New Grid: Reinvention & Resilience

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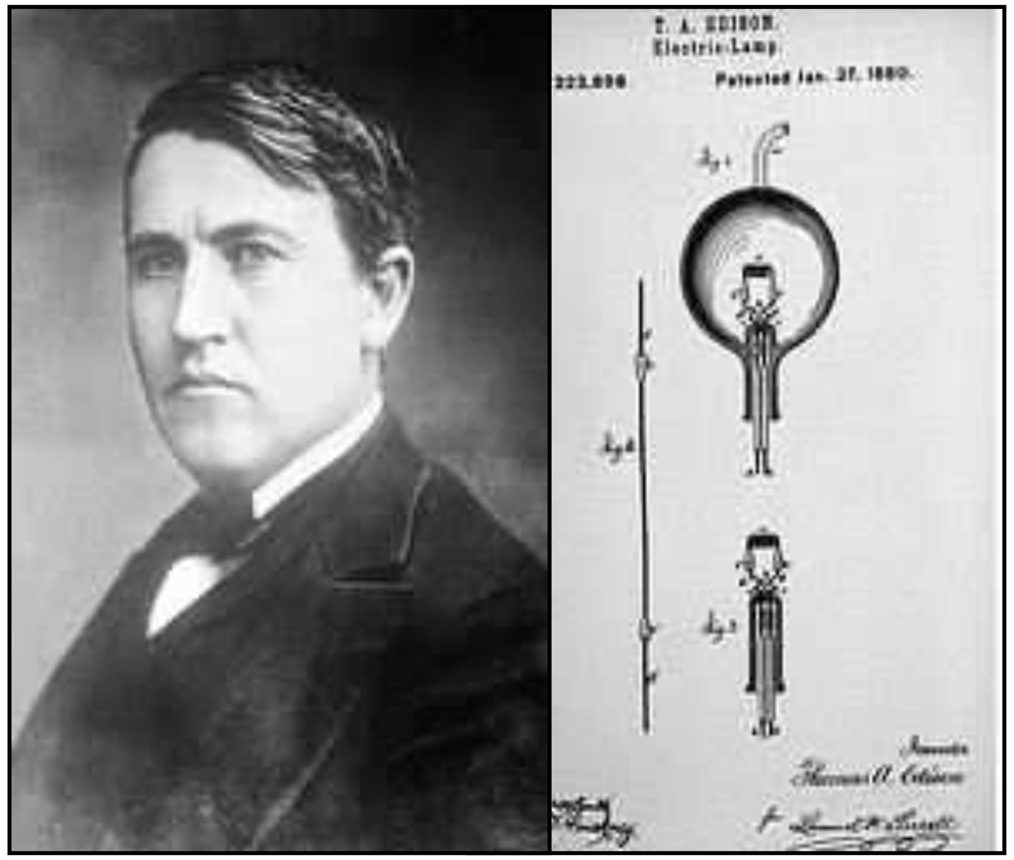
Disclaimer

The views expressed herein are the author's, and do not necessarily reflect the views of any organizations.

