ASHRAE Puget Sound Chapter

Code of Ethics Commitment

In this and all other ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, inclusiveness and respect for others, which exemplify our core values of excellence, commitment, integrity, collaboration, volunteerism and diversity, and we shall avoid all real or perceived conflicts of interests.

Diversity Commitment

ASHRAE is committed to providing a welcoming environment. Our culture is one of inclusiveness, acknowledging the inherent value and dignity of each individual. We proactively pursue and celebrate diverse and inclusive communities understanding that doing so fuels better, more creative and more thoughtful ideas, solutions and strategies for the Society and for the communities our Society serves. We respect and welcome all people regardless of age, gender, ethnicity, physical appearance, thought styles, religion, nationality, socio-economic status, belief systems, sexual orientation or education.

ASHRAE Puget Sound Chapter does not endorse any of the products, services, or technologies demonstrated or presented in this meeting.

Thank You Sponsors!

PLATINUM

TRANE®

P2S INC

MacDonald-Miller

FACILITY SOLUTIONS®

Upcoming Events

November Chapter Meeting: Strategies to Reduce EUI at a Hospital Facility

Event Details

- **Date:** November 21, 2024 12:00 pm – 2:00 pm PST
- **Venue:** Swedish Issaquah
- **Categories:** Chapter Meeting

Brad Shaw, Sr. Building Automation Engineer and Certified Energy Manager for Providence Swedish Puget Sound Region. Brad has 25 years of Hospital Facilities Engineering experience with a focus on building automations for the last 10+ years. He is a Certified Energy Engineer and member of the Association of Energy Engineers and the Washington State Society for Healthcare Engineering (WSSHE).

Andrea Piña, Facilities Manager Swedish Issaquah, Swedish Redmond and Swedish Mill Creek Andrea has 24+ years in working in Hospitals with the last 10 years in Facilities Engineering. She is an active member of the Washington State Society for Healthcare Engineering and is currently President-Elect for the 2025 WSSHE Puget Sound Region Chapter.

Local Company Spotlights

Is Your Company Hiring?
We want to help you find your next great intern or entry-level employee!

Why Reach Out?

- Gain access to motivated ASHRAE students eager to learn and contribute.
- Enhance your company's visibility within the local community.
- Build a pipeline of talented individuals for future positions.

How It Works:
We'll send out email blasts describing your company and the related positions to our ASHRAE student members.

Get Started Today!
Contact students@pugetsoundashrae.org to get the ball rolling!

Nominating Committee

- Build Chapter leadership of tomorrow
- Selecting officers and BOG members
- Looking for (5) members that are representative of the local industry
- Please reach out if you would like to be a part of this committee

Grid Impacts of Building Electrification

Load Modeling and Forecasting

ASHRAE Puget Sound Chapter Meeting

23 October 2024

David P. Chassin, PhD

Eudoxys Sciences LLC, Marysville, Washington

Motivation

Simulations are used to plan system

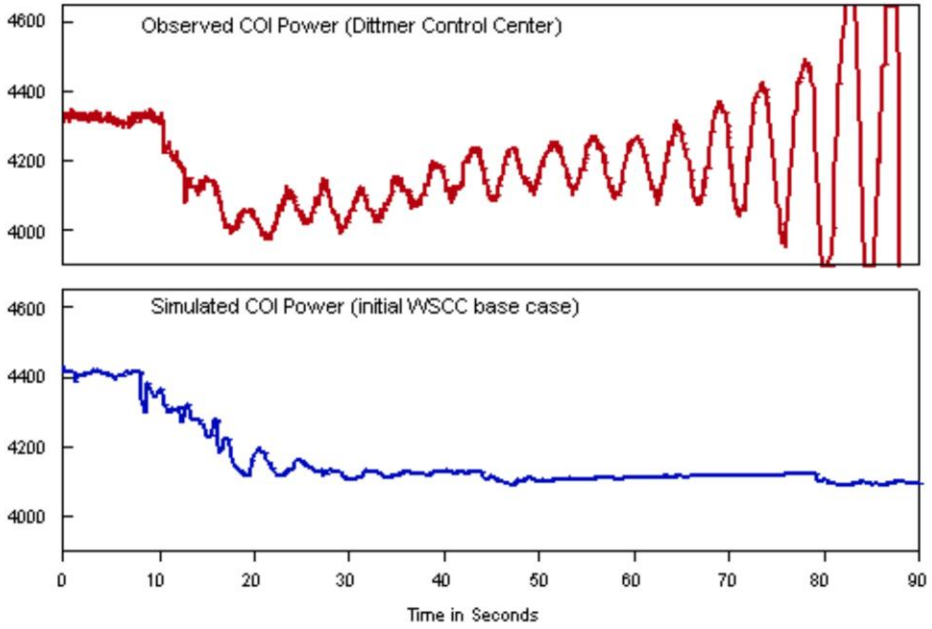
- **If simulations don't match reality, then … ?**

August 10 1996 Blackout

- **Serious model discrepancies**

Some contributing factors to model error

- **Generator parameters**
- **Protection settings**
- **Load models ← Focus of today's talk**



Today's Topics

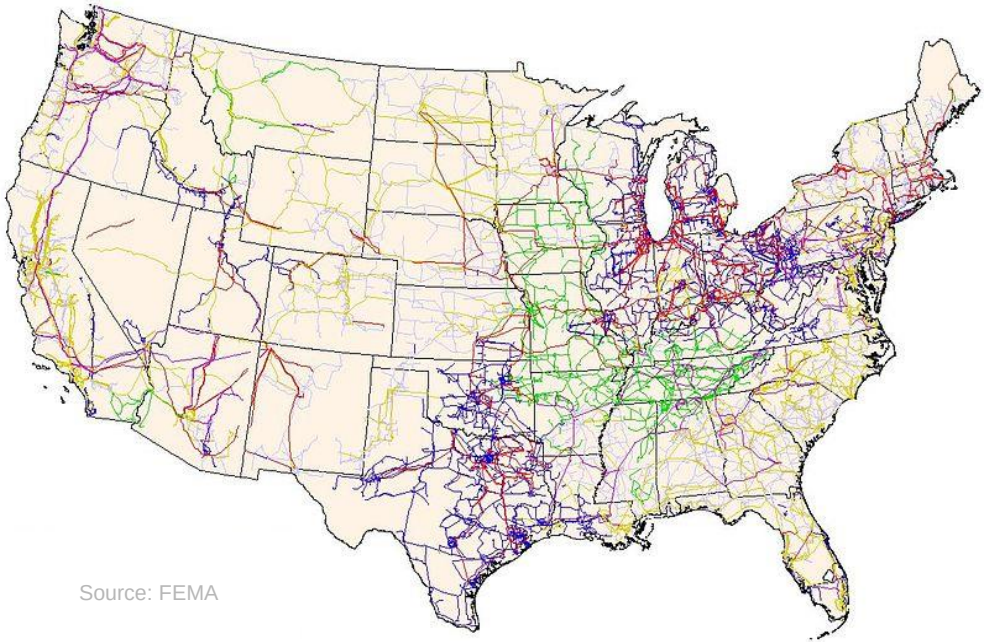
1. **Electric Grid Primer**
2. **Load Modeling for Reliability**
3. **NERC Resource Adequacy Planning**
4. **Challenges and Opportunities**

Caveat: Results presented here are preliminary and not yet peer reviewed.

