Grid Energy 101

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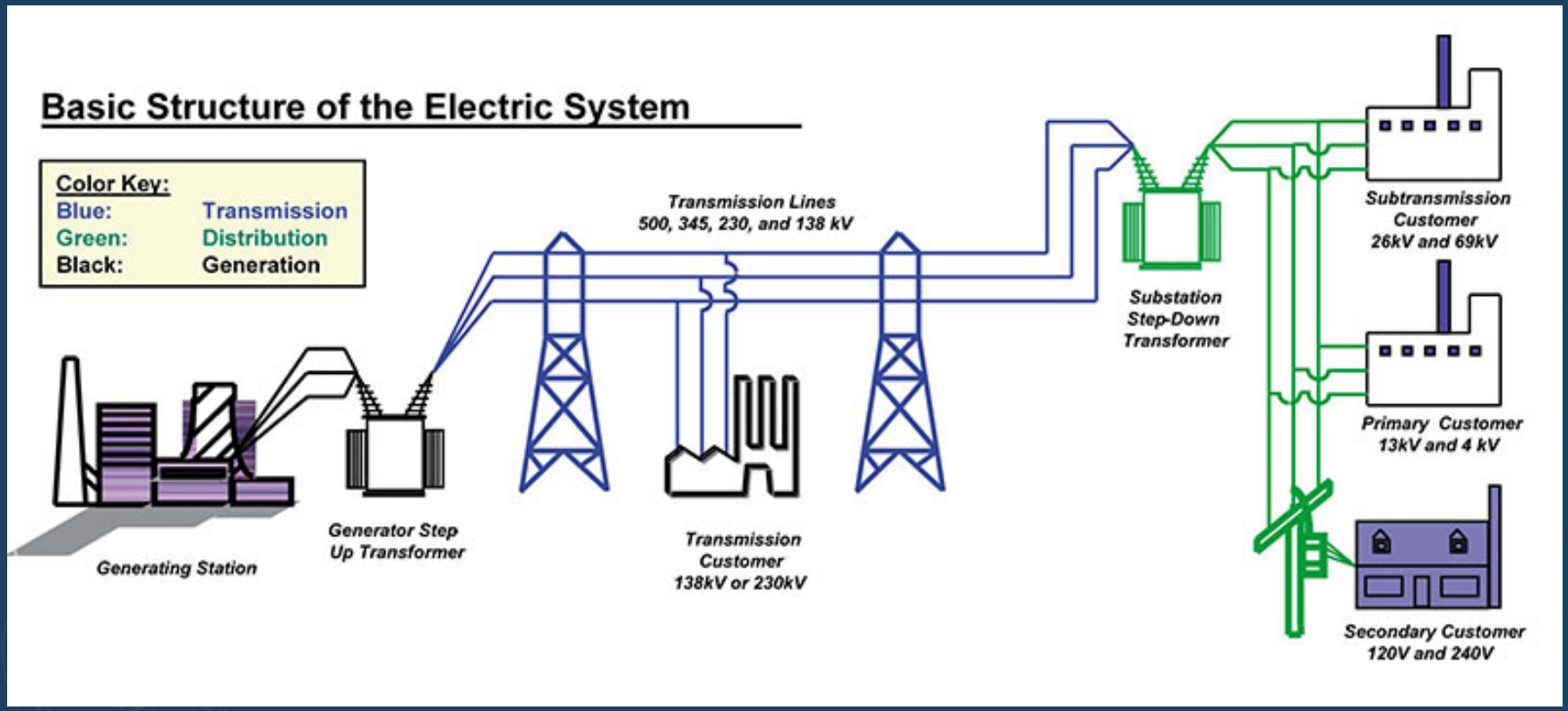
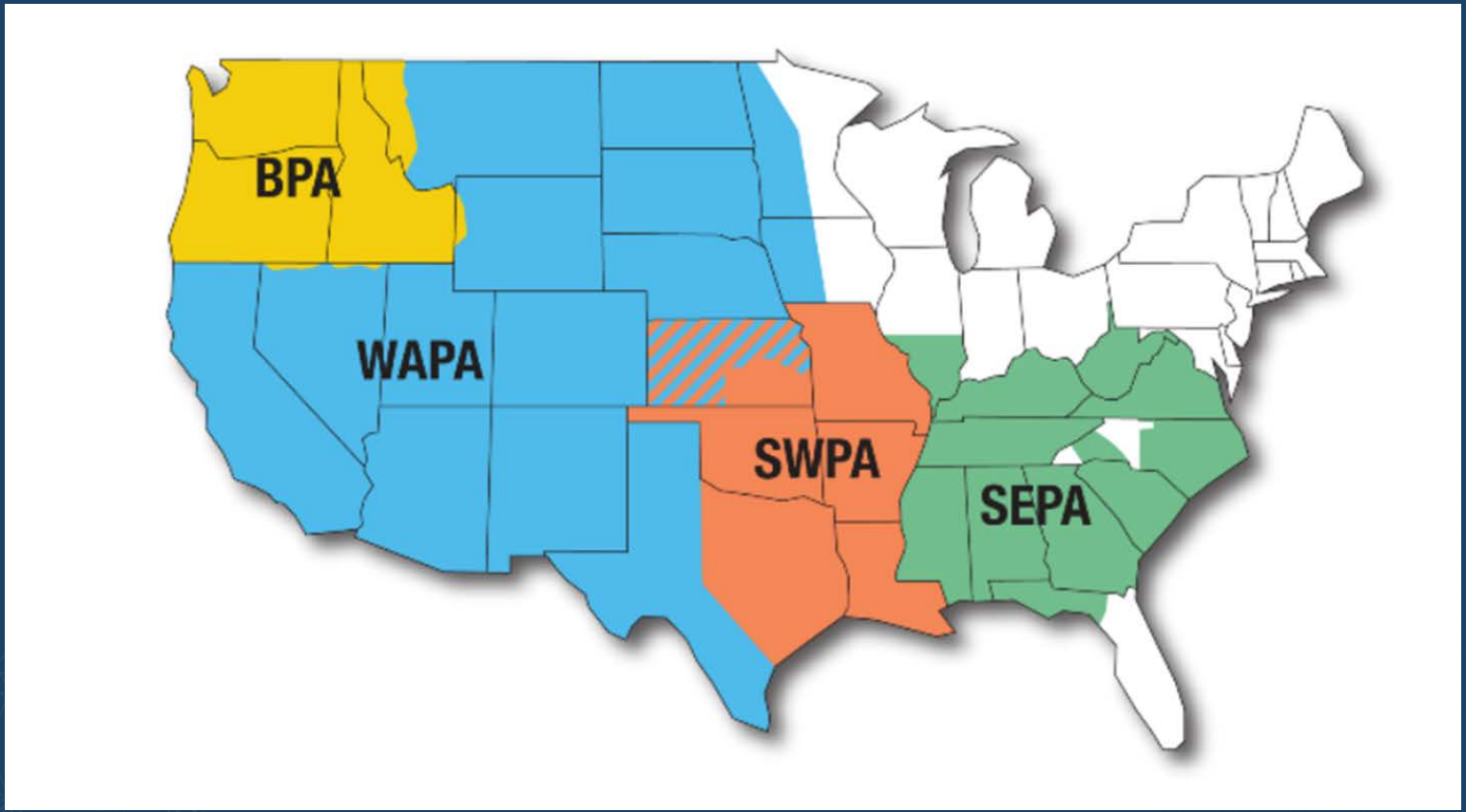
Grid Energy 101

