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NSF

Introduction to SCADA for Renewables
(A Six Module Course)

<u>Course Learning Objectives</u>

1. **Describe** SCADA system basics and important differences with other control systems
2. **Demonstrate** competency of the key components of a SCADA system and their functions
3. **Describe** the different communication systems used in SCADA
4. **Demonstrate** competency of the role and capabilities of operator interfaces
5. **Demonstrate** competency of implementing SCADA in real world applications, specifically renewable energy applications (install, operation, maintenance)
6. **Identify** emerging technical trends, shifts, and innovations impacting SCADA and its application in the renewable energy sector

Introduction to SCADA for Renewables

Course Outline / Curriculum Learning Modules:

Module 1 **SCADA Overview**

Module 2 Components and Functionality

Module 3 Basics of SCADA Communications

Module 4 Human/Machine Interface

Module 5 Applications within Renewable Energy Industry

Module 6 Emerging Trends in SCADA for Renewables

Module 1 – SCADA Overview
Learning Objectives

- **Understand** the course intent and the study topics to become versed in SCADA
- **Understand** the history of SCADA
- **Understand** the fundamentals of industrial control systems, distributed control systems, and their core components
- **Understand** the definition of a SCADA system, why SCADA is important
- **Understand** characteristics, strengths, and weaknesses of SCADA systems versus other control systems, i.e. DCS
- **Understand** the terminology associated with SCADA systems for monitoring power systems (solar, wind, energy storage, etc.)
- **Understand** the key devices and components and their purpose in a SCADA system; especially for monitoring power systems (solar, wind, energy storage, etc.)
- **Understand** the basic communication structure for a SCADA system
- **Understand** the difference between Proprietary vs Open or Mix and Match systems
- **Understand** the differences between data collection, process monitoring, and process control
- **Describe** types of SCADA system applications for the Renewable Energy (RE) Industry
- **Identify** key features and benefits of the integration of RE and SCADA systems
- **Understand** how SCADA facilitates data analysis to improve RE operating performance
- **Observe** SCADA system in use, if possible, at a power facility – SCADA design considerations, operating philosophy and requirements, end-user operation of the SCADA system

References and Additional Learning Material

- https://www.allaboutcircuits.com/technical-articles/an-introduction-to-scada-systems/
  Overview article on SCADA systems

- https://www.affinityenergy.com/avoid-solar-energy-loss/
  How SCADA can be used to improve solar power system operations

- https://www.solarpowerworldonline.com/2019/08/advanced-scada-functionality-solar-trimark/
  Advanced features that can be leveraged in SCADA for solar power systems

- https://www.youtube.com/watch?v=rmDdK38w-uw
  Short video of SCADA for wind power application

- https://blog.norcalcontrols.net/solar-pv-plant-operations
  Resource blog for SCADA solar applications

What is SCADA

A range of process control systems and formats are used to operate industrial processes:

- Local Control – controls located at the machine or at the point of use
- DCS – Distributed Control System
- SCADA – Supervisory Control And Data Acquisition