"Prediction is hazardous, especially about the future."
– Danish proverb

Source: Midwest Reliability Organization

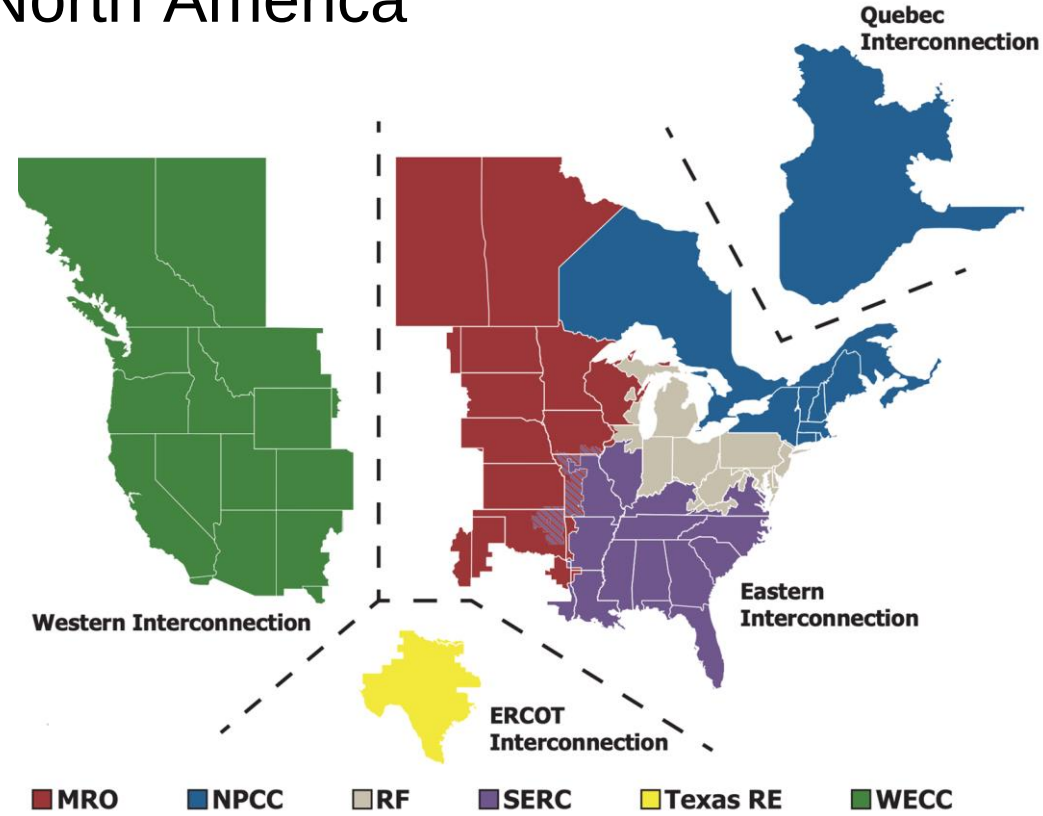
Chapter 1
Bulk Power Systems



Source: FEMA

Four interconnections in North America

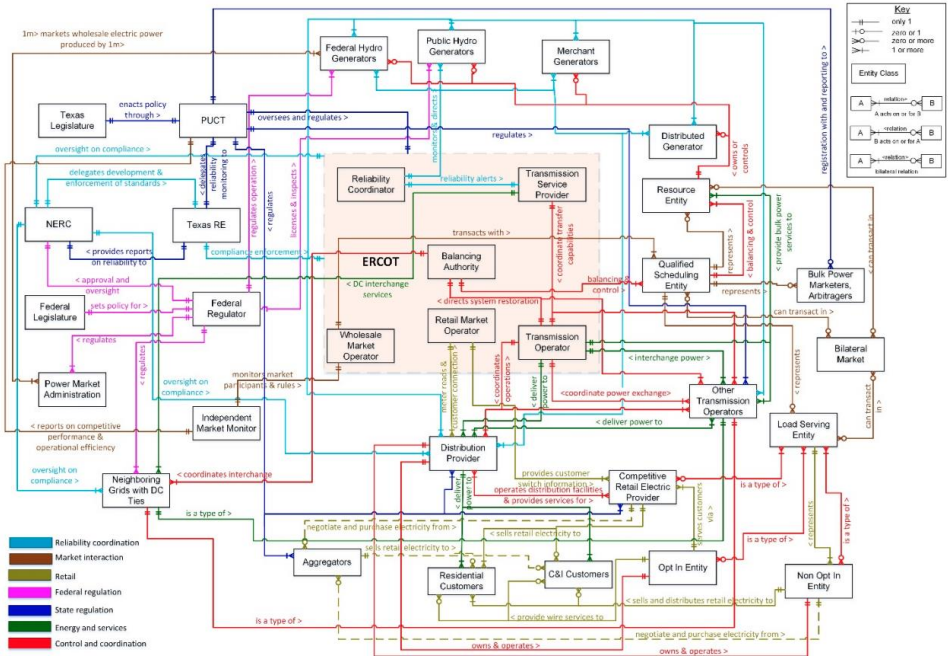
- **Oversight by NERC (except Texas)**
- **Multiple overlapping reliability orgs**
- **Physical separation**
  - Frequencies
  - Voltages
  - Generation
  - Loads
  - Few DC links



Source: NERC Interconnections

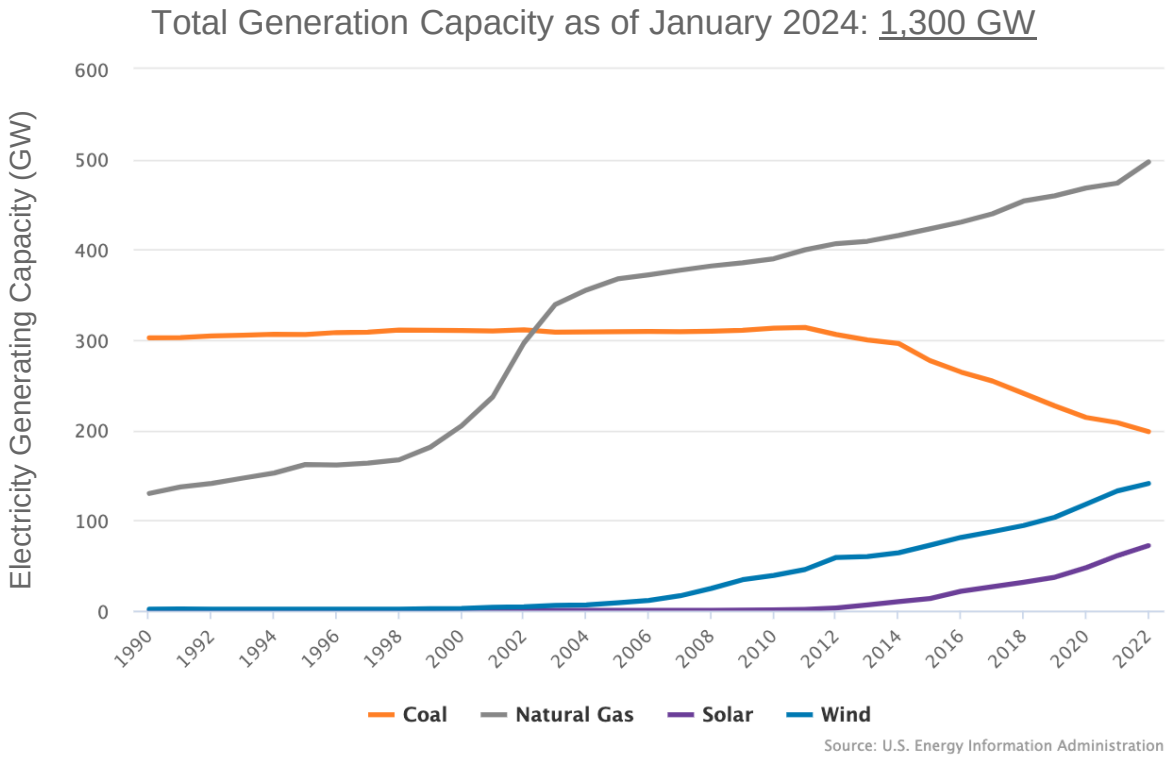
Complex Industry Structure

- **Technical**
  - Planning
  - Operations
- **Financial**
  - Wholesale/bilateral markets
  - Power marketers
  - Res/Com/Ind/Agr/Pub retail tariffs
- **Organizational**
  - Power marketing agencies
  - Investor-owned utilities
  - Public utilities
  - Cooperatives
  - Merchant generators
- **Regulatory**
  - Congress
  - Federal agencies (FERC, NERC)
  - State legislatures
  - State agencies
  - Local utility commissions

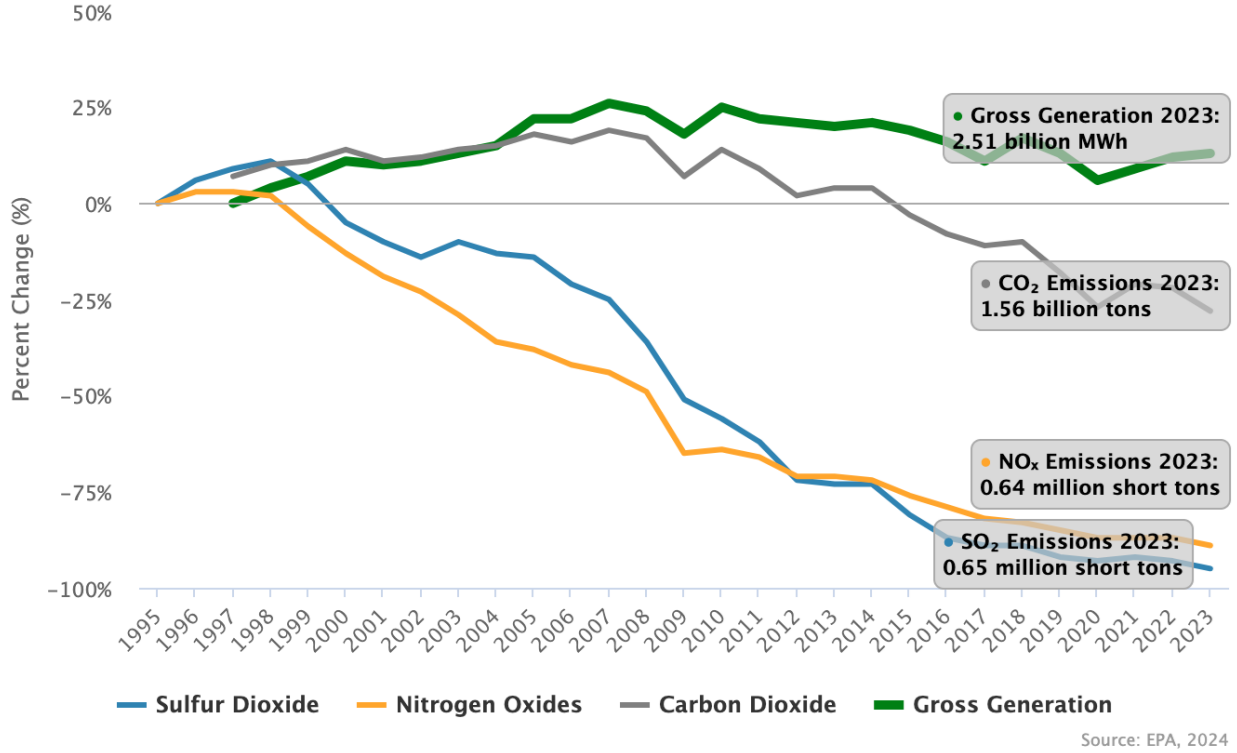


Source: [ERCOT]