- Objective
  - Obtain a better understanding of how the electrical grid functions, in order to ask the right questions and to formulate a plan to become an active member of the interconnected electrical grid.

Basic Structure of the Electric System



WAPA is One of Four Power Marketing Administrations (PMA's)

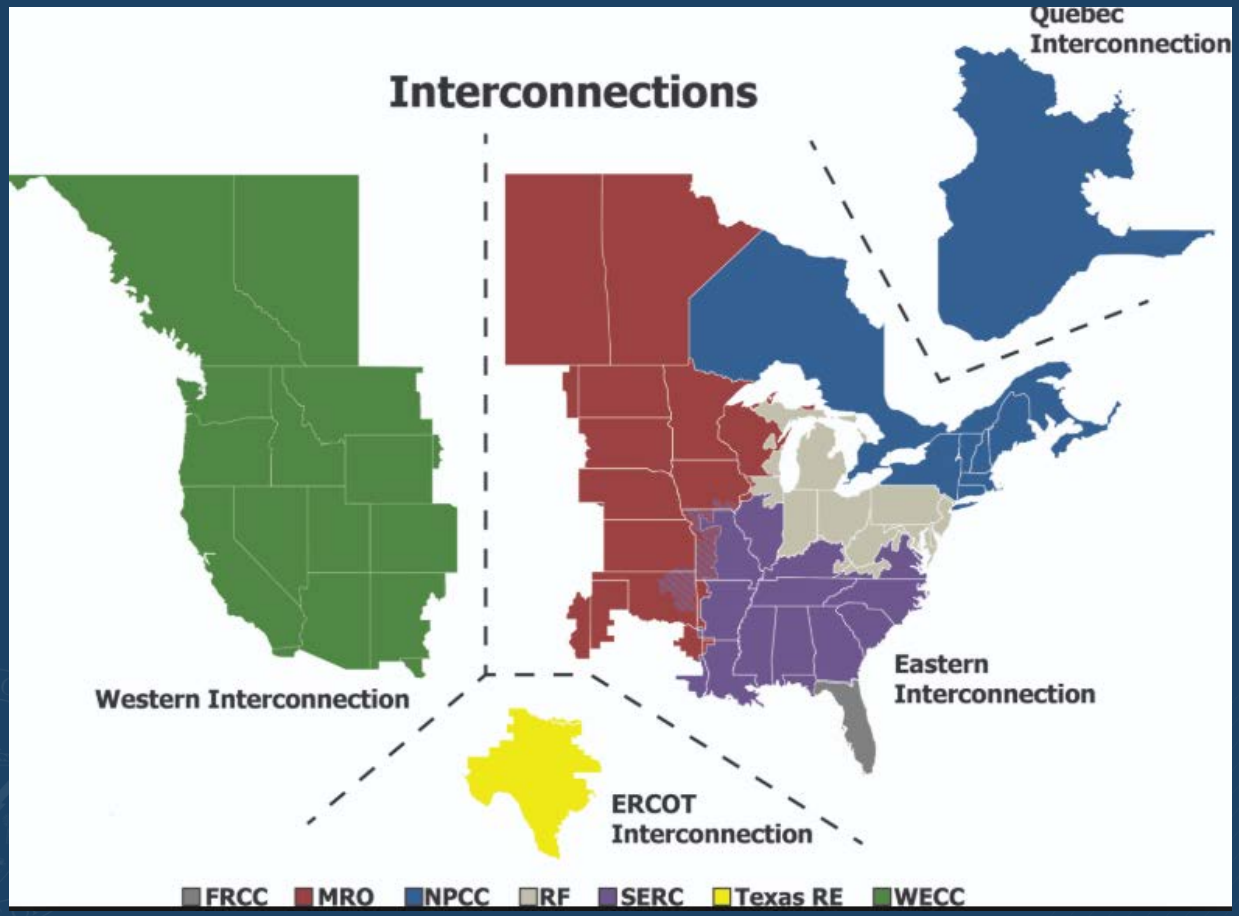


WAPA Offices

Regions

- Headquarters
- Desert Southwest
- Sierra Nevada
- Colorado River Storage
- Rocky Mountain
- Upper Great Plains

The 4 Interconnections that make up the Grid



Who Operates the Electrical System

- The System Operator
  - Transmission System Operator (TSO)
  - Automatic Generation Control (AGC)
  - Transmission Scheduling & Security (TSS)
  - Distribution System Operator (DSO)
  - Generation Operator (GO)
  - Reliability Coordinator (RC)

Transmission System Operator

- Responsible for the Transmission and Substation side of the System.
- Keeping the Transmission and Substation equipment at peak performing capability is the number two priority.
  - What is the number one priority?
  - Field Worker Safety.