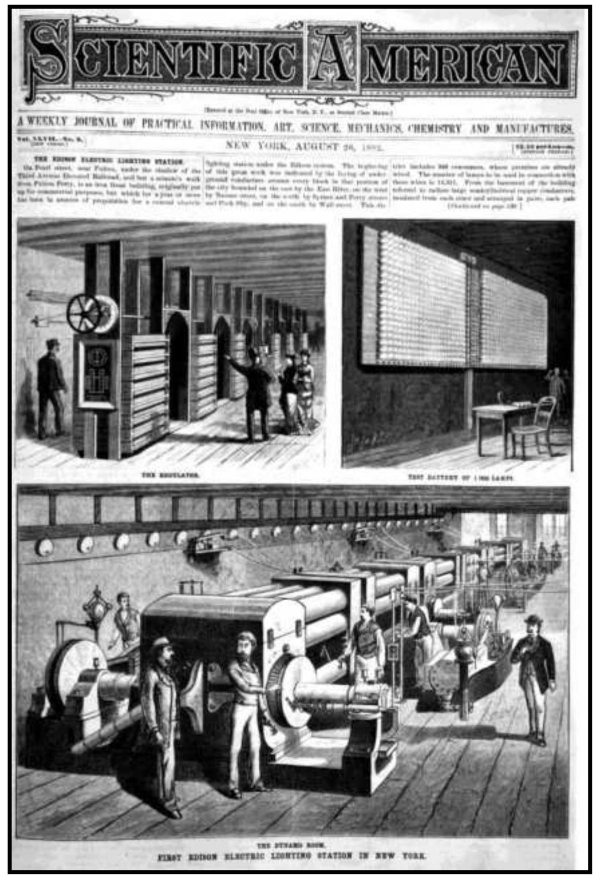
My 35-Year Career in Energy Field

- Academic (teaching, research)
- Manufacturing (invention, application)
- Electric Utility (planning, operations)
- Standards Organization (consensus building)
- Regulatory Agent (collaborating with lawyers and economists for bigger social impact)
- Consulting on energy transformation

Frontiers - A New Energy Industry

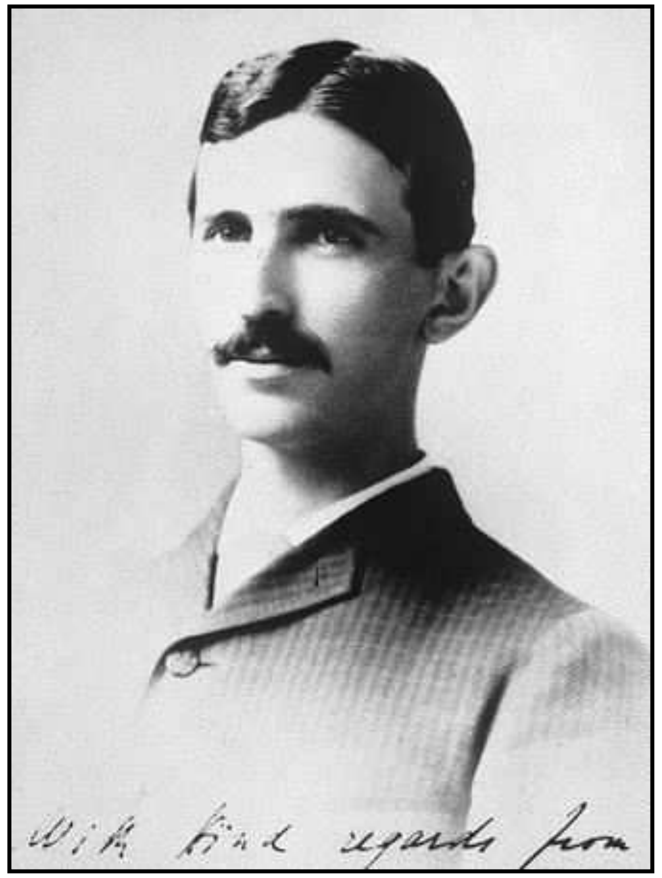


Thomas Edison and his incandescent light patent



Edison's 1st commercial plant, Pearl St., NY 1882

Samuel Insull built the reliable "power pool", reducing production costs and rates and increasing efficiency



Nikola Tesla, inventor of the induction motor and a comprehensive system for polyphase AC power

- Edison opened his first electric power plant in New York in 1882
- Within a decade, electric power had spread to every corner of the globe

