Regional Transmission Landscape

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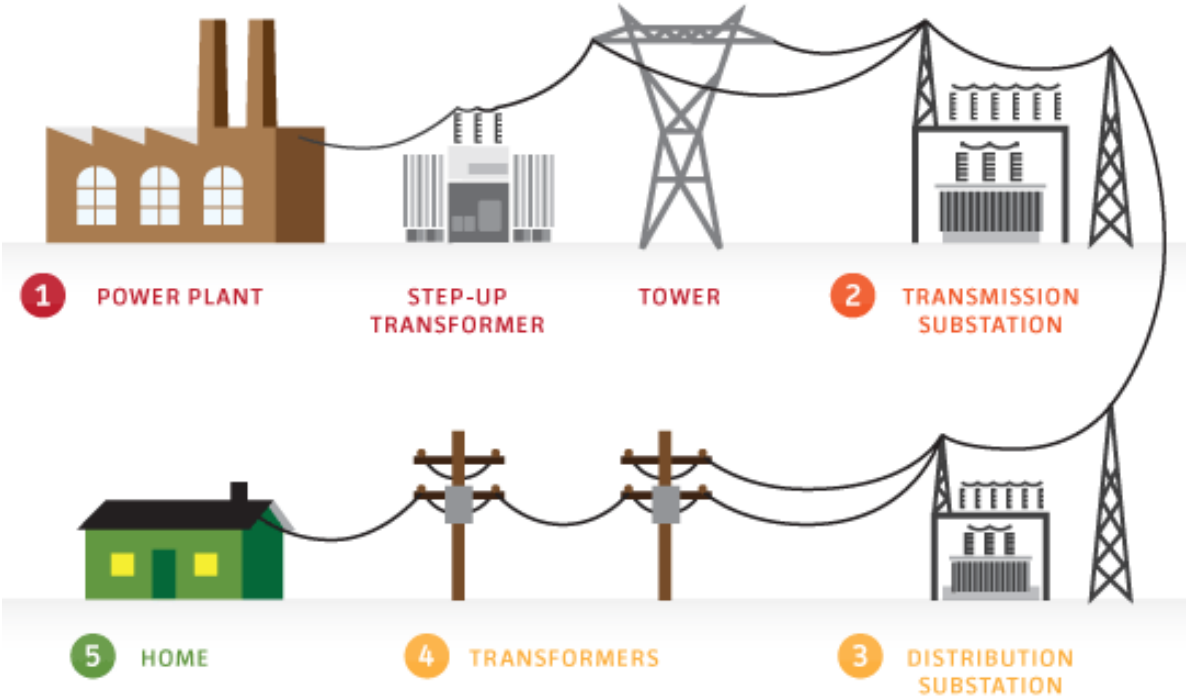
Topics

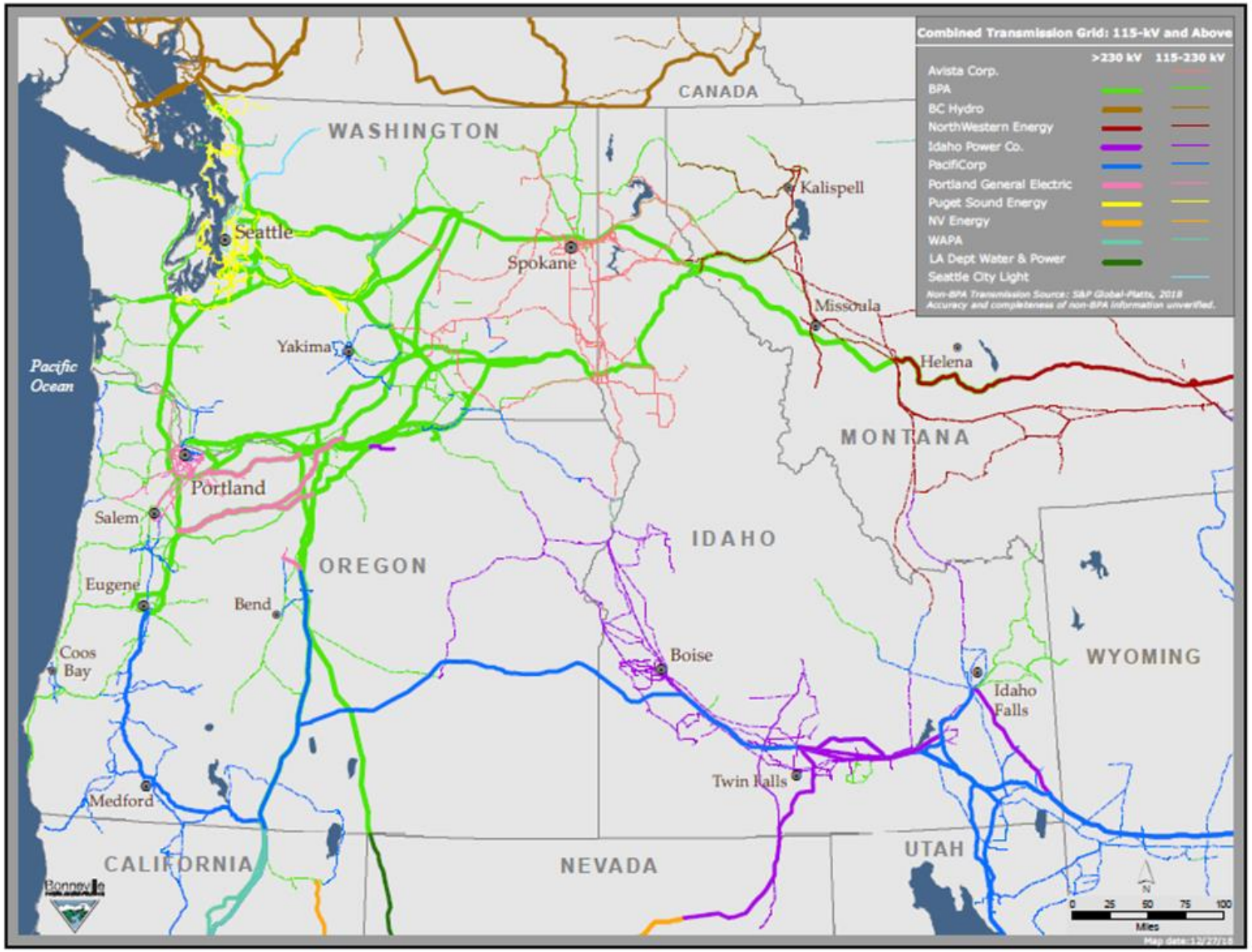
- Electric Utility System Fundamentals
- Key Entities (Responsibilities/Roles)
- Western & Pacific Northwest Landscape
- Challenges and Opportunities