Generation Mix Changing



Emissions Impact



Source: EPA, 2024

Load Mix Changing

***Yesterday*:**

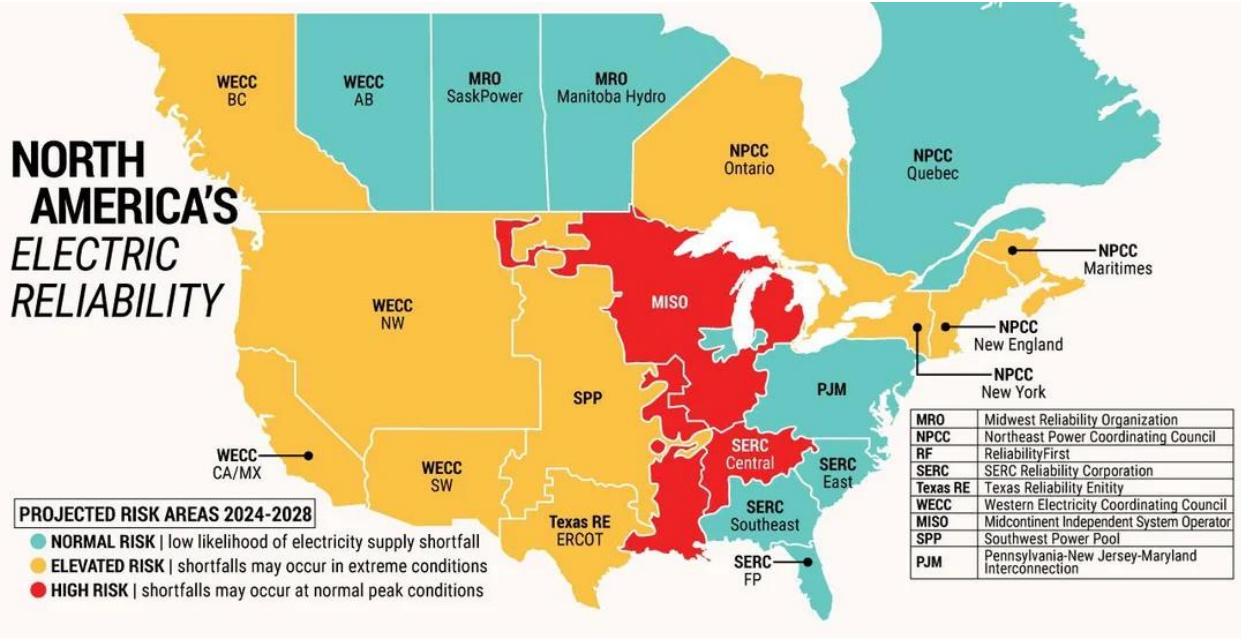
- ❑ **Resistive heating**
- ❑ **Conventional AC cooling**
- ❑ **Incandescent (resistive) lighting**
- ❑ **Resistive cooking**
- ❑ **Appliance (washer, dryer, refrigerators)**
- ❑ **No vehicle charging**
- ❑ **No energy storage**
- ❑ **Induction motors (fans and pumps)**
- ❑ **No distributed generation**

***Tomorrow*:**

- ➔ **Heat pumps (VFD)**
- ➔ **High-efficiency AC cooling (VFD)**
- ➔ **Compact fluorescent and LED lighting**
- ➔ **Gas cooking → Radiant/induction cooking**
- ➔ **Energy Star appliances (eco features)**
- ➔ **Plug-in vehicles**
- ➔ **Battery storage systems**
- ➔ **VFD motors (fans and pumps)**
- ➔ **Significant distributed generation**

Source: NERC LMTF Technical Reference Document (2016)

Chapter 2
Load Modeling for Reliability



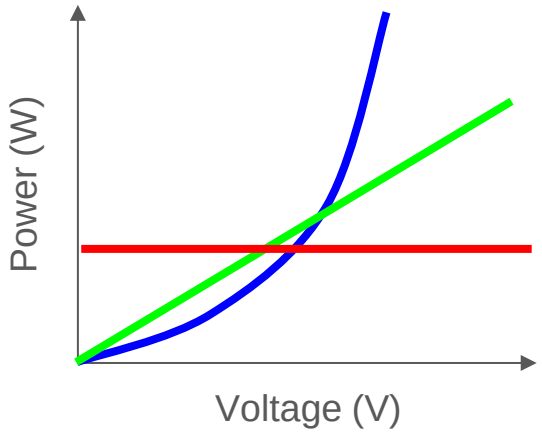
Source: Geopolitical Futures

Two Important Factors

***Voltage* changes affect load power**

$$Total\ Power = V^2 / Z + V I + P$$

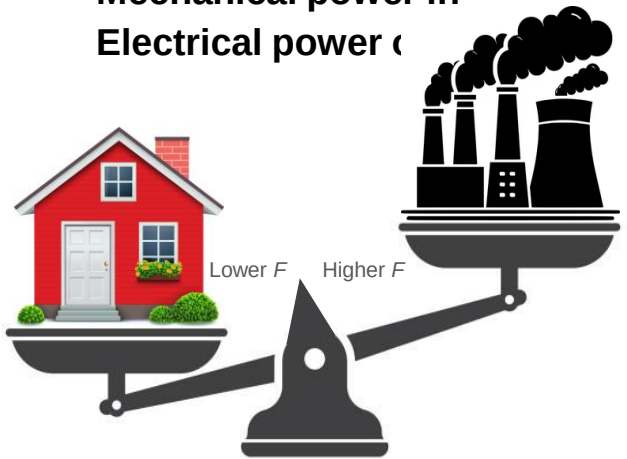
Z	Constant impedance loads
I	Constant current loads
P	Constant power loads



***Frequency* changes as power balance shifts**

$$Frequency\ change = (P_M - P_E) / M$$

M	Inertial constant
P_M	Mechanical power in
P_E	Electrical power c



Characteristics of Major Load Types

Resistive Loads

- **Constant impedance (V^2 sensitivity)**
- **“Grid-friendly”**

Electronic Loads

- **Fast over-current trip (power surges)**
- **Constant power (no voltage sensitivity)**

Induction Motors

- **Stalling behavior (reactive power spikes)**
- **Thermal tripping (frequency overshoot)**

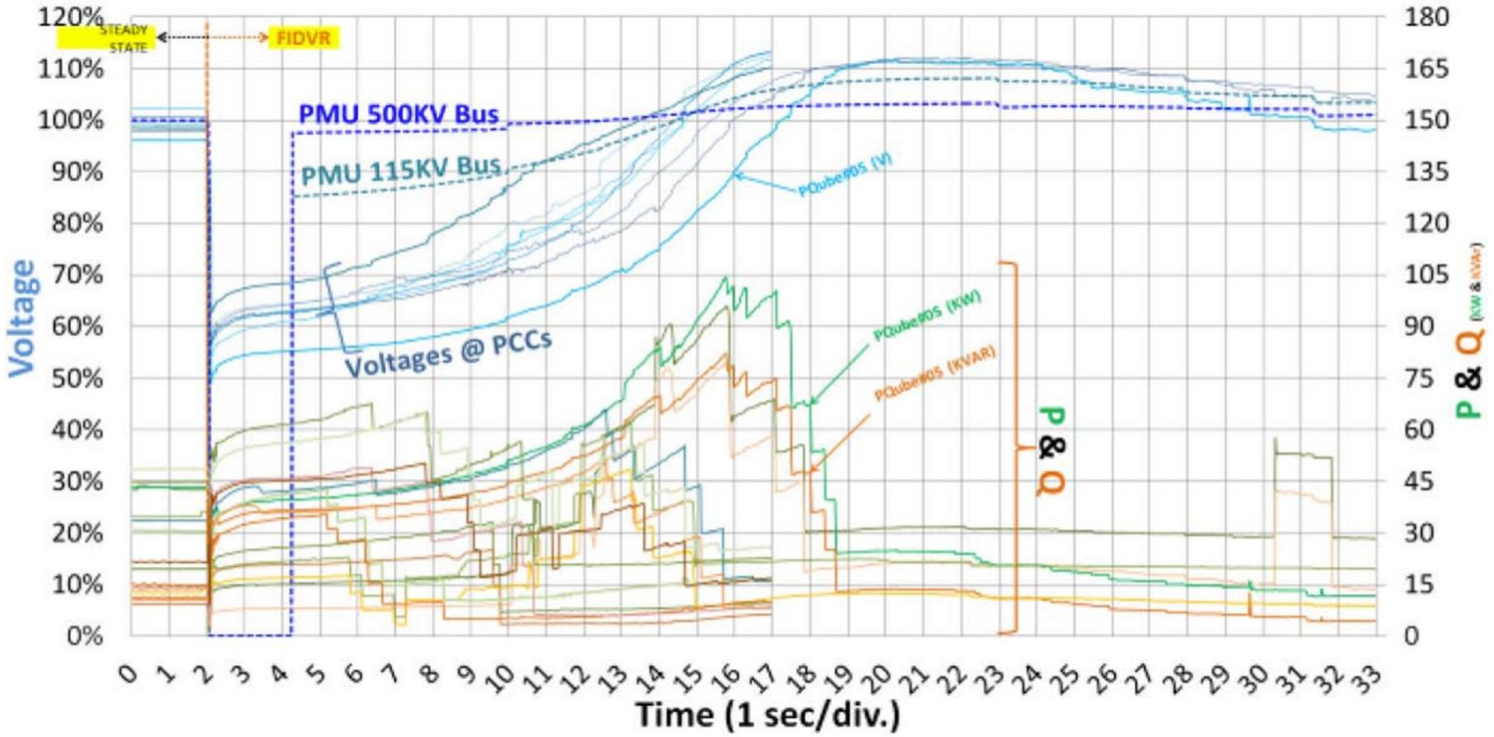
Distributed Generation

- **“Negative” loads (protection issues)**
- **Intermittency (forecasting issues)**

