GRID DEPLOYMENT OFFICE

National Transmission Planning Study

U.S. Department of Energy

October 2022

Housekeeping

Questions?

If you have technical questions – please put them in the chat box for the host.

Please submit your questions in the chat box and reference the speaker.

Optimal Viewing

Grid Deployment Office

Maria Robinson

Director, Grid Deployment Office,
U.S. Department of Energy

GRID DEPLOYMENT OFFICE

Grid Deployment Office

U.S. Department of Energy

October 2022

Grid Deployment Office

Mission Statement: The Grid Deployment Office (GDO) works to provide electricity to everyone, everywhere by maintaining and investing in critical generation facilities to ensure resource adequacy and improving and expanding transmission and distribution systems to ensure all communities have access to reliable, affordable electricity.

Power Generation Assistance Division	The Power Generation Assistance Division works with existing generation facilities to ensure resilience and reliability.
Transmission Division	The Transmission Division supports innovative efforts in transmission reliability and clean energy analysis and programs, and energy infrastructure and risk analysis in support of the Administration's priorities to enhance grid resilience.
Grid Modernization Division	The Grid Modernization Division oversees activities that prevent outages and enhance the resilience of the electric grid.

GDO
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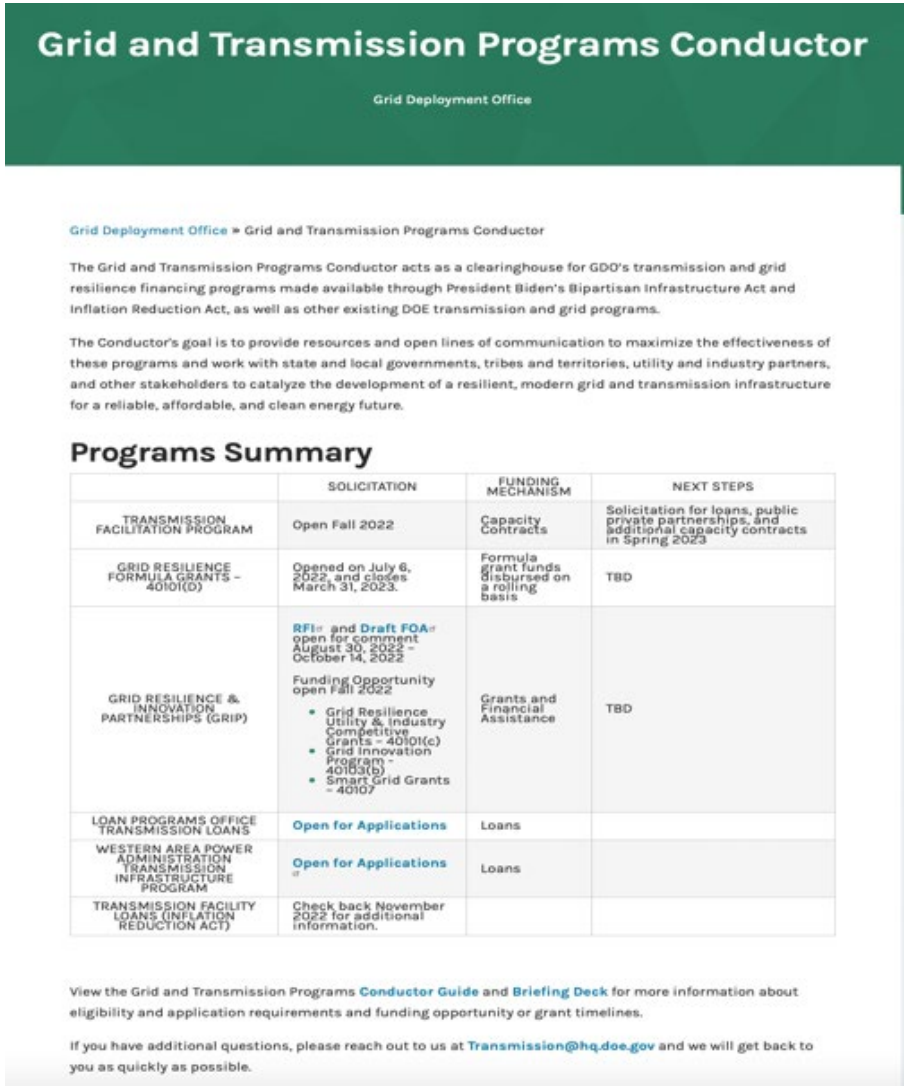
Learn More about the Grid Deployment Office

The Grid and Transmission Programs Conductor acts as a clearinghouse for GDO's transmission and grid resilience financing programs.

Find information on Grid and Transmission programs within:

- Bipartisan Infrastructure Law
- Inflation Reduction Act
- And other existing DOE transmission and grid programs



Grid and Transmission Programs Conductor

Grid Deployment Office

Grid Deployment Office » Grid and Transmission Programs Conductor

The Grid and Transmission Programs Conductor acts as a clearinghouse for GDO's transmission and grid resilience financing programs made available through President Biden's Bipartisan Infrastructure Act and Inflation Reduction Act, as well as other existing DOE transmission and grid programs.

The Conductor's goal is to provide resources and open lines of communication to maximize the effectiveness of these programs and work with state and local governments, tribes and territories, utility and industry partners, and other stakeholders to catalyze the development of a resilient, modern grid and transmission infrastructure for a reliable, affordable, and clean energy future.

Programs Summary

	SOLICITATION	FUNDING MECHANISM	NEXT STEPS
TRANSMISSION FACILITATION PROGRAM	Open Fall 2022	Capacity Contracts	Solicitation for loans, public private partnerships, and additional capacity contracts in Spring 2023
GRID RESILIENCE FORMULA GRANTS – 40101(D)	Opened on July 6, 2022, and closes March 31, 2023.	Formula grant funds disbursed on a rolling basis	TBD
GRID RESILIENCE & INNOVATION PARTNERSHIPS (GRIP)	RFI and Draft FOA open for comment August 30, 2022 – October 14, 2022 Funding Opportunity open Fall 2022 • Grid Resilience Utility & Industry Competitive Grants – 40101(c) • Grid Innovation Program – 40103(b) • Smart Grid Grants – 40107	Grants and Financial Assistance	TBD
LOAN PROGRAMS OFFICE TRANSMISSION LOANS	Open for Applications	Loans	
WESTERN AREA POWER ADMINISTRATION TRANSMISSION INFRASTRUCTURE PROGRAM	Open for Applications	Loans	
TRANSMISSION FACILITY LOANS (INFLATION REDUCTION ACT)	Check back November 2022 for additional information.		

View the Grid and Transmission Programs Conductor Guide and Briefing Deck for more information about eligibility and application requirements and funding opportunity or grant timelines.