Transmission System Operator

- Monitoring the Bulk Electric System (BES), enabling Personnel to respond immediately to emergency situations so an uncontrolled separation will not happen with the loss of a single element.
- What does that statement really mean?
  - Say for example, if a 500 kV line trips; we operate our system to keep the loss of one line in the electrical system from causing a cascading outage, the system will automatically respond causing no major issues.
  - The next line could create system issues, so after the loss of the first line, the TSO makes sure the system is ready for the loss of the next line.

Automatic Generation Control Operator

- A view from the AGC desk can be like comparing the electrical system to a plane in flight.
  - The pilot is the heart of the plane, the pilot is charged with maintaining the balance of the plane.
  - That balance in the Bulk Electric System (BES) means the balance of generation and load.
  - Load is the use of electricity by our customers' and generation is a product of the US Bureau of Reclamation (USBR).
  - Load and generation must always be balanced.
    - The trick is to keep it balanced at 60hz
- In the United States the standard is to maintain the balance of load and generation at 60 cycles (HZ).

What is your preference, for balance?

Transmission Scheduling & Security

- At the Transmission Scheduling & Security (TSS) desk the operator is responsible for making sure energy scheduled to flow on our transmission lines has the rights to do so.
- Energy scheduled to flow on the transmission system is scheduled using an electronic tag, referred to as an “e-tag”.
  - Energy moved across boundaries with other entities must all be e-tagged.
  - If a tag is missing or incorrect the system will start to go out of balance.

Distribution Operator

- Provides and operates the “wires” between the transmission system and the end-use customer.
- For those end-use customers who are served at transmission voltages, the Transmission Owner also serves as the Distribution Provider. Thus, the Distribution Provider is not defined by a specific voltage, but rather as performing the Distribution function at any voltage.

Generation Operator

- The entity that operates generating unit(s) and performs the functions of supplying energy and Interconnected Operations Services.
- Entity that owns and maintains generating units.

Reliability Coordinator

- The entity that is the highest level of authority who is responsible for the reliable operation of the Bulk Electric System, has the Wide Area view of the Bulk Electric System, and has the operating tools, processes and procedures, including the authority to prevent or mitigate emergency operating situations in both next-day analysis and real-time operations.

Typical voltage levels found on the Grid

- Extra High voltage (EHV)
  - 500kV
  - 345kV
- High Voltage Transmission
  - 230kV
  - 161kv
  - 138kV
  - 115kV
  - 92kV
- Sub-transmission
  - 69kV
  - 60kV
  - 34.5kV
- Distribution (Neighborhoods)
  - 21kV
  - 16kV
  - 13.8kV
  - 12kV
  - 4kV

We have an EHV system so we can transfer more power greater distances. (every electrical circuit has some type of losses)