Reliability Studies

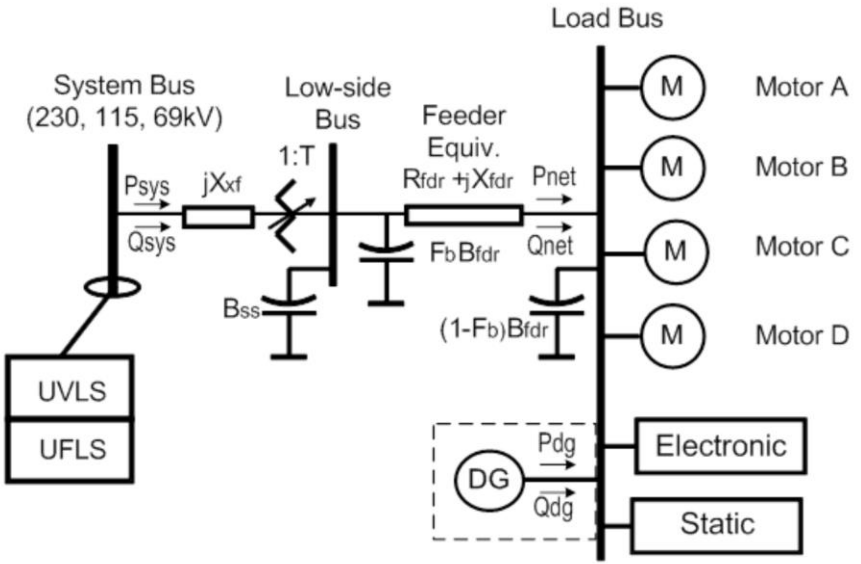
- **Objectives**
  - Evaluate adequacy of resources and identify potential reliability issues
  - Project supply vs. demand and identify long term issues and trends
  - Provide a framework for discussions and recommendations about reliability
- **Approach**
  - Verify how system behaves under various scenarios
  - Validate how well simulation replicates known events
- **Size of models**
  - Eastern → ~75,000 nodes
  - Western → ~25,000 nodes
  - Texas → ~10,000 nodes
- **Time frame of simulations: 30s at <1ms timestep**

Fault-Induced Delayed Voltage Recovery (FIDVR)



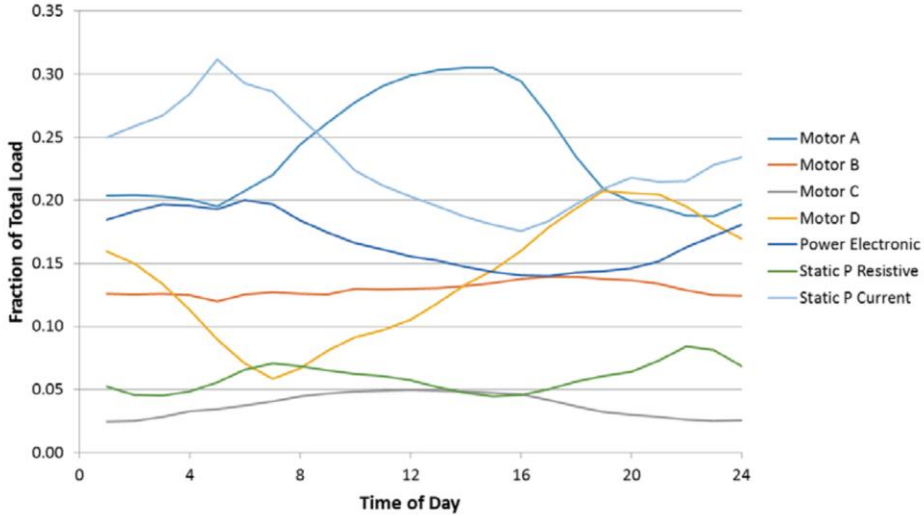
Composite Load Model

- **Salient features of “modern” loads**
  - Static (ZIP)
  - Induction motors (various torque/inertia)
  - Electronic loads
  - Distributed generation
- **Coming soon to the load models**
  - EV chargers
  - Energy storage

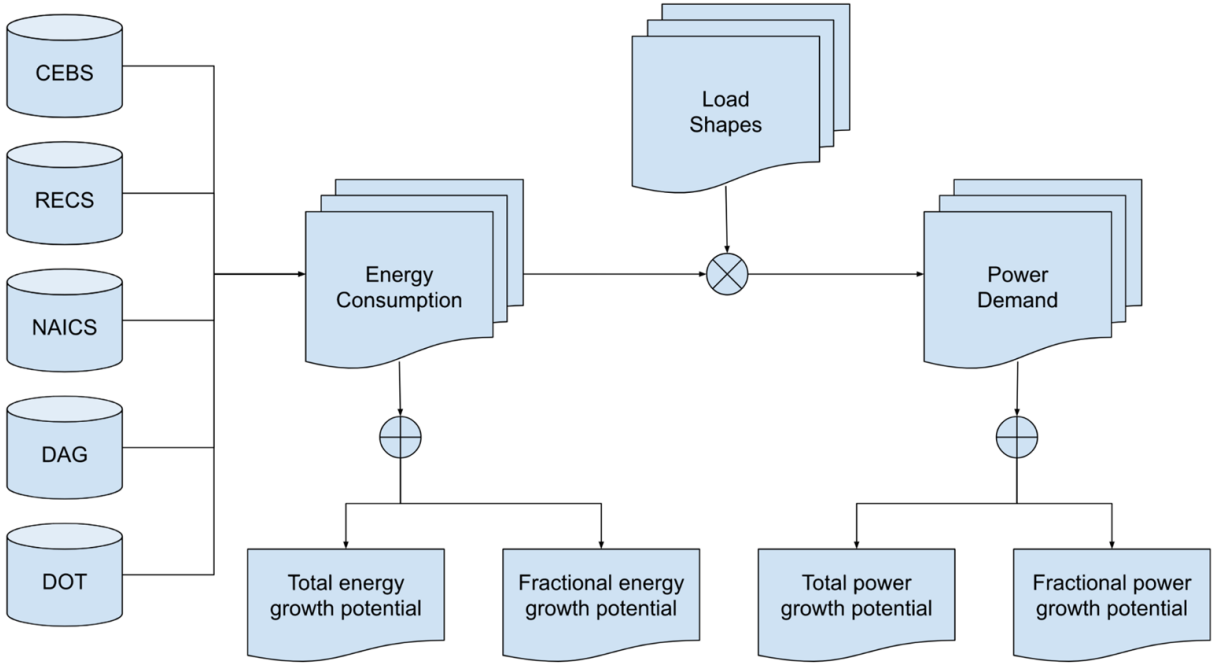


Impact of changing generation & load mix

- **Reduced inertia**
  - Fewer large rotating machines (generation)
  - Fewer small direct-drive motors (load)
  - Faster frequency response (inverters)
- **Increased electronic (“P”) loads**
  - Reduced voltage response
  - Increased over-current trip sensitivity



Chapter 3
NERC Resource Adequacy Planning



Electrification Load Growth

Water heating	→	**Heat pump water heaters**
Cooking	→	**Electric appliances**
Space heating	→	**Heat pumps (more AC?)**
Drying	→	**Electric dryers**
Commercial processes	→	**Electric heating and cooking**
Industrial processes	→	**Electric heating (cement?)**
Agricultural processes	→	**Electric heating/motors (fertilizers?)**
Vehicles	→	**EV charging infrastructure**
Public services	→	**Electric water treatment**

Energy Sectors and Factors

Sectors

- **Commercial**

  14 building types

- **Residential**

  5 home types

- **Industrial**

  20 industries (5 major, except cement)