Safety

Reliability

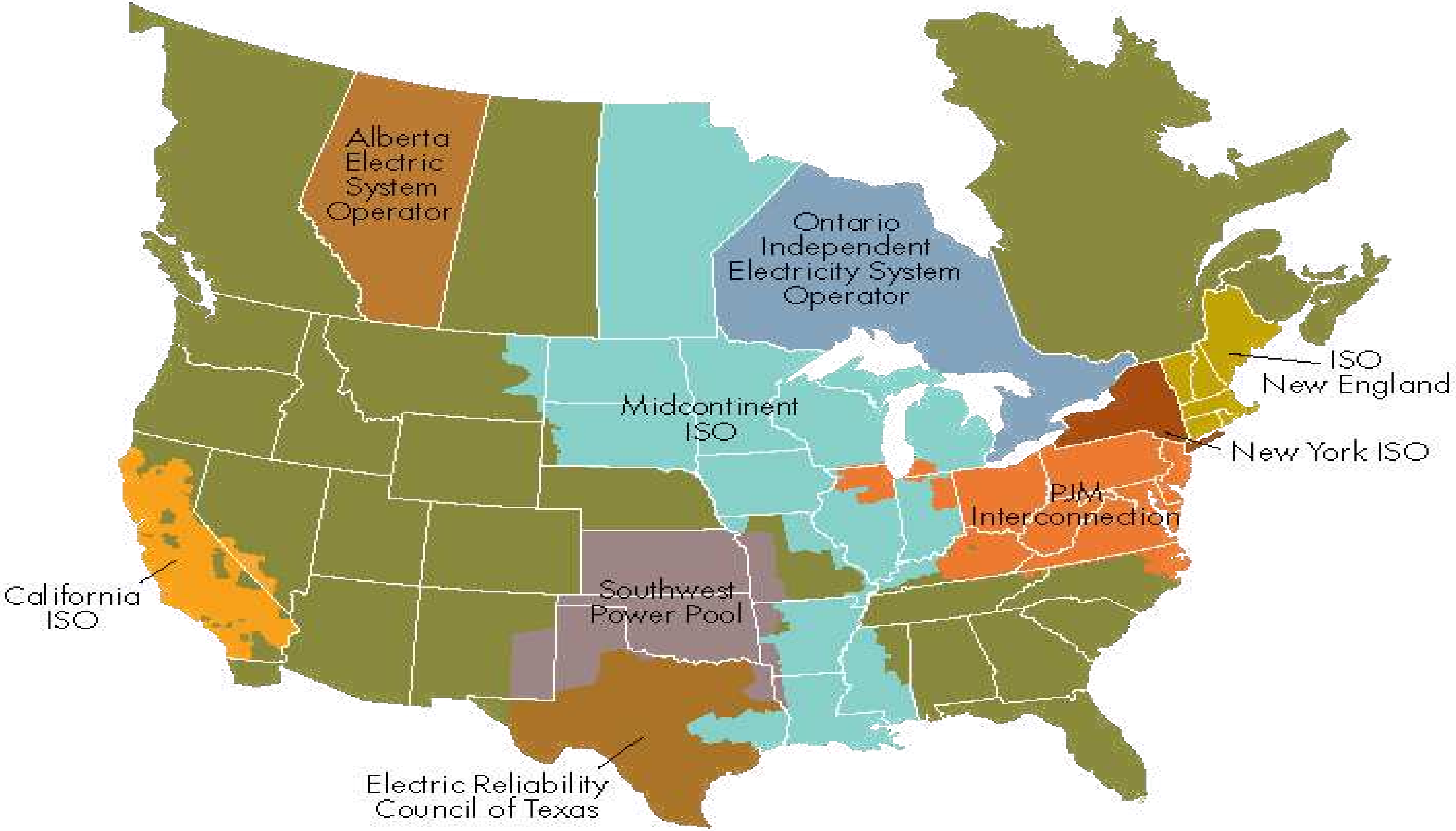
Cost-effectiveness

Spectacular Results

Year	Share of Homes with Service	Kwh Consumed per Home	Price Paid
1912	16%	264	9.1₵
1920	35%	339	7.5₵
1948	90%	1,563	3.0₵

Source: U.S. Department of Commerce, Historical Statistics of the United States, Colonial Times to 1970, Part 2, Series S, 108-119.

