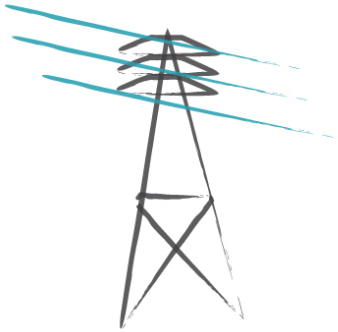


WECC

# Introduction to System Operations

# Course Outline

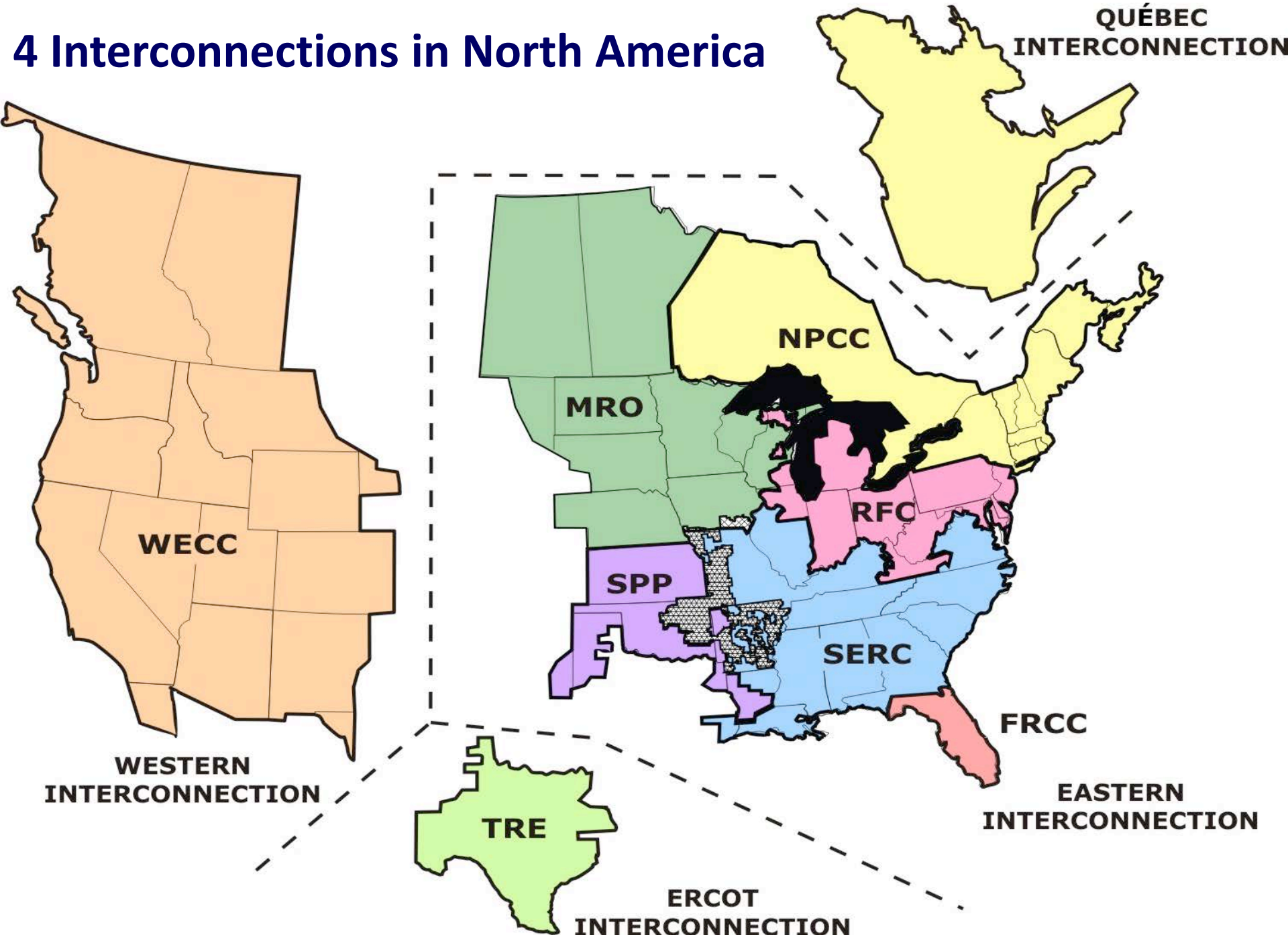
1. Introduction to WECC
2. Fundamentals of Electricity
3. Power System Overview
4. Principles of Generation
5. Substation Overview
6. Transformers
7. Power Transmission
8. System Protection
9. Principles of System Operation

# 1 | Introduction to WECC

- What is an interconnection?
- Regulatory agencies
- The evolution of reliability in the North American electric system