Typical Equipment found on the Grid

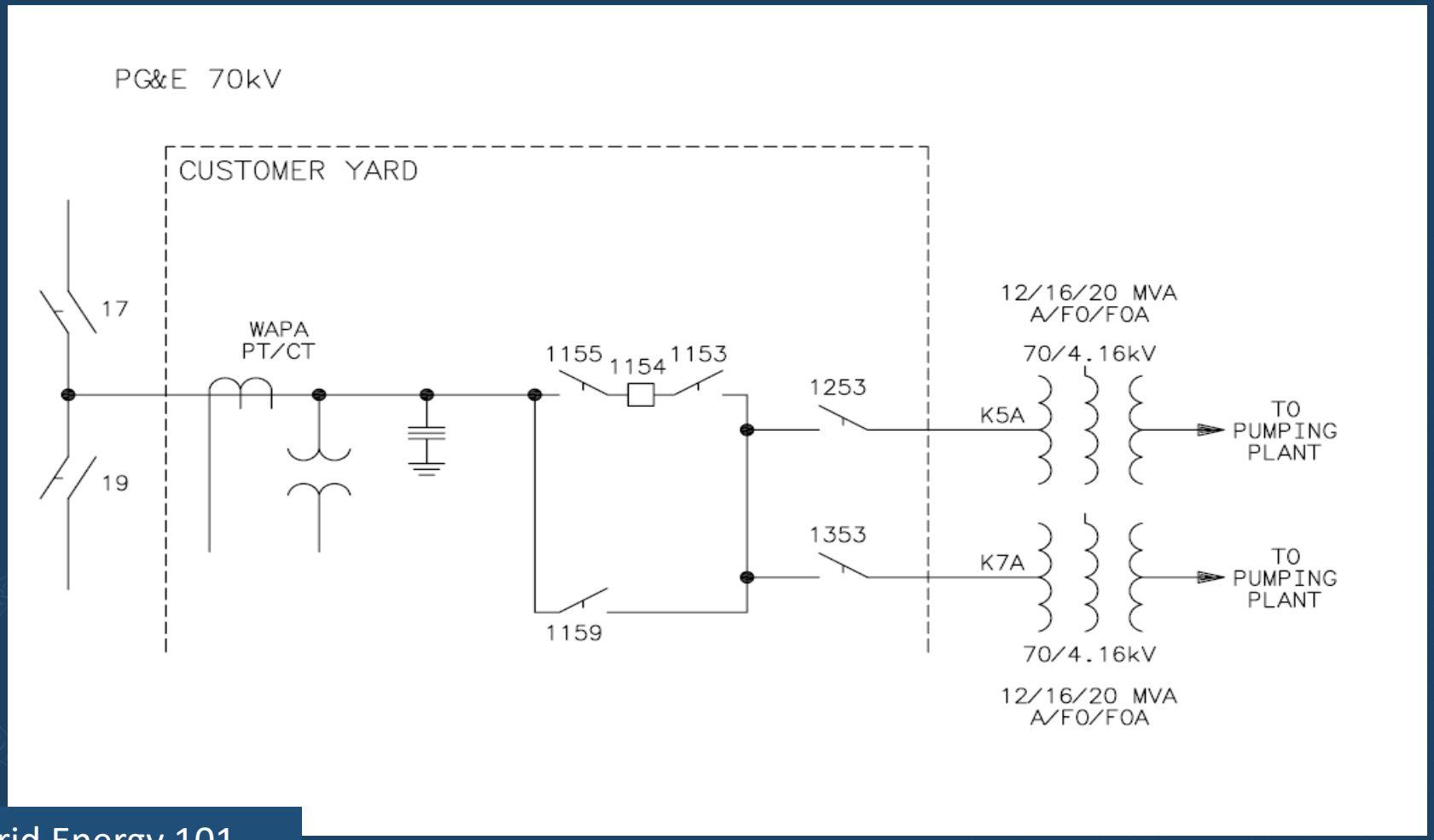
- Substations
  - Circuit Breakers
  - Transformers
  - Capacitors
  - Reactors
  - Fuses
  - Station Service
  - Insulators
  - Bushings
  - Bus work
  - Pothead
  - Control building
  - Controls and relay protection.
  - Lightning Arrestors
  - DC control System

- Lines
  - Insulators
  - Bushing
  - Wires
  - Poles / Towers
  - Transformers
  - Fuses
  - Pothead
  - Reclosers
  - Capacitors
  - Reactors