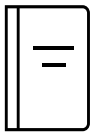
If you have additional questions, please reach out to us at Transmission@hq.doe.gov and we will get back to you as quickly as possible.

www.energy.gov/gdo/conductor

Building a Better Grid Initiative

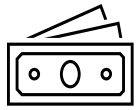
Engagement and collaboration

- States
- Tribal nations
- Stakeholders
- Federal agencies
- ISO/RTOs
- EROs



Enhanced transmission planning

- Transmission Needs Study
- National Transmission Planning Study
- Atlantic Offshore Wind Transmission Study



Federal financing tools ($20+B)

- Transmission Facilitation Program ($2.5B)
- Smart Grid Investment Matching Grant Program ($3B)
- Grid resilience grants for states, Tribes, and utilities ($10+B)
- Loan guarantee programs
- Transmission Facility Financing ($2B), Siting of Interstate Electricity Transmission Lines ($760M)

Transmission permitting process

- Streamline permitting with federal agencies
- Public private partnerships
- Designation of National Corridors

Transmission-related R&D

- "Next generation" electricity delivery technologies
- Supporting activities

One Stop Shop: [the DOE Grid and Transmission Programs Conductor]

National Transmission Planning Study

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GRID DEPLOYMENT OFFICE

National Transmission Planning Study

Hamody Hindi & Carl Mas

October 21, 2022

www.energy.gov/gdo/national-transmission-planning-study

Agenda

- Study Objectives
- Study Updates
  - Public Engagement
  - Scenario Analysis
    - Framework
    - Sensitivities
    - Early Takeaways
    - Next Steps
- Timeline

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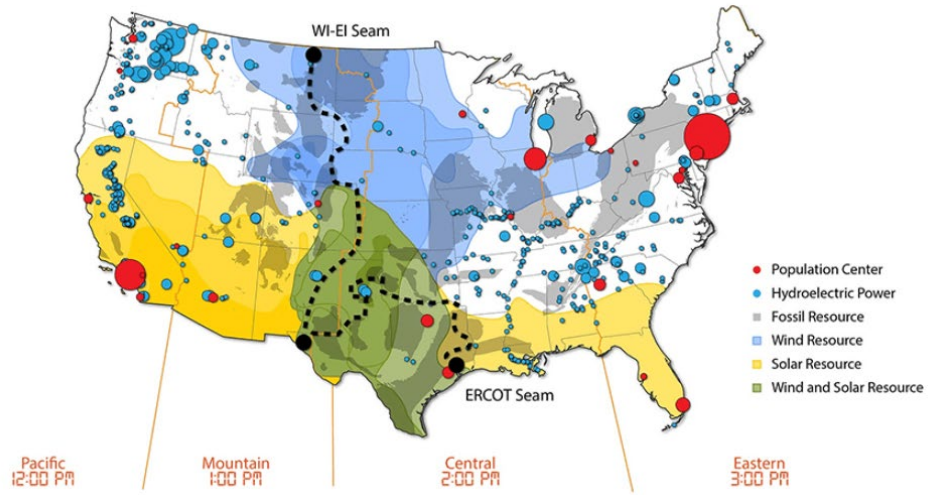
Project Team

- This study is conducted by a joint National Renewable Energy Laboratory (NREL) and Pacific Northwest National Laboratory (PNNL) project team
- This study builds on past projects and expertise at NREL and PNNL with the support and direction of DOE's Office of Electricity and Grid Deployment Office

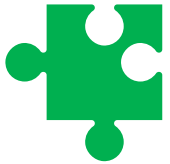


U.S. DEPARTMENT OF ENERGY

Office of Electricity

North American Energy Resilience Model

Objectives of the study



Identify interregional and national strategies to accelerate cost-effective decarbonization while maintaining system reliability

Inform regional and interregional transmission planning processes, particularly by engaging stakeholders in dialogue

Results help prioritize future DOE funding for transmission infrastructure support

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What the Study is and is not doing

What the study will do

- Link several long-term and short-term power system models to test a number of transmission buildout scenarios
- Inform existing planning processes
- Test transmission options that lie outside current planning
- Provide a wide range of economic, reliability, and resilience indicators for each transmission scenario

What the study will not do

- Replace existing regional and utility planning processes
- Site individual transmission line routes
- Address the detailed environmental impacts of potential future transmission lines
- Provide results that are as granular as planning done by utilities
- Develop detailed plans of service

National Transmission Planning Study Scope

Public Engagement: Four Aspects

- Public Input
- Existing Convenor Groups
- Technical Review Committee
- Tribal Outreach

Many others…

Themes from Public Comments

- **Modeling**
  - Recommendations for specific reports and other online resources
  - Leverage existing corridors and infrastructure, grid enhancing technologies
  - Account for climate change impacts
  - Distributed Energy Resources (DER) are key drivers as well as electrification
  - Develop actionable tools, methods and plans; engage at regional level; maintain feasible scope

- **Policy**
  - Received information on existing policies and encouraged to work with states to ensure state policies are up to date
  - Non-binding incentives and goals may influence outcomes

- **Land Use/Environmental**
  - Permitting and siting challenges (e.g., buried lines and use of existing rights of way will reduce local opposition)
  - Equity considerations

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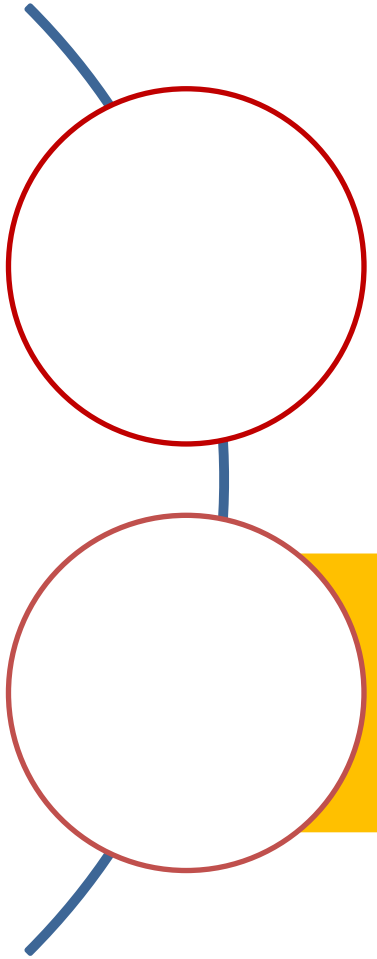
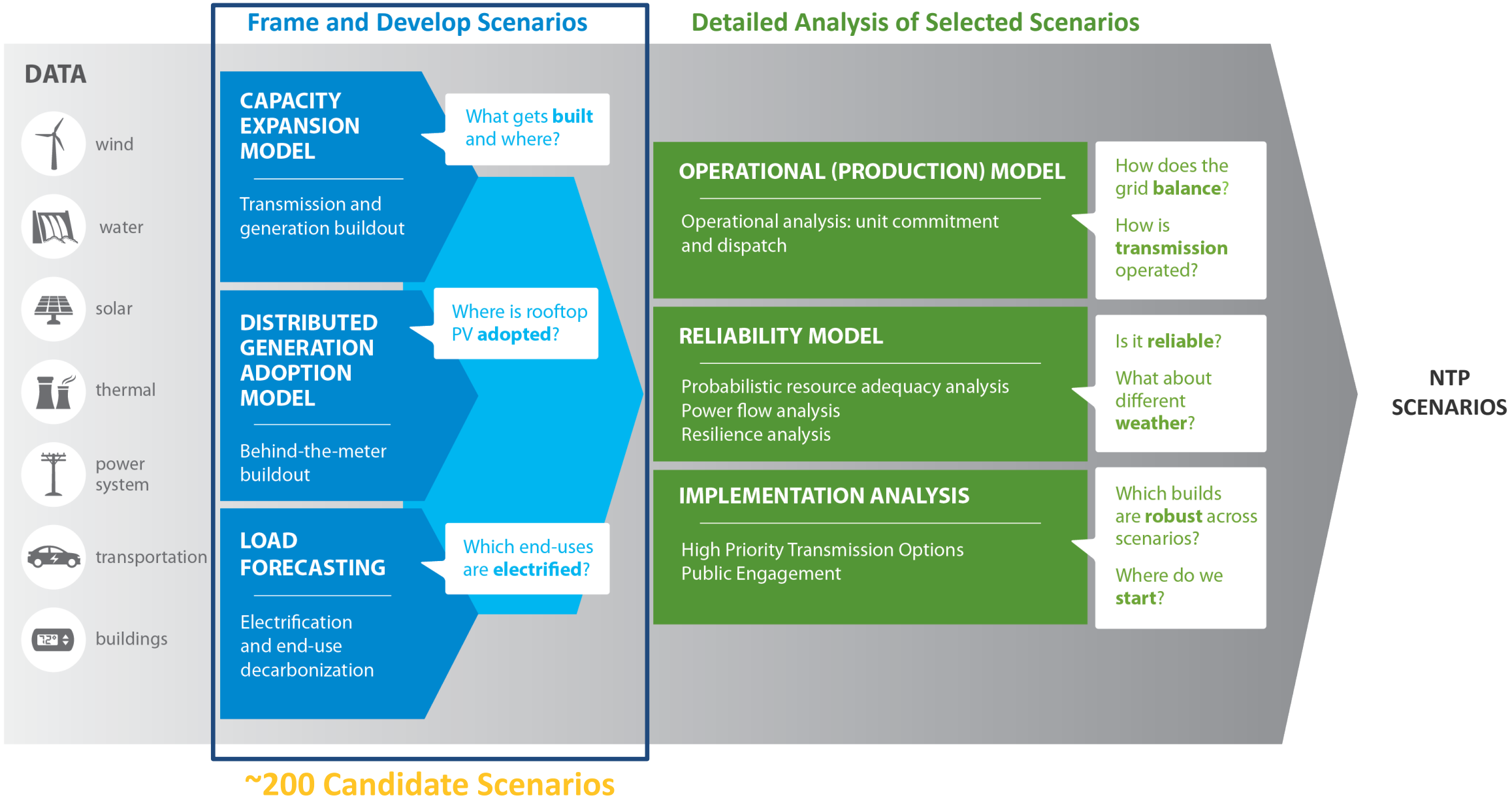
National Transmission Planning Study Scope