- **Agricultural**
- **Transportation**
- **Public Services**

Factors

Commercial

- **Building vintage**
- **Building type**
- **Building size**

Residential

- **Vintage, type, and household income**

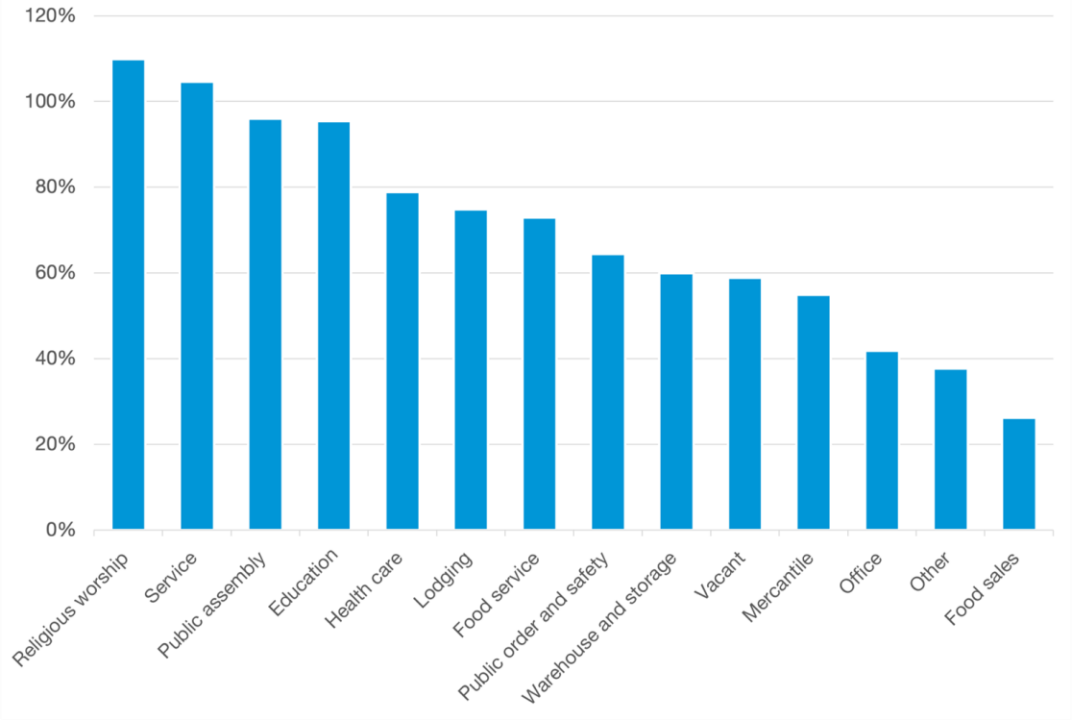
Industrial

- **Facility type**

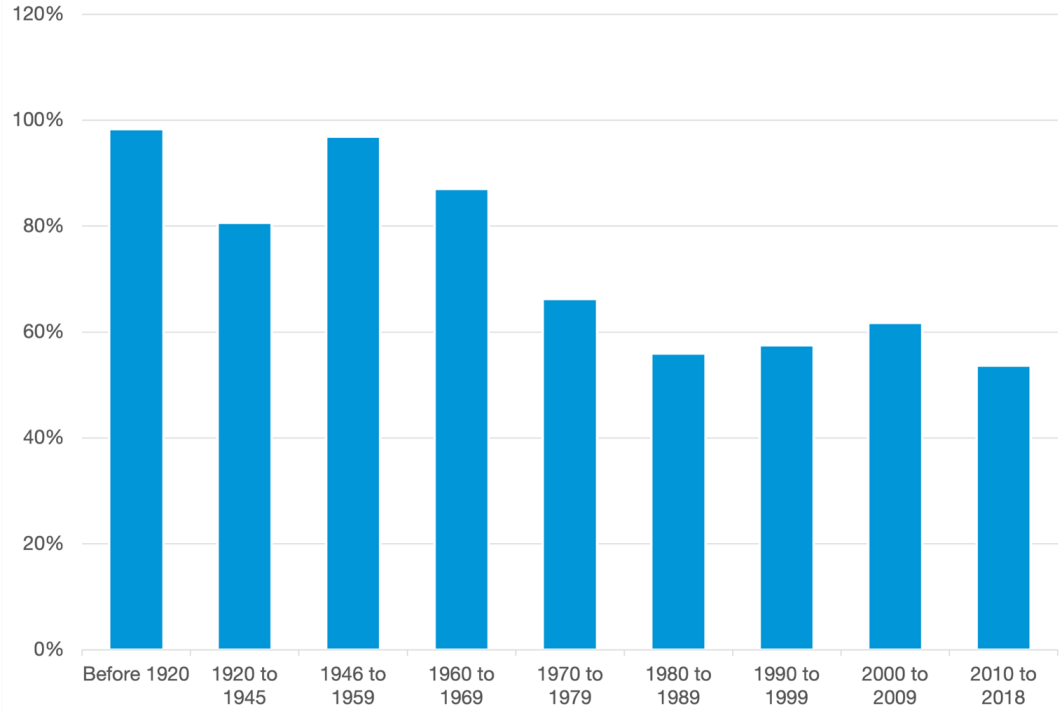
Transportation

- **Vehicle type**

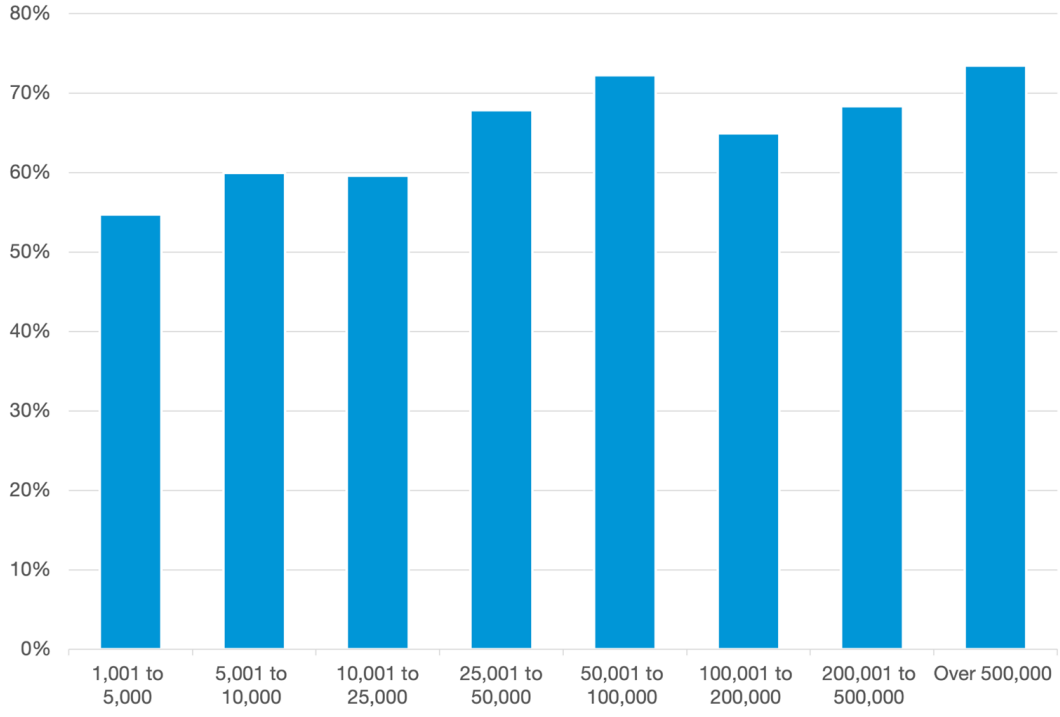
Commercial building electrification load growth by type



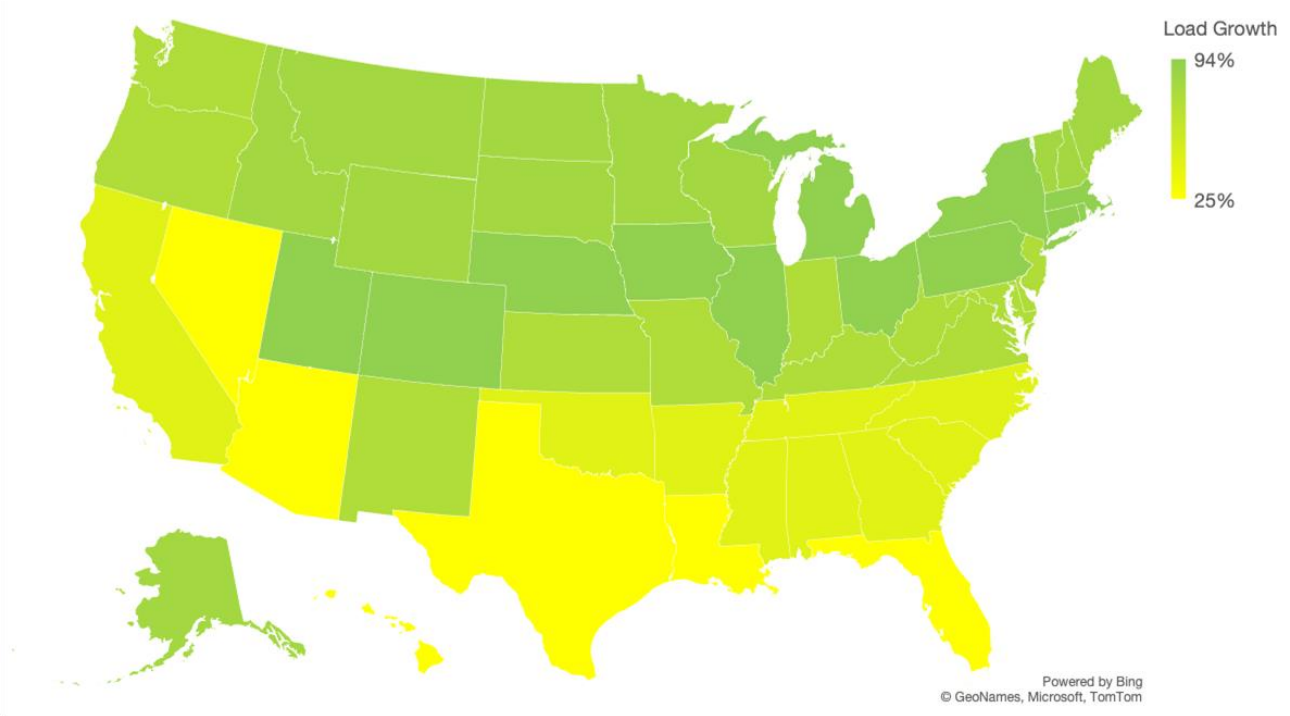
Commercial building electrification load growth by vintage



