant server network with backup/failover capability).
2. Communication front-end processors (FEP).
3. Full graphics user interfaces.
4. Relational database servers for archival of historical power system events) and data server/Web server for access to system points at real-time (values and events).

- The elements and components of the typical distribution control system are illustrated in the next Figure.

JAUNTY Erasmus+

8.9.1 Host Computer system

DA system architecture



8.9.1 Host Computer system

SCADA Servers

- As SCADA has proven its vital value in operation during stormy weather conditions, service restoration, and daily operations, the dependency on SCADA has created a requirement for highly available, reliable and high-performance systems.
- Redundant server network hardware operating in a “live” backup/failover mode is required to withstand the high availability design criteria. High-performance servers with abundant physical memory, redundant array of independent disks (RAID) hard disk systems.

8.9.1 Host Computer system

Communication Front-End Processors (FEP)

- The current state of the host to field communications device still depends heavily on serial communications. This requirement is satisfied by using the FEP.
- The FEP can be organized in several forms based on bus architecture and operating system.
- Location of the FEP in relation to the SCADA server can vary based on system requirements.
- In some configurations, the FEP is located on the LAN with the SCADA server. In other cases, existing communications hubs may dictate that the FEP reside at the communication hub.
- The incorporation of the wide area network WAN into the architecture requires a more robust FEP application to compensate for less reliable communications (in comparison to LAN).

8.9.1 Host Computer system

Communication Front-End Processors (FEP)

- In general, the FEP will include three functional devices:

1. A network/CPU board,
2. Serial cards, and
3. Time code receiver.

- FEP Functionality should have the ability to download configuration and scan tables. The FEP should also support the ability to dead band values (i.e., report only those analog values that have changed by a user-defined amount). FEP network and SCADA servers should be able of supporting worst-case conditions (i.e., all points changing outside of the dead-band limits), which typically happens during severe system disturbances conditions.

8.9.1 Host Computer system

Full Graphics User Interface

- The recent trend in the graphical user interface (GUI) is a full graphics (FG) user interface.
- Nowadays, character graphics consoles are still utilized by many utilities, SCADA vendors are aggressively moving their platforms towards a full graphics UI.
- Full graphic displays prove the ability to display power system dynamic network along with the electric distribution facilities in a geographical (or semigeographical) perspective.
- The advantage of using a full graphics interface becomes evident in particular for distribution control centers as SCADA is deployed beyond the substation control room where feeder diagrams become critical to distribution operations.

Relational Databases, Data Servers

- A relational database is simply defined as a collection of data items organized as a set of formally-described tables from which data can be accessed or reassembled in many different ways without having to reorganize the database tables.
- Power system quantities such as circuit breakers status, bus coupler status, digital alarms and feeder loading (MW, MWH, MQH, and three phase ampere loading), and bus volts provide valuable information to the distribution planning engineer.
- The availability of event data loggers is important in fault analysis. Utilizing of relational databases, data servers, and Web servers by the operation and engineering functions provide access to power network information and data while preventing the SCADA server from non-operating personnel.

8.9.1 Host Computer system

Host to Field Communications

- Serial communications to field devices can occur over several mediums: copper wire (RS485/RS232), fiber, radio, leased line and even satellite. Leased telephone circuits, fiber, and satellites have a relatively high cost. New radio technologies offer an attractive communications solution. One of such technologies is the Multiple Address Radio System (MAS)

8.9.1 Host Computer system

Field Devices

- Distribution Automation (DA) or distribution management systems DMS field devices are multi-featured installations considering a broad range of control, operations, planning, and system performance issues for the utility personnel.
- Each device provides specific SCADA functionality, supports system control operations, includes fault detection, collecting planning data and records power quality information. Usually, these devices are found in the distribution substation and at specific locations along the distribution line.
- The multi-featured capability of the DA device increases its ability to be integrated into the electric distribution system. The functionality and operations capabilities supplement each other with respect to the control and operation of the electric distribution network.

