Resilient Electric Grid Consortium of North America Symposium 2022 (RECONS 2022)

Introduction

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TEXAS A&M UNIVERSITY

Center for Infrastructure Renewal (CIR) Overview

- We are in the Center for Infrastructure Renewal (CIR) building on the Texas A&M RELLIS campus
  - RELLIS stands for the six Texas A&M Aggies' core values: respect, excellence, leadership, loyalty, integrity and selfless service
  - Texas A&M University (TAMU) is part of the Texas A&M University System, which also includes the Texas Engineering Experiment Station (TEES)
  - RELLIS, which has about 2000 acres, was initially a small community known as Riverside (it is on the Brazos River); in World War II is became the Bryan Army Air Field. After the war it was turned over to Texas A&M and hosted many WWII veterans. For many years it was the A&M Riverside Campus, which was mostly used for research. Since 2017 it has been RELLIS, and is actively being developed
- Important for today: if you don't have a TAMU parking pass, make sure the front desk knows your license plate; parking enforcement here is very efficient!! WIFI access here is very easy.

Today's Agenda with a Focus on Grid Resiliency

Session 1: Tom Overbye (Chair) (9 to 10:20, Room 1107-1108)

9:00 – 9:20	Welcome and Introduction (Thomas Overbye, ECE TAMU)
9:20– 9:40	"Environmental and Equity-Aware Electric Grid Optimization: An Example based on Wildfire Risk Mitigation" (Line Roald, University of Wisconsin – Madison)
9:40 – 10:00	"Earthquake and Coastal Resilience in the US Pacific Northwest: A Marine Perspective to Electrical Infrastructure" (Eduardo Cotilla-Sanchez, Oregon State)
10:00 – 10:20	"Resiliency to Ransomware" (David Nicol, University of Illinois at Urbana-Champaign)
10:20 – 10:40	Break

Session 2: Ashlynn Stillwell (Chair) (10:40 to Noon, Room 1107-1108)

10:40 – 11:00	"Leveraging Machine Learning to Predict Power Outages during Winter Storm Uri" (Stephanie Paal, TAMU)
11:00 –11:20	"Scalable Human-Centered Demand Flexibility in Extreme Events (Le Xie, TAMU)
11:20 – 11:40	"Technical, Environmental and Social Challenges of Building Resilient Electrical Grids in México", (Miguel Robles Pérez, National Autonomous University of Mexico)
11:40—Noon	"Resiliency as Shaped by Climate Change and Environmental Justice", (Judy Cardell, Smith College and Jess Wert, TAMU)

We've got a great set of speakers for today!!

All the slides will be available later with a link provided at smartgridcenter.tamu.edu/

Today's Agenda, cont.

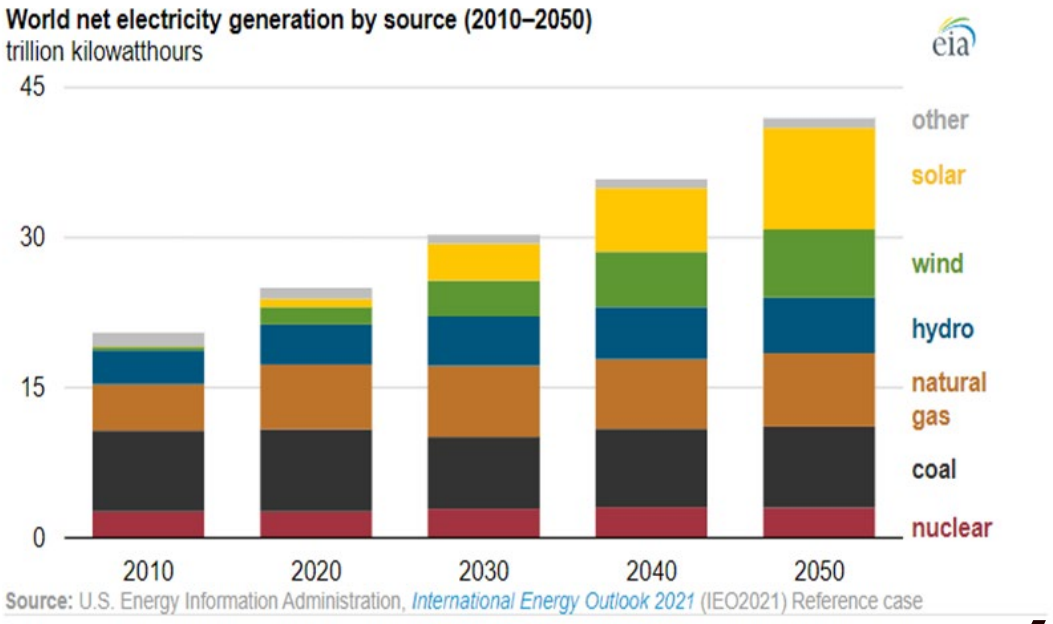
Lunch (Room 1107-1108) and Control Room Hands-On Activities and Demos (Rooms 3339 and 3350)

Noon – 13:10	Lunch at Pre-function Area; Control room Hands-on Activities in Rooms 3339 and 3350
	Session 3: Line Roald (Chair) (13:10 to 14:30, Room 1107-1108)
13:10 – 13:30	"Grid and Community Resilience" (Zhihua Qu, University of Central Florida)
13:30 – 13:50	"Enhancing Power Grid Resiliency with Microgrid Restoration" (Karen Butler-Purry, TAMU)
13:50 – 14:10	"Rapid Method for Impact Analysis of Grid-edge Technologies on Power Distribution Networks" (Antoine Lesage-Landry, Polytechnique Montréal)
14:10 – 14:30	"Virtual Water Transfers as a Consideration for Grid Resiliency" (Ashlynn Stillwell, Universit of Illinois at Urbana-Champaign)
14:30 – 14:50	Break
	Session 4: Adam Birchfield (Chair) (14:50 to 16:30, Room 1107-1108)
14:50 – 15:10	"Linking K-12 Teaching and Mentoring Programs with Research in Electric Power Grids" (Cynthia Lima and Niko Gatsis, University of Texas at San Antonio)
15:10 – 15:30	"Using a Risk Metric to Understand the Impact of Real and Potential Grid Changes on Risk and Resilience: Cordova as a Case Study" (David Newman, University of Alaska)
15:30 – 15:50	"Cyber-Attack Detection for Power Systems based on Nonlinear Spatial-Temporal Modeling." (Dongliang Duan, University of Wyoming)
15:50 – 16:10	"The Electric Distribution System and Resiliency" (Miroslav Begovic, TAMU)
16:10 – 16:30	"Electric Energy System Decarbonization Strategies and Resiliency" (Lindsay Anderson, Cornell)
16:30	Adjourn

Also be sure to go up to the third floor lab for some fun and interactive electric grid simulations