Electric Transmission Overview



- Transmission enables end-users to access cost-effective, clean, and diverse supply sources
- Transmission is necessary and important for keeping the lights on and getting to a low carbon energy future

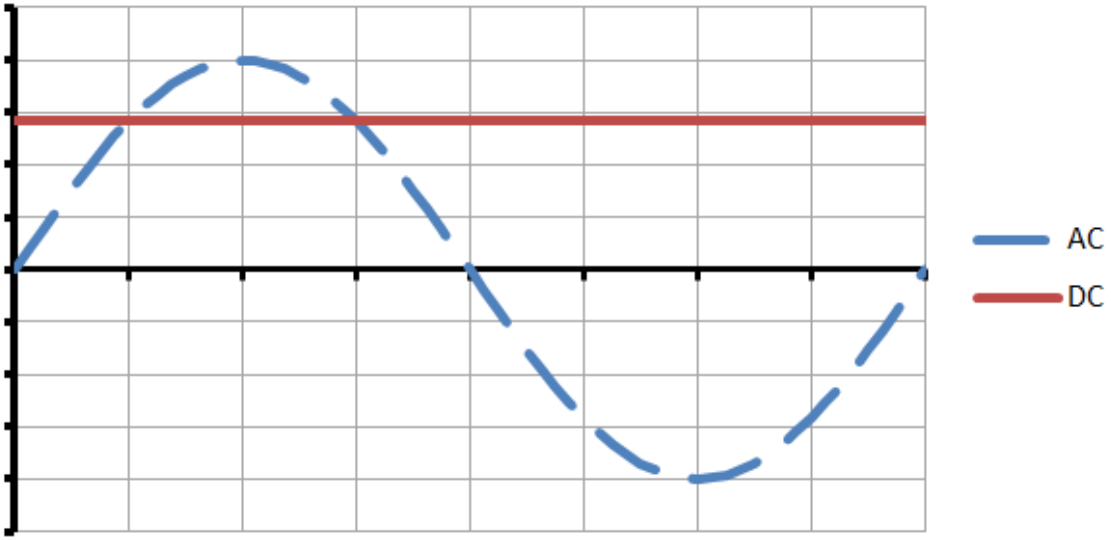
Pacific NW Transmission Grid



Electric Utility System Fundamentals

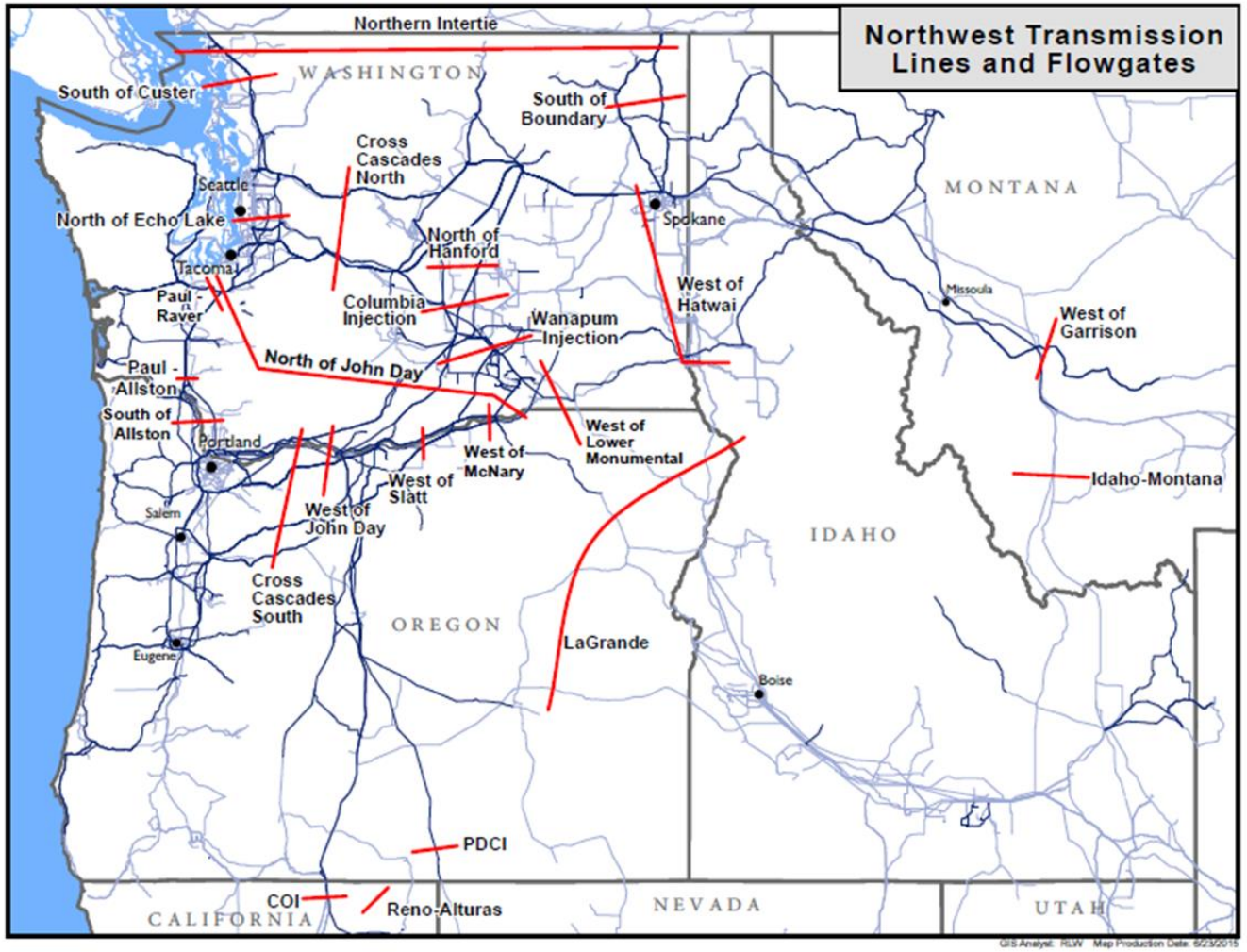
- Supply must equal demand at all times
  - Generation + Imports = Load + Exports
- Power flows are dictated by the laws of physics
  - Power automatically distributes based on electrical characteristics (path of least resistance)
  - Contract path (point A to point B) is an approximation
- Safety and reliability are the priorities
  - Electricity is an essential public service that needs to be very reliable
  - Safety-conscious decisions protect customers, employees, and the public
- Interconnected system benefits everyone
  - Increases system stability, reliability, and diversity across a large footprint