Public engagement

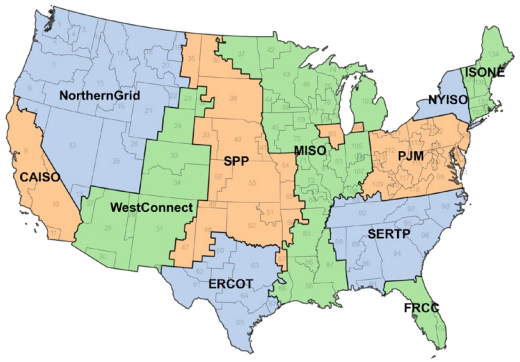
Scenario analysis

NTP Scenario Analysis Relies on Multiple Linked Modeling Exercises

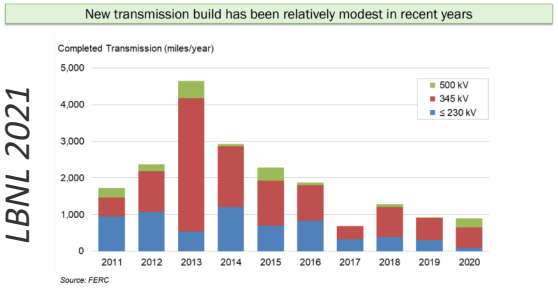


Transmission Paradigms

Limited

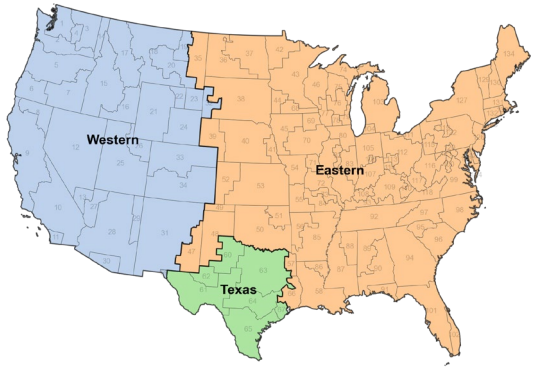


- **Intra-regional** transmission expansion within planning regions only
- Cap annual transmission builds based on recent (since 2009) average of ~1.4 TW-miles/yr.



LBNL 2021

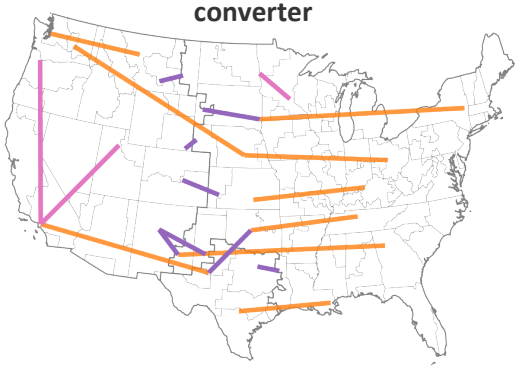
AC



- **Intra-interconnection** transmission expansion between 134 zones (no new back-back DC ties across seams)
- Transmission cost and losses based on AC transmission (500 kV).

LCC

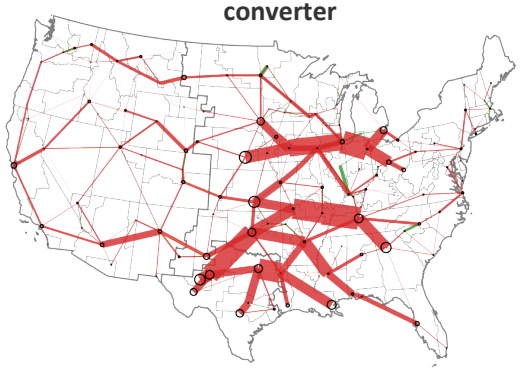
HVDC line-commutated converter



- **Inter-interconnection** transmission expansion (new back-back DC ties allowed)
- HVDC (point-to-point line-commutated converter) expansion allowed
- Available LCC connections identified based on preliminary scenarios.

VSC

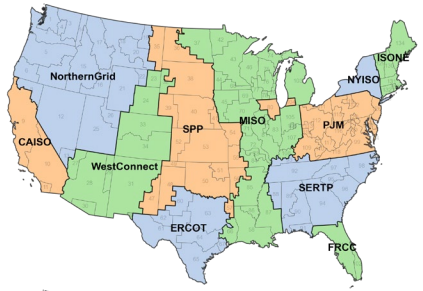
HVDC voltage-source converter



- **Macrogrid** multiterminal HVDC network designed by the model and specific to the scenario
- Transmission lines and voltage-source-converter capacities are decided separately
- VSC builds are not allowed until 2032.