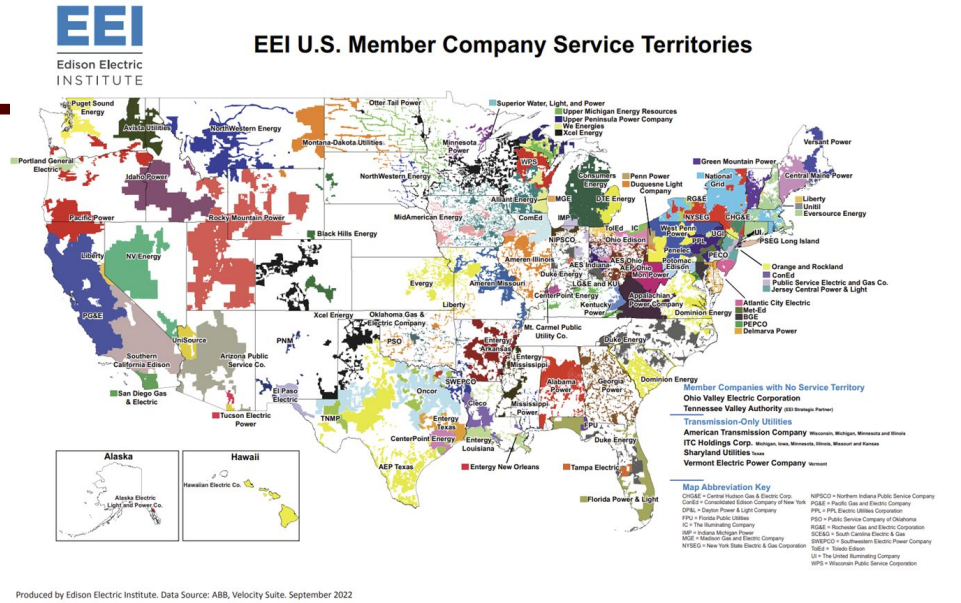
A Bright Electric Future

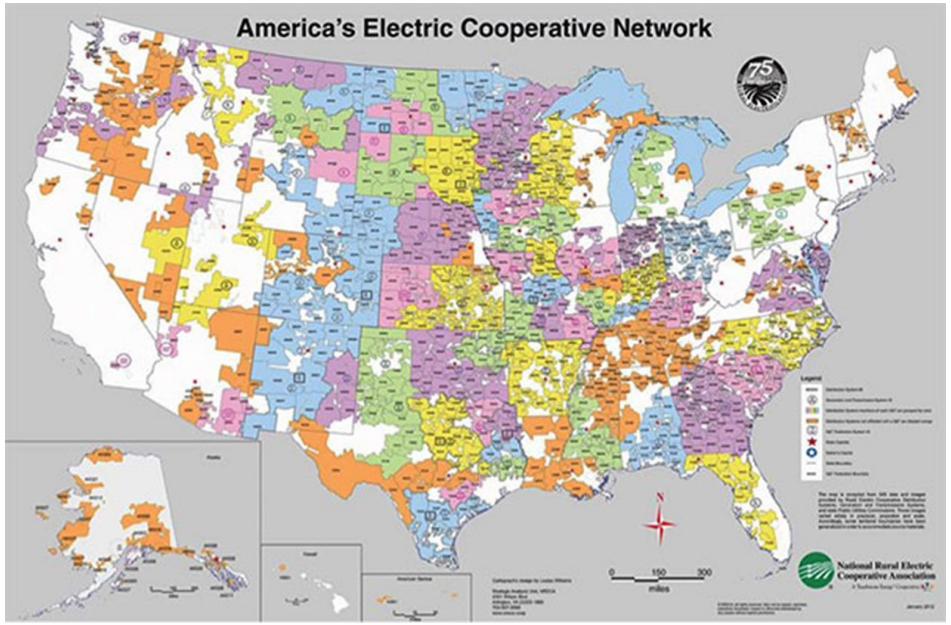
- Electricity is crucial for modern society, and our electric energy future could be quite bright!
- Electric grids worldwide are in a time of rapid transition, with many positive developments including the addition of large amounts of renewable generation, transportation electrification, smart grid controls, etc.
  - The grid of the future is likely to be quite different from the one of the recent past
  - A goal of Biden Administration is to achieve carbon pollution-free electricity by 2035
- There are lots of good engineering challenges and it is a great time for students entering the field!!



Size of Electricity Sector

- Just in the US retail electricity sales are more than $400 billion per year
- Yearly investments in the electric grid are more than $100 billion (combined generation, transmission, distribution)
- There are many thousands of entities involved in providing electricity
  - For example 900 electric coops in the US and more than 450 municipal grids
- Resiliency needs to take place throughout the entire enterprise, including the supply chain

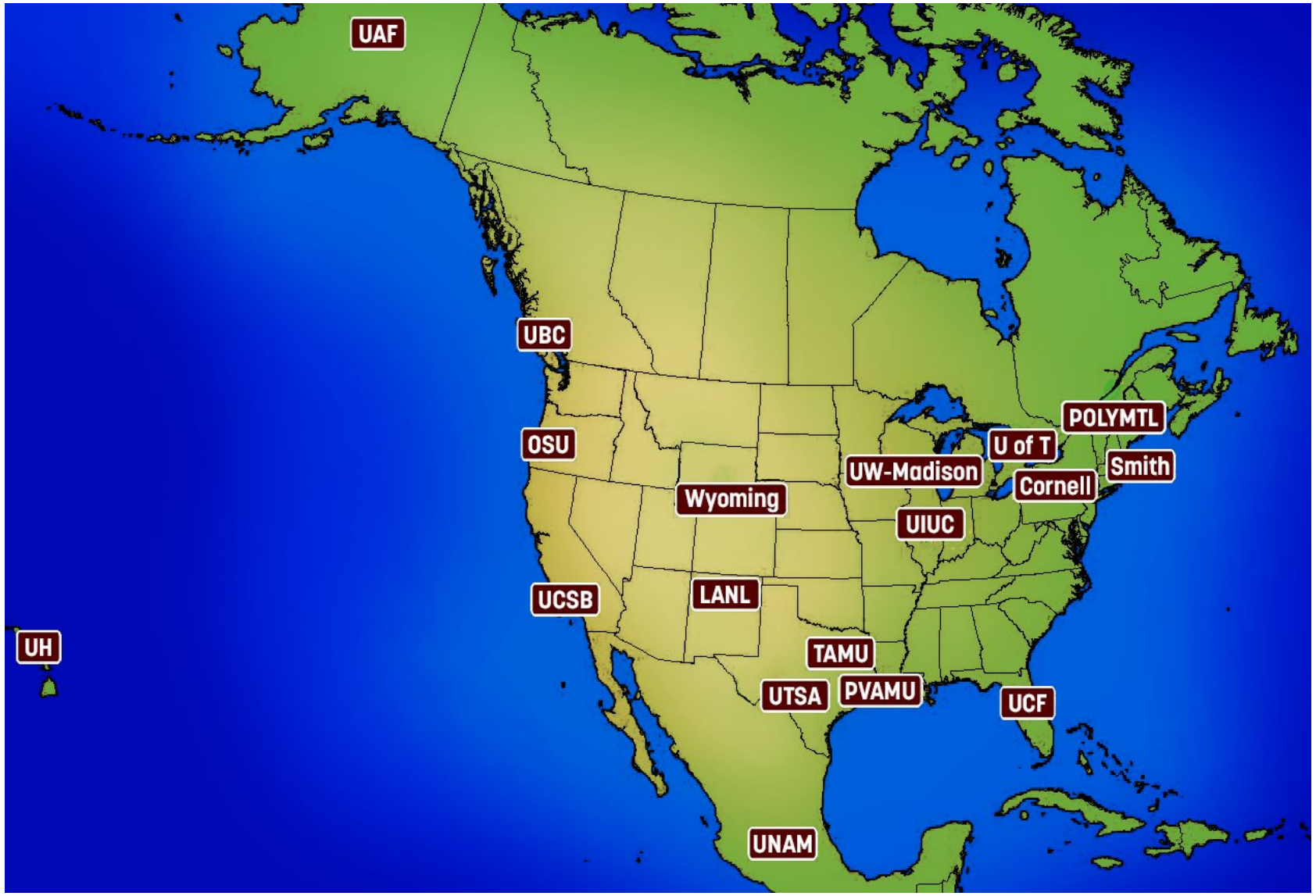




Improving Electric Grid Resilience

- As the electric grid changes, a goal is to make it more resilient
- Through the US Infrastructure Investment and Jobs act of 2021 the Department of Energy (DOE) is providing more than $14 billion in financial assistance to states, Indian tribes, utilities and other entities to provide products and services for enhancing the reliability, resilience and efficiency of the electric grid
  - The goal is to do this in a way that benefits all Americans
  - Since the largest US grids are interconnected with Canada and Mexico (ac and dc), this effort involves the entire continent
- DOE recognizes the important role that universities can play in this process, and the benefits of university consortiums
  - Consortiums can bring a diversity of expertise

