RET Site: Research Experience in Cybersecurity for Nevada Teachers (RECNT)
Cyber-Physical System Security

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Introduction

In this lesson, 5E (Engage, Explore, Explain, Elaborate, Evaluate) instructional model is used to teach students how electrical energy is delivered to the consumers, modern power grid structures, cyber threats on power grids, tools and methods to analyze cyber threats, and possible solutions to keep power systems resilient to cyber-attacks.

Modern Power Grids

What makes a power grid "SMART": The digital technologies and equipment that gather information along the transmission lines and allow for two-way communication between the utility and its customer.

Phasor Measurement Unit (PMU): A device that produces synchronized phasor, frequency, and rate of change of frequency (ROCOF) estimates from voltage and/or current signals and a time synchronizing signal.

Supervisory Control and Data Acquisition (SCADA): SCADA system supervises, controls, oprimizes generation and transmission systems.

Tools and Methods
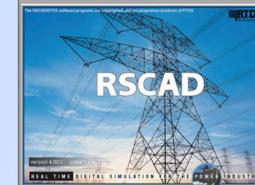
Real Time Digital Simulator (RTDS)
Consist of hardware and software designed to perform real-time power system simulation .

RSCAD (by RTDS) Simulation Software
Allows user to:
- Create power system models and testbeds
- Run simulation
- Analyze simulation results
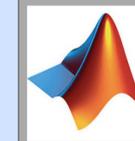
MatLab
- The same tool used by Engineers that provides a scientific environment for analyzing data, conducting research, and developing programming skills.

WireShark
- A network protocol analyzer
- Needed to analyze IEEE Std C37.118.2-2011 Synchrophasor Data

OpenPDC/PMU Connection Tester
- A Windows GUI application that allows the user to validate and test, data streams from the phasor measurement devices, as well as provide visual graphs of the synchrophasor data in real-time.

What Makes Up a Power Grid

Electricity generation, transmission, and distribution

power plant generates electricity

transmission lines carry electricity long distances

distribution lines carry electricity to houses

transformer steps up voltage for transmission

neighborhood transformer steps down voltage

transformers on poles step down electricity before it enters houses
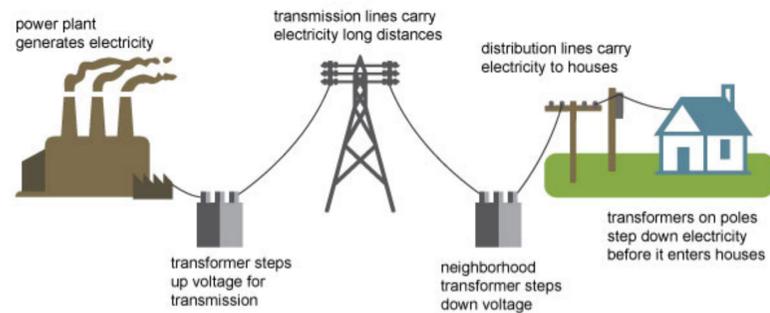
Source: Adapted from National Energy Education Development Project (public domain)

Cybersecurity Applications
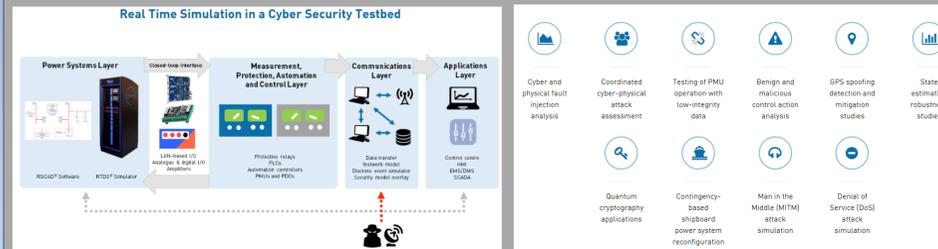
Real Time Simulation in a Cyber Security Testbed

Engagement

Discussion: Can you imagine not having electricity in your hometown for more than a day, a week, or even a month? How would you feel? How would your life be affected? Would you feel different if you lived in a different part of the world? Would you feel different if you lose your electricity during different seasons of the year, such as winter or summer?
Online Game: Game-based learning helps educators to stimulate students interest and get them personally involved in the lesson. Power the Grid is a real-time-strategy tycoon game that simulates the power grid.

Exploration

In small groups, students will explore the internet and conduct research on the parts that make up a Power System SmartGrid, specifically what actually makes that it "SMART" and why. Emphasis will be placed on the students to find the Phasor Measurement Unit (PMU) and relate how it is used in the Power System Smart Grid and its importance.
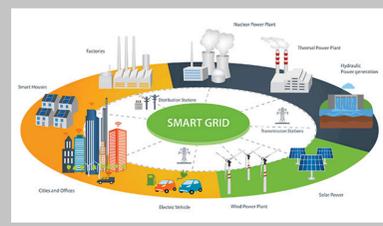
Explanation

Based on the students' previous knowledge of network communications and IP/TCP packets, they will explain how the Power System SmartGrid network communications SynchroPhasor TCP packets are similar as well as different from the protocol set by the IEEE Std C37.118.2-2011 (Standard for Synchrophasor Data Transfer for Power Systems - Smart Grid.)
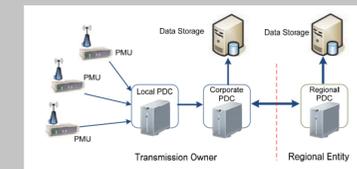
Elaboration

Students will learn to use industry-based simulation software to extend previously learned concepts.
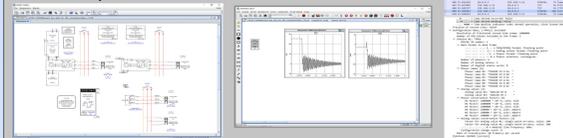
RSCAD Build Power System

RSCAD Run/ Analyze)

WireShark Capture/Analyze

MatLab - Analyze

OpenPDC Manager - Analyze

Evaluation

1. Students will work in small groups(2 to 3 students per group).
2. They will follow a rubric of instructions to build their own basic SmartGrid Power System. The system will include 2- generators, 3- buses, 1- load, transmission lines, and one PMU.
3. Students will use all of the previously learned software to build the system, monitor the system, and manipulate a SynchroPhasor packet. The students will monitor the visual graphics in OpenPDC and determine if their packet has had any effect on the PMU data.
4. Upon completion of the project, the students will present their findings to the class in a PowerPoint presentation, app, digital story or video.