Scenario Framework: 24 Core Scenarios

4 transmission paradigms X 2 demand cases X 3 emissions targets



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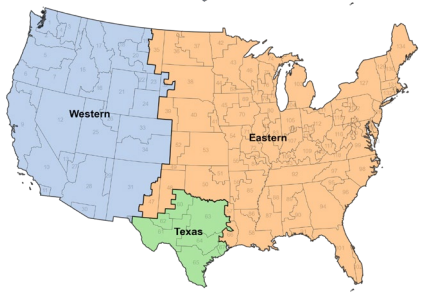

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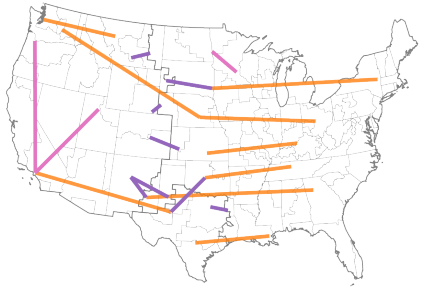

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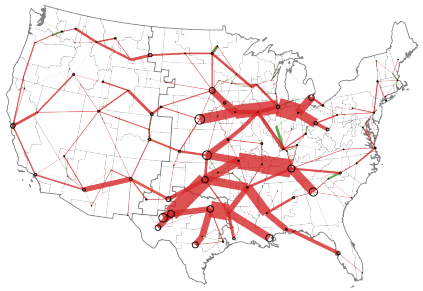
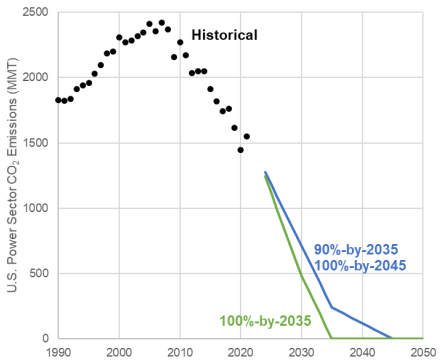


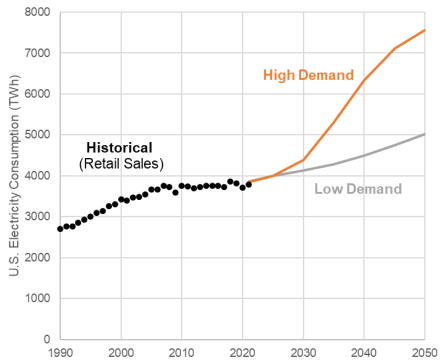
VSC

Demand Growth →

Emissions Target ↓

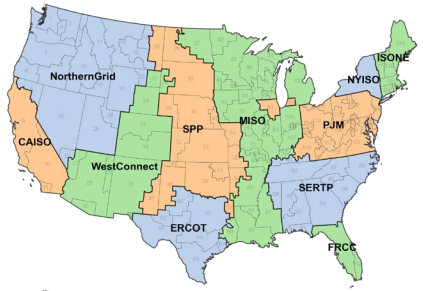
Current Policies Low Demand	**Current Policies** High Demand
90-by-2035 Low Demand	**90-by-2035** High Demand
100-by-2035 Low Demand	**100-by-2035** High Demand





Scenario Framework: 168 Sensitivities

4 transmission paradigms X 3 emissions-demand combinations X 14 sensitivities



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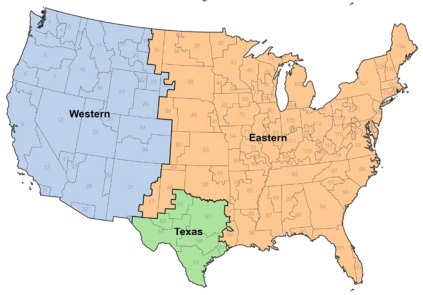

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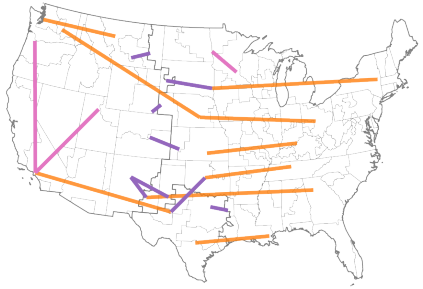

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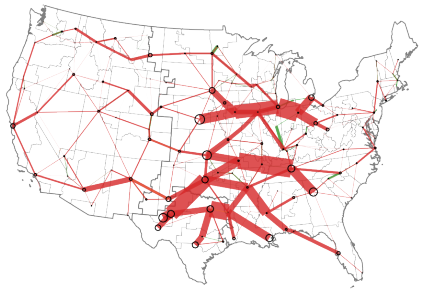

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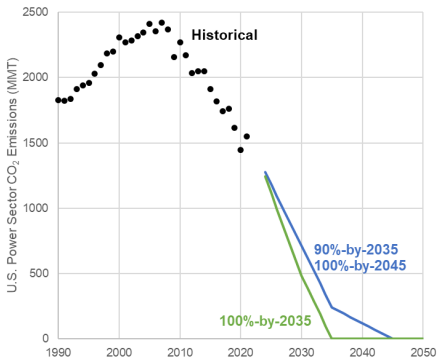

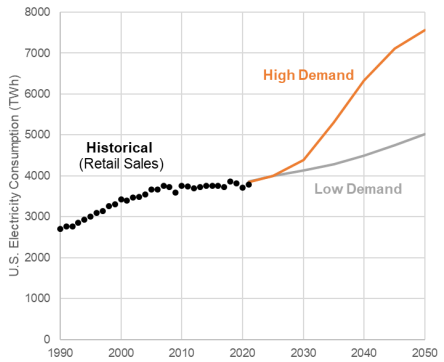

Sensitivity
Transmission 5x cost
Gas (high and low) price
PV + battery low cost
Wind low cost
Siting limited
More distributed PV
Demand peak shaving
H2 (high and low) price
+ Nuclear SMR + DAC No CCS or new nuclear
Climate
Many challenges

Scenario Framework: 168 Sensitivities

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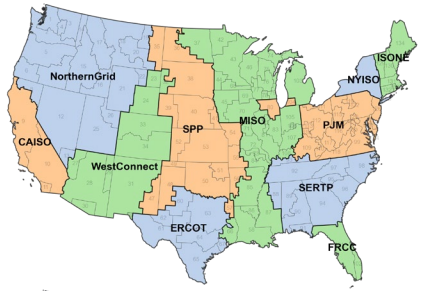

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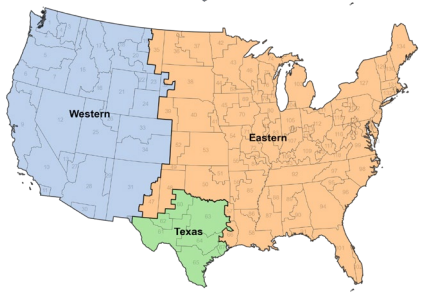

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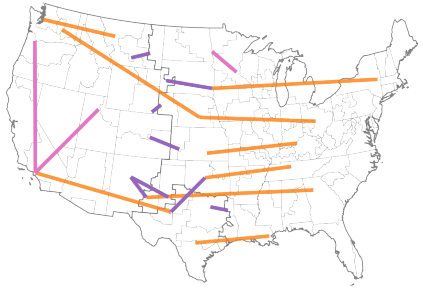

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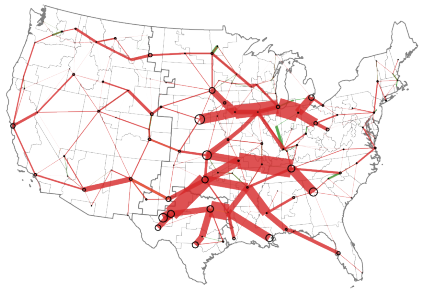