Resilient Electric Grid Consortium of North America (RECON)



An overarching goal of RECON is to become a highly effective resource to help the states, tribes, utilities and others including regional entities meet energy resilience and decarbonization goals

What is Grid Resilience?

- Merriam Webster Dictionary (resilience in general)
  - "An ability to recover from or adjust easily to misfortune or change"
- EPRI & North American Transmission Forum (NATF)
  - The ability of the system and its components (… equipment and human …) to minimize damage and improve recovery from non-routine disruptions, including High Impact, Low Frequency (HILF) events, in a reasonable amount of time"
- The President's National Infrastructure Advisory Council defines resilience as, "the ability to prepare for and adapt to changing conditions and reduce disruptive events' magnitude and duration."
- Resilience needs to be present in grids of all sizes, and present throughout the grid (fuel-supply, generation, transmission, distribution, markets, software, etc.)

One Aspect: High-Impact, Low-Frequency Events

- In order to enhance electric grid resiliency we need to consider the almost unthinkable events
- These include what the North American Electric Reliability Corporation (NERC) calls High-Impact, Low-Frequency Events(HILFs)
  - Large-scale, perhaps long duration blackouts
  - HILFs identified by NERC were 1) a coordinated cyber, physical or blended attacks, 2) pandemics, 3) geomagnetic disturbances (GMDs), and 4) HEMPs

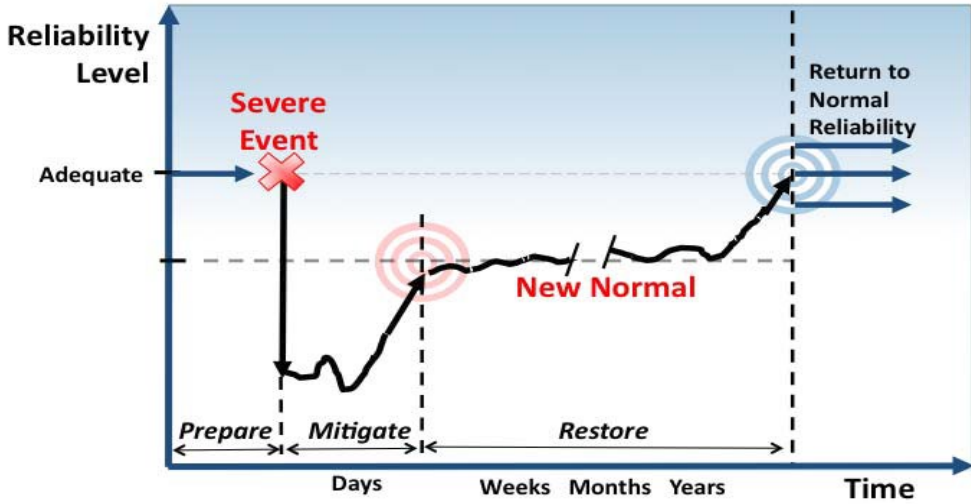


Image Source: NERC, 2012

- What if during the early stages of COVID there had been blackouts?
- What are the “known unknowns” and the “unknown unknowns”?
- Mitigation cost relative to risk needs to a key consideration!

Transmission Resilience

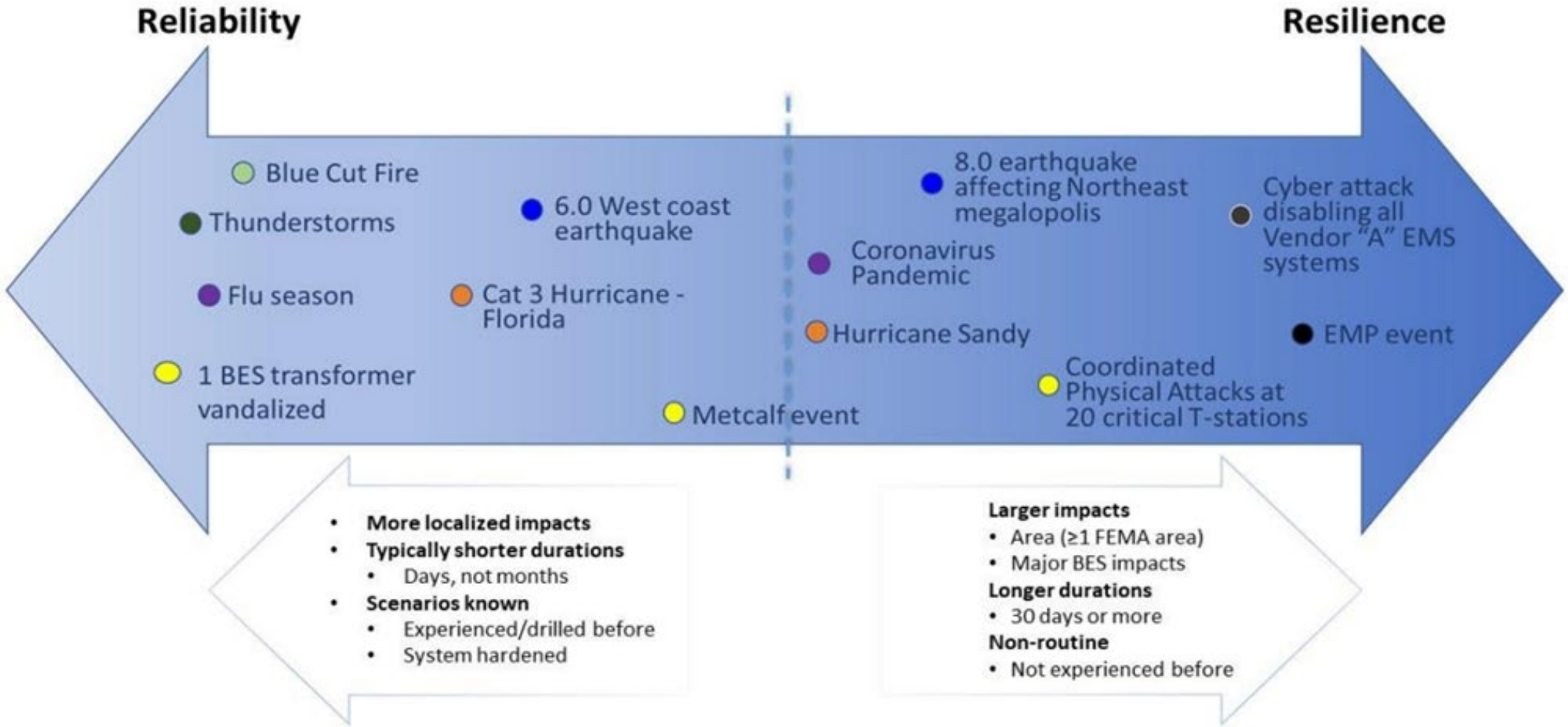
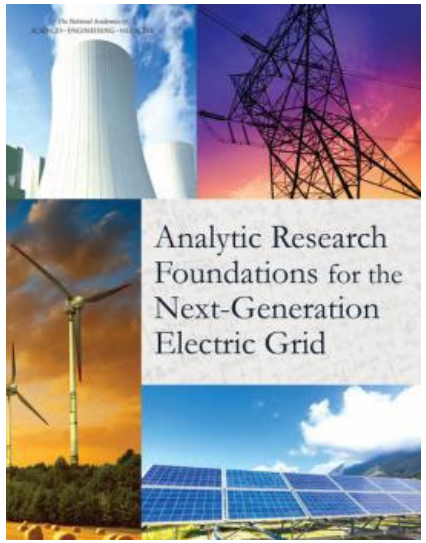


