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# Introduction to SCADA for Renewables (A Six Module Course)

#### **Course Learning Objectives**

- **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 1SCADA 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 5 – Applications in the Renewable Energy Industry Learning Objectives

- Understand how SCADA functions and is utilized in various RE power generation applications
- Create and operate a basic SCADA system for a solar power application project under various scenarios
- **Demonstrate** troubleshooting of issues from solar power application project
- Generate data collection, analysis, and operating reports from the application project
- **Understand** how SCADA is used for energy storage applications
- Understand how SCADA for RE applications can be combined with energy storage systems
- Configure solar power project to include energy storage and operate project under various scenarios
- Generate data collection, analysis, and operating reports from the application project
- Understand how SCADA for RE applications and/or energy storage is used in grid response applications
- Understand positives and negatives of RE grid response with SCADA vs traditional grid response options

### SCADA – How is it used in daily operations?

- Software is used to interface between the actual control and the human display
- Makes gathering data easy
- Makes control of the asset easy
- Makes monitoring many assets at one time possible

#### **Data Acquisition**

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• Data can be processed into many different forms

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- Reports
- Logs
- Graphs
- Lists

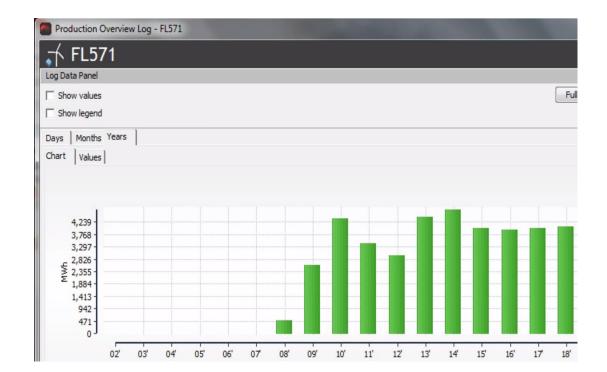
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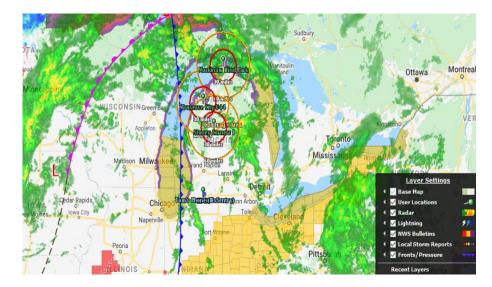
### **Users of Data**

- System Operators
- Local Managers
- Technicians
- Utility Companies



#### **System Operators**

- Use Data to Monitor Power Production
- Dispatch Assets to Correct Faults
- Plan Work Schedules
- Plan Shutdown of Production for Maintenance



#### **Local Managers**

- Coordinate Scheduled and Unscheduled Maintenance
- Produce Daily Production Reports
- Produce Daily Availability Reports
- Monitor Performance of Assets

Plant production	×	\$	Wind power overview	×
Total Produced active	92826.54 MWh	Grid	Power (30 sec)	-19.50 kW
Total production for current month 87.63 MWh Total production for current year 1570.84 MWh		Win	d Speed (30 sec)	<mark>5.90 m/s</mark>
Last update time 6/13/202		Las	t update time	6/13/2021 11:45:30 AM

9

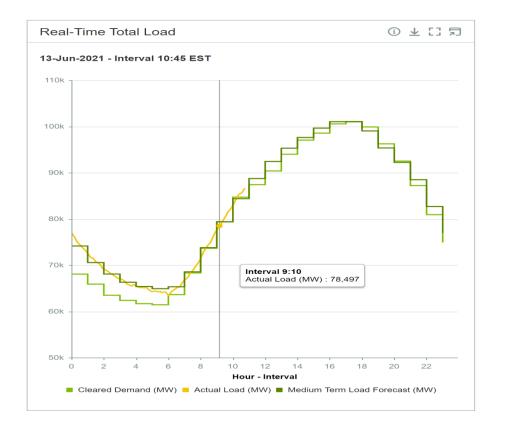
## Technicians

- Gather Data to Troubleshoot a Fault
- Use Data from Other Machines to Compare
- Collect Parameter Lists for Comparison
- Use Data to Commission the Assets

emperatures in °C				
MGB Bearing 150	Main Bearing 1	Gen CoolWater Return	Nacelle	
Gear Bearing ▼	Main Bearing 2	Generator CoolWater Forward	Terminal Box	
HGB Bearing 152	Control Panel	Generator Bearing DE	Transformer ▼ ▼ ▼ -40 47 133 220 45 °C	
HGB Bearing 450 ▼ ▼ -40 47 133 220 52 °C	MGB CoolWater Forward V V -40 47 133 220 40 °C	Generator Bearing NDE		
MGB Bearing 451 ▼ ▼ -40 47 133 220 52 °C	HGB CoolWater Return ▼ ▼ -40 47 133 220 37 °C	Generator Stator L1		
MGB Bearing 452	MGB OilSump ▼ ▼ -40 47 133 220 53 °C	Generator Stator L2		