# What Is An Interconnection?

# 4 Interconnections in North America



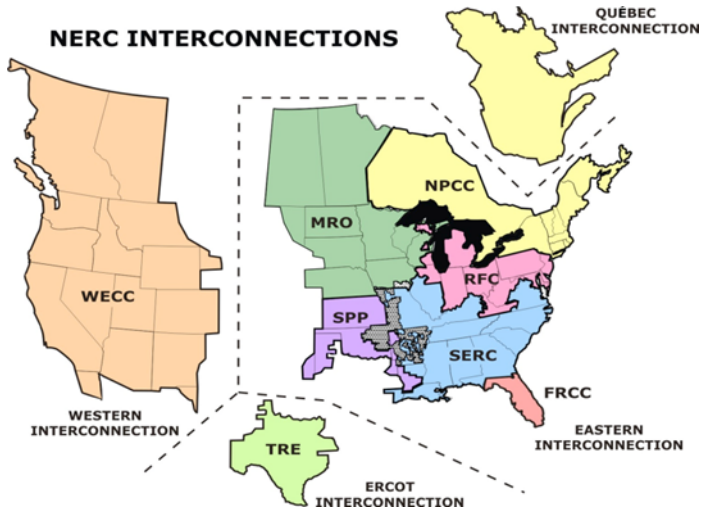
# Interconnections

**The 2 largest alternating current (AC) power grids are:**

- Eastern Interconnection
- Western Interconnection

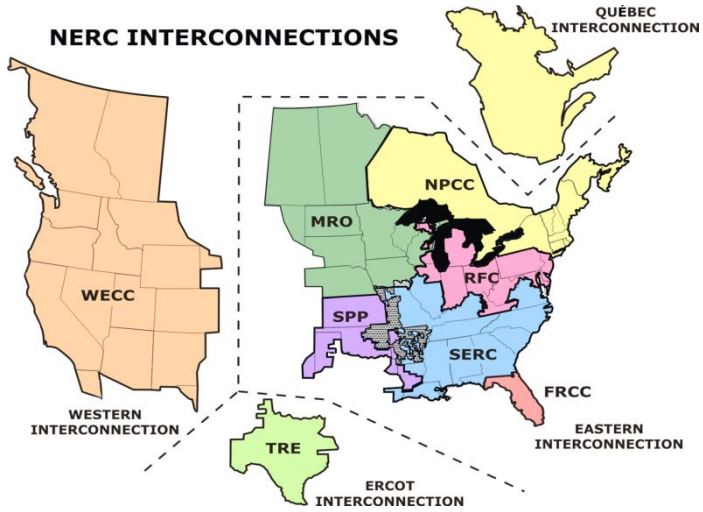
**The 3 smaller alternating current (AC) power grids are:**

- Quebec Interconnection
- Alaska Interconnections
- Texas Interconnection



# The Eight North American Regional Entities

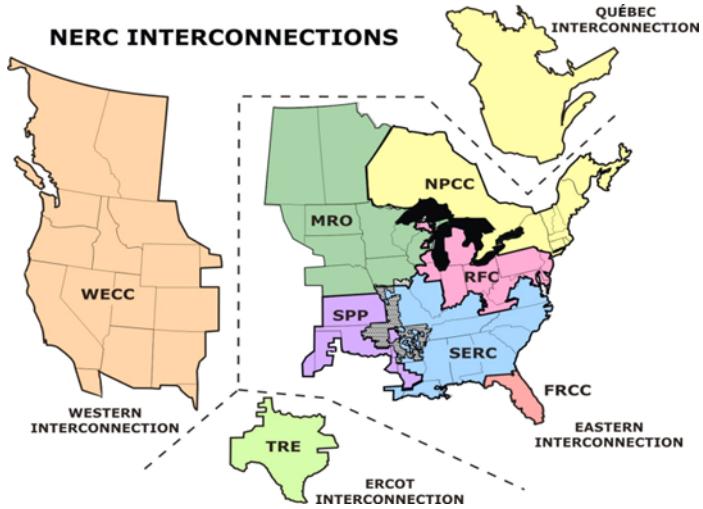
- Western Electricity Coordinating Council (WECC)
- Florida Reliability Coordinating Council (FRCC)
- Midwest Reliability Organization (MRO)
- Northeast Power Coordinating Council (NPCC)
- ReliabilityFirst Corporation (RFC)
- SERC Reliability Corporation (SERC)
- Southwest Power Pool, RE (SPP)
- Texas Reliability Entity (TRE)

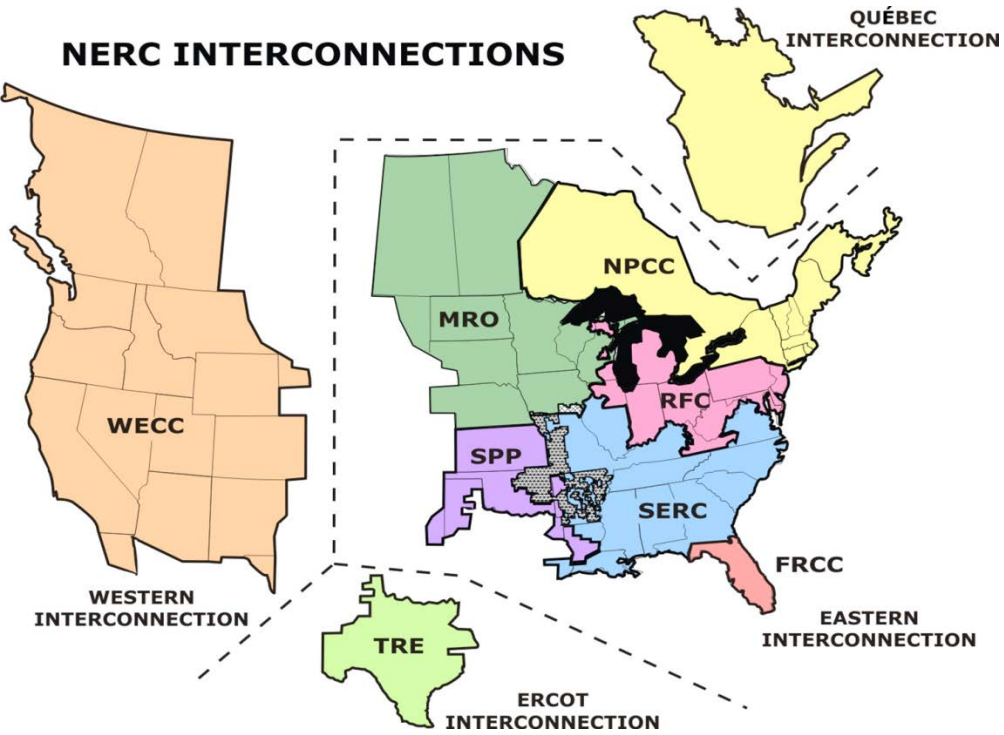


# North American Interconnections

| | |
|---|---|
| Eastern | 610,000 MW |
| Western | 140,000 MW |
| Texas | 69,000 MW |
| Quebec | 21,000 MW |

(2015 Projected Demand)






## 60 Hz

All electric utilities are tied together at a synchronized frequency operating at an average of 60 Hz.