Image Source: www.natf.net/docs/natf/documents/resources/resiliency/transmission-resilience-overview.pdf

Several Recent Reports on Resiliency

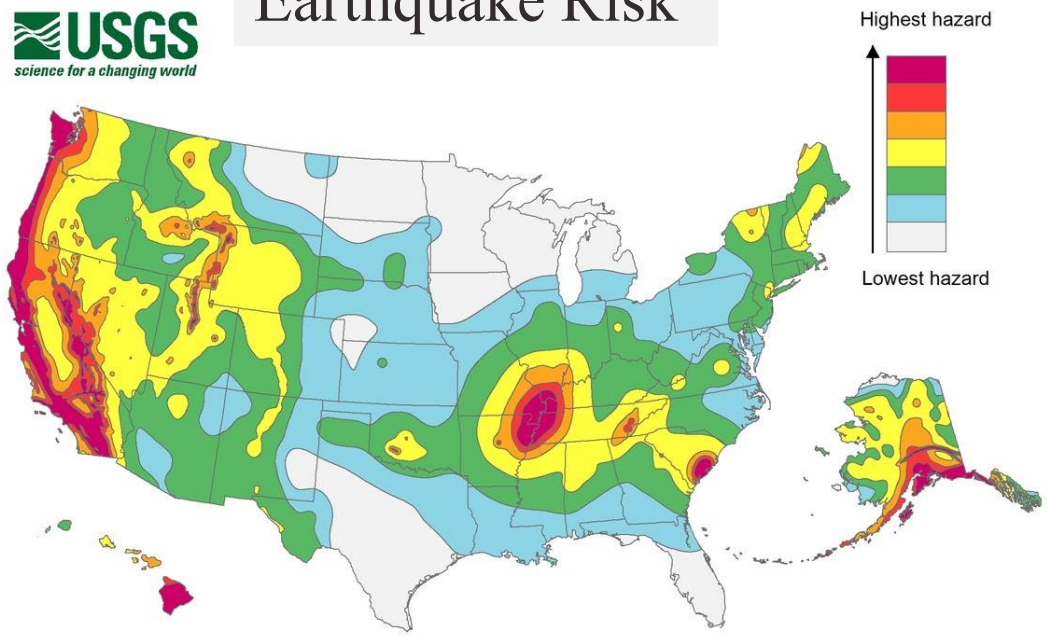
- *Analytic Research Foundations for the Next-Generation Electric Grid*, 2016
  - Make everything as simple as possible but not simpler [maybe from Einstein]
- *Enhancing the Resilience of the Nation's Electricity System*, 2017
- US Department of Energy Transmission Innovation Symposium, May 2021
  - www.energy.gov/oe/transmission-innovation-symposium



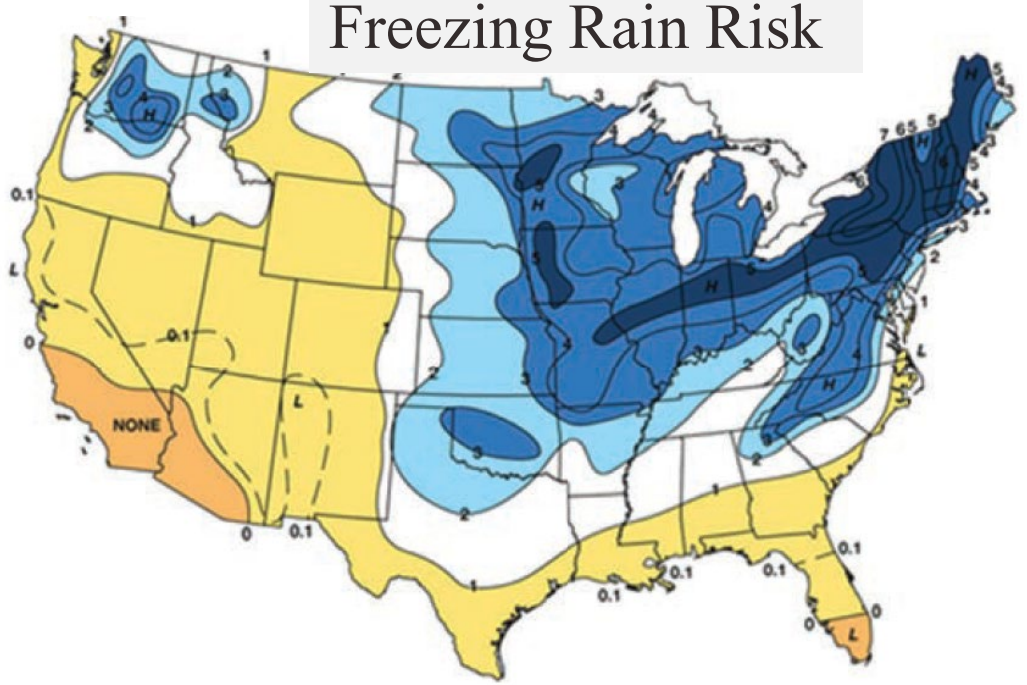
Resilient to What?

- A key question on resiliency is to determine the likely threats
  - Some are geographic, and some may are hard to quantify
- Some metrics are dependent on the threat, and some are independent