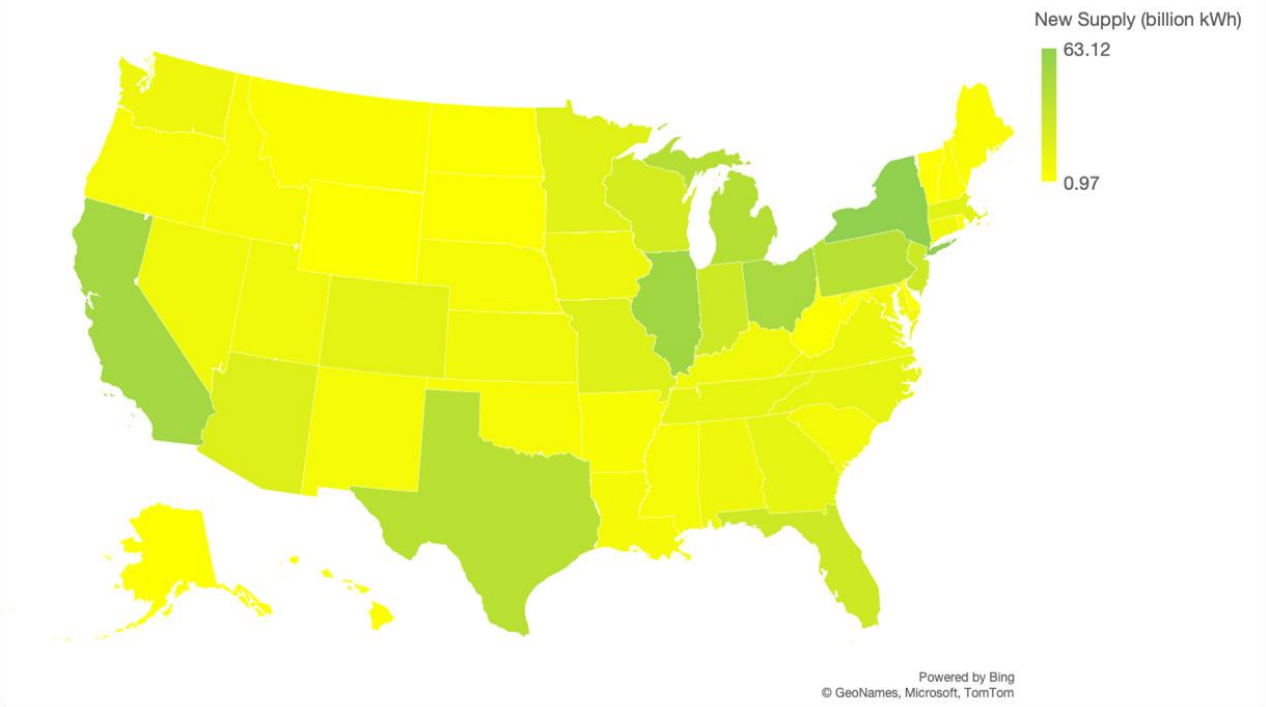
Commercial building electrification load growth by size



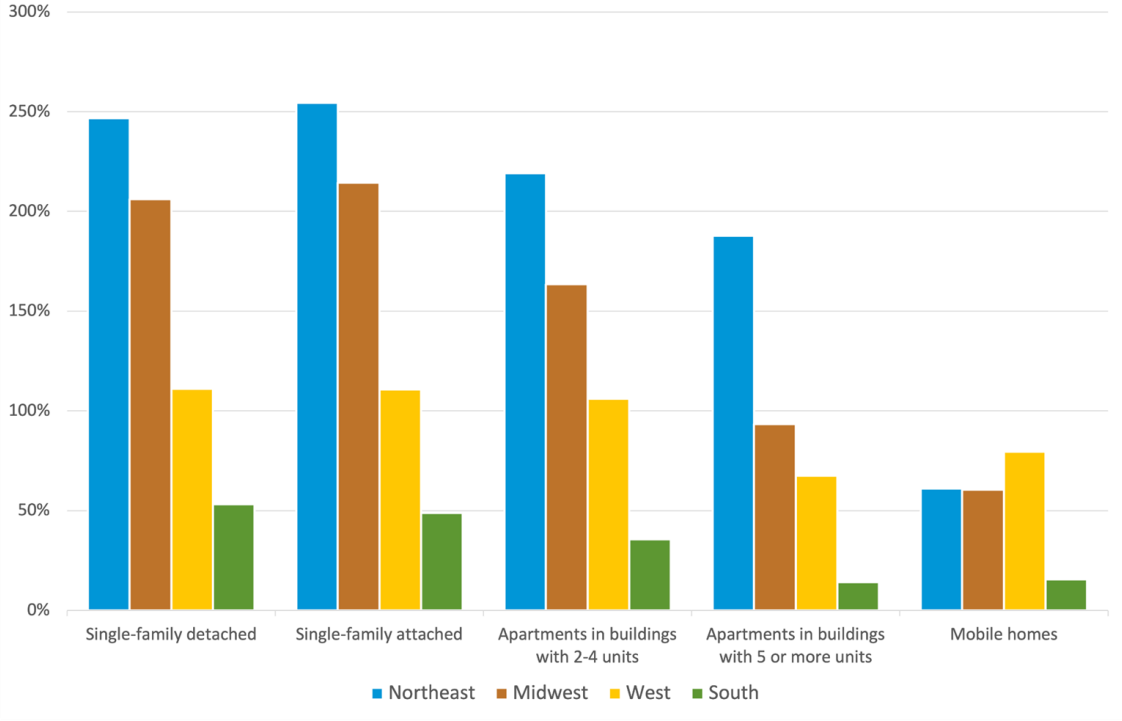
Commercial building electrification load potential growth



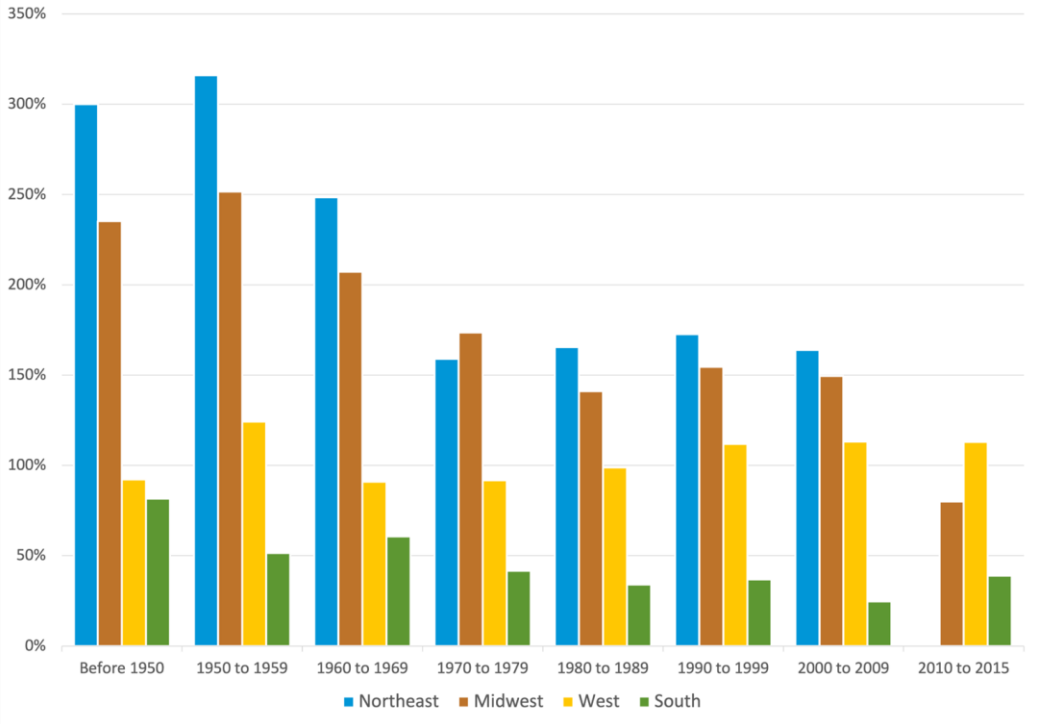
Commercial building electrification new energy supply



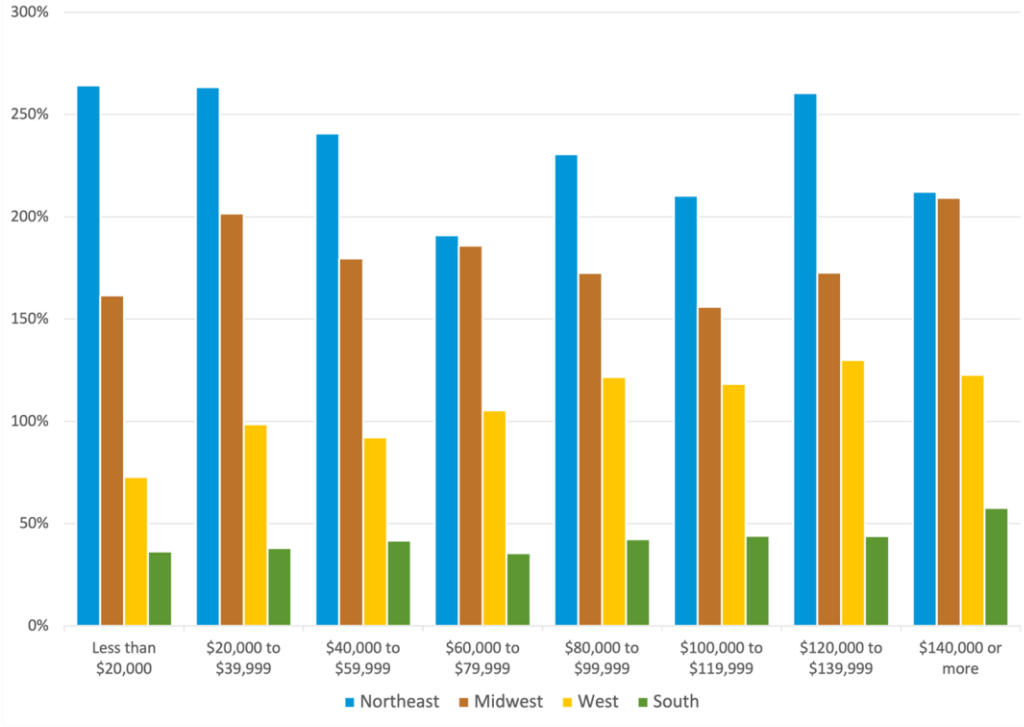
Residential building electrification load growth by type