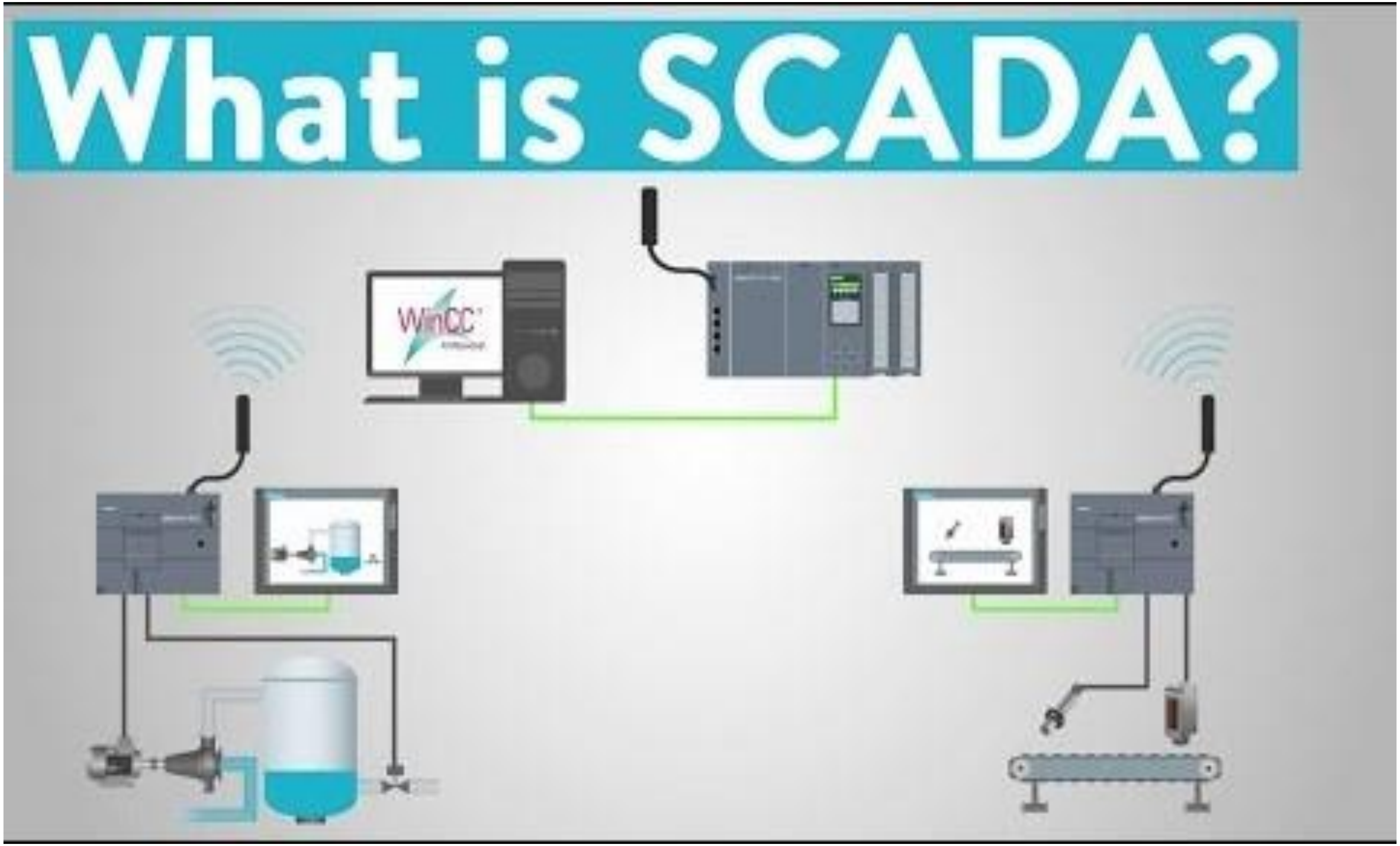
Importance of SCADA

At the site or operator level, a SCADA system enables operators to:

- Manage the day-to-day performance of a process or plant site as efficiently and profitably as possible
- Prevent failure, damage, or other costly equipment issues by alerting operators of problems, maintenance needs, and operational anomalies.
- Monitor processes, adjust to changes, and troubleshoot issues by providing real-time data at their fingertips

At the enterprise level, a SCADA system enables business owners or stakeholders to:

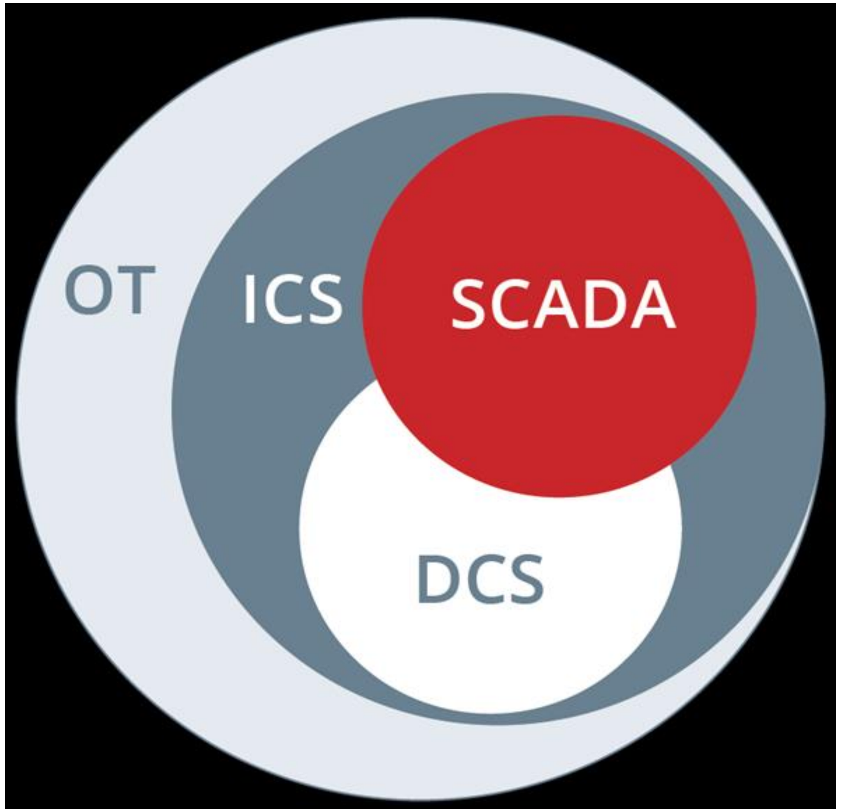
- Leverage process data to make more informed projections and financial decisions
- Efficiently manage a network of plants or assets to maximize overall profitability


What is SCADA?
WinCC

Comparing DCS and SCADA (1)

Both DCS and SCADA systems are similar in that they are a collection of software and hardware components that:

- Gather and present data to operators from remote devices and processes (temperature, flow rate, voltage, position indication, etc.)
- Allow supervision and control of plant operations, locally and remotely
- Make decisions about processes with the aid of operator input
- Allow a human to manually take over in unusual circumstances



Source: https://www.securicon.com/whats-the-difference-between-ot-ics-scada-and-dcs/

Comparing DCS and SCADA (2)

But they are different in that DCS emphasizes process level operations while SCADA is event driven and based on data gathering.

Additionally:

- DCSs have built-in operator interface software with tag databases, while SCADA requires additional software to set up the interface and tags
- SCADA is not recommended for safety systems. If safety is a primary concern, then DCS offers advantages
- For time-sensitive processes, SCADA systems may have a slight advantage as the processing time is generally faster than DCS, but the gap has narrowed
- SCADA is often network based, i.e. LAN or WAN
- Requirements or needs for an open communication architecture favor SCADA
- SCADA is generally more scalable and flexible for use across multiple sites or remote locations

DCS and SCADA can also be merged into a singular supervisory system leveraging the best of both