AC and DC Applications



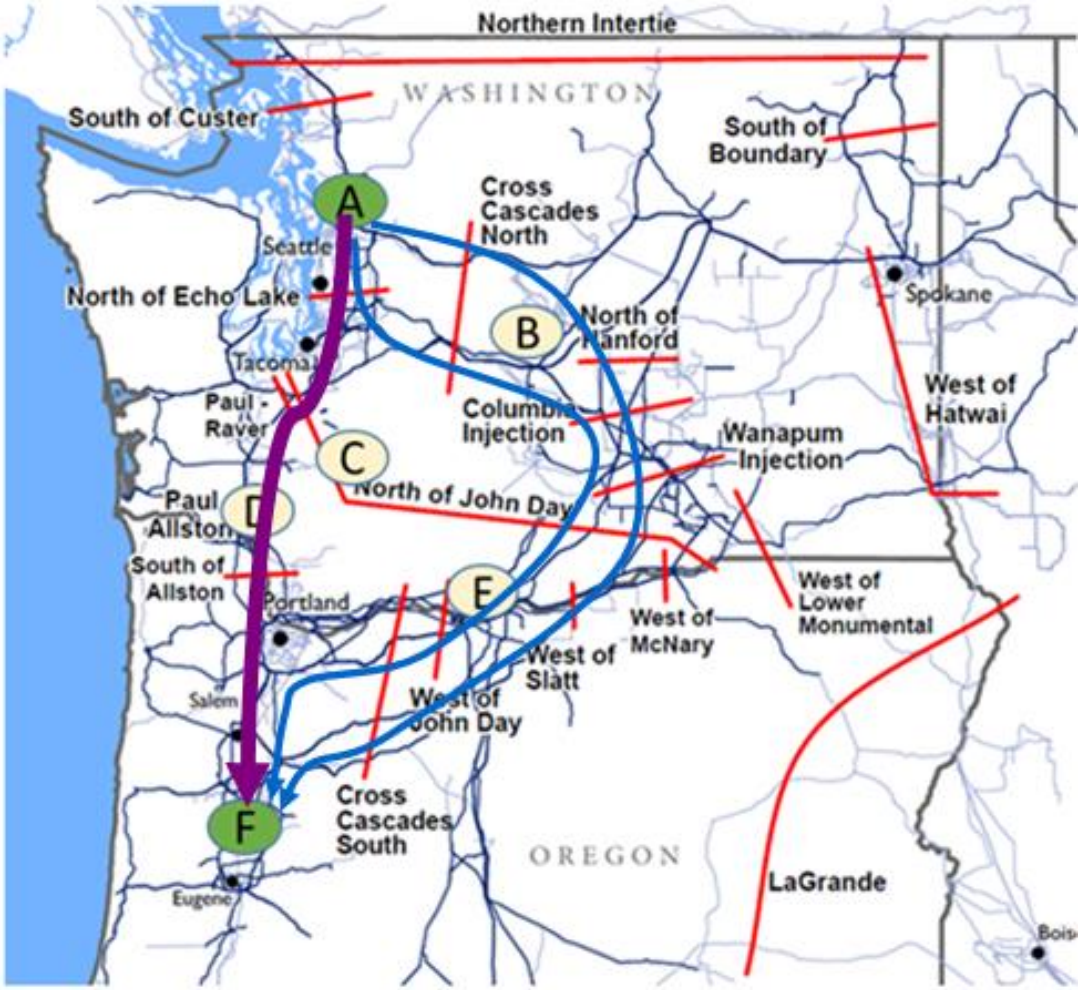
- Alternating Current (AC)
  - Widespread high voltage power transmission and distribution technology because it is easier to transform between voltage levels
- Direct Current (DC)
  - Low voltage applications like consumer electronics, batteries, and solar PV
  - Limited to niche applications for high voltage transmission (several hundred miles without any connections in the middle)
  - Pacific Direct Current Intertie (PDCI) between The Dalles and Los Angeles

Flowgates and Paths



Flowgates and paths consist of one or more transmission facilities that are operated in a coordinated manner and are monitored for congestion management

Contracts vs. Physics



Example:

- A seller near Seattle wants to sell generation to a buyer with load near Eugene
- They enter a transmission service contract for the right to move power from a point of receipt (A) to a point of delivery (F)
- Physical power flow is more complicated. It automatically splits across multiple paths

Key Entities:
Roles and Responsibilities

Portland General Electric

CHELAN COUNTY

Market Participants

- Federal power marketing administrations
  - BPA & WAPA
- Load-serving entities (LSE) and integrated Utilities
  - Publicly-owned
  - Investor-owned
- Independent power producers (IPP) and independent transmission companies (ITC)
- End-users

Regulators

- Federal Energy Regulatory Commission (FERC)
  - Independent United States government agency that regulates the interstate transmission and pricing of electricity, natural gas, and oil
- Electric Reliability Organization (ERO)
  - Consists of North American Electric Reliability Corporation (NERC) and seven Regional Entities, including Western Electricity Coordinating Council (WECC)
  - Mission is to assure the effective and efficient reduction of risks to the reliability and security of the grid
- Public Utility Commissions
  - State agency charged with regulating investor-owned utilities and setting retail rates

Balancing Authorities

- Each Balancing Authority in the Western Interconnection ensures load / resource balance for its Balancing Authority Area in real time
- Operating reserves are capacity set aside to deal with unforeseen variation in load and resources
  - Providing reserves for variable resources (wind and solar) is an important consideration for renewable policy