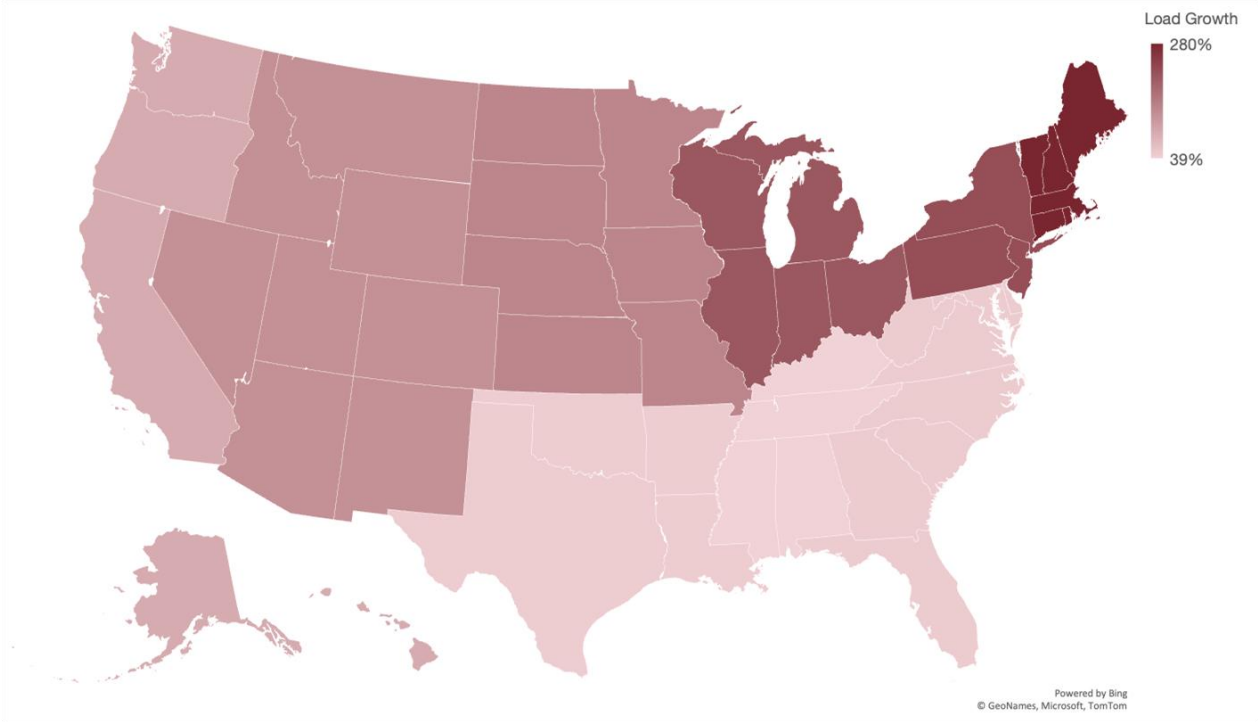
Residential building electrification load growth by vintage



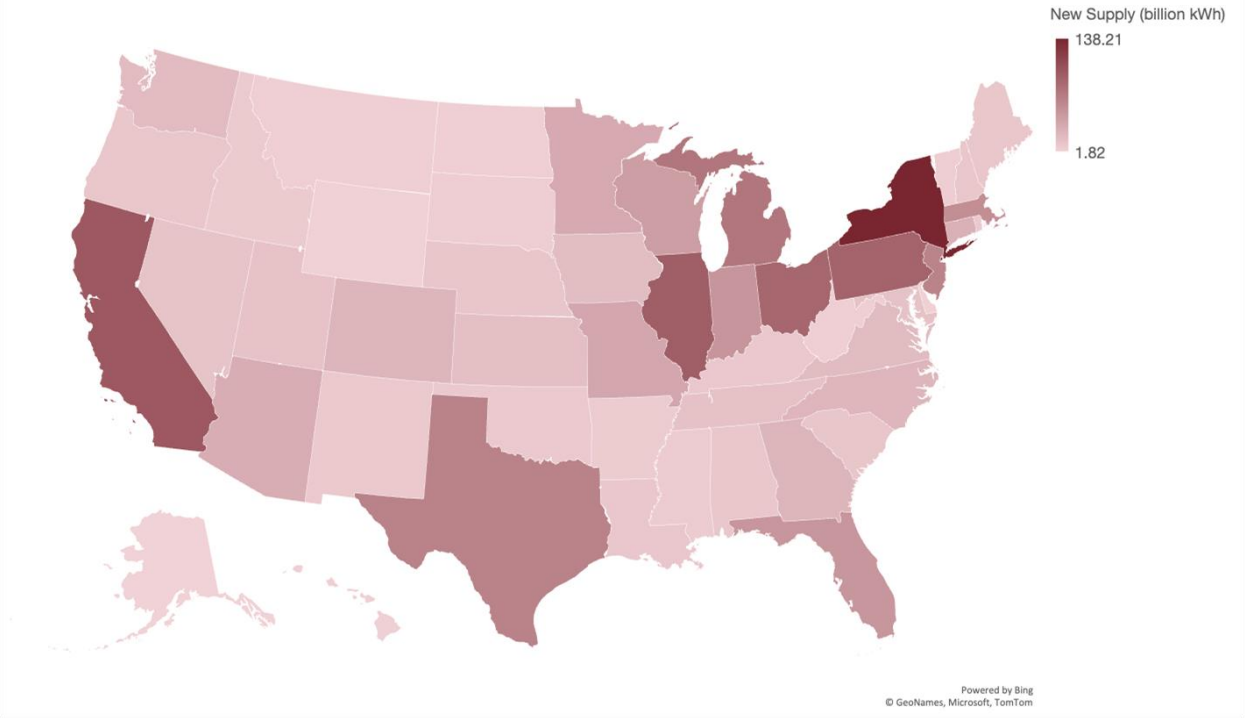
Residential building electrification load growth by income



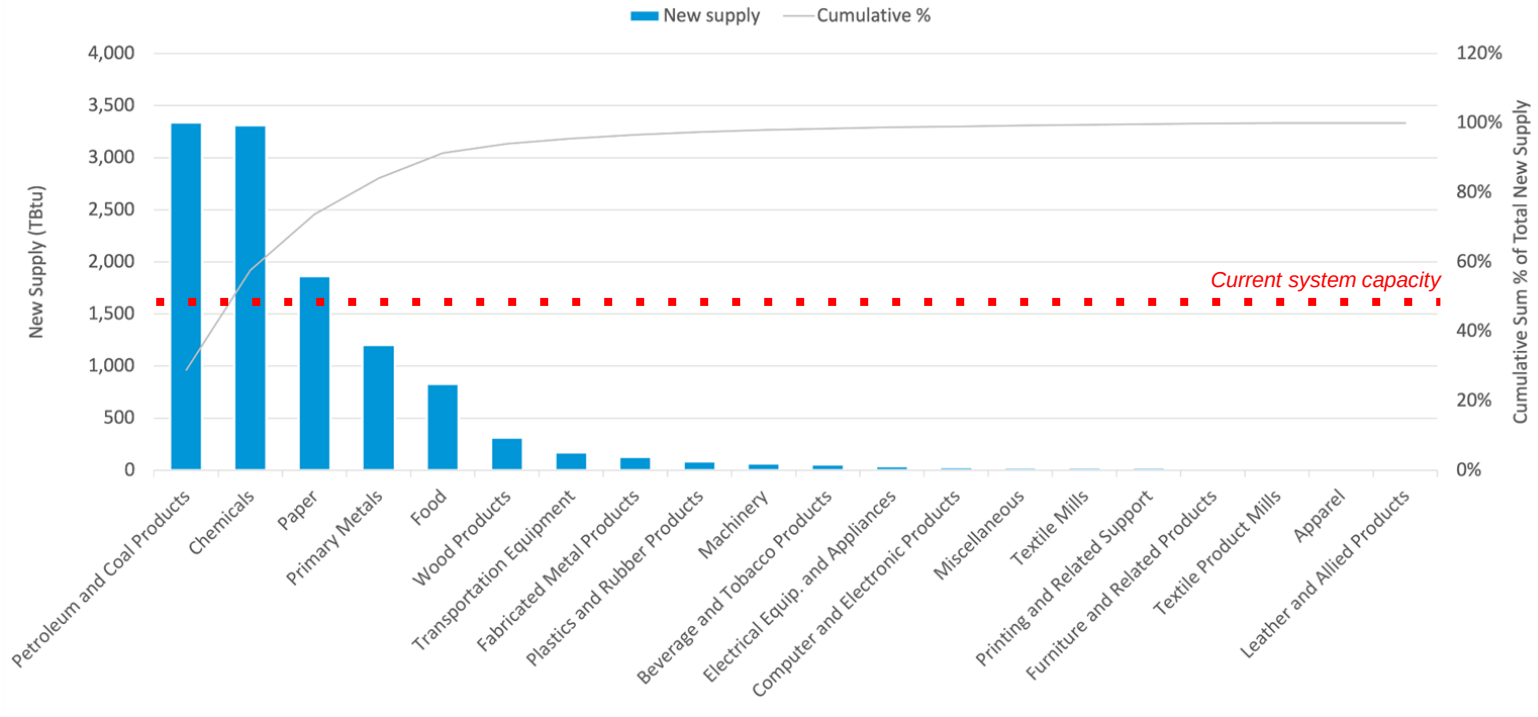
Residential building electrification potential growth