The Eastern Interconnection is tied to:

- Western Interconnection by 6 DC ties
- Texas Interconnection with 2 DC ties
- Quebec Interconnection with 4 DC ties and a VFT

# Regulatory Agencies

# The Interconnected System Regulatory Agencies

| | |
|---|---|
| FERC | Federal Energy Regulatory Commission |
| NERC | North American Electric Reliability Corporation |
| WECC | Western Electricity Coordinating Council |

# Regulatory Agencies
## Federal Energy Regulatory Commission (FERC)

- Established in 1920 as the FPC
- Reorganized in 1977 as FERC
- Independent agency that reports to DOE
- Regulates high voltage interstate transmission of electricity and natural gas transportation
- Transmission Open Access
- Office of Markets & Reliability

# Regulatory Agencies
# FERC

**Applicability**

- Market rules for jurisdictional entities
- Reliability rules for all *"users, owners, & operators of the bulk power system"*
- Authority to issue economic sanctions

- Licenses & inspects hydroelectric projects.
- Oversees environmental matters related to hydroelectricity projects & major electricity policy initiatives.

# Regulatory Agencies
# FERC

**Mission**

FERC regulates & oversees energy industries in the economic & environmental interest of the American public.

**Vision**

Dependable, affordable energy through competitive markets.

**How the Commission is Appointed**

FERC is composed of 5 commissioners who are appointed by the President with the advice & consent of the Senate. Commissioners serve 5-year terms, & have an equal vote on regulatory matters.

There is no review of FERC decisions by the President or Congress, maintaining FERC's independence as a regulatory agency & providing for fair & unbiased decisions. The Commission is funded through costs recovered by the fees from the industries it regulates.

# Regulatory Agencies
# FERC

**How does FERC govern?**

Delegated Authority to an Electric Reliability Organization (ERO):

North American Electric Reliability Corporation (NERC)

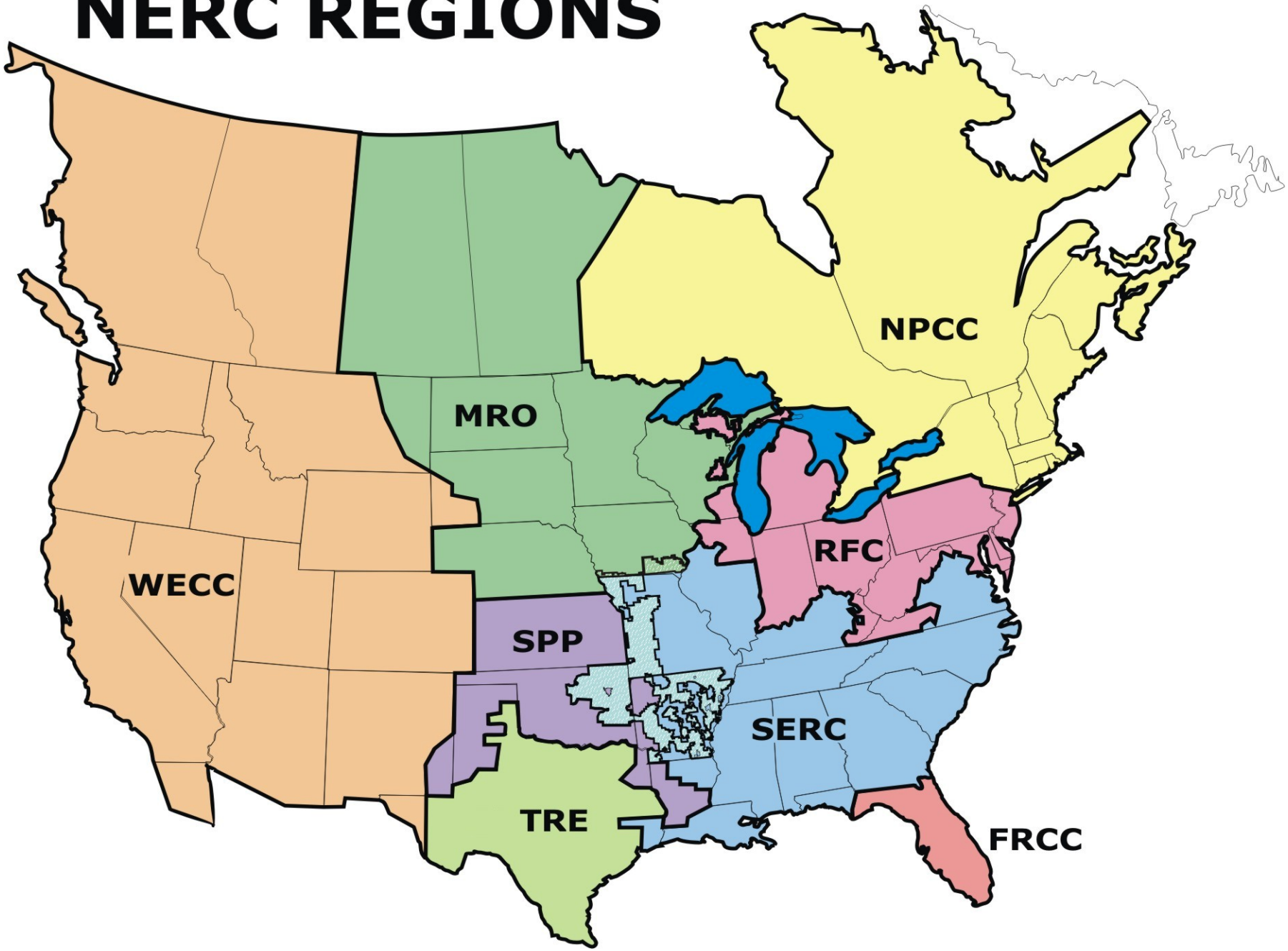
# Regulatory Agencies

## North American Electric Reliability Organization (NERC)

# Regulatory Agencies
# NERC

- Established in the late 1960's
- 2007 established as the Electric Reliability Organization (ERO) with oversight from FERC
- Develops and enforces Reliability Standards
- Compliance Enforcement with Sanctions
- Oversees 8 Regional Reliability Entities
- North America including Canada & northern part of Mexico
- Delegates authority to WECC

