Cyber Infrastructure for the Smart Grid

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Power Grid and What can go wrong
Electric Power Grid

- Electric power system grid can be defined as the entire apparatus of wires and machines that connects the sources of electricity with customers.
- Power grid is generally divided in generation, transmission, distribution and loads.

http://www.ee-scholarship.org/about-power-engineering-careers/video-library/
Power System Structure

Basic Structure of the Electric System

- **Basics**
- **Generation & transmission**
- **Substations & transformers**
- **Control centers**

Credit: Jim McCally, Iowa State

http://tcip.mste.illinois.edu/
North American Interconnection...
Energy Control Centers

Energy Control Center (ECC):
- SCADA, EMS, operational personnel
- “Heart” (eyes & hands, brains) of the power system

Supervisory control & data acquisition (SCADA):
- Supervisory control: remote control of field devices
- Data acquisition: monitoring of field conditions
- SCADA components:
  - Master Station: System “Nerve Center” located in ECC
  - Remote terminal units: Gathers data at substations; sends to Master Station
  - Communications: Links Master Station with Field Devices

Energy management system (EMS)
- Topology processor & network configurator
- State estimator and power flow model development
- Automatic generation control (AGC), Optimal power flow (OPF)
- Security assessment and alarm processing
Remote terminal unit

Substation

SCADA Master Station

Communication link

Energy control center with EMS

EMS 1-line diagram

EMS alarm display
More energy control centers
What Can go Wrong
Lightning

lightning induced flashover!
Lightning
Wind and snow

hurry up, I can't hold it much longer
Deterioration (insulation failure)
What can go wrong

- Lightning
- Wind and snow
- Deterioration (insulation failure)
- Animals (mainly squirrels & snakes, but sometimes….)

Time for a nap?
What can go wrong

- Lightning
- Wind and snow
- Deterioration (insulation failure)
- Animals (mainly squirrels & snakes, but sometimes….)
- Trees
What can go wrong

- Lightning
- Wind and snow
- Deterioration (insulation failure)
- Animals (mainly squirrels & snakes, but sometimes….)
- Trees
- Accidents
- Man made error (mistakes)

All of the previous situations cause faults.
Faults are dangerous situations that can hurt people and destroy equipment.
Protection equipment removes faults:
- Fuses detect faults and melt a wire. Must be replaced.
- Relays detect faults and signal circuit breaker to trip.
- Circuit breakers open lines. Can be re-used.