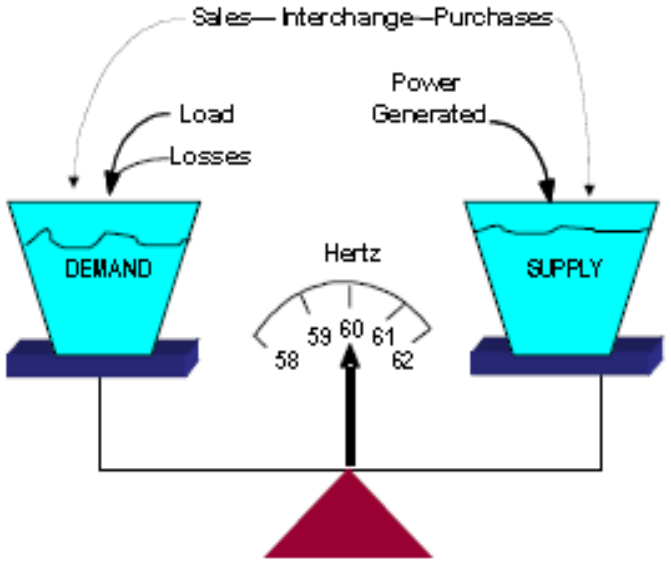
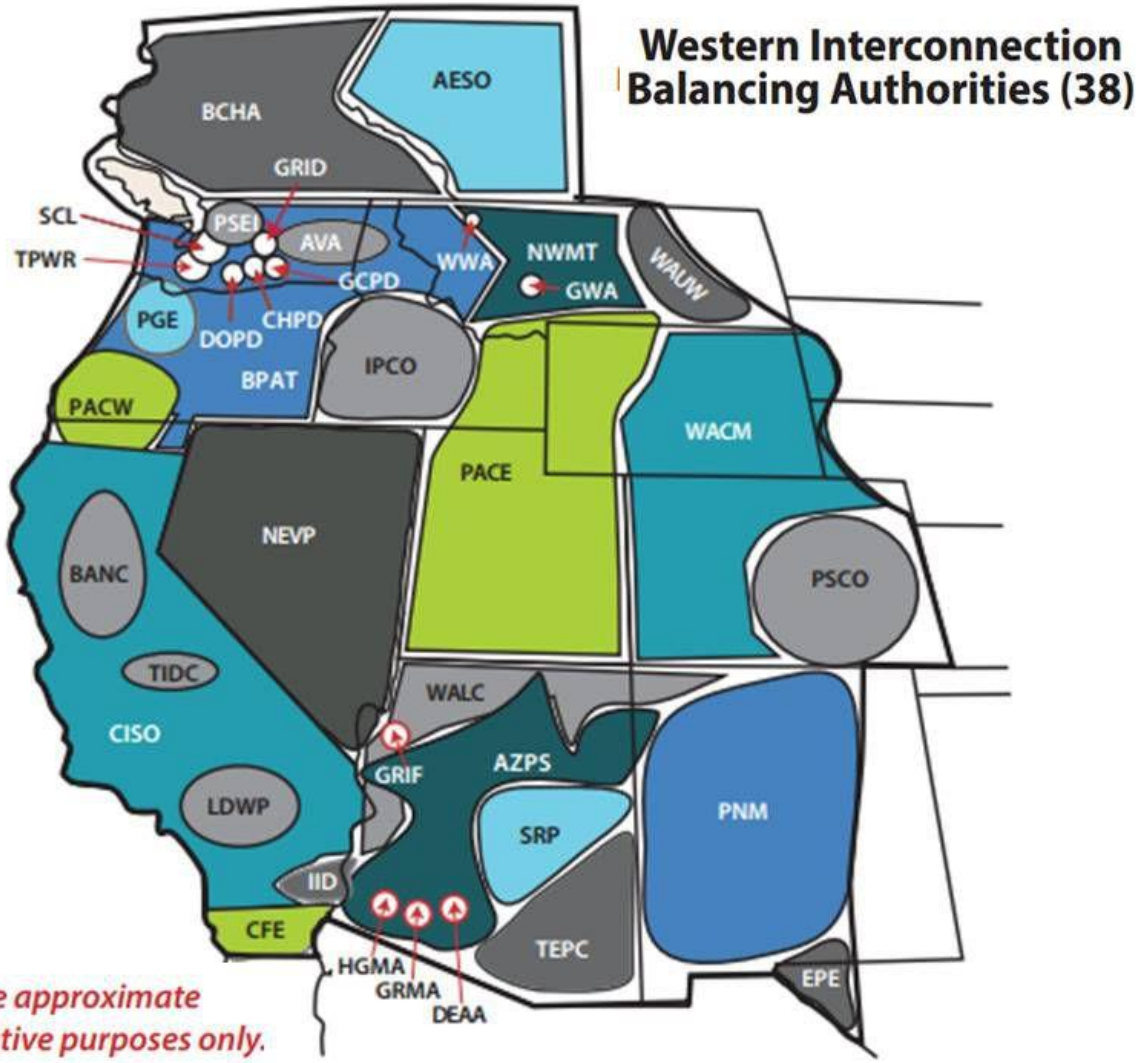
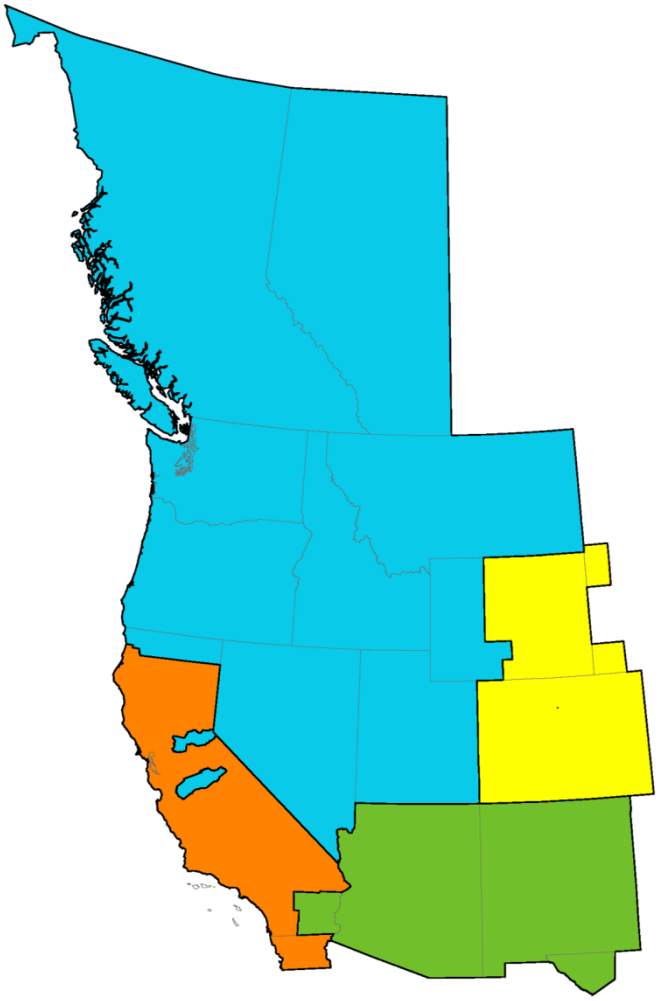