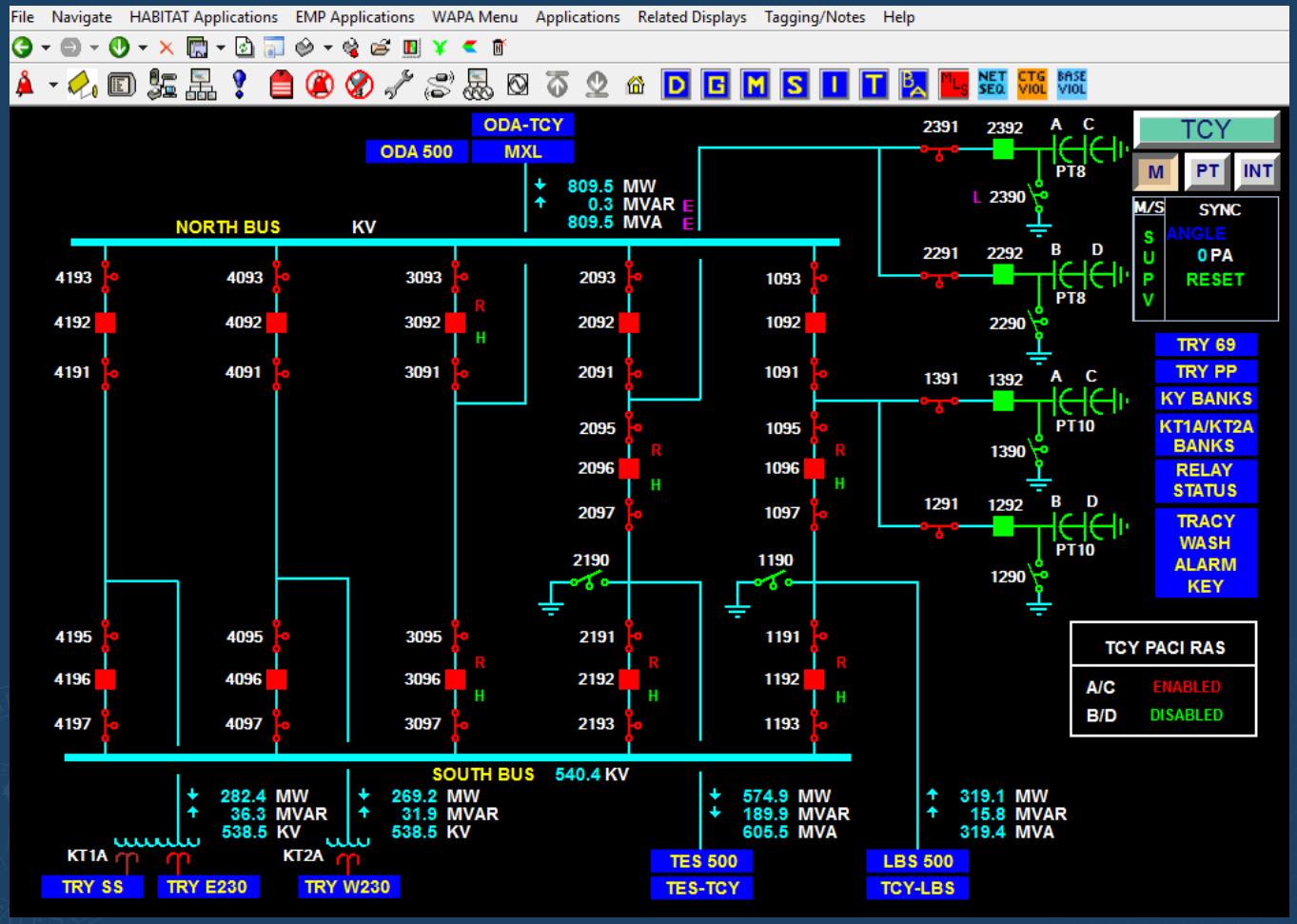
- Power Plants
  - Prime mover
  - Fuel
  - Cooling
  - Heat / Water / Steam
  - Control systems
  - Reactors