# NERC REGIONS



# Regulatory Agencies
# NERC

**Mission**

To improve the reliability & security of bulk electric system in North America. To achieve that:

- Develops & enforces reliability standards;
- Monitors bulk electric system;
- Assesses future adequacy;
- Audits owners, operators, & users for preparedness;
- Educates & trains industry personnel

NERC relies on diverse & collective expertise of industry participants

# Regulatory Agencies
# NERC

**Reliability Standards Development**

NERC Standard Development Process

- Open, inclusive, all industry segments
- Ballot Body approval takes 67%
- Approved by NERC Board – submitted to FERC
- FERC accepts, conditionally accepts, or remands
- After FERC accepts – Mandatory Compliance with Economic Sanctions

# Regulatory Agencies
# NERC

**Business Practice Development**

- Dissolved the NERC Market Committee
- Split standards into reliability & business components & gave NAESB the business
- Only NERC involvement in development of business practices is as a NAESB member

# NAESB

NAESB serves as an industry forum for the development & promotion of standards which lead to a seamless marketplace for:

- wholesale & retail natural gas
- wholesale & retail electricity,

As recognized by its customers, business community, participants, & regulatory entities.

# Regulatory Agencies
## Western Electricity Coordinating Council (WECC)

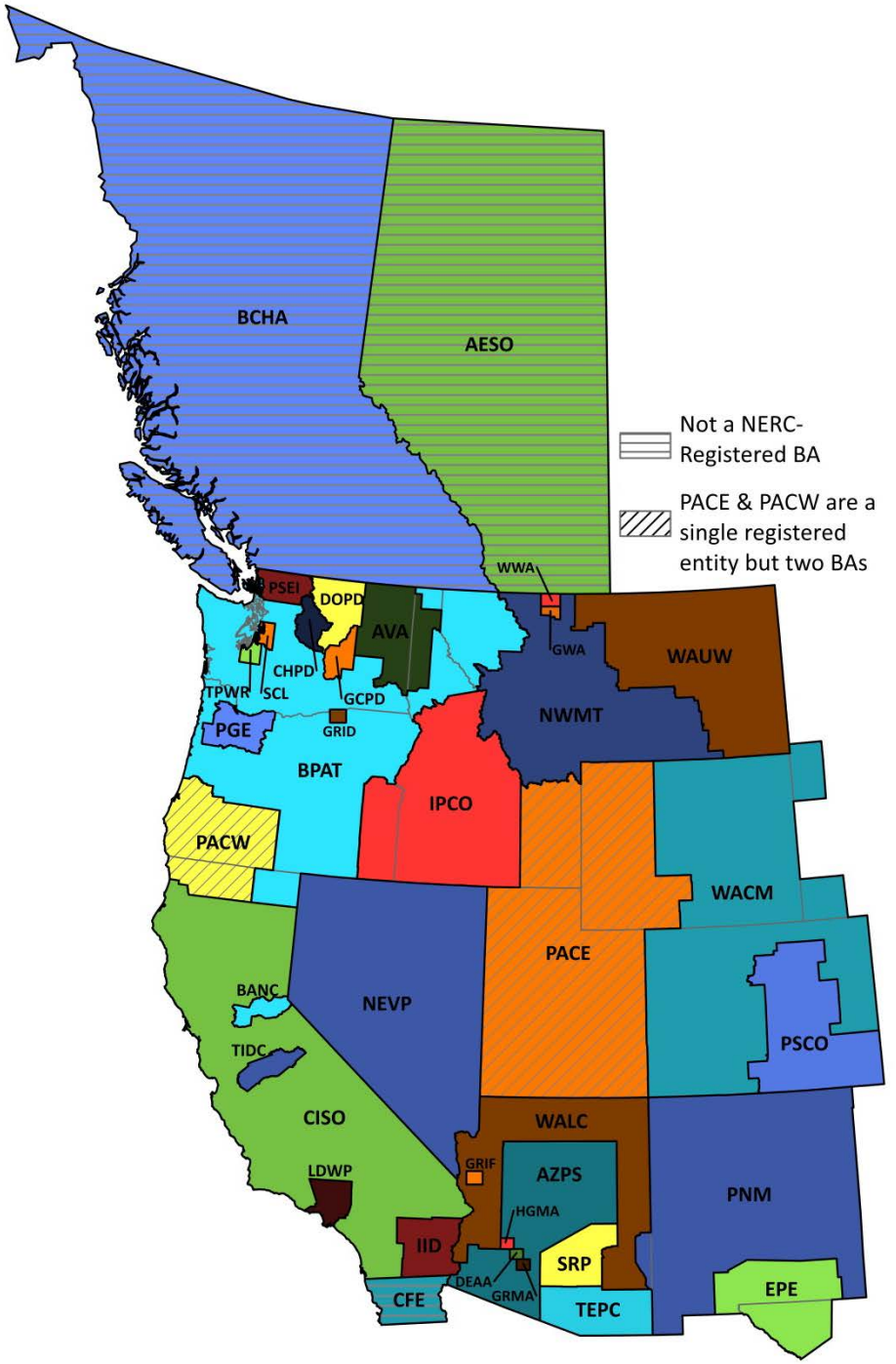

LEGEND
BRITISH COLUMBIA
MONTANA
IDAHO
OREGON
WYOMING
NEVADA
UTAH
COLORADO
CALIFORNIA
ARIZONA
NEW MEXICO
MEXICO
SEE SEATTLE TACOMA AREA DETAIL
SEE PORTLAND AREA DETAIL
SEE SAN FRANCISCO SACRAMENTO AREA DETAIL
SEE LAS VEGAS AREA DETAIL
SEE LOS ANGELES AREA DETAIL
SEE PHOENIX AREA DETAIL
SEE DENVER AREA DETAIL
SEATTLE – TACOMA AREA DETAIL
PORTLAND AREA DETAIL
SAN FRANCISCO – SACRAMENTO AREA DETAIL
LOS ANGELES AREA DETAIL

# WECC Interconnection

Geographically the largest & most diverse of the eight Regional Entities in NERC.