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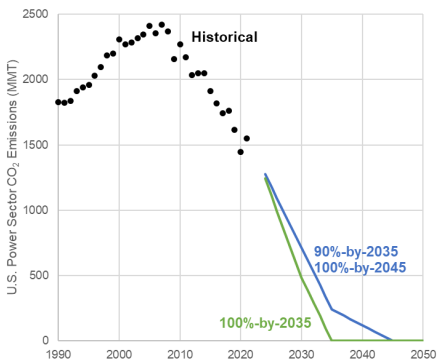

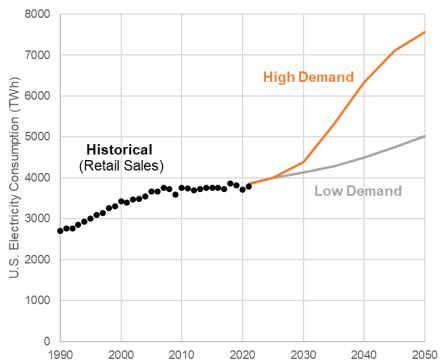

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→	Siting limited
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	Demand peak shaving
→	H2 (high and low) price
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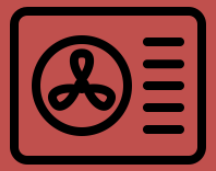
→	Climate
	Many challenges

More Detail on Scenarios Framework…

Energy policies

Demand growth & electrification



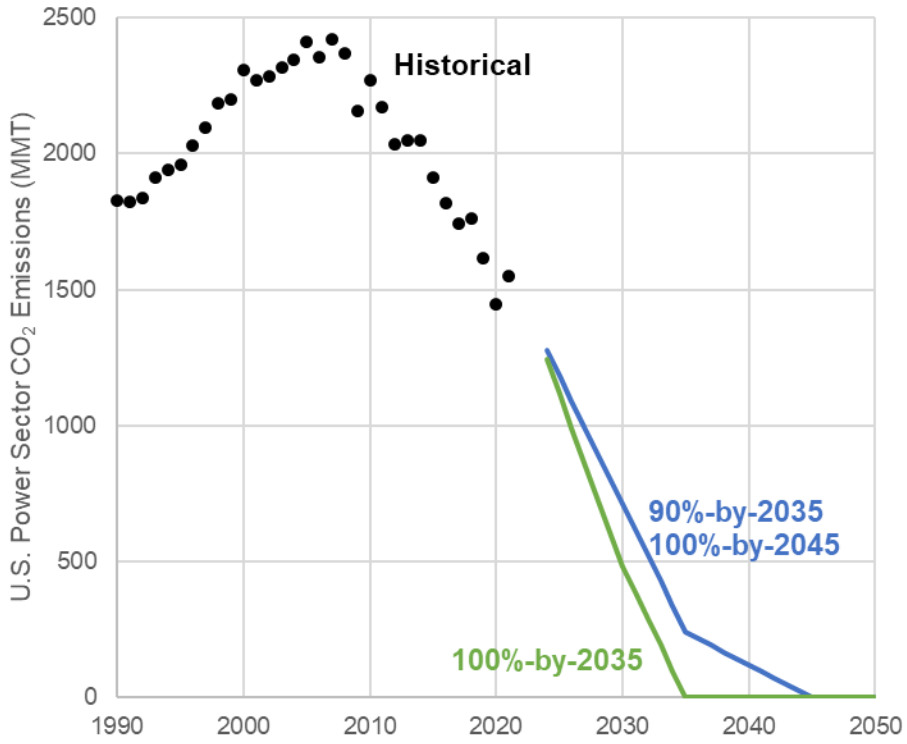
Sensitivities

State and Federal Energy Policy Updates

Three emissions targets

1. **Existing policies only**
2. **100% by 2035**
3. **90% by 2035, 100% by 2045.**

} Modeled as national CO_2 cap



Updates to existing policies

- **State:**
  - Revised based on latest LBNL data from May 2022 (emp.lbl.gov/projects/renewables-portfolio)
  - Feedback from TRC and state experts (37 total) on targets, technology mandates, technology eligibility, credit trading.
- **Federal:** The Inflation Reduction Act (next slide).

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Inflation Reduction Act (IRA) of 2022: Initial representation

- PTC: $28.6/MWh (10-yr) for biopower, land-based wind, utility PV
- ITC: 40% for batteries, concentrating solar, geothermal, hydro, nuclear, offshore wind, pumped-hydro
- Captured CO2 incentive: $85/tCO2 (12-yr) for bioenergy-CCS, fossil-CCS
- No equivalent transmission tax credit is modeled
- Conservative phase out assumption: 2032 regardless of decarbonization

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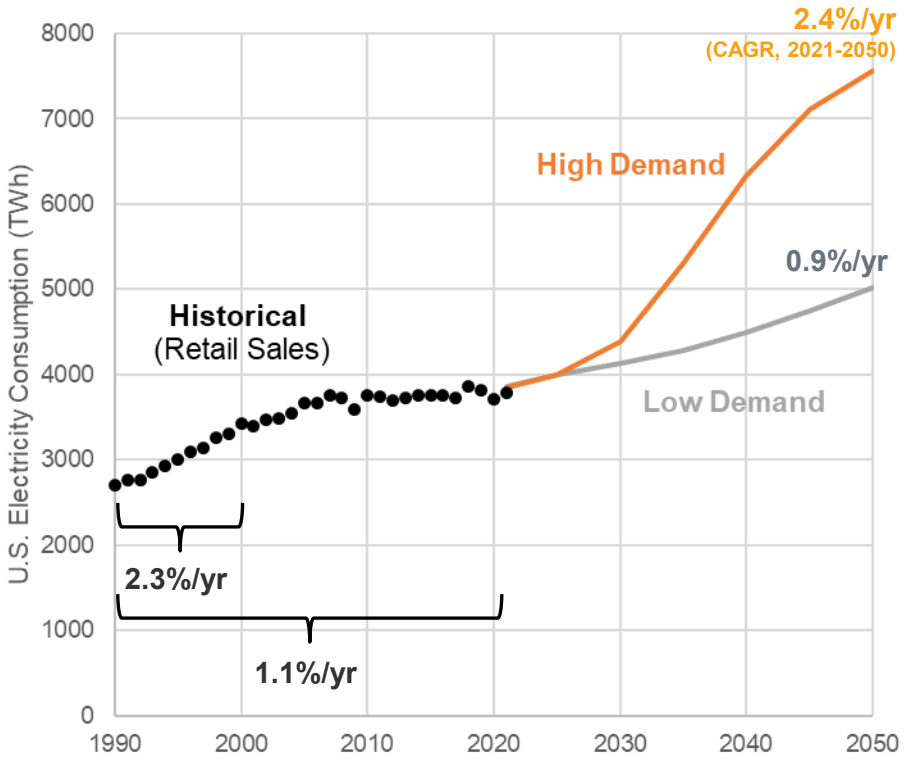
Demand Growth and Electrification Assumptions