#### **Utilities and Grid Operators**

- Use Data to Help Balance the Grid
- Meet Customer Demands for Electricity
- Set Pricing for Electricity
- Plan Generation Levels Day Ahead

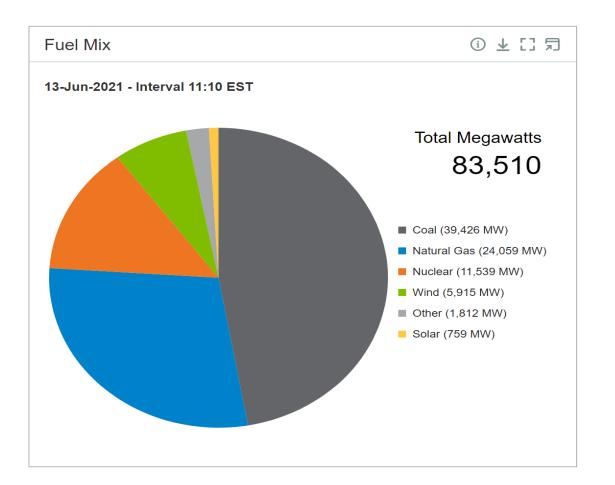


#### **Other Data**

- Fuel Mix
- Import and Export
- Pricing and Demand
- Weather Related

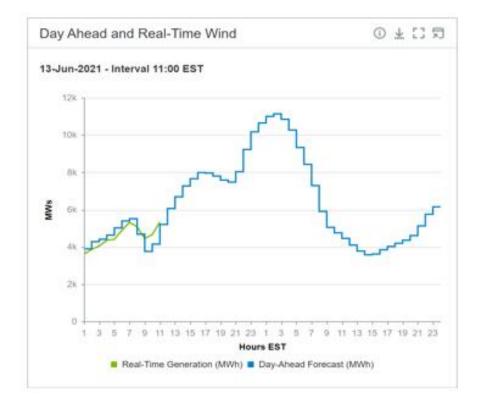
## **Fuel Mix**

- Data Collected From All Sources
- Renewable Production Varies
- More Wind = More Wind Power
- More Sun = More Solar Power



#### **Day Ahead Forecasting**

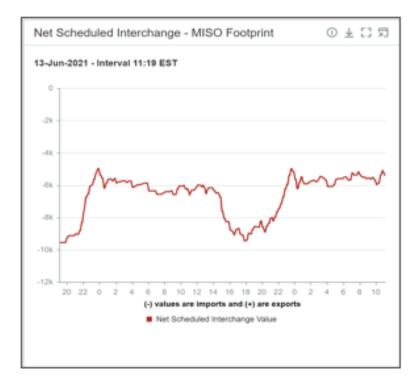
- Weather Predictions Determine Amount of Renewable Power Expected
- Bids are Placed by Generating Units Based on Expected Power

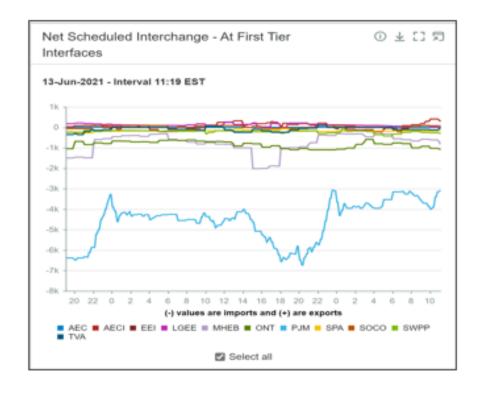


Region	Market Participant Code	Date/Time Beginning (EST)	Date/Time End (EST)	MW	LMP	Type of Bid Bid ID	PRICE1	MW1
North	122062236	3/15/2021 0:00	3/15/2021 1:00	1740	0.93	F 122073042		1740
Central	122062236	3/15/2021 0:00	3/15/2021 1:00	1318	20.17	F 122073033		1318
North	122062236	3/15/2021 0:00	3/15/2021 1:00	3	3.49	F 122073561		3
North	122062236	3/15/2021 0:00	3/15/2021 1:00	16	-15.06	F 767746013		16
Central	122062236	3/15/2021 1:00	3/15/2021 2:00	1330	19.71	F 122073033		1330
North	122062236	3/15/2021 1:00	3/15/2021 2:00	1754	2.78	F 122073042		1754
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#### **Planning for Import and Export**

- Sometimes Excess Power can be Exported to Other Areas
- Sometimes Power Needs to be Imported from Other Areas