Service territory extends from Canada to Mexico.

- Alberta & British Columbia
- Northern Baja California & Northern Mexico
- All or portions of the 14 Western United States



# Regulatory Agencies
# WECC

## About WECC

### Governance

- Board of Directors
- Committees
  - Operating Committee
  - Planning Coordination Committee (PCC)
  - Market Interface Committee (MIC)

### Training & Workshops

### Regional Standards Development

- Open / Inclusive / Transparent / Accepted by NERC/FERC

### Compliance Enforcement & Audits

# Regulatory Agencies
# WECC

## Introduction to WECC

The term WECC has two connotations:

- First: WECC refers to the organization which develops regional reliability standards, reviews and enforces compliance, and promotes electric system reliability through delegated operations and planning activities.
- Second: WECC refers to the generators, transmission lines, substations, and other physical facilities making up the interconnected electrical network (the Western Interconnection).

# Regulatory Agencies
# WECC

**Mission**

WECC is a 501c(4) non-profit Utah corporation with the mission to do the following consistent with its Bylaws:

- 1) maintain a reliable electric power system in the Western Interconnection that supports efficient competitive power markets ("Reliability Mission"); and
- 2) assure open and non-discriminatory transmission access among Members and provide a forum for resolving transmission access disputes between Members consistent with FERC policies where alternative forums are unavailable or where the Members agree to resolve a dispute using the mechanism provided in the Bylaws ("Transmission Access Mission").

# Regulatory Agencies
# WECC

**History**

- Power systems have existed in the West since the 1880s. Over time, those systems have interconnected with one another.
- As energy transfers between systems became larger and more common, it became necessary to perform coordinated technical studies and to coordinate planning and operating activities.
- Several planning organizations developed, including the Western United States Transmission Study Group and the Pacific Intertie Study Group.

# Regulatory Agencies
# WECC

**History**

- In 1967, utility executives formed the Western Systems Coordinating Council (WSCC) to promote reliability by bringing the region's planning and operating coordination activities under one organization.
- The WSCC technical staff was established in 1971 to perform planning studies and coordinate WSCC committee activities.
- The WSCC Dispatcher Training Program was established in 1981 to provide system operator training.

# Regulatory Agencies
# WECC

**History**

- WECC was formed on April 18, 2002, by the merger of the Western Systems Coordinating Council (WSCC), and two regional transmission associates: the Southwest Regional Transmission Association and the Western Regional Transmission Association (WRTA).

# Regulatory Agencies
# WECC

**History**

- WECC is one of eight electric reliability councils in North America, and the only one operating in three countries. WECC's footprint encompasses a geographic area equivalent to over half of the United States.

# Regulatory Agencies
# WECC

## WECC Post Bifurcation

- New independent governance structure – a nine-member Board of Directors – seated and active February 13, 2014.

- Member Advisory Committee (MAC) – designed to provide technical and policy input to the Board – officially active February 13, 2014.

- Can completely and effectively fulfill their role as the Reliability Assurer in the Western Interconnection, *e.g.*, participating on Event Analysis teams, performing Compliance and Enforcement activities for the RC, now Peak Reliability.

- WECC's reliability mission is clearer as they seek to meet the reliability needs of the Western Interconnection – today, tomorrow, and into the future – now with an added emphasis of serving the public interest.

# Regulatory Agencies
# WECC

**WECC is a Stakeholder Supported Organization**

- Operating Committee - OC
- Market Interface Committee - MIC
- Planning Coordination Committee - PCC
- Regional Standards Development
  - Open / Inclusive / Transparent / Accepted by NERC/FERC
- Compliance Enforcement & Audits
- Training Sessions & Workshops

# Regulatory Agencies
# WECC

**Operating Committee – OC**

- Many Subcommittees
- OTS
- ISAS
  - Implementation
  - Highly effective subcommittee
  - Implementation focused

# Regulatory Agencies
# WECC

**Market Interface Committee – MIC**

- Interrelation between markets & reliability
- Scope includes commercial business practices in the West
- Policy driven not implementation driven
- Subcommittees – Policy Focused
  - Market Issues Subcommittee (MIS)
  - Seams Issues Subcommittee (SIS)

# Regulatory Agencies
# WECC

**Planning Coordination Committee (PCC)**

- The purpose of the PCC is to advise & make recommendations to the WECC Board of Directors (Board) on all matters within the jurisdiction of WECC that pertain to maintaining the reliability of the Western Interconnection through evaluating generation & load balance, & evaluating the adequacy of the physical infrastructure of interconnected bulk electric systems within the Western Interconnection.

# Regulatory Agencies
# WECC

**WECC Reliability Standard Development Process**

- Open, inclusive, all industry segments
- Approved by lead Standing Committee
- Approved by WECC Board of Directors
- No NERC standard or more stringent
- Approved by NERC Board – submitted to FERC
- FERC accepts, conditionally accepts, or remands
- Mandatory Compliance with Sanctions

# Regulatory Agencies
# WECC

**WECC Business Practice Development**

- WECC has moved away from business practice development and eliminated existing standards.
- Requirement with compliance but no economic sanctions.