Two demand growth cases

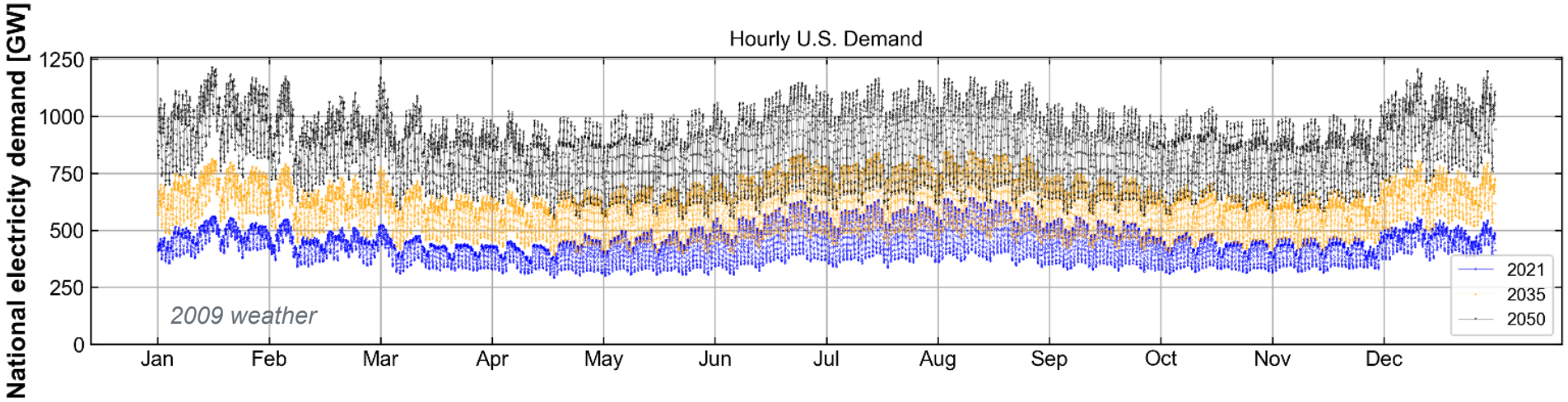
1. **Low Demand** (e.g., business-as-usual)
2. **High Demand** (e.g., net-zero economy by 2050).

Demand-side modeling details

- Trajectories are from the Baseline and Central cases from EER Annual Decarbonization Perspective 2022 (www.evolved.energy/post/adp2022).
- Service demand from EIA Annual Energy Outlook 2022 Reference (www.eia.gov/outlooks/aeo/)
- Adjustments made based on feedback from TRC and state experts (31 total).

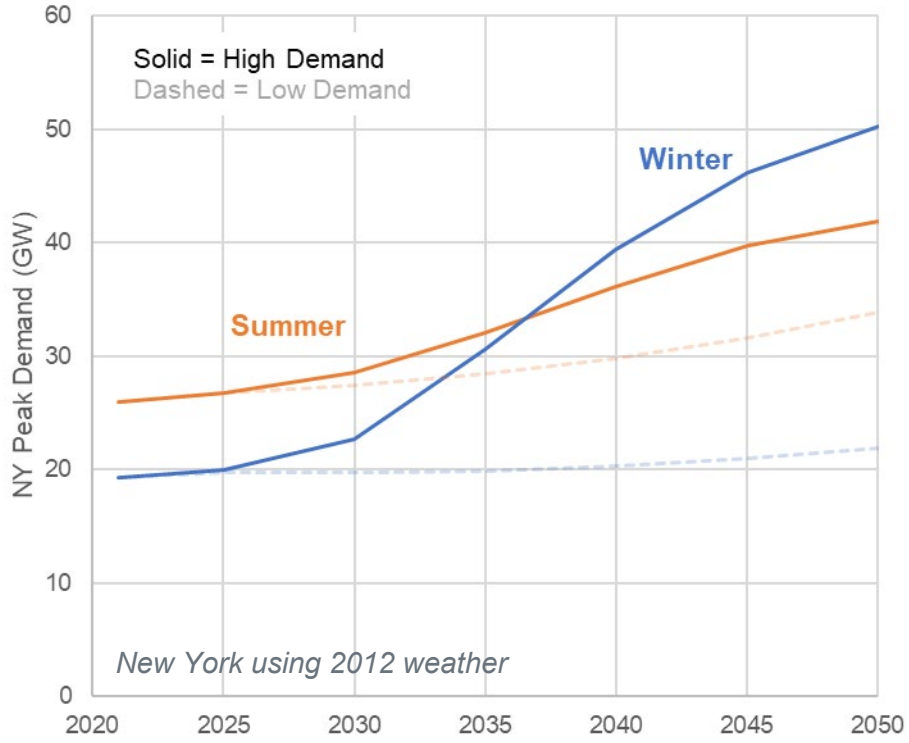


Electrification in the High Demand Case Changes Demand Profiles



- Electrification increases demand throughout the year, but winter demand grows fastest.
- Seven years of meteorological conditions are modeled.
- Gross “native” load shown (distributed generation is not netted out in figures)
- Top 80 peak hrs (~1%) reduced (40 hrs per half-year)* to reflect demand response.

*Except for New England winter to match input and analysis from ISO-NE.