Grids and Wholesale Electricity Markets in North America



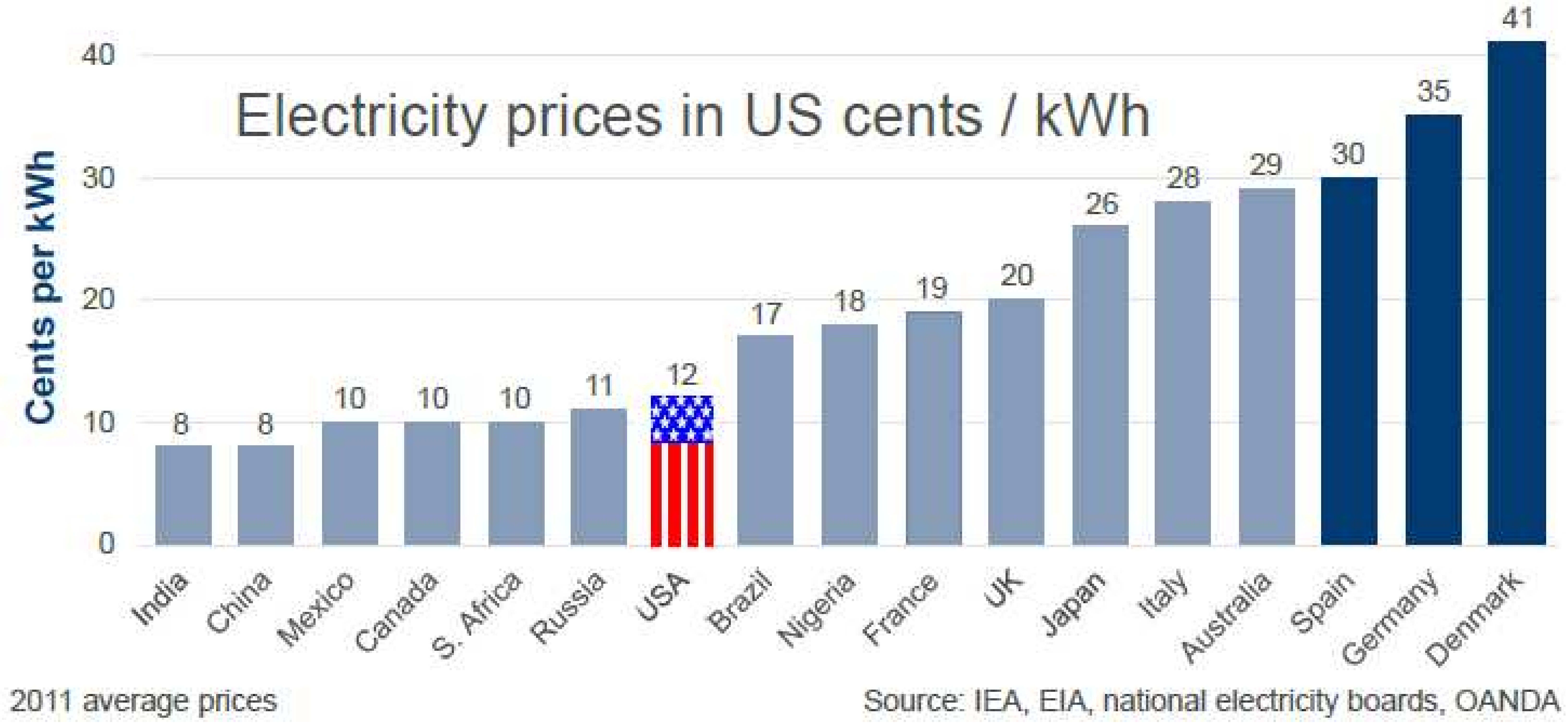
How We Got Here

- Frontiers - Engineers and Advanced Technology
- In 1920, US Congress established the Federal Power Commission (FPC) for licensing hydroelectric projects
- In 1935, authorized FPC to regulate both hydropower and interstate electricity
- From 1940 to 1950, FPC pressured electric utilities to extend power into neglected rural areas and to lower electricity rates to increase use
- In 1977, FPC changed its name to the Federal Energy Regulatory Commission (FERC)
- Determine whether wholesale electricity prices were unjust and unreasonable and, if so, to regulate pricing and order refunds for overcharges to ratepayers
- Yes, Lawyers and Economists…

Power Business After 100+ Years

Heavily regulated
Most capital-intensive industry
Grids build just big enough
to deliver electricity to end users