# Regulatory Agencies
# WECC

**WECC Reliability Standards Development Process**

- Open, inclusive, all industry segments
- Approved by WECC Standards Committee
- Approved by WECC Board of Directors
- No NERC standard or more stringent
- Approved by NERC Board – submitted to FERC
- FERC accepts, conditionally accepts, or remands
- Mandatory Compliance with Sanctions

# Regulatory Agencies
# WECC

**Compliance**

- FERC delegates compliance enforcement work to NERC who delegates to WECC.

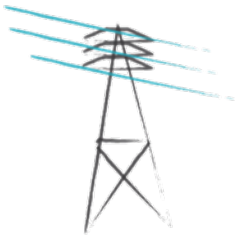
# Regulatory Agencies
# WECC

## WECC Compliance Enforcement

- Self-Certification Forms
- Table-Top Audits
- On-Site Audits

# Compliance Enforcement Process
# Step 1 - WECC

- Compliance Enforcement Program
- Self-Certification Forms
- Table-Top Audits
- On-Site Audits
- Makes final determination of non-compliance
- Assess mitigating circumstances
  - Self reporting
  - Mitigation plan identified
  - First time or repeat offense
- Determination of sanction
- Hearing or appeal process



WECC

# Compliance Enforcement Process
# Step 2 - NERC

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

- Evaluates to assure consistency across the regions of North America
- May remand a decision back to WECC but cannot independently change the sanction
- May be an avenue for appeal if WECC appeal does not yield resolution
- FERC is notified of all steps in the process
- NERC Violation Risk Factors & Violation Severity Levels range in scale of Risk & Violation severity. The fine "$" relate to a matrix.

# Compliance Enforcement Process
# Step 2 - NERC

## NERC Enforcement Actions

- The focus of NERC's compliance efforts is to ensure the reliability of the bulk power system in North America by fairly and consistently enforcing compliance with our standards. The table below provides information regarding enforcement actions designed to ensure bulk power system reliability through compliance with NERC's reliability standards. The most important takeaway from the notices below is that reliability is being improved across North America as a result of proactive efforts to prevent future system disturbances.

# Compliance Enforcement Process
# Step 2 - NERC

**NERC Enforcement Actions**

- All enforcement actions include correction of any issues identified where a mandatory NERC standard is not being fully met by a Registered Entity.
- United States law requires that NERC's enforcement actions involving entities operating in the continental U.S. be filed publically with the Federal Energy Regulatory Commission (FERC), who has oversight of NERC's activities as the Electric Reliability Organization or ERO. Any penalties or other enforcement actions become effective 30 days after filing unless FERC moves to review the penalty or settlement or a proceeding is initiated. Other provisions may exist within the Canadian provinces.

# Compliance Enforcement Process
# Step 2 - NERC

- The focus of NERC's compliance program is to improve the reliability of the bulk power system in North America by fairly and consistently enforcing compliance with NERC Reliability Standards. Specifically, the program is designed to ensure that the right practices are in place so that the likelihood and severity of future system disturbances are substantially reduced, while recognizing that no standards or enforcement process can fully prevent all such disturbances from occurring.
- In the United States, NERC and the eight Regional Entities monitor compliance through a number of discovery methods, including regularly scheduled compliance audits, random spot checks, compliance investigations, and the complaint process.
- The Compliance and Certification Committee (CCC) provides guidance and support for the program.

# Compliance Enforcement Process
# Step 2 - NERC

**NERC Reliability Assurance Initiative (RAI)**

- The Reliability Assurance Initiative (RAI) is a collaborative, multi-year effort among NERC, the Regional Entities, and industry to identify and implement changes to enhance the effectiveness of the Compliance Monitoring and Enforcement Program (CMEP). The goal of RAI is to implement a more robust risk-based program for compliance monitoring and enforcement of Reliability Standards.

# Compliance Enforcement Process
# Step 2 - NERC

**NERC Reliability Assurance Initiative (RAI)**

- It is not practical, effective, or sustainable to monitor all compliance issues to the same degree or treat all noncompliance in the same manner.
- Compliance monitoring and enforcement must be “right-sized” based on a number of considerations, including risk factors and registered entity management practices related to the detection, assessment, mitigation, and reporting of noncompliance.
- A risk-based approach is necessary for a proper allocation of resources. It also encourages registered entities to enhance internal controls, including those focused on the self-identification of noncompliance.

# Compliance Enforcement Process
# Step 2 - NERC

**NERC Reliability Assurance Initiative (RAI)**

- Over the course of 2013–2014, the ERO Enterprise tested a number of concepts, processes, and programs for implementation in 2015. NERC has published guides and program documents related to all of the new and expanded processes and programs to allow for implementation in 2015.

# Compliance Enforcement Process
# Step 2 - NERC

**Violation Risk Factor**

NERC has developed three (3) categories of **Risk Factors**:

- 1. Low
- 2. Medium
- 3. High

These factors are found is association with some of the NERC Reliability Standards they are always associated with a Time Horizon.

# Compliance Enforcement Process
# Step 2 - NERC

## Violation Risk Factor

- Example of High Risk:
- PRC-023-1: Transmission Relay Loadability
- **B. Requirements**
- **R1.** Each Transmission Owner, Generator Owner, and Distribution Provider shall use any one of the following criteria (R1.1 through R1.13) for any specific circuit terminal to prevent its phase protective relay settings from limiting transmission system loadability while maintaining reliable protection of the Bulk Electric System for all fault conditions. Each Transmission Owner, Generator Owner, and Distribution Provider shall evaluate relay loadability at 0.85 per unit voltage and a power factor angle of 30 degrees: [Violation Risk Factor: High] [Mitigation Time Horizon: Long Term Planning].