Basic Functions of a SCADA System

Monitor and gather process data in real-time

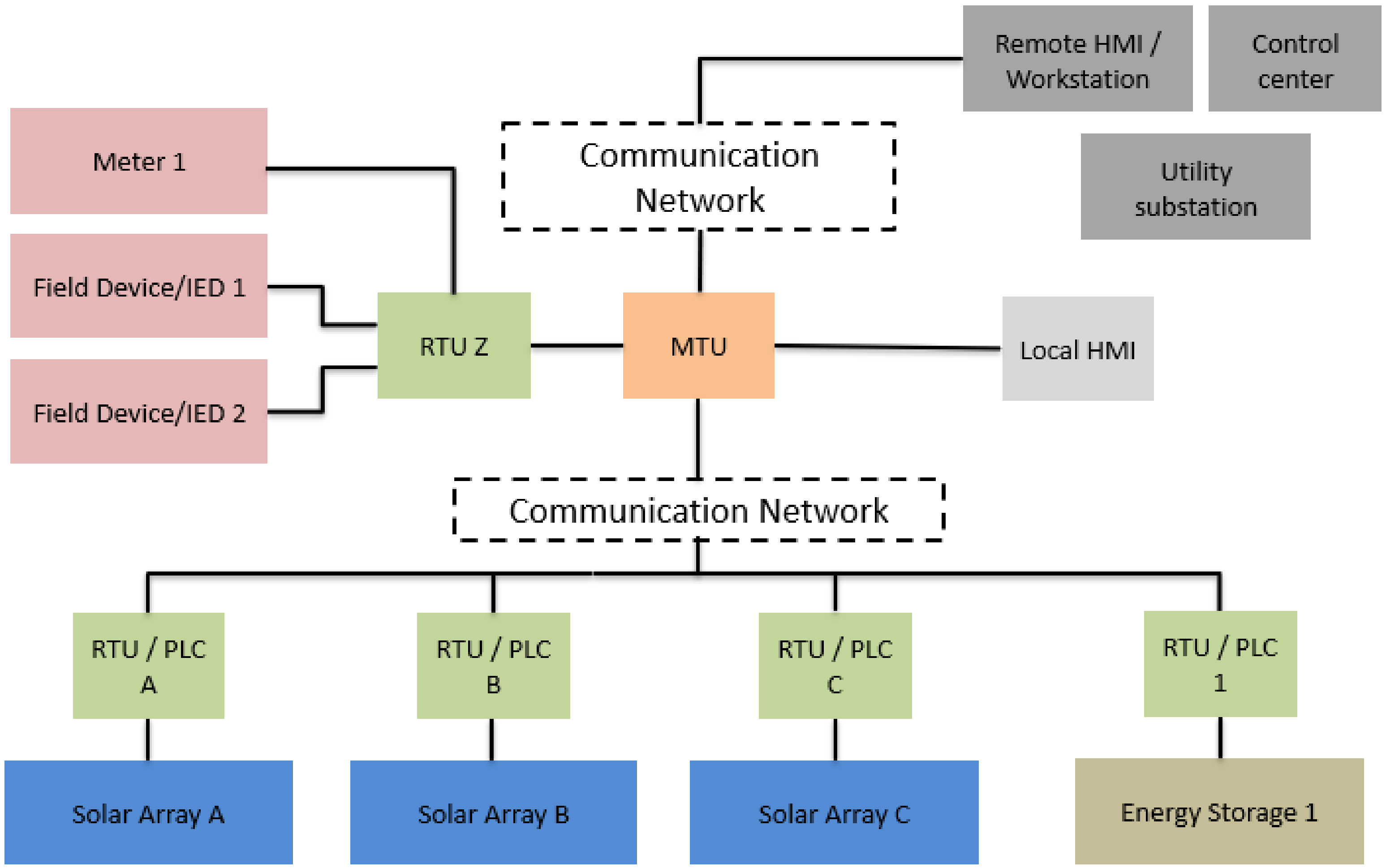
Interact with field devices and control stations via Human Machine Interface (HMI)

Record system events into a data file

Enable virtual monitoring and control of operations and processes

Provide information storage and reporting

SCADA System Diagram Example



Basic SCADA System Components

SCADA is a collection of hardware and software components:

- Sensors, switches, meters, etc.
- Remote Terminal Unit (RTU), Programmable Logic Controller (PLC)
- Master Terminal Unit (MTU)
- Human Machine Interface (HMI)
- Communication protocols

Basic operation of a SCADA System

- Field devices, such as sensors and switches, provide real time process signals to a RTU or PLC

- The RTU or PLC uses these inputs in its logic algorithms to manage or control process systems and communicate back and forth with both field devices and the MTU

- The computer-based core of the system, the MTU, initiates communication with the RTUs and/or PLCs, collects and stores data, supports the operator interface, and communicates with other systems

- HMIs enable system operators, maintenance personnel, engineers, and other stake holders to monitor and manage the process system or process network

SCADA Communication

Communication between field devices and RTUs/PLCs can be analog or digital

Communication between the MTU and the RTUs/PLCs is a critical part of a SCADA system

-- Can be wired or wireless (radio, cellular, satellite), usually a combination of both are used

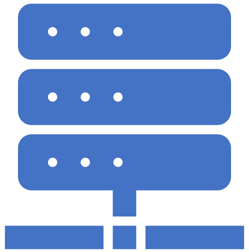
Communication protocols

-- Range of proprietary, vendor specific communication protocols and open communication standards exist

Proprietary vs Open SCADA (1)

- An **Open** SCADA System is a system where the major components all comply to certain industry standards to enable interoperability
- A **Proprietary** SCADA System is a system where all major components come from one vendor/manufacturer and the standards are usually specific to that system and vendor

Proprietary vs Open SCADA (2)



Examples of

proprietary vendor protocols

SAP-bus (ABB)

Conitel (Leeds&Northrup)