Electricity Average Prices with Transmission and Distribution Delivery Cost

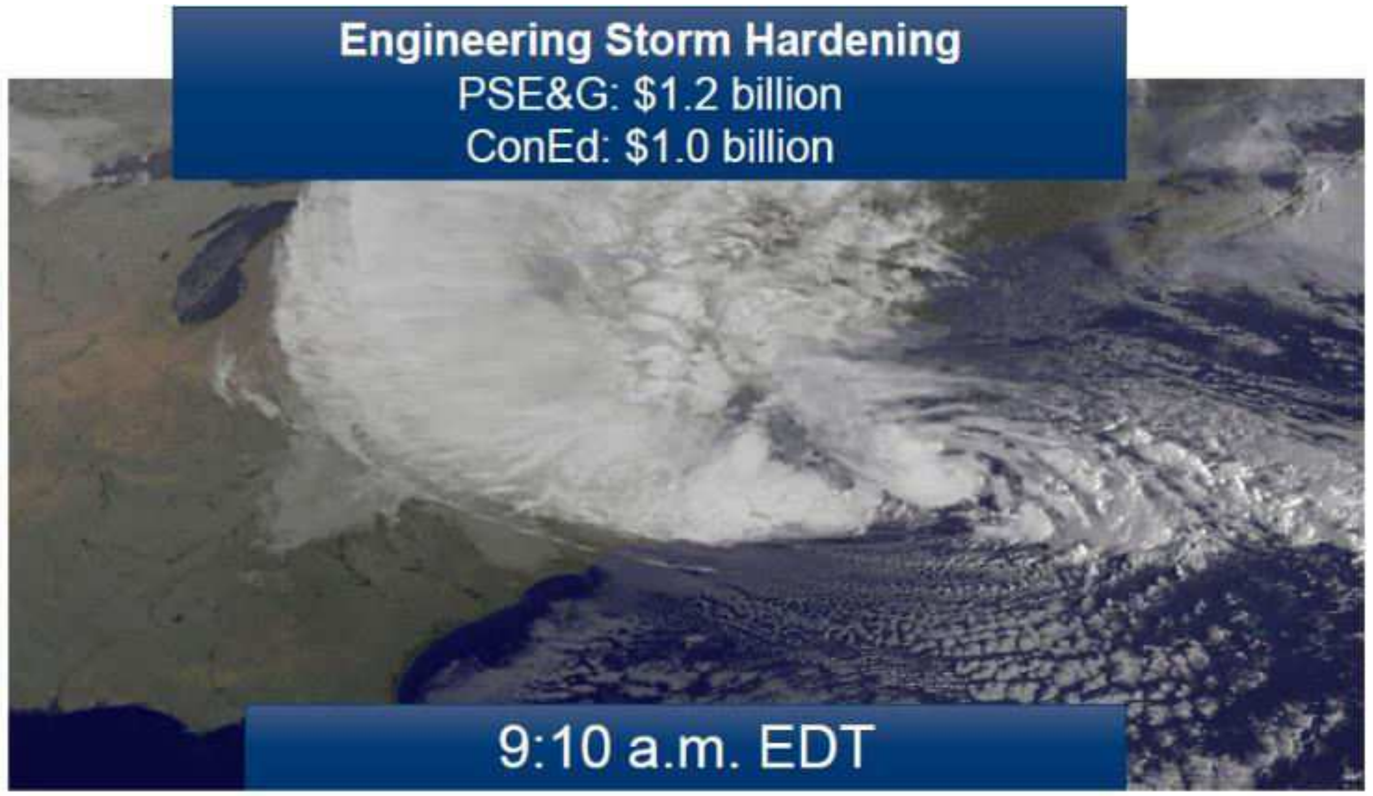


Distribution Reliability Metrics – IEEE Standard 1366

- Used by regulators and policy makers
  - SAIDI: System Average Interruption Duration Index
  - SAIFI: System Average Interruption Frequency Index
  - CAIDI: Customer Average Interruption Duration Index
  - CAIFI: Customer Average Interruption Frequency Index
  - MAIDI: Momentary Average Interruption Duration Index
  - MAIFI: Momentary Average Interruption Frequency Index
- Avg SAIDI – About 2 hours excluding major events