# Compliance Enforcement Process
# Step 2 - NERC

## Violation Risk Factor

- Example of **Medium Risk**
- PRC-023-1: Transmission Relay Loadability
- **R2.** The Transmission Owner, Generator Owner, or Distribution Provider that uses a circuit capability with the practical limitations described in R1.6, R1.7, R1.8, R1.9, R1.12, or R1.13 shall use the calculated circuit capability as the Facility Rating of the circuit and shall obtain the agreement of the Planning Coordinator, Transmission Operator, and Reliability Coordinator with the calculated circuit capability. [Violation Risk Factor: Medium] [Time Horizon: Long Term Planning]

# Compliance Enforcement Process
# Step 2 - NERC

## Violation Risk Factor

- Example of **Low Risk**:
- IRO-006-4: Reliability Coordination — Transmission Loading Relief (TLR)
- **B. Requirements**
- **R2.** The Reliability Coordinator shall only use local transmission loading relief or congestion management procedures to which the Transmission Operator experiencing the potential or actual SOL or IROL violation is a party.
- [*Violation Risk Factor: Low*] [*Time Horizon: Operations Planning*]

# Compliance Enforcement Process
# Step 2 - NERC

**Violation Risk Factor**

- These Risk Factors are developed based on the potential impact to the reliability of the Bulk Electric System.
- They are reviewed as needed and may change as each standard goes through its standard process.

# Compliance Enforcement Process
# Step 2 - NERC

## Violation Severity Levels

NERC has developed four (4) levels of **Violation Severity**

- Lower
- Moderate
- High
- Severe

Some Reliability Standards have a Severity Level associated with it. Not to be confused with the Levels of Non-Compliance.

# Compliance Enforcement Process
# Step 2 - NERC

## Levels of Non-Compliance

- NERC has developed four (4) levels of **Non-Compliance**:
  - Level 1
  - Level 2
  - Level 3
  - Level 4
- These levels of Non-Compliance are what NERC bases the sanction levied on entities that are found to be Non-Compliant either by self-reported violations or found in compliance audits.

# Compliance Enforcement Process
# Step 3 - FERC

- Accepts, modifies, or remands the WECC sanction amount for reliability standards
- Any sanctions regarding market rules & standards of conduct are managed by FERC with zero involvement of NERC or WECC


LEGEND
BRITISH COLUMBIA
MONTANA
IDAHO
OREGON
WYOMING
NEVADA
UTAH
COLORADO
CALIFORNIA
ARIZONA
NEW MEXICO
MEXICO
SEE SEATTLE TACOMA AREA DETAIL
SEE PORTLAND AREA DETAIL
SEE SAN FRANCISCO SACRAMENTO AREA DETAIL
SEE LAS VEGAS AREA DETAIL
SEE LOS ANGELES AREA DETAIL
SEE PHOENIX AREA DETAIL
SEE DENVER AREA DETAIL
SEATTLE – TACOMA AREA DETAIL
PORTLAND AREA DETAIL
SAN FRANCISCO – SACRAMENTO AREA DETAIL
LOS ANGELES AREA DETAIL

# Western Interconnection RC

PEAKRELIABILITY
assuring the wide area view

## Reliability Coordinator (RC) – Peak Reliability

The Reliability Coordinator is responsible for the reliable operation of the Western Interconnection in accordance with WECC and NERC standards. The RC's access transmission reliability and coordination emergency operations among the operating entities within the Western Interconnection. The RC function is responsible for having a wide-area view, as well as operating tools, processes, procedures, and the authority to prevent or mitigate emergency operating situations in both next-day analysis and during real-time conditions. Monitoring is defined as the ability to monitor the complete Western Interconnection.

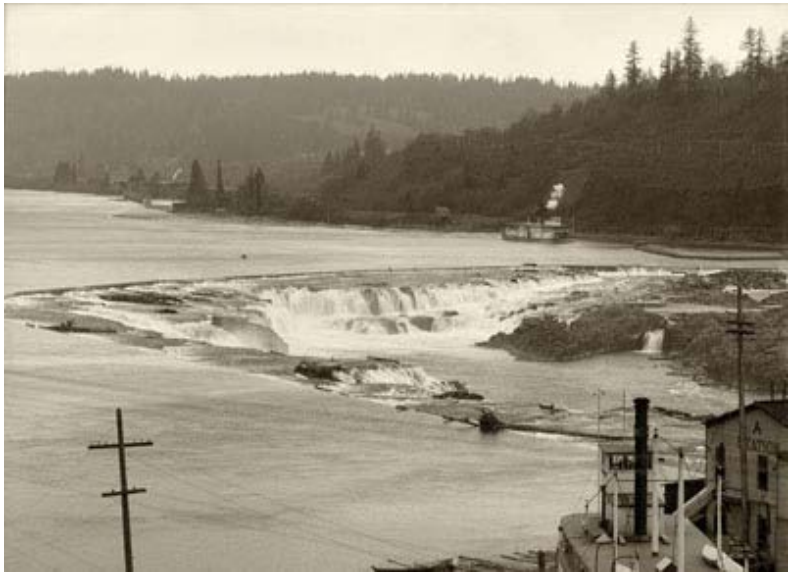
# Evolution of the North American Electric System

# 1889

1889 The first long distance transmission of DC electricity in the United States was switched on at Willamette Falls Station in Oregon City, Oregon.