Examples of

open protocol standards

Modbus

Profibus

IEC 60870-5-101 or 104

IEC 61850

DNP3 (used commonly for utilities)

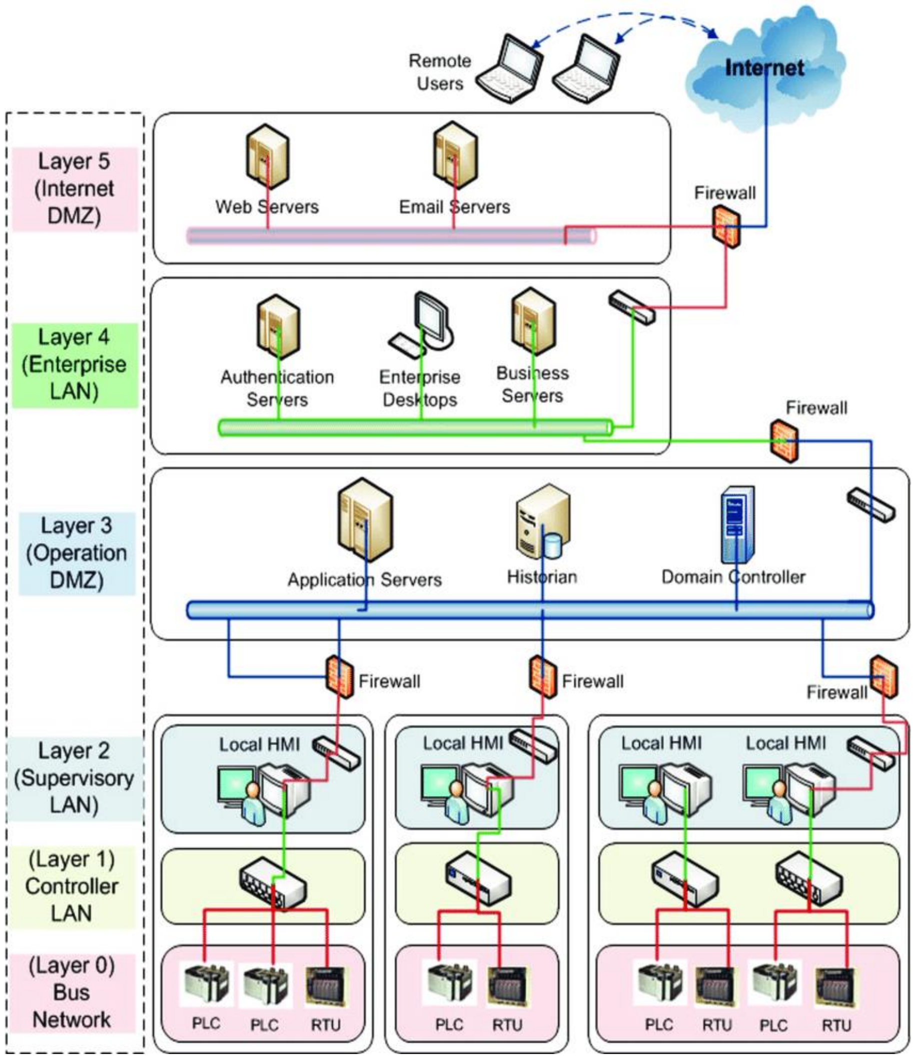
Applications of SCADA in RE

Monitor and control of operations at RE generation sites, such as solar farms and wind farms, or even a network of distributed RE generation sites