https://ieeexplore.ieee.org/document/6209381

Major Events

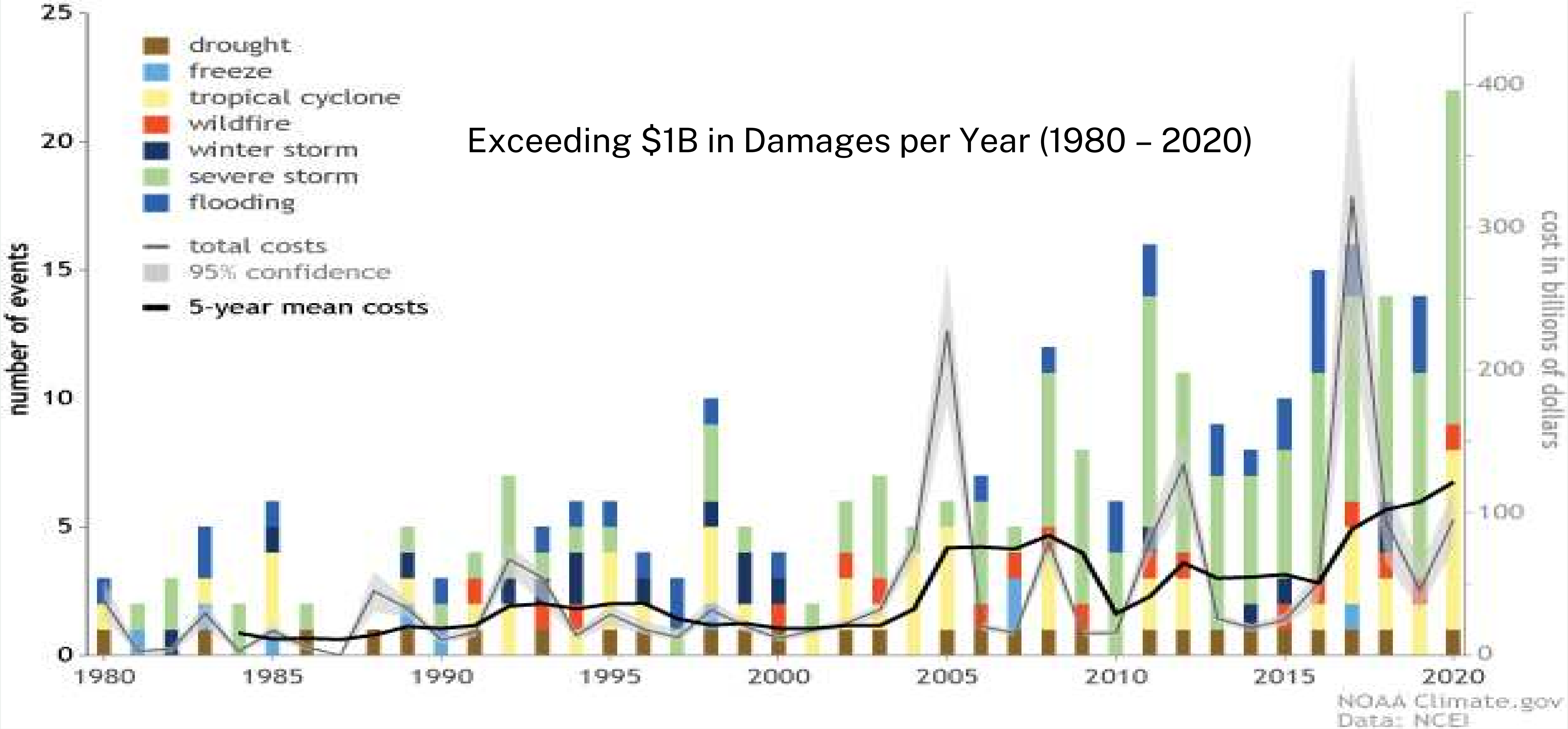


Superstorm Sandy (Oct 29, 2012) knocked out 50+ transmission lines in NY/NJ areas.

Hurricane Ida (8/26-9/4, 2021) knocked out all transmission lines into New Orleans.

Texas Rolling Blackouts (Feb 15-17, 2021)

U.S. Economic Losses Due to Natural Disasters



Trend and Reinvention

- Data Centers
- Cyber Threats
- DER
- EV
- Storage
- Microgrids
- Green Hydrogen
- ...