Modern RTU

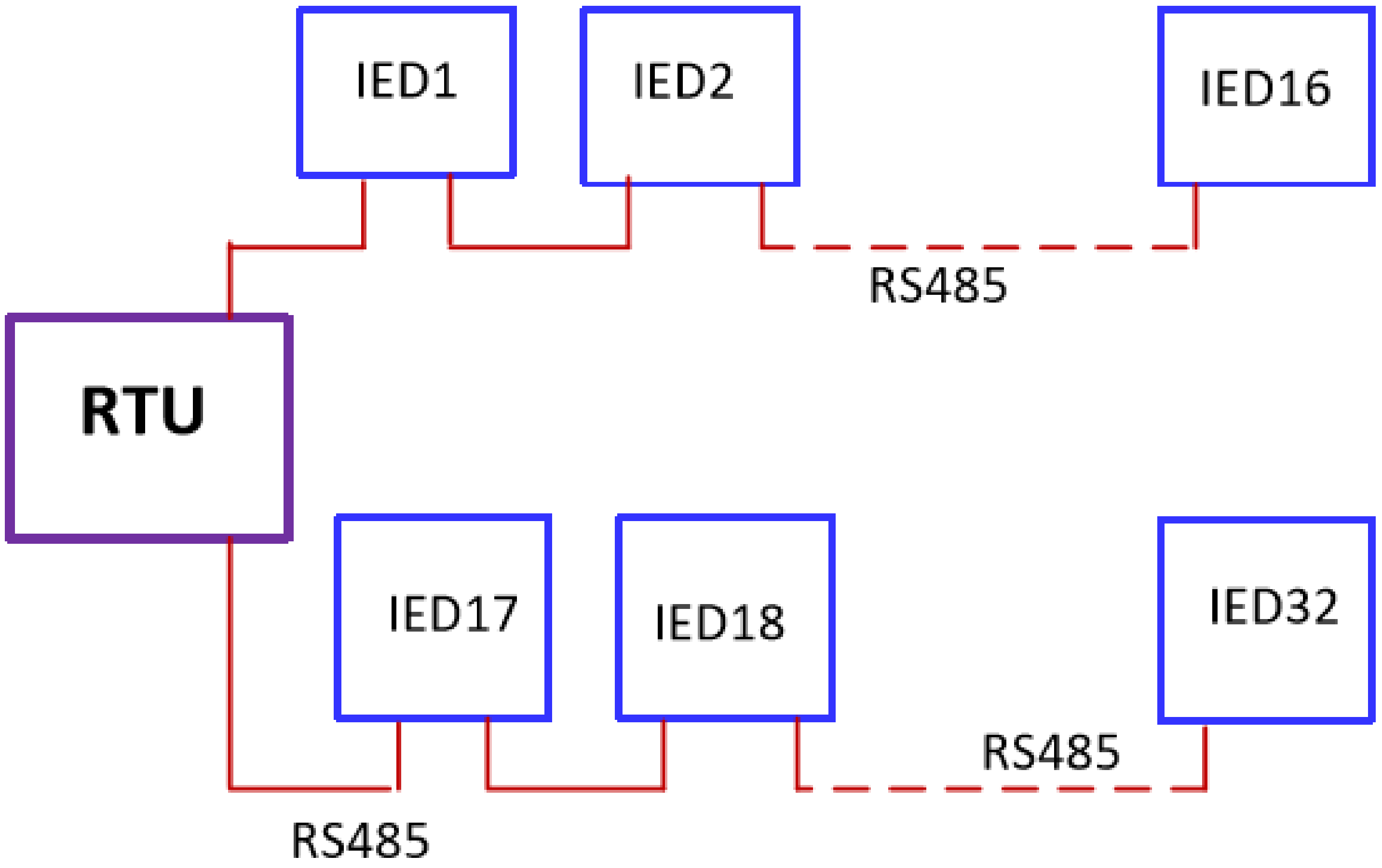
- Presently, modern RTU is modular in architecture with advanced capabilities to support data processing functions.
- The modular RTU design supports installation configurations ranging from the small point count required for the pole-mounted distribution transformer to the very large point count required for large power substations and power plant switchgear installations.
- The modern RTUs modules include expandable analog input/output, digital input/output points, accumulated input units, and communication cards with power supply.

8.9.1 Host Computer system

Modern RTU

- The RTU installation requirements are met by assembling the necessary number of RTU cards or rackmounted modules to accommodate the analog, control, digital, and communication requirements for the site to be automated. The packaging of the reasonable point count RTUs is chosen for the distribution line requirement.
- The substation automation has the option of installing the traditional RTU in one cabinet with connections to the substation IED devices or distributing the RTU modules at the devices within the substation with fiber-optic communications between the modules.
- The distributed RTU modules are integrated to a data concentrating unit which in turn communicates with the host SCADA computer system.