Earthquake Risk

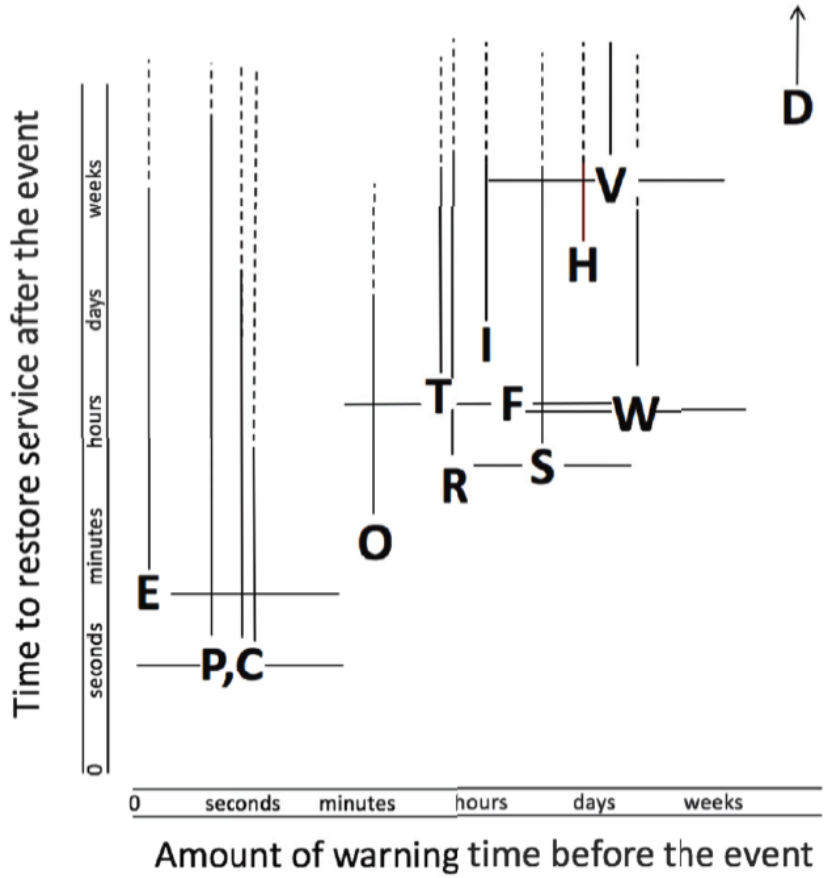


Freezing Rain Risk



Source: *Enhancing the Resilience of the Nation's Electricity System*, 2017

Some Electric Grid Risks



C = cyber attack (ranging from state/pro on left to good hacker on right)
D = drought and associated water shortage
E = earthquake (in some cases with warning systems)
F = flood/storm surge
H = hurricane
I = ice storm
O= major operations error
P = physical attack
R = regional storms and tornados
S = space weather
T = tsunami
V = volcanic events
W= wild fire

This image (from the 2017 National Academy's report) does not mention cold weather, though it is discussed in the report itself

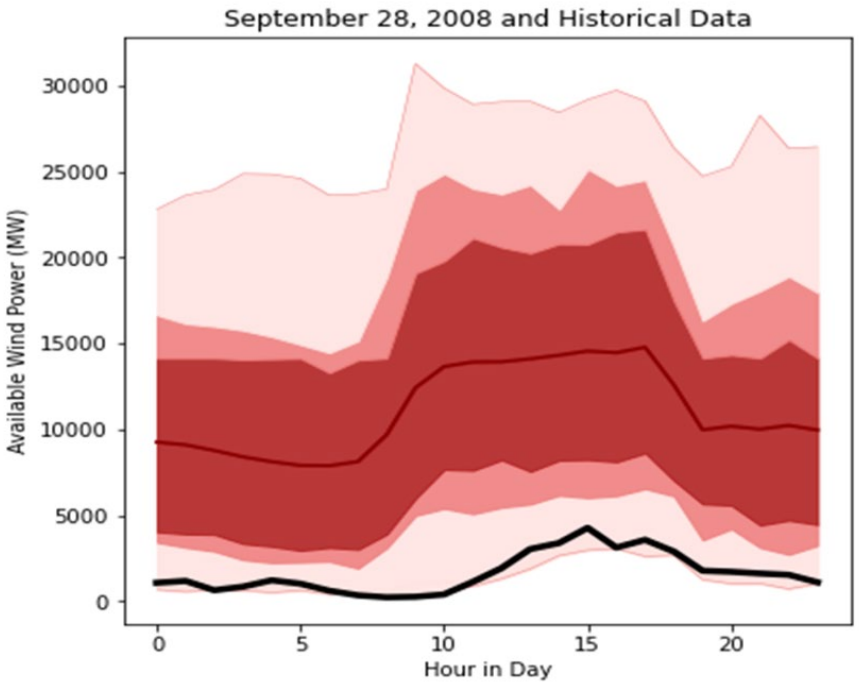
FIGURE 3.1 Mapping of events that can cause disruption of power systems. The horizontal placement provides some indication of how much warning time there may be before the event. The vertical axis provides some indication of how long it may take to recover after the event. Lines provide a representation

Source: *Enhancing the Resilience of the Nation's Electricity System*, 2017

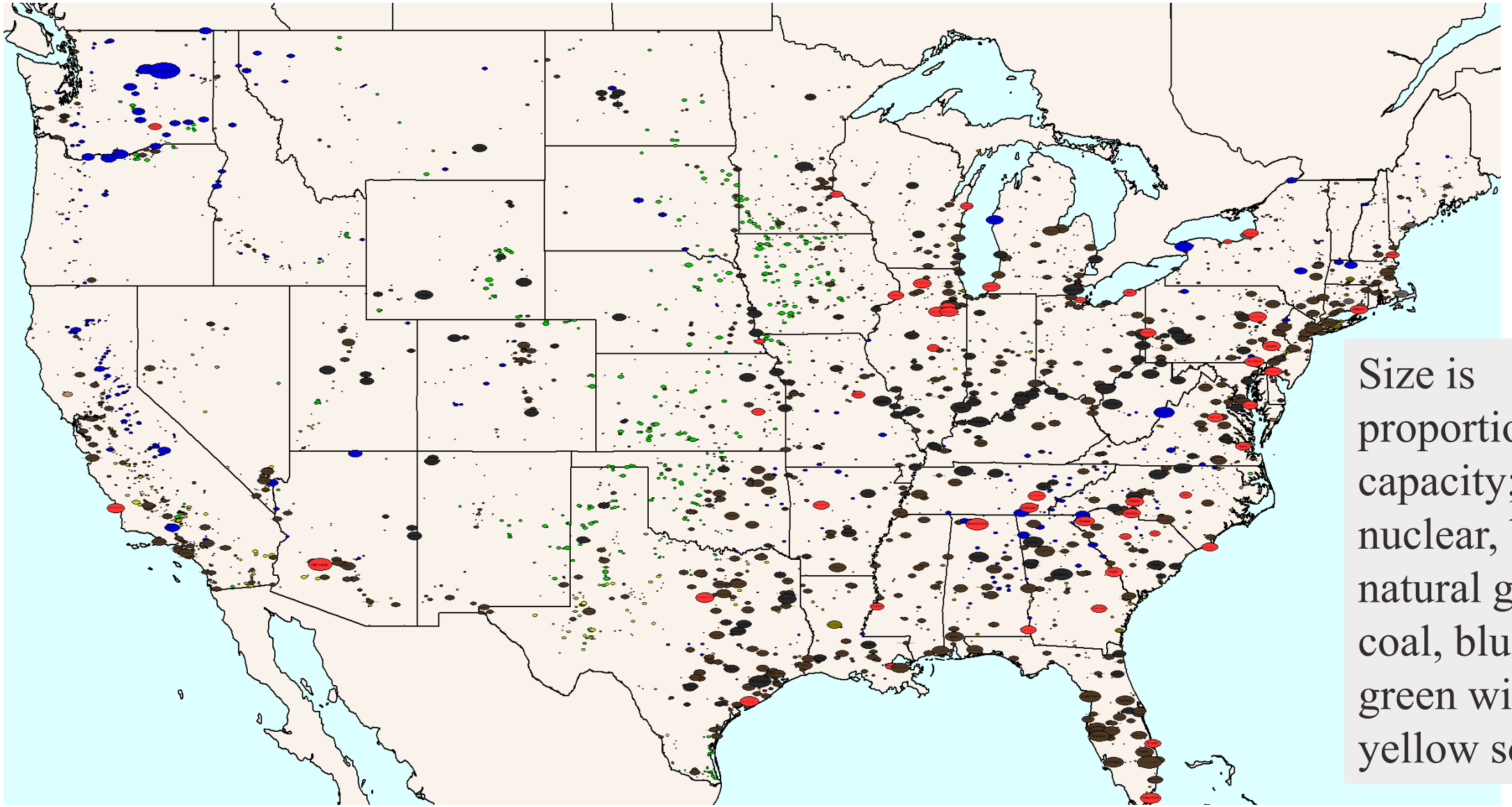
A Changing View on Resource Adequacy

- To provide electricity a grid must have enough generation. Previous views on resource adequacy looked at equipment failures, but usually assumed that there was adequate fuel supply
- With the rapid growth of wind and solar, and the potential for wind and solar droughts, this is rapidly changing
- As part of our resiliency work at TAMU we have obtained North American weather data going back to the 1940's and are now looking for wind and solar droughts by applying past weather to today's (or future) generation portfolios