Figure 3. Generation-Demand Balance

Balancing Authorities



Northwest Power Pool



- Reserve sharing saves members an estimated $1 billion per year by spreading contingency reserve requirements over a larger footprint
- Seasonal reliability assessments with members focused on meeting summer and winter peak loads

Northwest Power and Conservation Council

- The 1980 Northwest Power Act authorized the states of Idaho, Montana, Oregon, and Washington to form the Council
- The Act requires the Council to develop, with broad citizen participation, a regional power plan and fish and wildlife program
  - The Council develops a 20-year power plan, which it revises every five years, to ensure the Northwest of an efficient and reliable power supply
    - Prioritizes cost-effective energy efficiency, followed by cost-effective renewable resources
    - The plan guides BPA's resource decision-making, Council is required to approve any new BPA energy resource acquisition greater than 50 aMW
  - The Council's Fish and Wildlife program recommends projects for BPA to fund
- Wholesale power revenues from BPA fund the Council

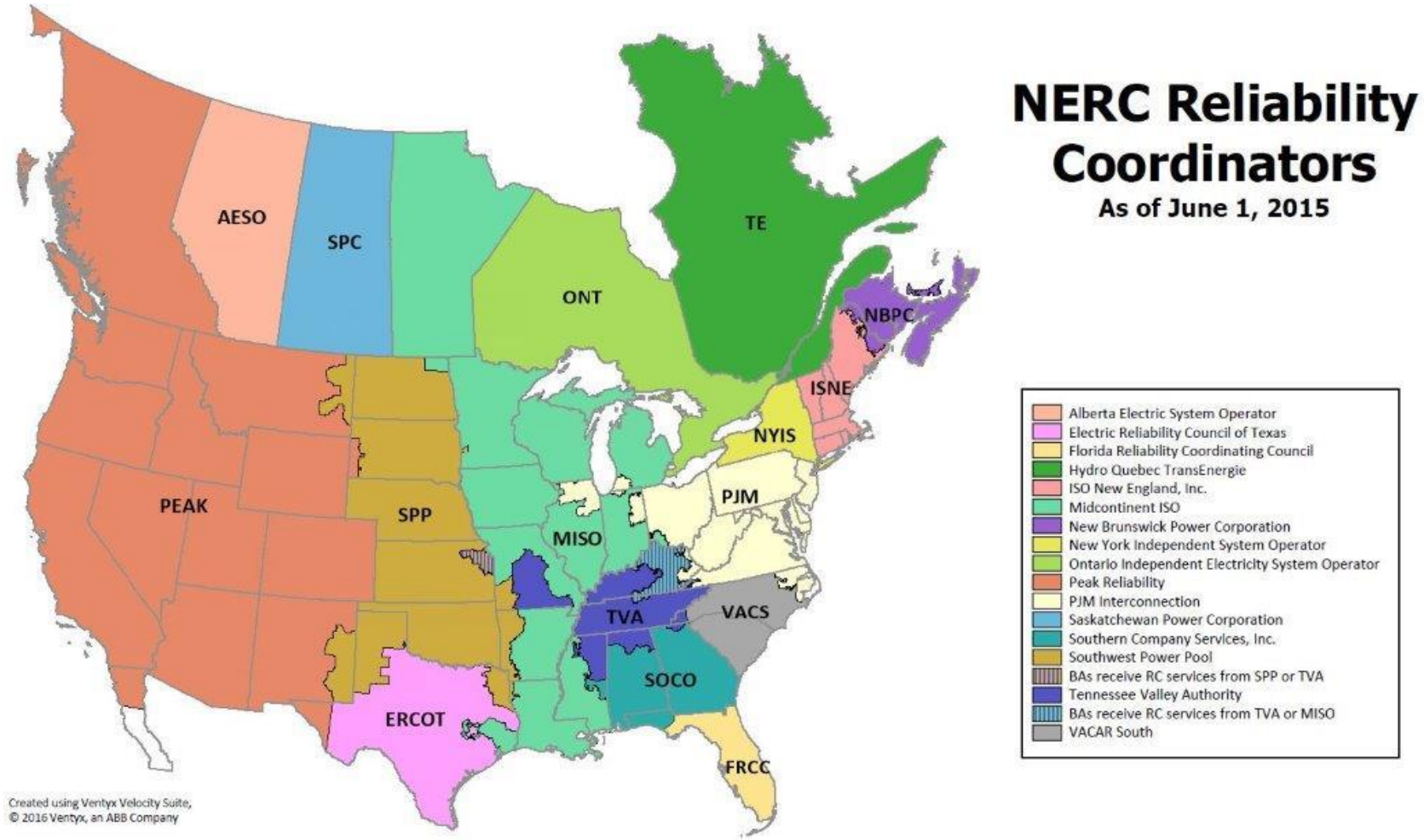
Reliability Coordinator Responsibility

- The Reliability Coordinator (RC) maintains the highest level of responsibility for reliable operations of the bulk electric system with:
  - Clear decision-making authority to act and direct actions to preserve the integrity and reliability of the system
  - Wide area view that enables system monitoring beyond that of other operators
  - Operating tools, process and procedures to prevent or mitigate emergency operating situations