#### **Data Capabilities**

All Parts of the Grid have Data Capability

- Generation Source
- Substations
- Transmission Systems
- All used together to Make Grid Management Possible

#### **Troubleshooting Remote**

- Depends on Good Data Collection
- Individual Generation Assets Collect Data Continuously
- Data is Accessed and Used to Determine the Source of the Fault
- Technicians and System Operators Depend on Processed Data

### **Case Study**

Pitch Servo Motor Overheat Fault

- Electric Pitch Control System in a Wind Turbine
- Servo Motor Temperature is Monitored by the Control System
- Parameters are Established Within the Controller to Protect the Motor
- Control System Takes Specific Actions When Temperature Reaches Set Point

### Start of Event

- The Control System in the Wind Turbine Detects a High Temperature
- Alarm is Sent to the Monitoring Operator (Local and System Operators)
- The Operator can Acknowledge the Alarm and Start Working the Problem

#### **Operator Action**

• Operator Acknowledges the Alarm

1anual stop	Last update time 3/21/2	2021 3:21:15 PM	Last upd
lacel.pos<>wir		e Data 💽 Favorites Nacelle Direct [°] Yaw Motor 199.60 True 196.90 False	Bra ope

#### **Investigating the Cause**

- The Operator (or Technician) Starts to Investigate Possible Causes
- Logs Into the Controller to Gather Data About the Fault

Login	
User Name	
tls	
Password	
•••••	
Login (active)	Login (read-only)*

#### Logged Into the Control System

• Once Logged In the Control Menu Options Appear

O: Production G1	Yaw .:	0 11m/s 1137/12rpm 1473kW	
MAIN MENU			
Űnit Info			
User Account Info			
0S			
″ System			
″ Shutdown			
Älarm Server			
Álarm Client			
Application WTG 60H	z		

#### **Checking Parameters**

• The Pitch Motor Temperature Parameter can be Checked



### **Referencing the Manufacturers Material**

• Checking Documentation for Parameters

PLU PDU Temp SHH xx °C

- View: 99, Edit: 99
- Min.: 0, Max.: 150, Default: 60
- Max. temperature for the PLU pitch motors.

### **Checking the Fault Data**

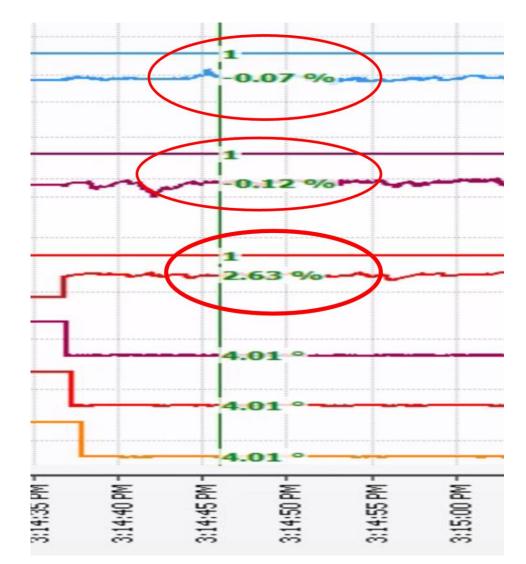
- Modern Machines Store Data Before and After a Fault
- This Data Can be Used to Gain Information About the Fault
- Can Be Compared to Other Data
- Data Used to Support Theories About Cause of Fault

#### **Trigger Data**



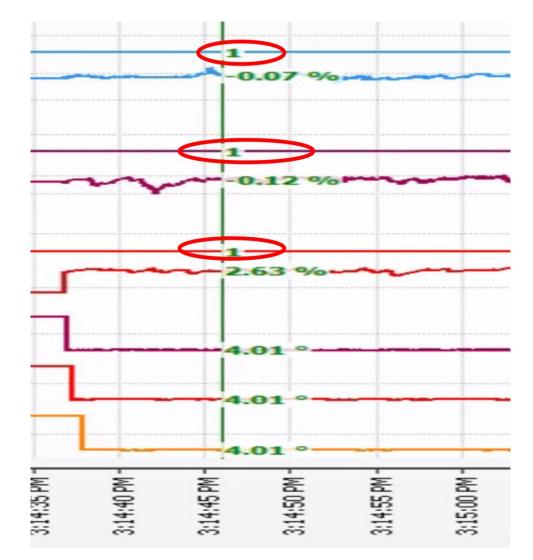
#### **Data Supported Theories**

- Increased Torque on Motor Could Cause It
- The Motor Torque is Compared to the Other Blades
- Motor Torque is Higher on the Faulted Blade
- More Information is Required to Determine Cause