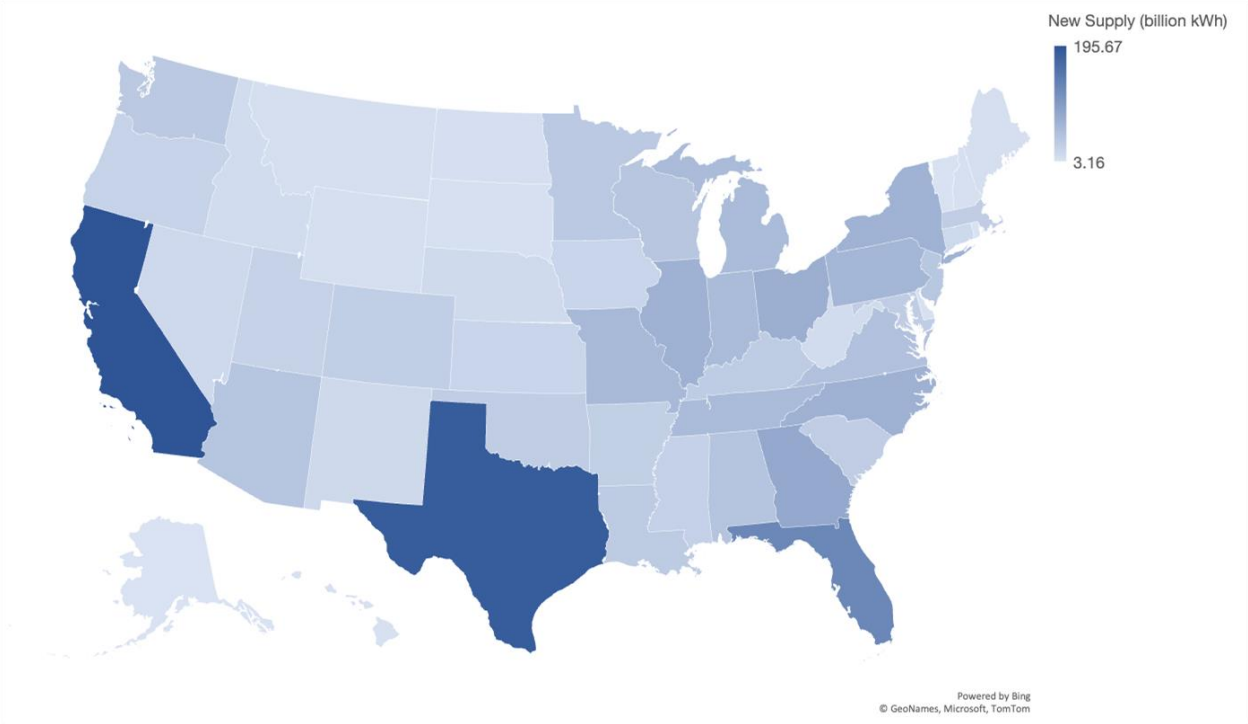
Residential building electrification new supply



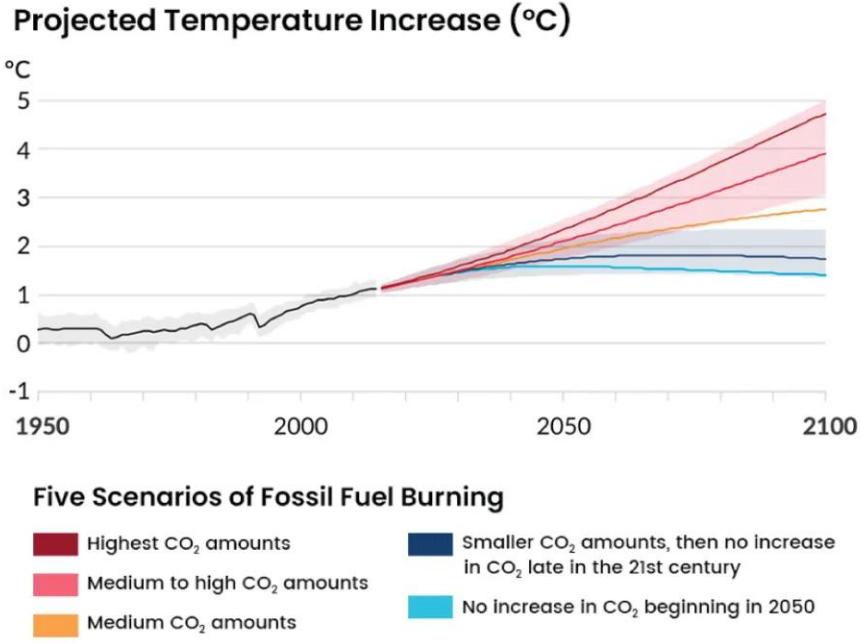
Industrial electrification new supply



Transportation electrification new supply



Chapter 5
Challenges and Opportunities



Source: UCAR

Challenges and Opportunities

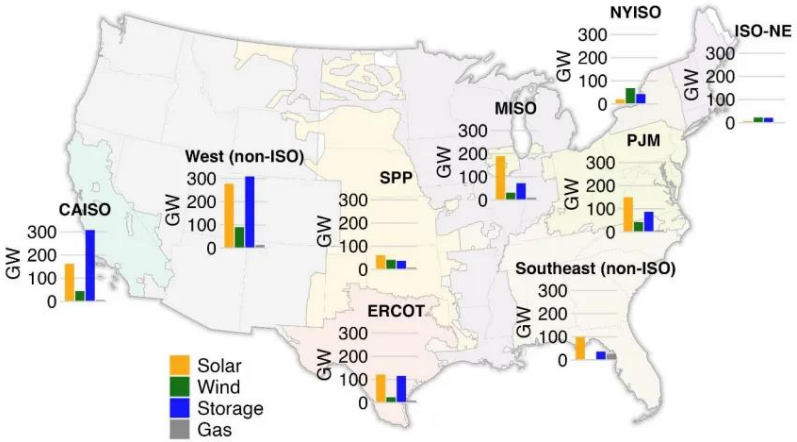
- **Costs**
  - Electric panel capacity upgrades
  - Accelerated appliance retrofits
  - Distribution asset upgrades
  - Transmission network upgrades
  - New generation resources
- **Secondary load growth effects**
  - E.g., opt-in eco modes in new appliances
- **Changing demographics/behaviors**
  - EV demand growth regional uncertainty

- **Benefits**
  - Reduced greenhouse gas emissions
  - Reduced indoor air pollution
  - Reduced gas infrastructure costs
  - Improved resilience and life safety
  - Improved gas resource utilization
- **Data Centers**
  - Interconnection queue uncertainty
  - Large-load interconnection standard

Data Centers: 10-year Generation Gap

Generation queue: <1,600 GW

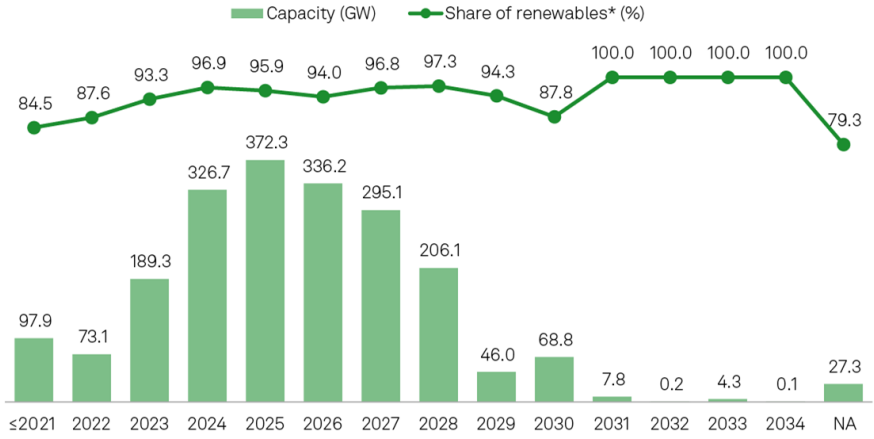
(95% renewables w/ >1,000 GW storage)



Source: Lawrence Berkeley National Laboratory

Data Center requests: >2,000 GW

(i.e., does not include electrification load growth)



Source: S&P Global

Total Generation Capacity as of January 2024: 1,300 GW

Closing Thoughts

- **Very preliminary results**
  - Annual updates by DOE, EPRI, NERC, ...
- **Missing data**
  - Industrial electrification solutions/strategies
  - Agricultural loads
  - Regional EV adoption rates
  - Medium and heavy duty vehicles
  - Public service loads
- **Role of changing resource mix**
  - Renewables
  - Distributed energy resources
  - Storage
- **Impacts assessments**
  - Electricity pricing (feedback)
  - Local, state, and federal policies
  - Grid resilience (vs. reliability)

Thank you

Contact me: dpchassin@gmail.com

Further Reading

Managing Periods of Bulk Power System Instability (Part 1)

Managing Periods of Bulk Power System Instability (Part 2)

Managing Periods of Bulk Power System Instability (Part 3)

Model Validation for the August 10 1996 System Outage

NERC LMTF Technical Reference Document Dynamic Load Modeling

NERC EV Modeling Technical Reference Document