1890 Destroyed by flood

1891 Replaced with AC power system



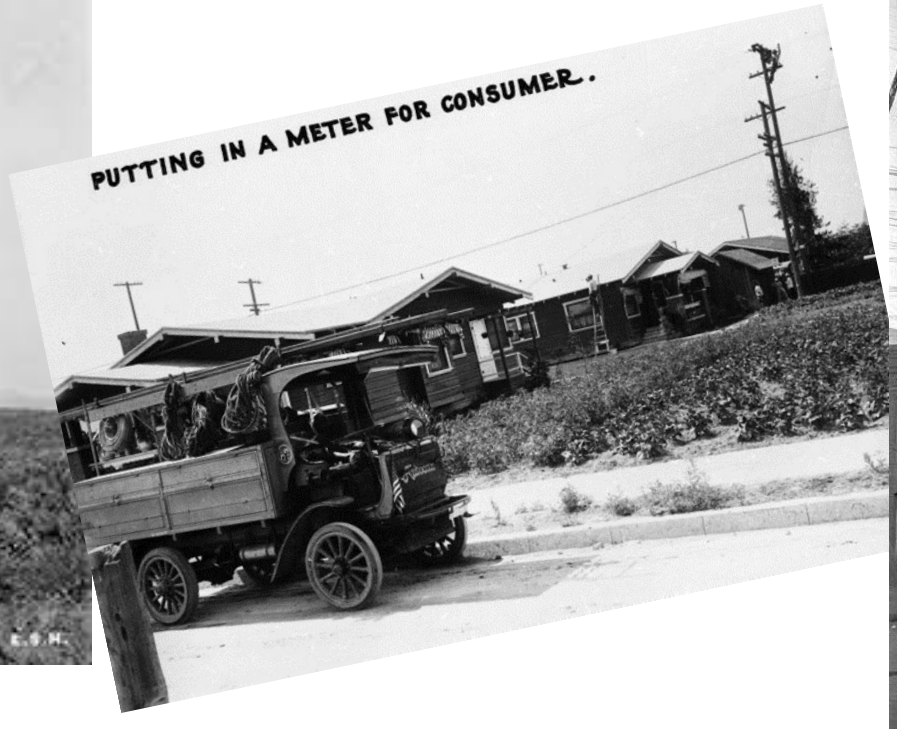
*1889*

*1891*

*OffbeatOregon, By Finn J.D John, Jan. 1, 2012*

# 1920

Federal Power Commission (FPC) is established.
No standards are in place.


# 1960's

North American Power Systems Interconnection Committee (NAPSIC) is formed as an informal voluntary organization.

The nation faces an energy crisis with chronic brownouts and the OPEC embargo ( 1970's) calling for a reorganization of the FPC which ultimately happens in 1977 (FERC).

# 1965
# The Great Northeast Blackout

# 1967

Western Systems Coordinating Council (WSCC) is formed as a trade organization.

35 years later the WSCC becomes WECC in 2002.

# 1968

National Electric Reliability Council (NERC) is formed in response to the 1965 Blackout.

The utilities maintain voluntary NAPSIC operating guidelines.

# 1977
# New York Blackout

## New York Times Report:

The New York Times ON THE WEB

D. Gorton/ The New York Times

Emergency surgery was performed outdoors on dozens of injured New Yorkers at the Brooklyn Jewish Hospital under spotlights powered by Fire Department generators.

BACK | NEXT

# 1977

Federal Energy Regulatory Commission (FERC) is reorganized from the FPC.


FERC is empowered by the Department of Energy (DOE) to propose voluntary standards.

# 1981

In recognition of Canada's participation in voluntary compliance, NERC changes its name from:

National Reliability Council

to

*North American Electric Reliability Council*

# 1989
# Hydro Quebec Blackout

## The Day the Sun Brought Darkness

Artist Rendition of the 1989 blackout . Credit: NASA

# 1992

NERC for the first time states that conformance to regional reliability policies should be mandatory.

# 1996

Two major blackouts in the western United States prompt the formation of the (WSCC)

Western Systems Coordinating Council

The WSCC creates a voluntary reliability management system.

# 2002

Western Systems Coordinating Council (WSCC)

Becomes

Western Electricity Coordination Council (WECC)

# 2003
# The Great Northeast Blackout

# 2003
# The 2003 Northeast Blackout

Blackout in Eastern U.S. & Canada

- August 14, 2003
- Joint U.S. & Canada Task Force Blackout Report

# Major Events

# 2004

Investigation of the 2003 blackout report concludes:

*The single most important recommendation for preventing blackouts is for the U.S. government to make Reliability Standards mandatory and enforceable.*

# 2005

U.S. Legislation Following 2003 Blackout:

- Energy Policy Act of 2005
- Principle feature:

  Mandatory standards with economic sanctions via FERC

# 2007

NERC becomes the Electric Reliability Organization (ERO) called for in the 2005 Power Act.

FERC approves NERC's reliability standards and delegates authority to enforce compliance.

NERC Reliability standards become mandatory.

# 2007

NERC delegates authority to 8 regional entities

WECC is the Western regional entity

# 2008
# South Florida Blackout

"Map of USA highlighting Florida". Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Map_of_USA_highlighting_Florida.png#/media/File:Map_of_USA_highlighting_Florida.png

# 2008

First non-compliance fine was issued to Florida Power and Light (FPL)

# 2011
# Southwest Blackout

"Southwest Blackout of 2011" by Own work - File:Southwest Blackout of 2011.png. Via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Southwest_Blackout_of_2011.svg#/media/File:Southwest_Blackout_of_2011.svg





| YEAR | EVENT | # PEOPLE | TIME | CAUSE | RESULT |
|---|---|---|---|---|---|
| 1965 | The Great Northeast Blackout | 30 million | 13 hrs. | Incorrect relay setting | 1968 NERC is formed Voluntary Guidelines |
| 1977 | New York Blackout | 9 million | 26 hrs. | Lightning strike | 1977 FERC is Formed |
| 1989 | Hydro Quebec Blackout | 6 million | 9 hrs. | Geo magnetic storm | 1992 NERC states reliability policies should be mandatory |
| 2003 | 2003 Northeast Blackout | 50 million 30 hours | 30 hrs. | Line sagging into tree | 2007 Reliability standards become mandatory |
| 2008 | South Florida Blackout | 590,000 | 3 hrs. | Primary and secondary protection disabled | 2008 1st fine is issued |
| 2011 | Southwest Blackout | 2.7 million | 12 hrs. | Switching error initiated lack of operating in N -1 condition | |



# Check Your Knowledge:
## The Interconnected System

1. What is FERC and what is their role?
2. What is NERC  and what is their role?
3. What is WECC and what is their role?
4. How to these organizations interact?
5. How do these organizations impact the electric utility industry?