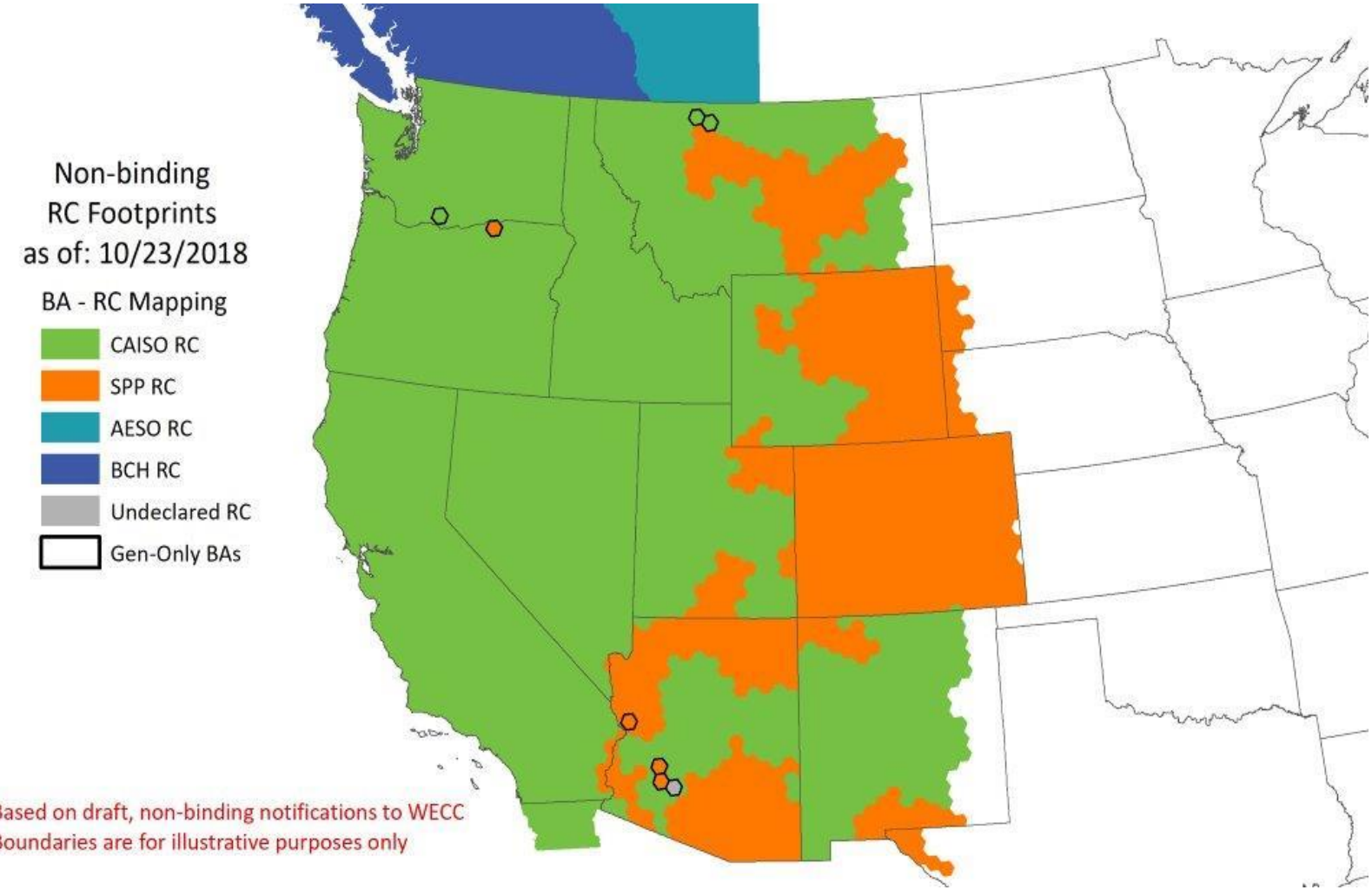
Reliability Coordinator Services

- Each RC is NERC certified and provides the same core services required by NERC standards
  - Outage coordination
  - Day-ahead operation planning and analysis
  - Real-time assessment
  - Real-time monitoring and analysis
  - System restoration coordination

Reliability Coordinator Areas Today



Expected RC Areas by Dec. 2019



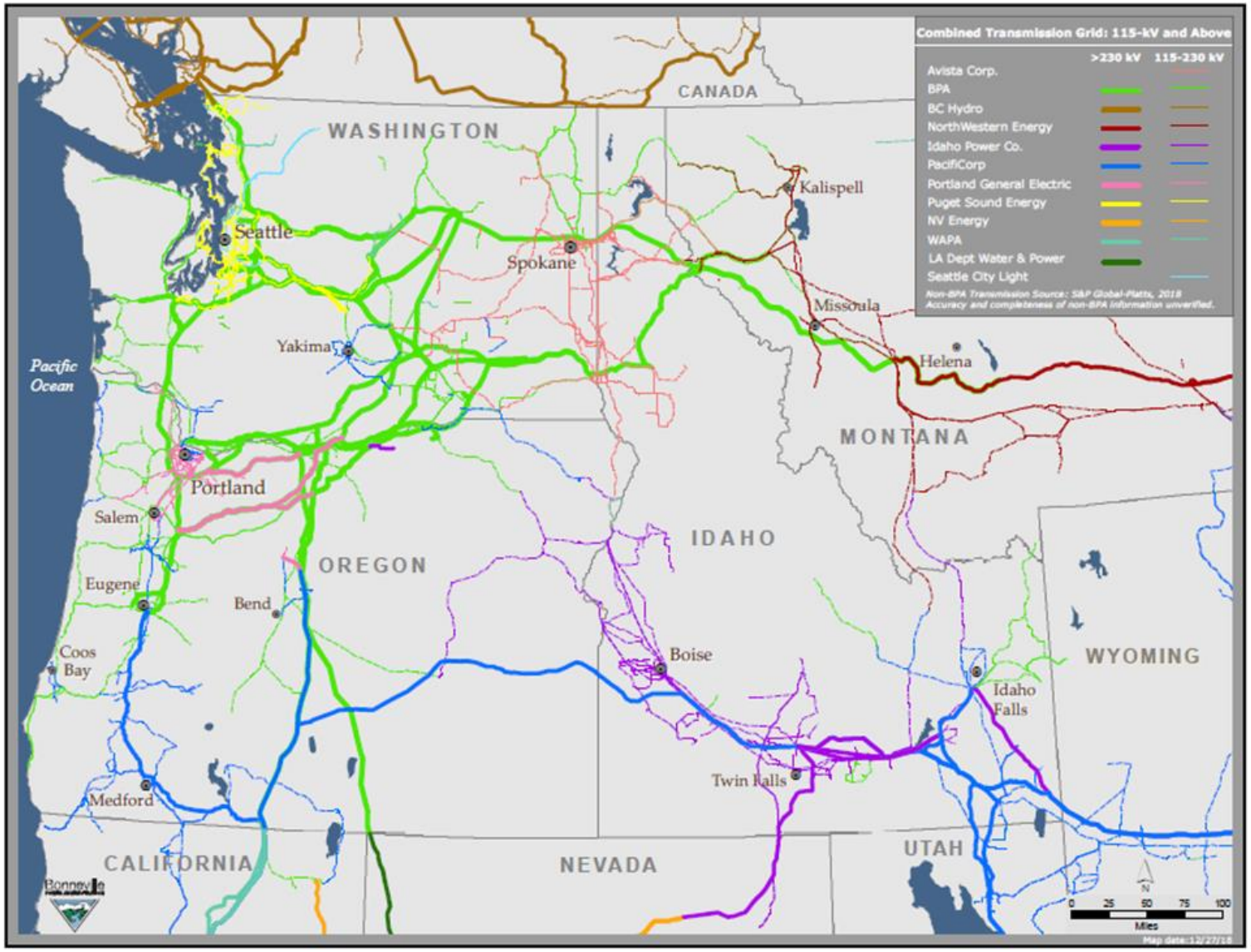
Regional Planning Organization (RPO)