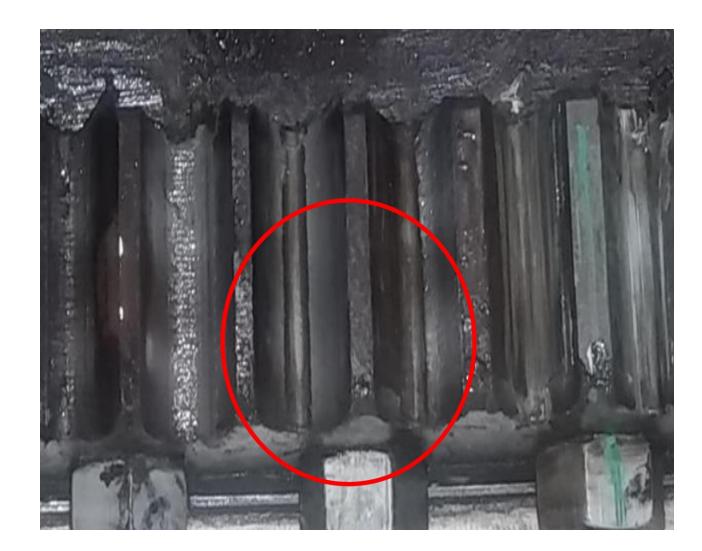
## **Other Theories**

- Motor Brake Stuck On
- Blade Bearing Binding
- Pitch Gear Box Issue
- Worn Open Gear Teeth Requiring More Holding Torque
- All Motor Brakes Appear to Be Open



#### **Root Cause Determined**

- Technicians Dispatched to Machine
- Inspection Found Worn Teeth on the Open Gear
- Caused Increased
   Torque Demand
- Blade Open Gear
   Was Replaced



#### **Case Study Summary**

- The Control System Reported the Fault
- The System Operator Started Diagnostics
- Site Technicians Inspected Based on Theories Supported by Data
- Root Cause was Improper Heat Treatment on Gear

### **Supervisory Control**

- Allows Control of Machine
- Can Be Local at Machine Through Human Machine Interface (HMI)
- Can Be Remote Through Software and Remote Connection
- Passwords Assign Different Levels of Privilege (access to control level)

#### **Machine Control**

- Software Allows for Control of Systems
- Changing Parameters
- Activating Motors and Heaters
- Changing Signals

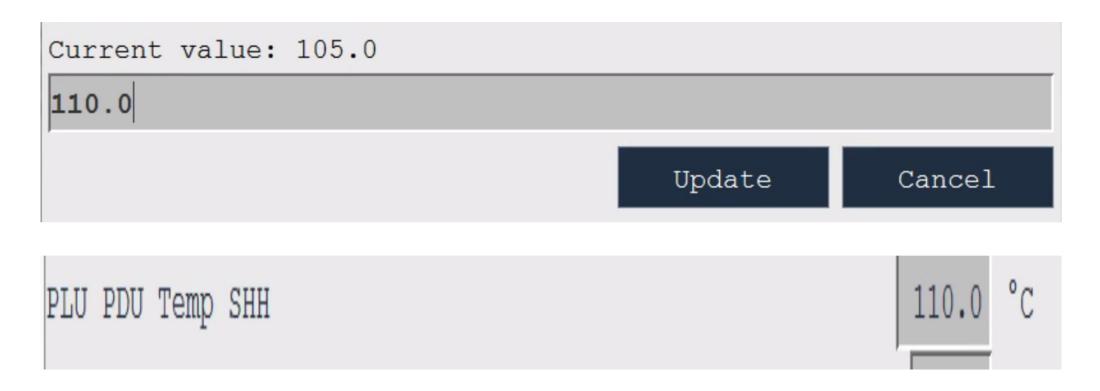
### **Parameter Changes (1)**

- Adjusting Parameters
- Changing the Pitch Motor Temperature Parameter



#### **Parameter Changes (2)**

- The Parameter is Selected
- The New Value is Typed In and Updated



#### **Motor Control**

- Motors Controlled Through Remote
- Grease Pump Motor Control

SERVICE		<<
PitchLubPumpOnTimer	0.0	S
PitchLubrictionPumpIntervalTimer	22229.7	S
Gen. Lub.Pump Man. On	0	

#### **Turning the Unit On**

• Turning the Unit On

Update	Cancel
	Update

#### **Feedback Data**

- Verifying the Unit is On
- Uses a Sensor to Indicate the Piston is Moving From Grease Moving

LubGen Pump ON	1
LubGen CycleCompl	
LubGen Pump ON	1
LubGen CycleCompl	$\bigcup_{1}$

#### **Curtailment – Local and Remote**

- Wind Turbines Are Able to Be Turned Up and Down Easily
- Can Adjust Output Levels Quickly
- Used by Utilities and Grid Operators to Control Grid Levels
- Done Through Remote Signaling

#### Summary

- Supervisory Control and Data Acquisition (SCADA)
- Allows Remote Control
- Collects and Stores Data for Use Later
- Vital to Operations, Grid Control and Reporting Production