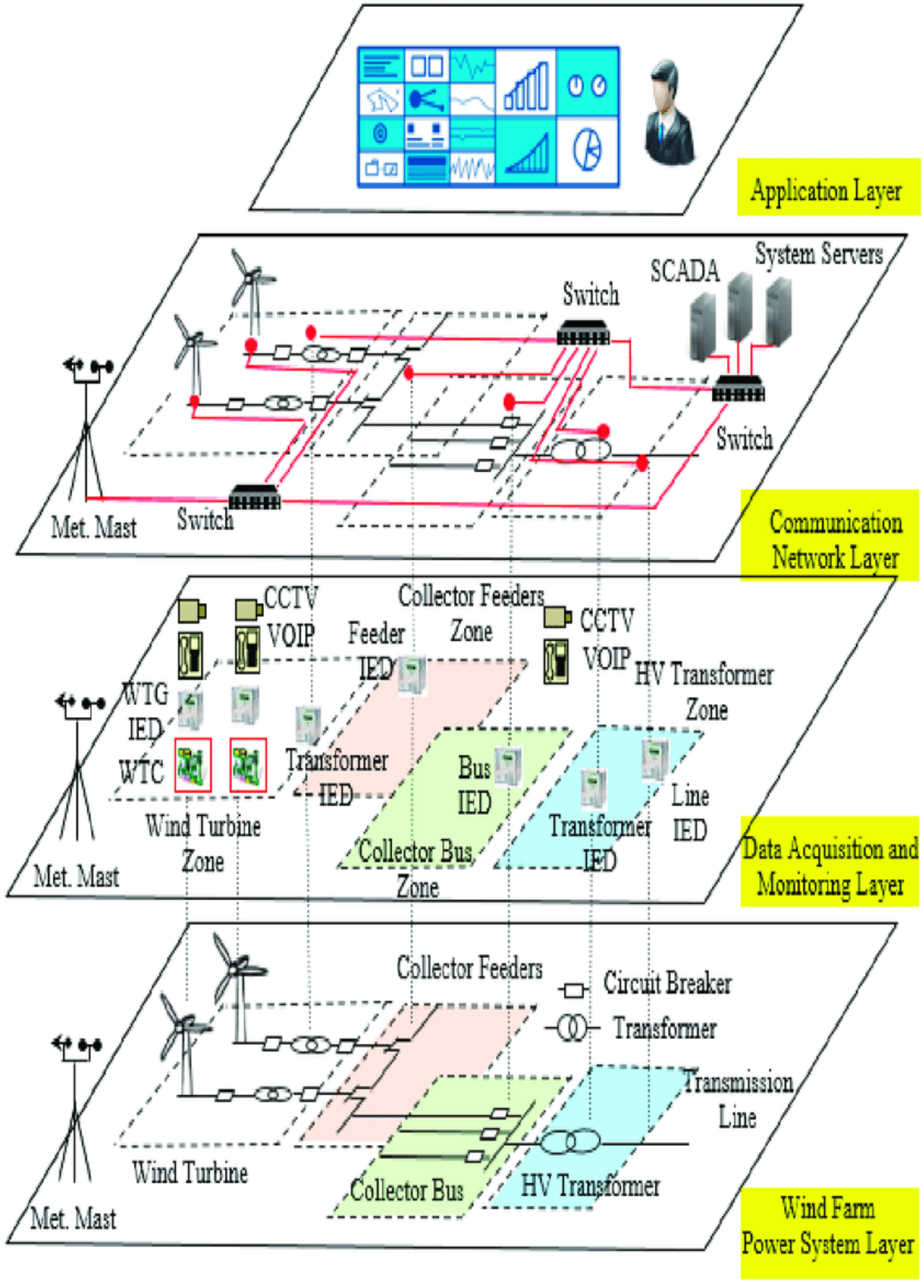
Integration of RE generation sites with the power grid

Integration of energy storage systems with both RE generation site(s) and the power grid

Examples of SCADA Architecture in RE



SCADA Systems: Challenges for Forensic Investigators - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Layers-of-a-SCADA-system_fig3_234138890 [accessed 27 Sep, 2020]



Source: Communication Architecture for Grid Integration of Cyber Physical Wind Energy Systems - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Proposed-architecture-of-the-cyber-physical-wind-energy-system-SCADA-supervisory_fig6_320312821

Advances in SCADA for RE

With new technologies, improving system integration, and more powerful analytics SCADA enables:

- Finite system performance management down to the device level (i.e. individual inverter or panel)
- Intelligent alarm processing
- Advanced predictive maintenance to minimize outages and downtime
- Automatic power generation control
- Predictive system output incorporating multiple weather data and weather forecast sources for operations planning and financial optimization
- System coordination with utility energy management systems (EMS)
- Real time performance optimization of a network of distributed operating sites
- Real time theoretical vs actual power output analytics
- Real time production value calculations and financial optimization
- Event sequence recording and reporting, document management, and report generation

QUESTIONS?