- An RPO supports reliability of the grid and facilitates efficient expansion
- Coordination within a region & between regions
  - FERC Orders 890 and 1000

Western & Pacific NW Landscape

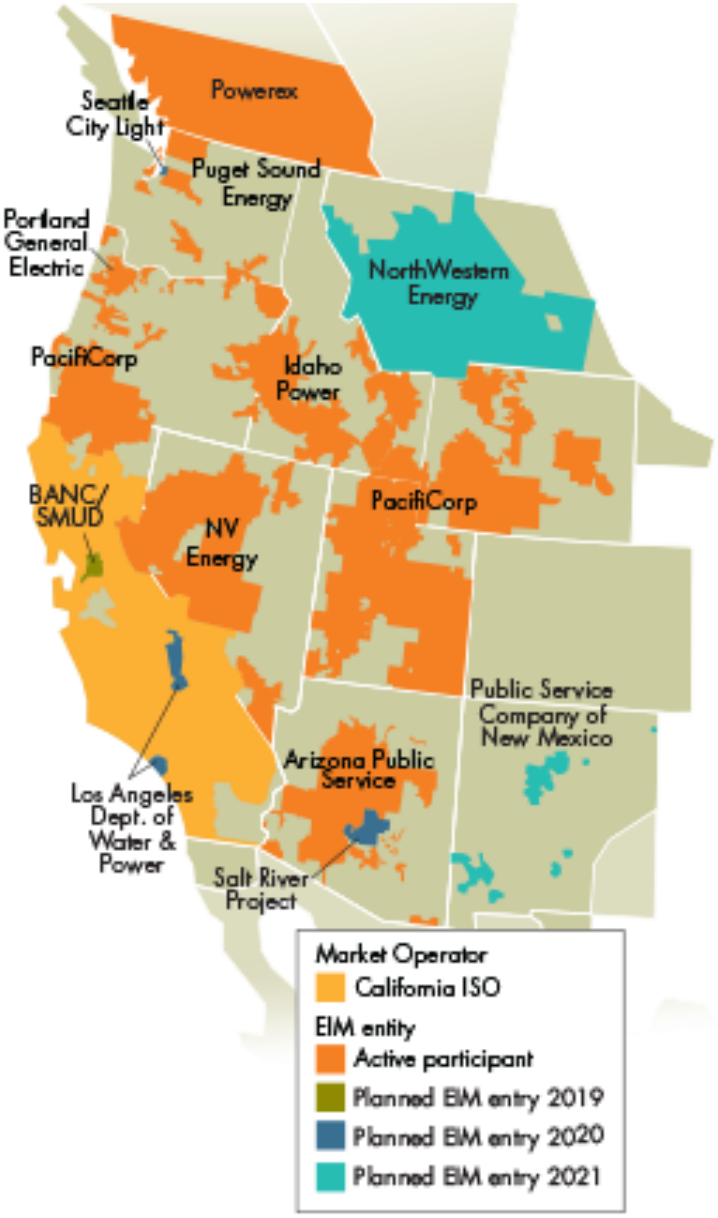
- Traditional power flow patterns
  - High E->W flows in winter across Cascades to serve local load
  - High N->S flows in spring and summer through WA and OR to CA related to exports, but S->N from CA is very rare
  - Flows respond to hydro, wind, and solar availability
- Emerging patterns
  - High exports to CA around sunset have pushed peak N->S flows to a couple hours later in recent years
  - S->N transfers of surplus solar expected (duck curve)
  - More bidirectional transfers between coastal and mountain states to take advantage of load / resource diversity