Physical Perspective

Single line Perspective



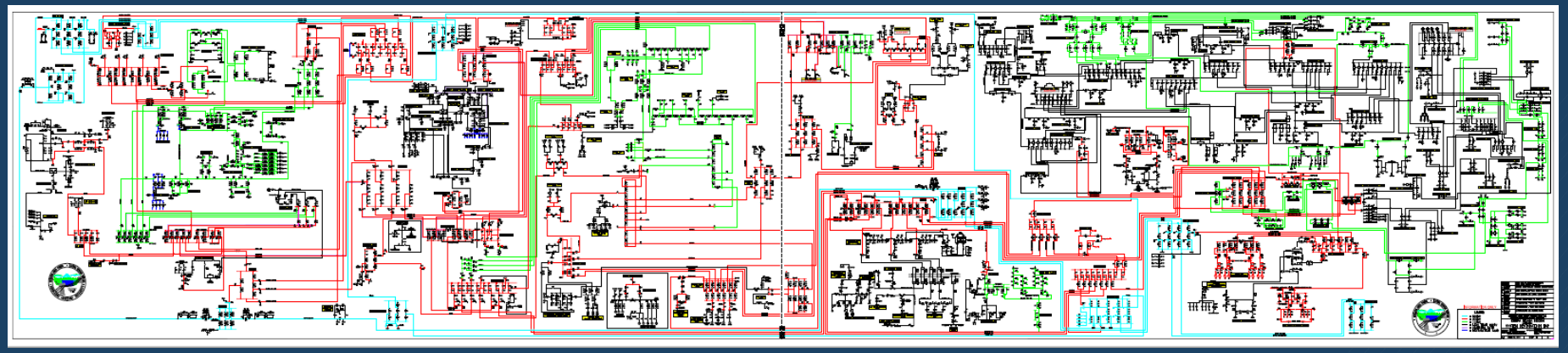
Utility Remote Control Perspective (SCADA)



Grid Energy 101

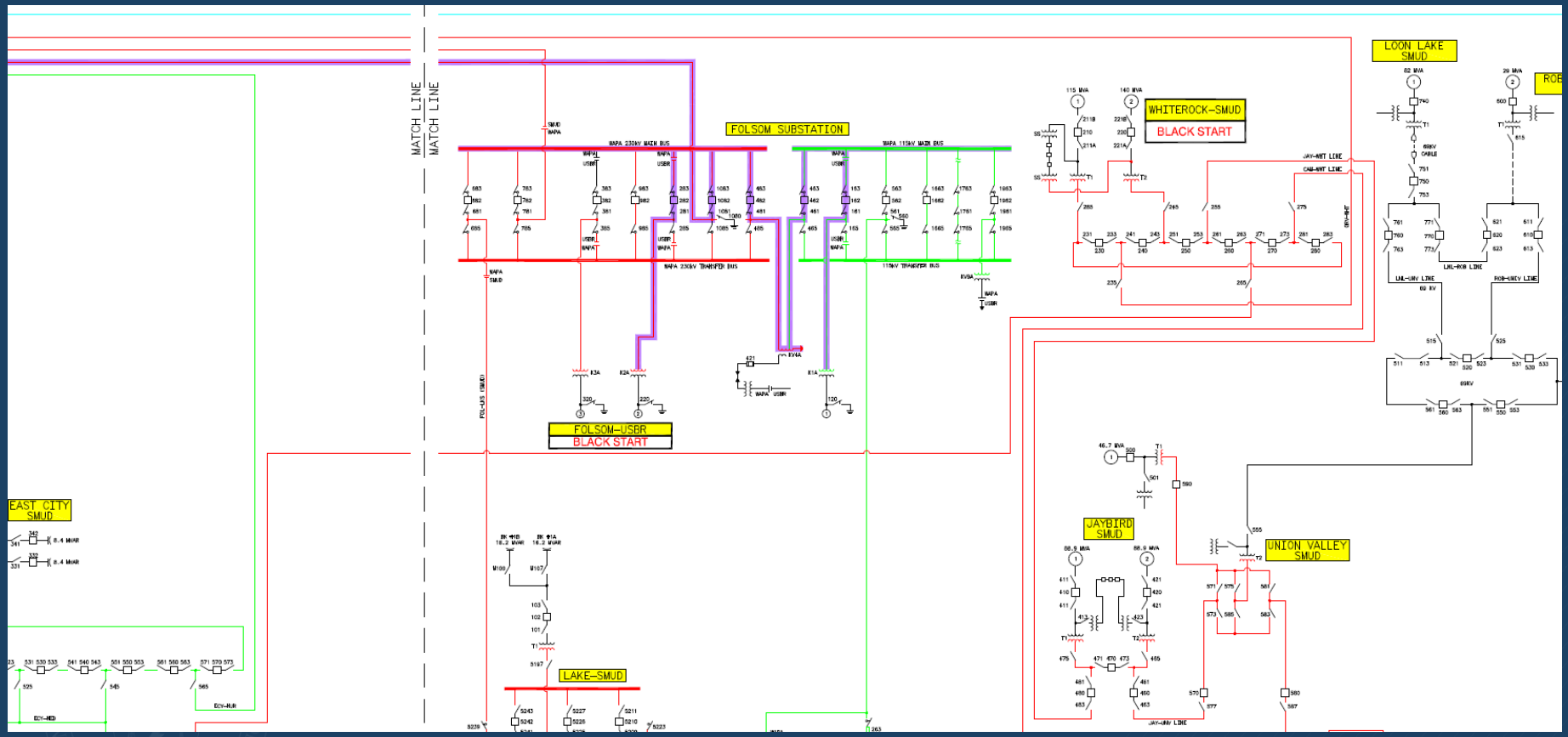
Supervisory Control and Data Acquisition (SCADA)
Part of an Energy Management System (EMS)