Three Mile Island nuclear plant will reopen to power Microsoft data centers

SEPTEMBER 20, 2024 · 1:40 PM ET

By C Mandler

The Three Mile Island nuclear plant is seen in March 2011 in Middletown, Pa.

Jeff Fusco/Getty Images

Still Need to Keep Lights On

Two Resilience Metrics Proposed by IEEE PES Distribution Resilience Working Group

- **Storm resilience metric**
  - Measure reduction of the number of customers without power for more than 12 hours
  - Consider the interruptions restored automatically without requiring human intervention
    - Distribution automation, advanced distribution management system, or microgrids, etc.
- **Calculation** - % of customers without power for more than 12 hours and total customer interruptions including customers automatically restored (avoided customer interruptions) through technology solutions

$$Storm\ event\ X = \frac{Sum\ of\ customers\ without\ power\ for\ more\ than\ 12\ hr}{Sustained\ Customer\ Interruptions + Avoided\ Customer\ Interruptions}$$

Note:

1. The threshold value is required for baselining.
2. Based on the threshold value, categorize each storm event as significant, large, medium, or small

https://sagroups.ieee.org/distreswg/

Two Resilience Metrics Proposed by IEEE PES Distribution Resilience Working Group (cont'd)

- Non-storm, gray sky days (GSD) resilience metric
  - Measure robustness and the ability to withstand most weather events
  - Vary by utility size
- Calculation
  - % of customer interruptions over the total customer base (e.g., 0.375% of the total number of customers)
- Consider certain weather criteria
  - ≥ average precipitation across the service territory (e.g., 1" of rain)
  - ≥ average maximum temperature across the service territory (e.g., 90°F max)
  - ≤ average minimum temperature across the service territory (e.g., 0°F min)
  - ≥ average maximum wind speed across the service territory (e.g., 25mi/h sustained wind speeds)

Challenges and barriers to their implementation

01. Policy

02. Cost

03. Scale

Policy Example - Federal Energy Regulatory Commission (FERC)

- Order 1920 - Issued May 13, 2024, 1,363 pages
  - Building for the Future Through Electric Regional Transmission Planning and Cost Allocation
- Votes - 2 to 1
- Dissent – ‘Shell Game’ ‘Serve a major policy agenda’ ‘Serve the profit-making interests of developers of politically preferred generation, primarily wind and solar, and to serve corporate “green energy” preferential purchasing policies’

Cost Example
Demand/Load Response – Load Paid Same as Generators?

- *Demand Response Compensation in Organized Wholesale Energy Markets*, Order No. 745 (2011)
  - Claimed jurisdiction over demand response in the RTO/ISO-run markets based on its effect on wholesale electricity prices
  - Ordered payments based on LMP: when demand response has the capability to balance supply and demand; and when demand response is cost-effective – i.e., FERC provided for comparable treatment for generation and demand response
- *Electric Power Supply Association v. FERC*, No. 11-1486 (D.C. Cir. May 23, 2014)
  - No, vacating Order No. 745 "in its entirety," as regulation of demand response is beyond FERC's authority
  - No, overcompensation, because the payment is, in fact, both LMP plus the savings from the avoided retail generation costs

- **US Supreme Court Rules in Favor of Demand Response, Jan 25, 2016**

Factors that Drive Changes

- Science and technology
- Business strategy
- Local Culture
- Politics (and geopolitics)
- Regulatory policy
- Law and the courts

Discussion Points
Scale - Energy transition is slower than initially targeted

- Not enough new infrastructure is being built (right kind, right place, right time)?
  - Big Load - Data Center (2-3 years)
  - Power Plant (6-7 years))
  - Transmission (15-20 years), siting, permitting, etc.
- Meanwhile, coal plant retirement continues, and its replacement (renewables, transmission, and storage) is being slowed down by
  - Inadequate planning
  - Grid connection issues
  - Slow regulatory approvals
  - Community opposition
  - Supply chain issues
- Success stories – Storage covered Texas and California peak load this summer!
- Keep going with more intelligence (data, sensors, AI)? Or need Plan B?

Presented by Dr. Jessica Bian

Thank you very much!

MIT Workshop