8.9.1 Host Computer system



Connection of IEDs to the RTU using serial port RS485

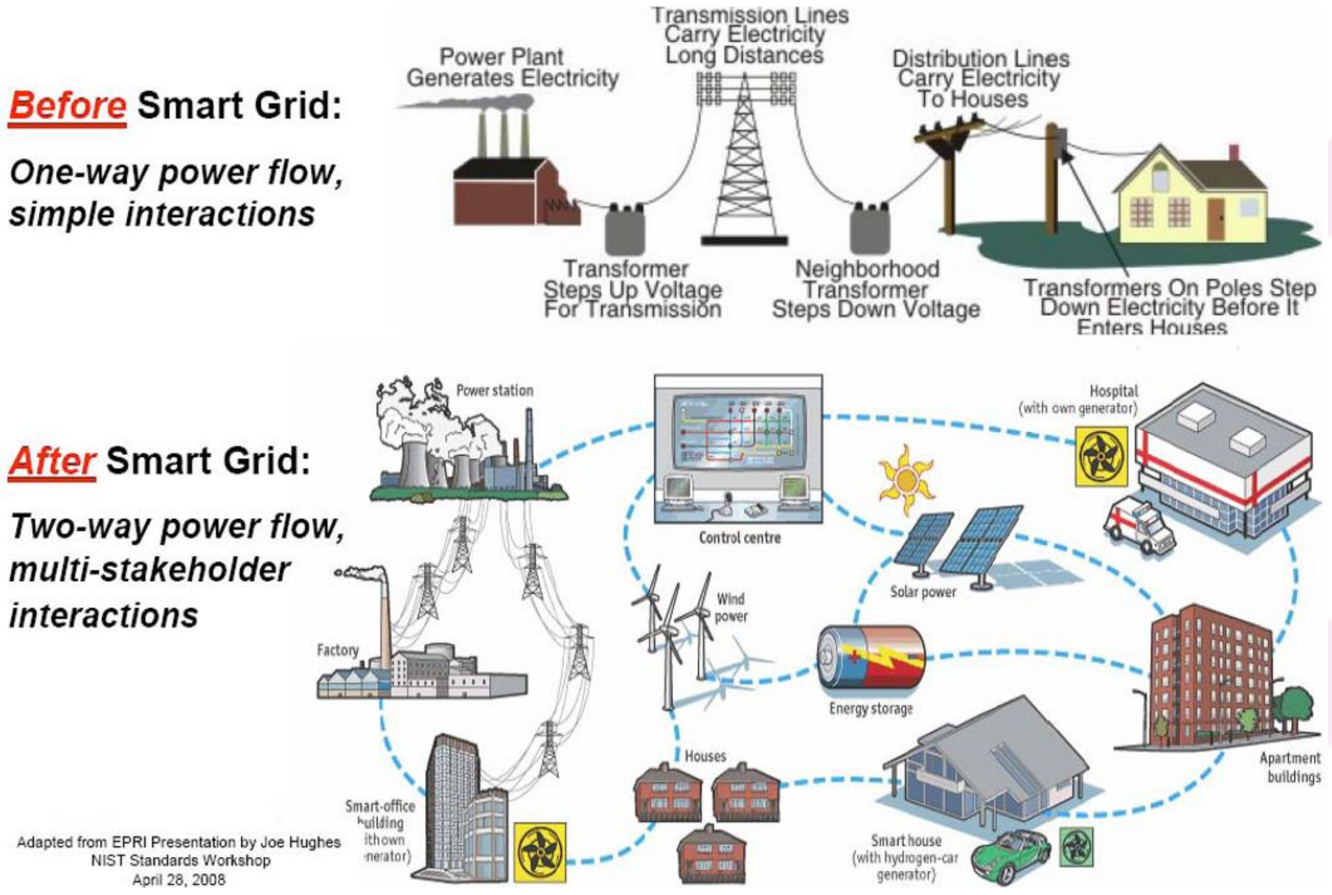
8.9.1 Host Computer system

PLCs and IEDs

- Programmable Logic Controller (PLC) and Intelligent Electronic Device (IED) are the main site components of the distribution automation system, which meet specific operating and data gathering requirements.
- The IEDs in substation include digital protection relays and digital meters. While there is some overlap in capability with the modern RTU. The PLCs can be integrated with the RTUs in the substation to assist in the remote operation of the substation. The typical PLC can support serial communications to an SCADA server. The RTU has the capability to communicate via an RS485 interface with the PLC. IEDs include digital meters, digital relays, and switchgear on specific substation equipment, such as breakers, switches, regulators, load tap changer LTC on power transformers, etc.
- The IEDs also have the ability to communicate to an SCADA server through serial or Ethernet ports. However, the IEDs are typically reporting to the modern RTU via an RS-485 interface or via status output contact points.

Summary

- In this chapter, the Smart Grid initiative was explored and described the integration of SCADA systems into the Smart Grid, including an overview of the problem domain as a whole.
- The evolution of the Smart Grid initiative to improve the electric utility power infrastructure have brought with it a number of opportunities for improving efficiencies and performance, but along with those benefits come challenges in the effort to assure safety, security, and reliability for microgrids, utilities and consumers alike.



Summary

- One of the considerations in designing the capabilities of the Smart Grid is the integration of Supervisory Control and Data Acquisition (SCADA) systems to allow the utility to remotely monitor and control network devices as a means of achieving reliability and demand efficiencies for the utility sectors.
- SCADA Optimizes Solar PV Energy Generation And Performance. Usually, wind energy assessment on a new wind farm is conducted with maximum effort prior to the installation of the turbines by using both numerical and experimental investigations.
- Communication technologies in smart grid with renewable energy sources are explored.

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