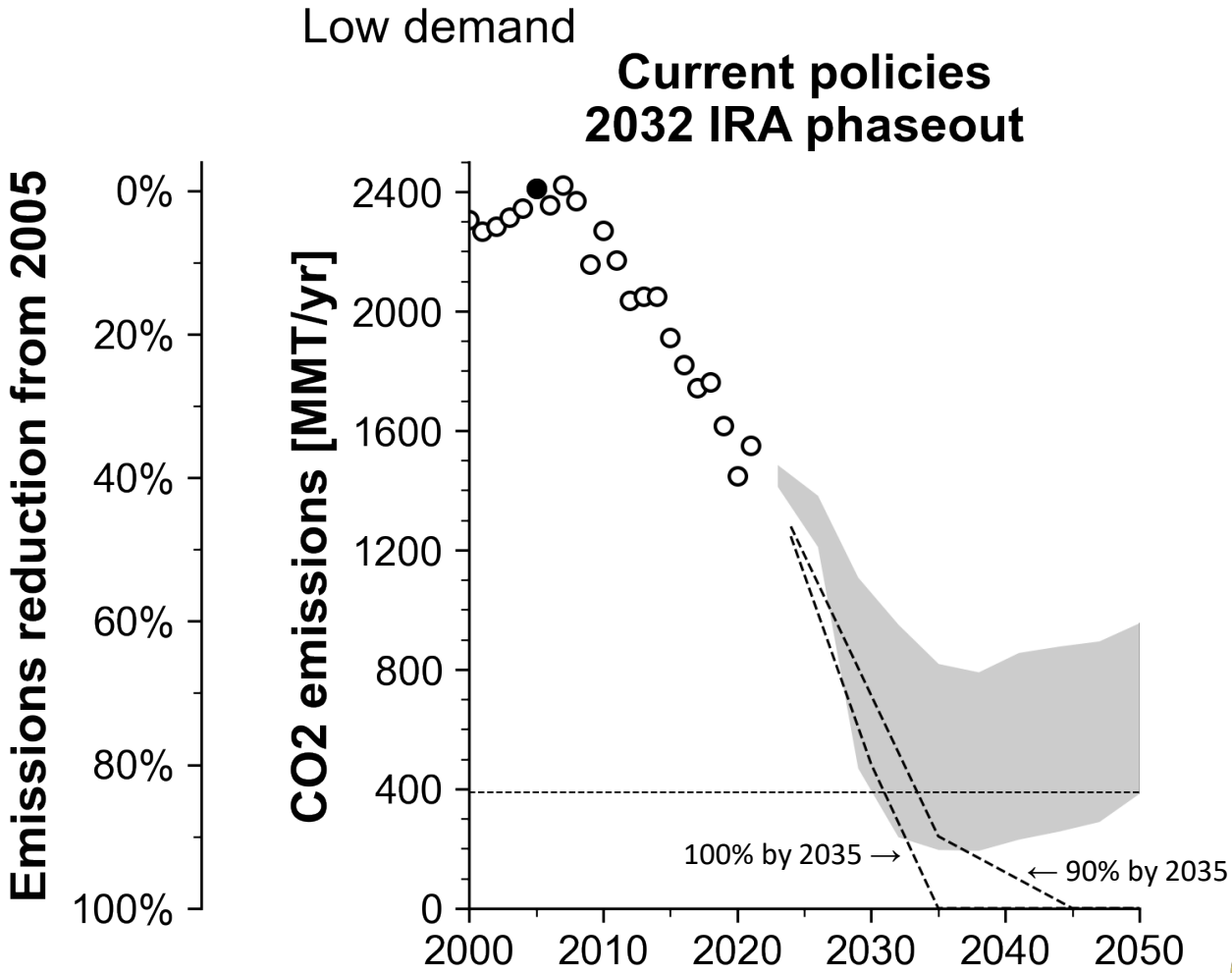


Wide-Ranging Sensitivities to Assess Robustness of Findings

Sensitivity	Variation	Default
Transmission 5x cost	5x higher	Varied sources, regional variations
Gas (high and low) price	Higher (AEO LOGR) Lower (AEO HOGR)	AEO Reference
PV + battery low cost	ATB Advanced	ATB Moderate
Wind low cost	ATB Advanced	ATB Moderate
Siting limited	Limited Access	Reference Access
More distributed PV	190 GW by 2035, 363 GW by 2050	134 GW by 2035, 181 GW by 2050
Demand peak shaving	Top 80 hrs per half-year clipped	Top 40 hrs per half-year
H2 (high and low) price	Higher ($40/MMBtu) Lower ($10/MMBtu)	$20/MMBtu
+ Nuclear SMR + DAC **No CCS or new nuclear**	Expanded (DAC, nuclear-SMR) Limited (no CCS, no new nuclear)	All except DAC, nuclear-SMR
Climate	Hydro availability from RCP8.5; reduced hydro capacity credit (80%), thermal summer capacity (85%), and transmission summer capacity (95%).	Historical performance
Many challenges	Limited access siting, no CCS and no new nuclear, high H2 costs, climate impacts	See above

Preliminary Finding #1

Emissions fall significantly with **current policies** and new interregional transmission, but not to zero. There is a large range of uncertainty in the magnitude of potential emissions reductions (gray-shaded area)



Interim results
Do not cite

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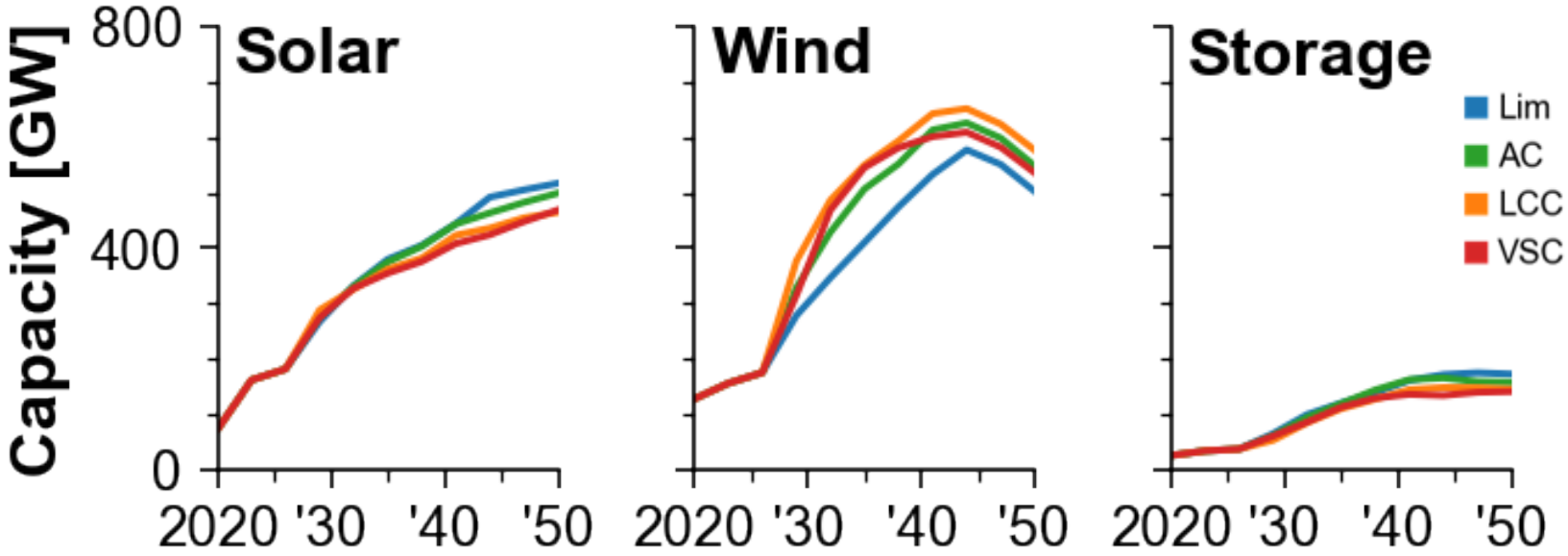
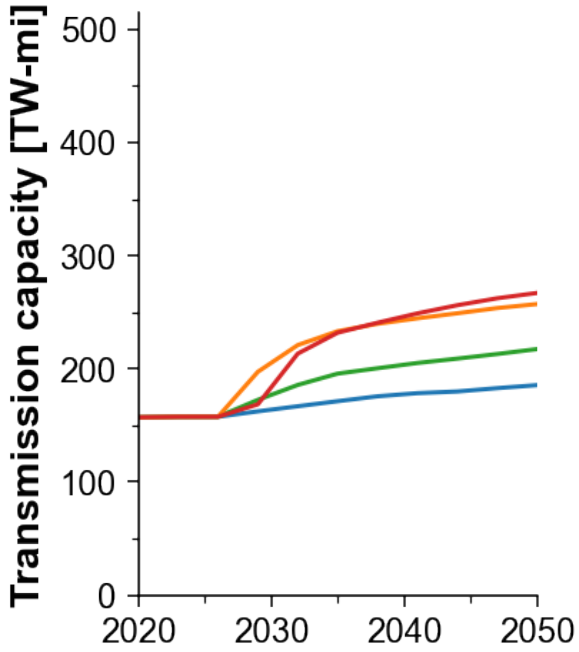
Preliminary Finding #2

There is notable growth in RE, storage, and transmission capacity even under the **current policies with low demand** scenarios, but fossil w/o CCS remains.