What the Grid looks like on Paper



The Federal Power System In Northern California
It's a Beast…..
Let's take a closer look…

Transmission Map



What is a Substation (Collector)

What is a Power Plant

- A variety of facilities generate electricity, including
  - Coal
  - Natural gas
  - Hydroelectric dams,
  - Nuclear
  - Wind turbines
  - Solar panels
  - Diesel
- The location of these electricity generators – and their distance from end users – varies widely.

Power Plants

- These technologies are also *physically* different, and are used and manipulated differently on the power grid as a result.
- For example, certain types of power plants, such as coal and nuclear power plants, have little short-term flexibility in adjusting their electricity output;
  - it takes a long time to ramp up or down their electricity output
  - Electricity can be generated at 13.8kV and then stepped up to 230kV to transmit to substations.

Power Plants

- Other plants, such as natural-gas fired plants, can be ramped up very quickly, and are often used to meet peaks in demand.
- More variable technologies, such as wind and solar photovoltaics, are generally used whenever they are available,
  - in large part because their fuel – sunlight and wind – is free.
- At any given time, there is also always a "reserve margin," a specified amount of backup electricity generating capacity that is available to compensate for potential forecasting errors or unexpected power plant shutdowns.

What is a Transmission Line (230kV)

- Transmission lines are necessary to carry high-voltage electricity over long distances and connect electricity generators with electricity consumers.
- Transmission lines are either overhead power lines or underground power cables.
- Overhead lines are not insulated and are vulnerable to the weather, but can be less expensive to install than underground power cables.
- Overhead and underground transmission lines are made of aluminum alloy and reinforced with steel; underground lines are typically insulated

Power Plant Types

Power Plant types

What is a Distribution Line or System (13.8kV)

- The distribution network is simply the system of wires that picks up where the transmission lines leave off. These networks start at the transformers and end with homes, schools, and businesses.
- The grid comes to an end when electricity finally gets to the consumer, allowing you to turn on the lights, watch television, or run your dishwasher.

What is the purpose of a Transformer

- **Transformers** are devices used in electrical circuits to change the voltage of electricity flowing in the circuit.
  - **Transformers** can be used either to increase the voltage (called "stepping up") or decrease the voltage ("step down")

Grid Components

- What do you see in this Picture?

Grid Components

- What do you see in these Picture?
  - The same exact thing?

Normal

Abby Normal

What type of equipment is in these photos?

Can you recognize the hazards?

What is the Purpose of a Circuit Breaker

- It breaks a circuit?
- A **circuit breaker** is an automatically operated electrical switch designed to protect an electrical **circuit** from damage caused by excess current from an overload or short **circuit**.
- Its basic **function** is to interrupt current flow after a fault is detected.

Grid Components

- What do you see in this Picture?

Grid Components

230kv CB

345kV CB

Grid Components

500kv CB

230kv CB

Grid Components

69kV CB

13.8kV CB

Metal Clad switchgear, Circuit Breakers

The House

The Weather Head

Gas Meter & Under ground electric service

Questions