Image is for Texas assuming 2021 wind generation

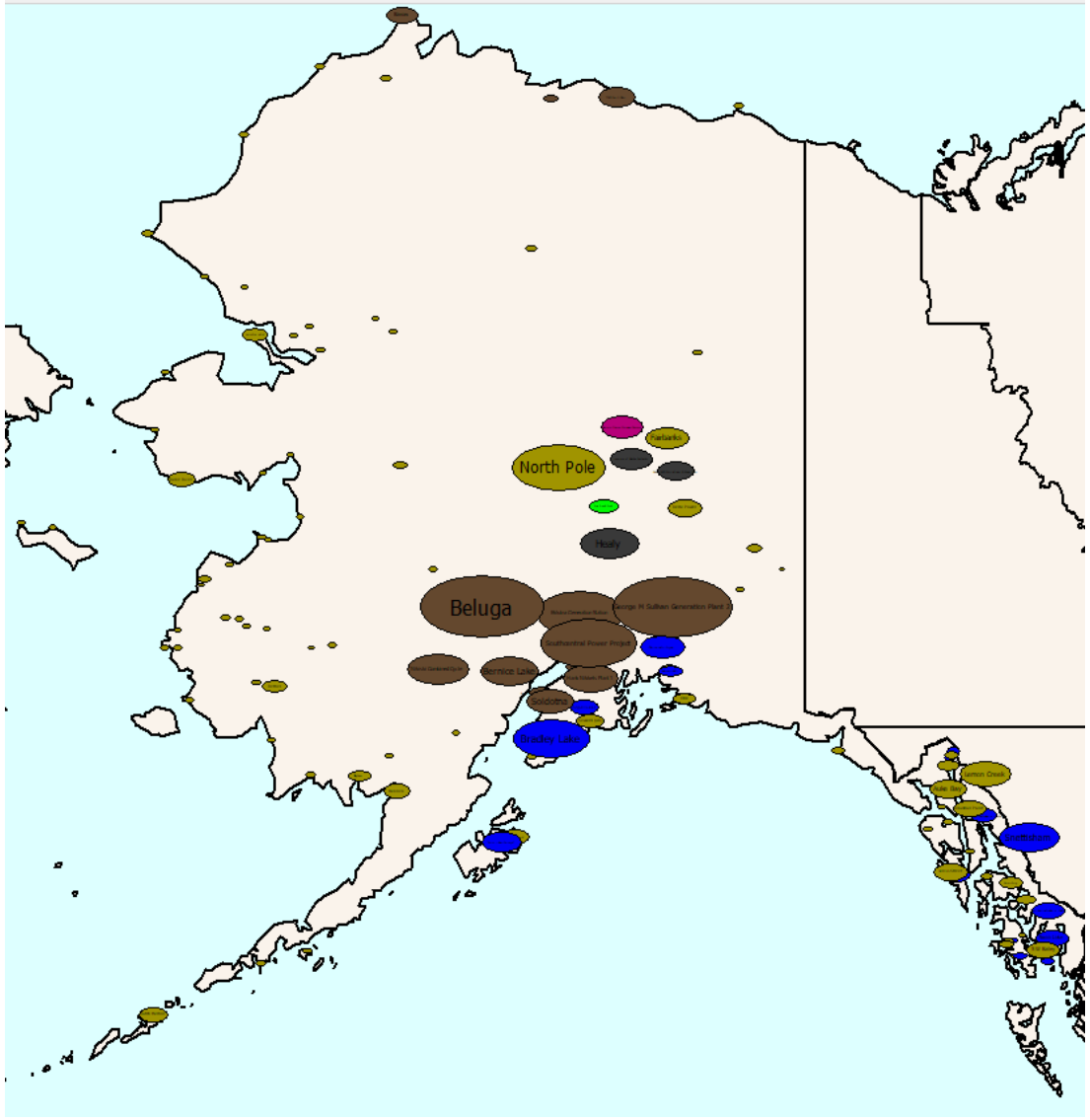


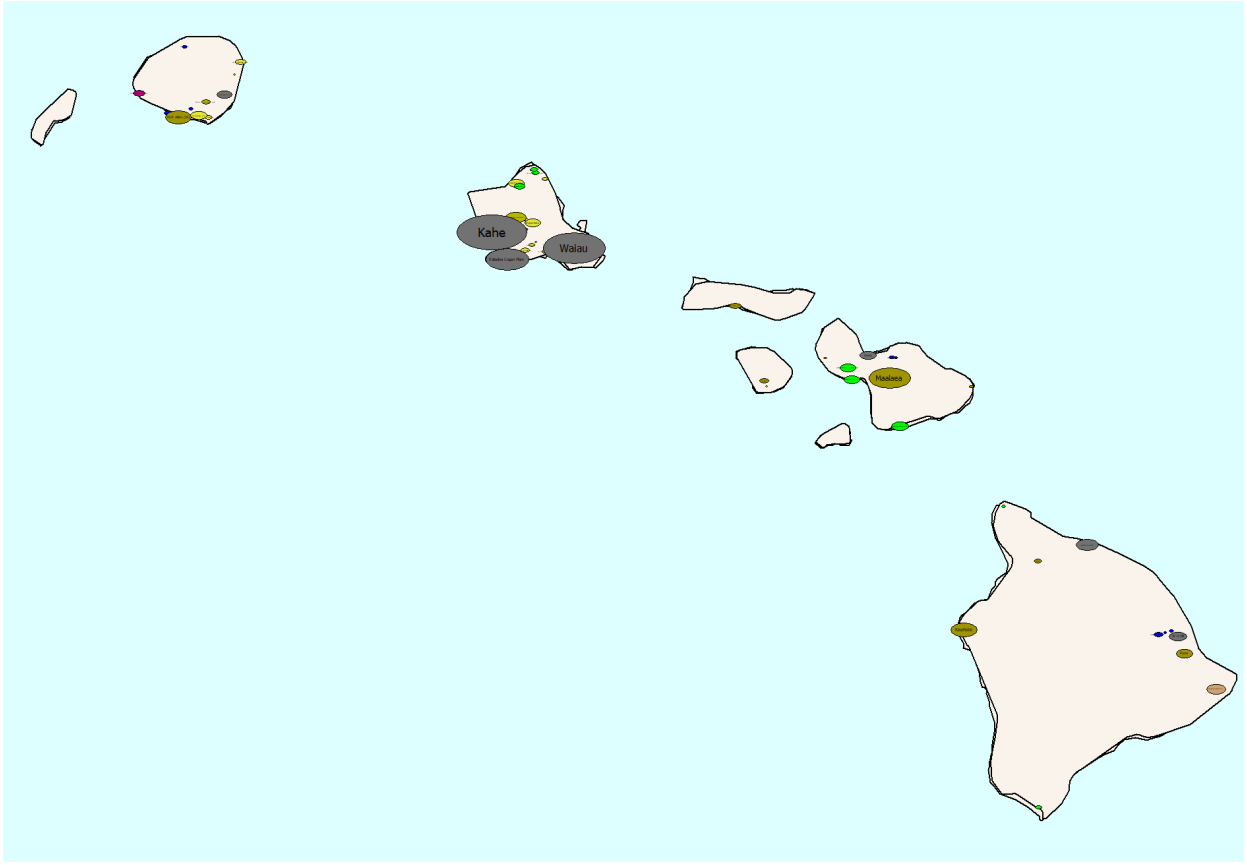
US Generation from 2021 EIA 860 Data



Size is proportional to capacity; red is nuclear, brown natural gas, black coal, blue hydro, green wind, yellow solar