Pacific NW Transmission Grid



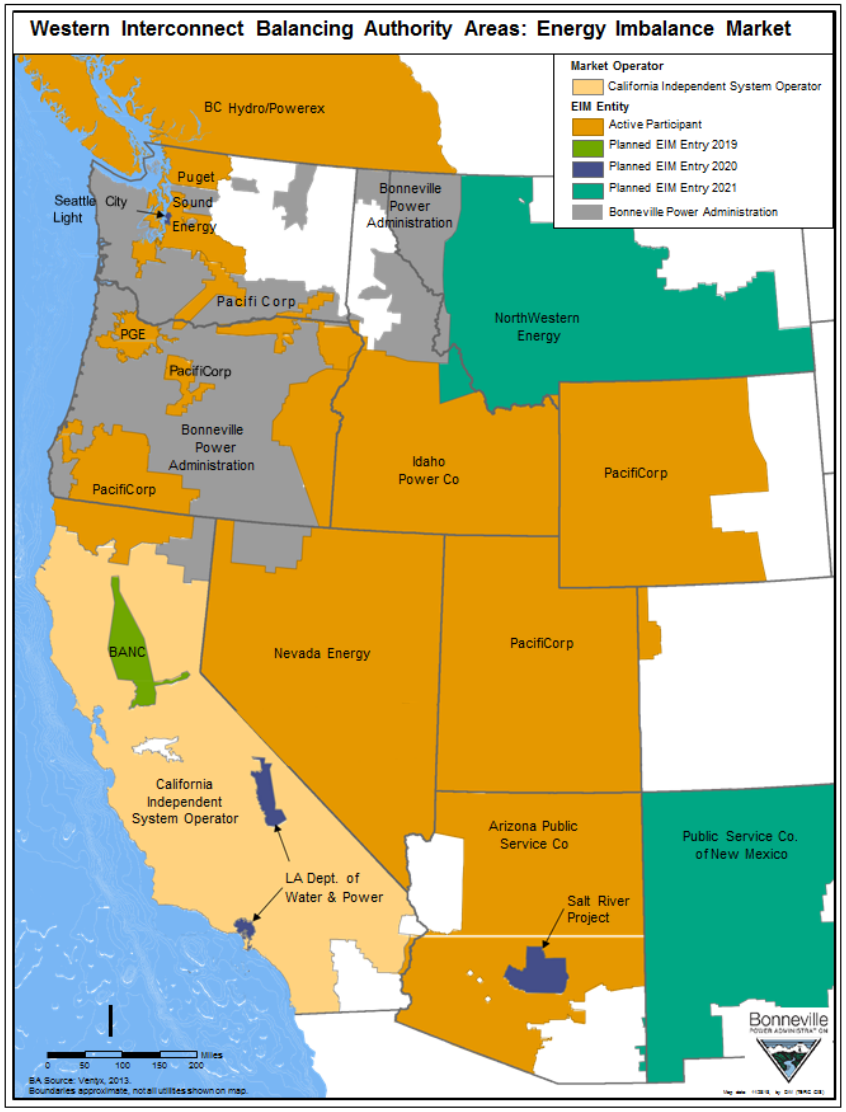
Western Energy Imbalance Market (EIM)

- Voluntary market that optimizes sub-hourly economic dispatch of participating resources for balancing supply and demand every five minutes
- Transmission and reliability constraints are honored
- Every participant must enter the trading hour fully balanced
- Larger footprint allows for resource diversity
- CAISO is the market operator



EIM with BPA

- BPA is currently determining how and under what conditions it could join the EIM, with a potential implementation date of April 2022



Challenges and Opportunities

- Safety and reliability
- Keeping costs low while meeting public policy objectives to reduce emissions
- Coal generation replacement
- Path to zero emissions
- Congestion management

Safety and Reliability

- The transmission system is planned and operated so that it can withstand the impacts of normal equipment outages without interrupting service to end-users
  - Prevention of all outages is not possible
- Multiple layers of defenses keep the public and workers safe
  - Detect and isolate short circuits quickly
  - Manage flows within system operating limits
  - Standards, best practices, training

Transmission Reliability Standards

- NERC and WECC Standards define specific performance requirements for the high voltage transmission system
  - Interruption of firm demand is only permitted as a corrective action in limited circumstances
- Transmission providers must annually demonstrate that their system can reliably serve projected loads and resources through the next ten years

Resource Adequacy vs. Transmission Reliability

- Resource Adequacy: demonstrate that there will be enough resources to serve loads
  - Address uncertainties in both supply and demand (weather, outages, growth, etc.)
- Transmission reliability: demonstrate that resources can be delivered to load under expected conditions (peak and off-peak)
  - Stress test

Keeping Customer Costs Low

- Scale solution to match need
  - Remedial action schemes (RAS)
  - Power flow control devices
  - Distributed energy resources (EE, DR, etc.)
  - Efficient redispatch
  - Conditional Firm transmission service
  - Transmission reinforcements
- Joint ownership by multiple utilities has been successful for decades
  - California – Oregon Intertie (COI)

Load Changes

- Load growth
  - Energy efficiency and shifts in the economy have offset demand growth in WA and OR over the last decade
  - Data center loads are attracted to the PNW's reliable, low cost electricity supply (hundreds of MW can show up at a rural location)
- Loads and resources connected through a power electronics interface can behave differently during disturbances than the traditional devices that they replace
  - Coordination between stakeholders (utilities, plant operators, equipment manufacturers) is important to prevent unintended operations
  - Inverter connected resources (solar PV, batteries, newer wind turbines) are a growing share of resource mix
  - Loads with a power electronic interface (computers, LED lights, variable speed drives) are a growing share of demand

Coal Generation Replacement

- Coal generation is being retired due to a combination of public policy and economic considerations
  - Boardman and Centralia Unit 1 by the end of 2020
  - Colstrip 1 & 2 by July 2022
  - Centralia Unit 2 by the end of 2025
  - Other plants in Mountain states within the next 10-15 years
- Multiple challenges and opportunities associated with replacing capacity, energy, and essential reliability services attributes while reducing emissions
  - Location of resources impacts transmission flows
  - Availability and cost of transmission impacts resource choices
  - Variable resources replacing dispatchable resources
  - Optimize transmission capacity utilization

Path to Zero Emissions in the PNW

- Wind, solar PV, and battery energy storage costs have dropped significantly in the last 5 years
- PNW winter peak load and resource characteristics present a challenge to get to 100% zero emissions
  - Two daily load peaks in winter (morning before sunrise, evening after sunset)
  - Will a cost-effective and scalable technology that can efficiently store days or weeks of energy emerge?
- Dispatchable resources still needed for flexibility and capacity
  - Explore opportunities to make load more dispatchable
- Effective coordination within the region and with other regions

Congestion Management

- Congestion occurs when demand for transmission across a path exceeds available capacity
  - Outages can cause or exacerbate congestion
- Transmission providers curtail transmission schedules by priority order and on a pro-rata basis when needed to keep flows within limits
  - Non-firm is curtailed before firm
  - Conditional firm can be curtailed at a lower priority under defined system conditions or for a specified number of hours per year