Making Sure to Include Alaska and Hawaii

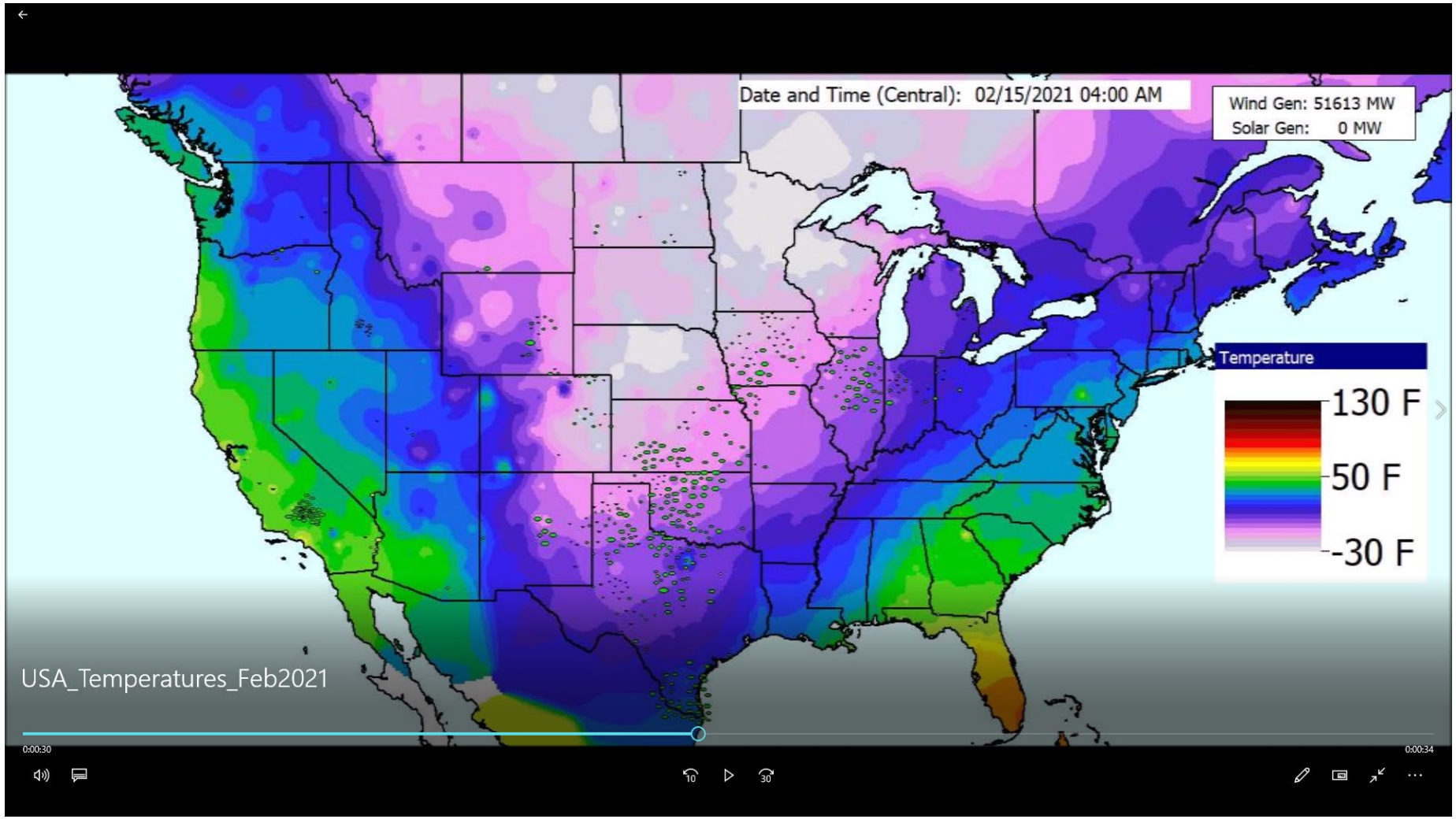




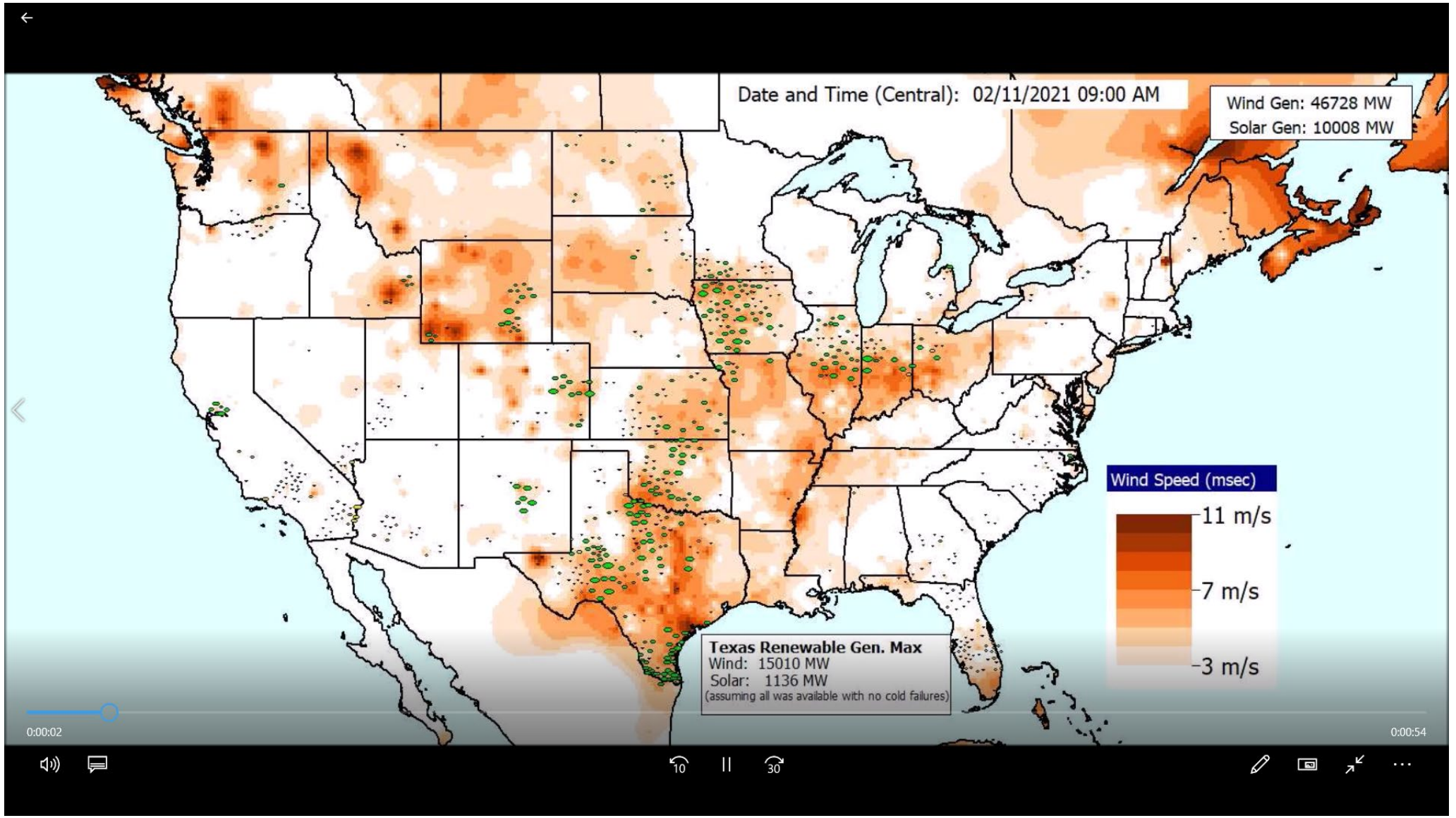
Same colors as before but with different size scales

Visualization of Temperatures, Feb 11 to 18, 2021

Videos are available at overbye.engr.tamu.edu/presentations/ (the first presentation from Nov 2022)

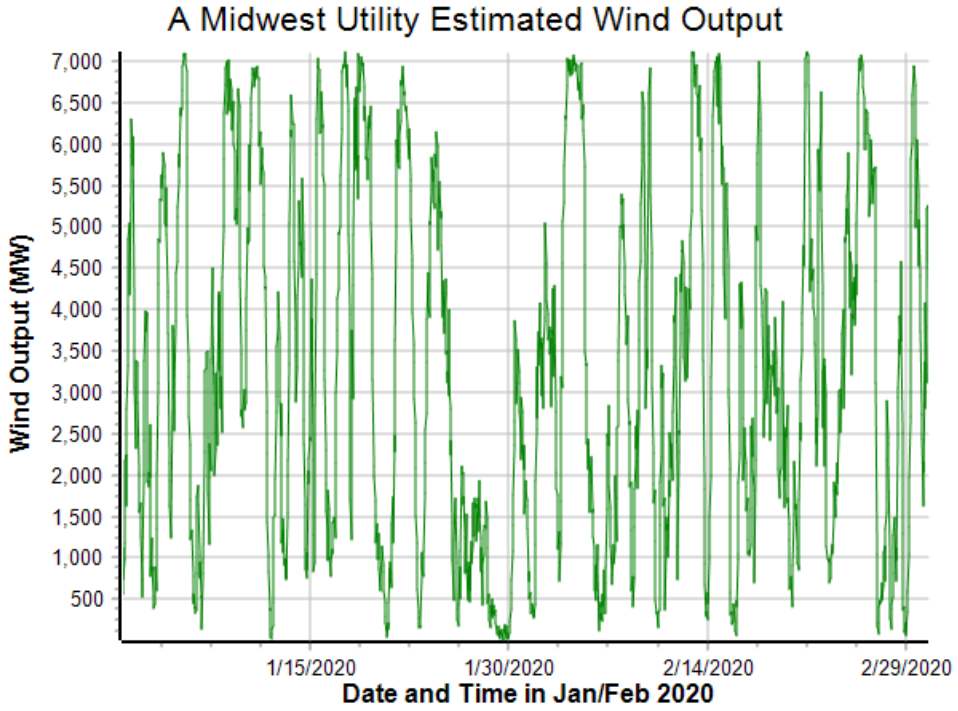


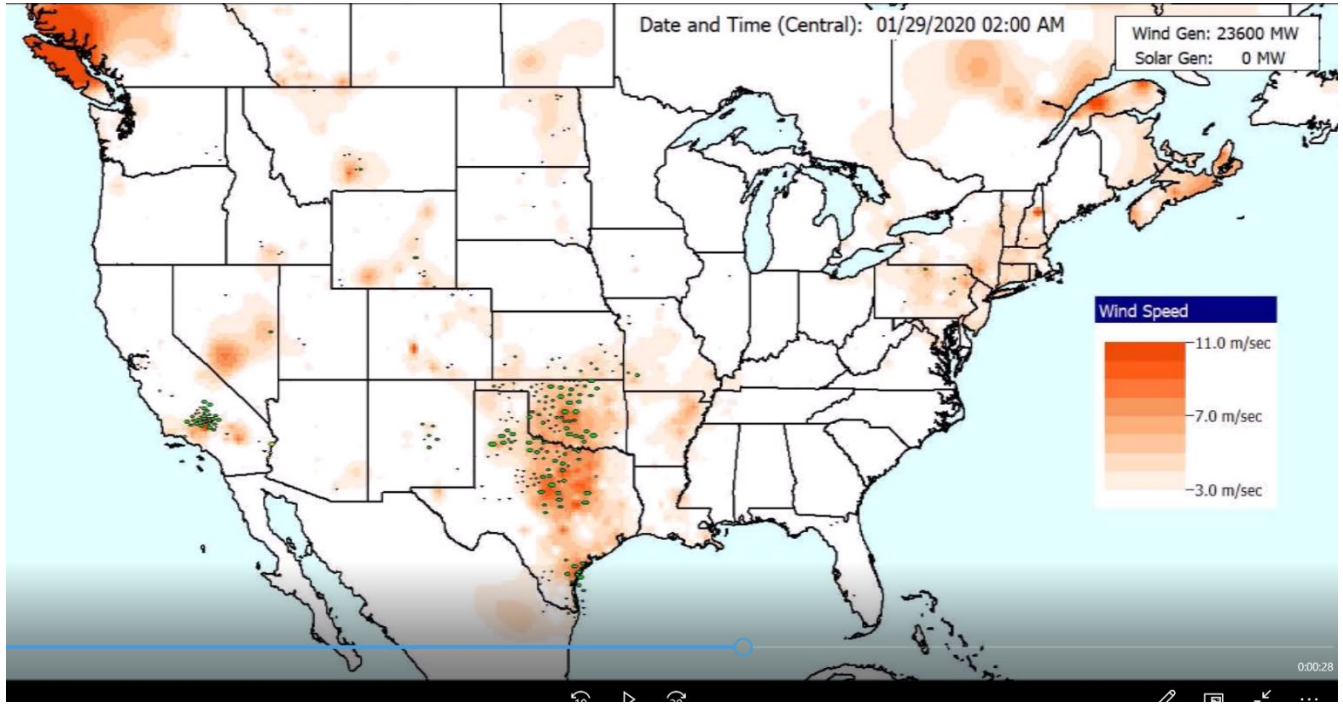
Visualization of Wind Speed, Feb 11 to 18, 2021



Midwest Wind Drought Late January 2020

- In late January 2020 there was a wind drought for four days in the Midwest. With the weather functionality it is very easily to model and visualize this event
  - Any future generator portfolio can be used with this weather





Thank You and Visit Our Third Floor Control Room During Lunch for Fun, Interactive Activities

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