Interim results
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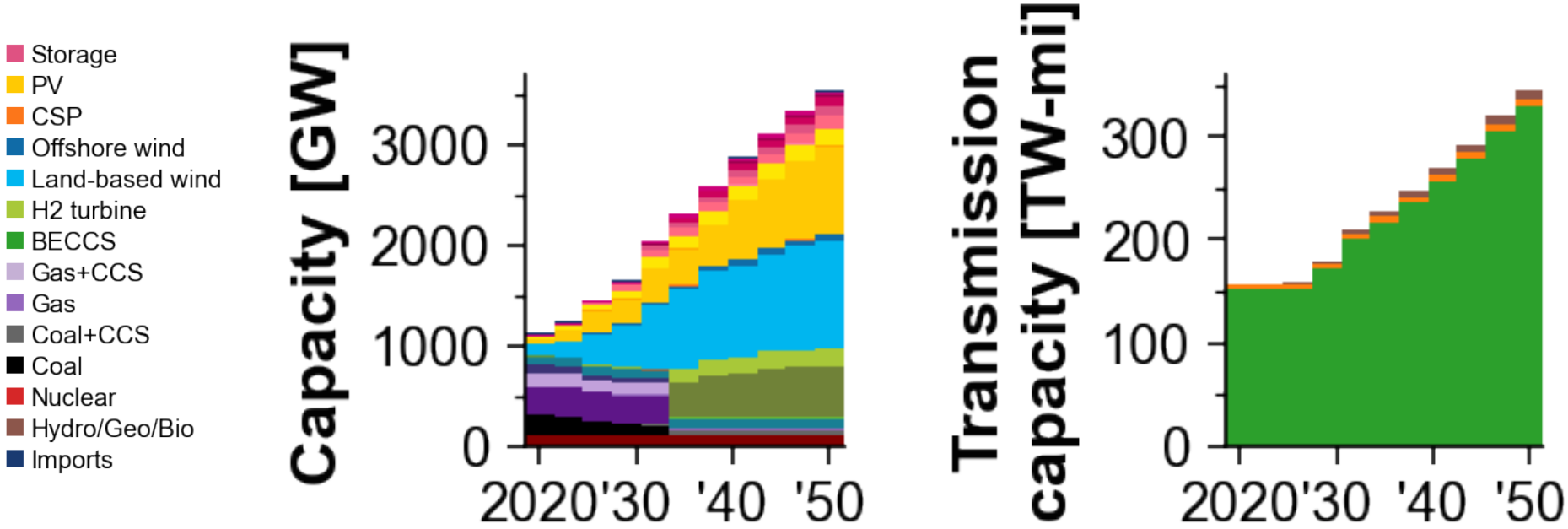
Preliminary Finding #3



The combination of **high demand growth and 90% or 100% emissions reduction** leads to RE, storage, and transmission capacities many times larger than today.

Interim results
Do not cite

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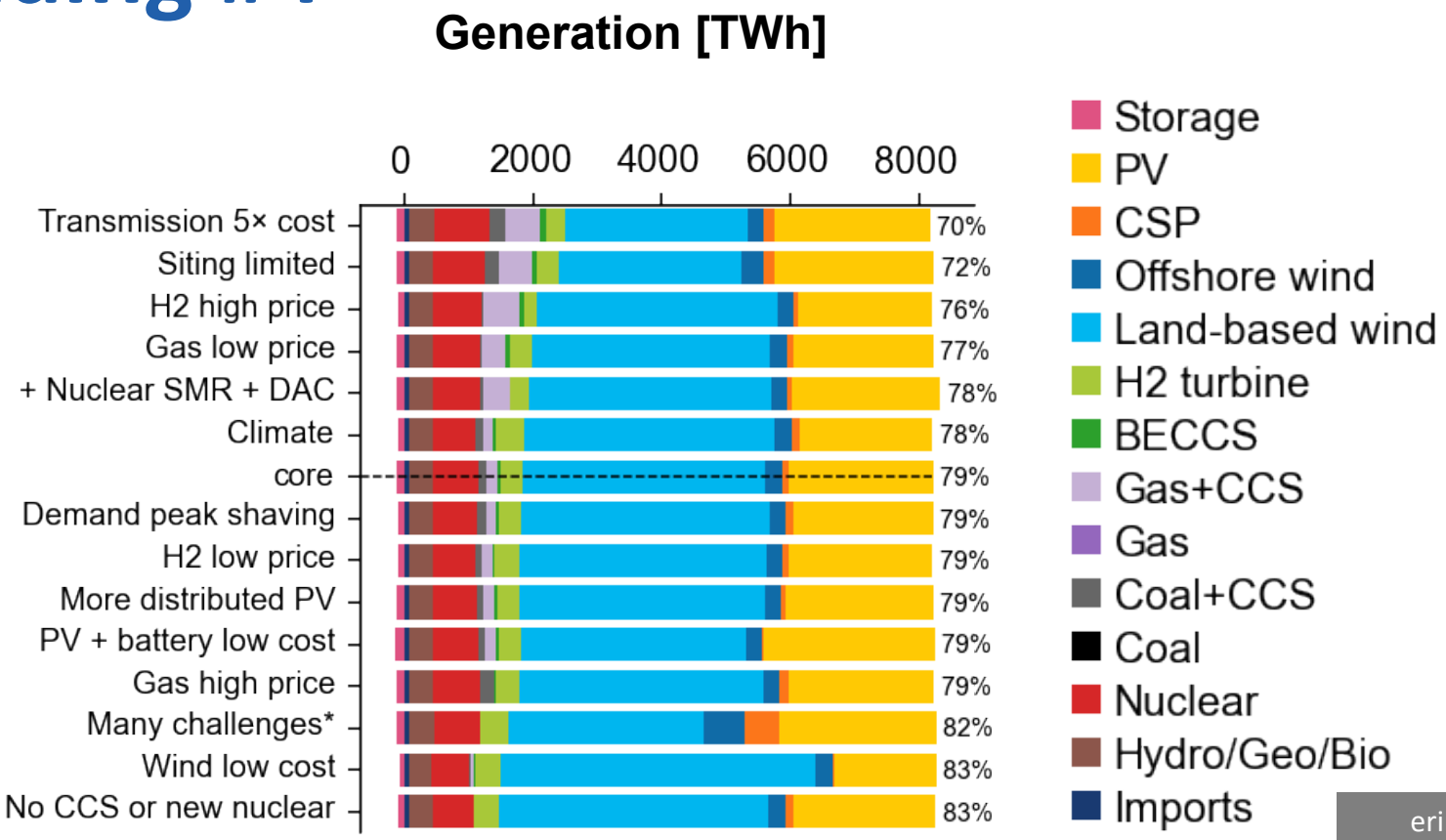
Preliminary Finding #4

100% by 2035, High demand, AC

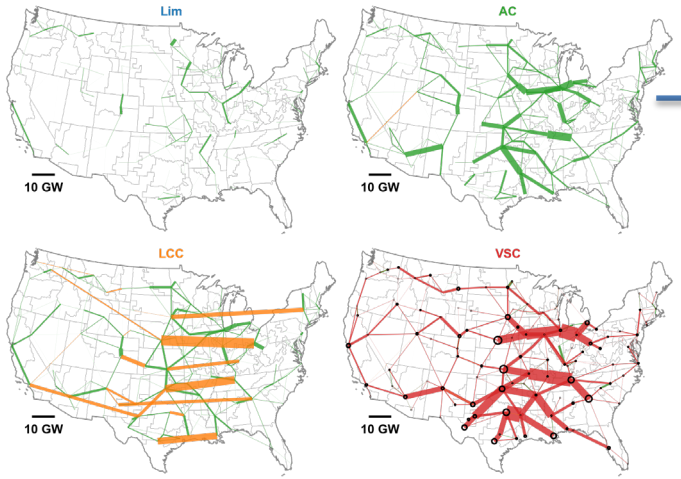
The majority of decarbonization is delivered by wind and solar, along with coordinated deployment of storage and transmission.

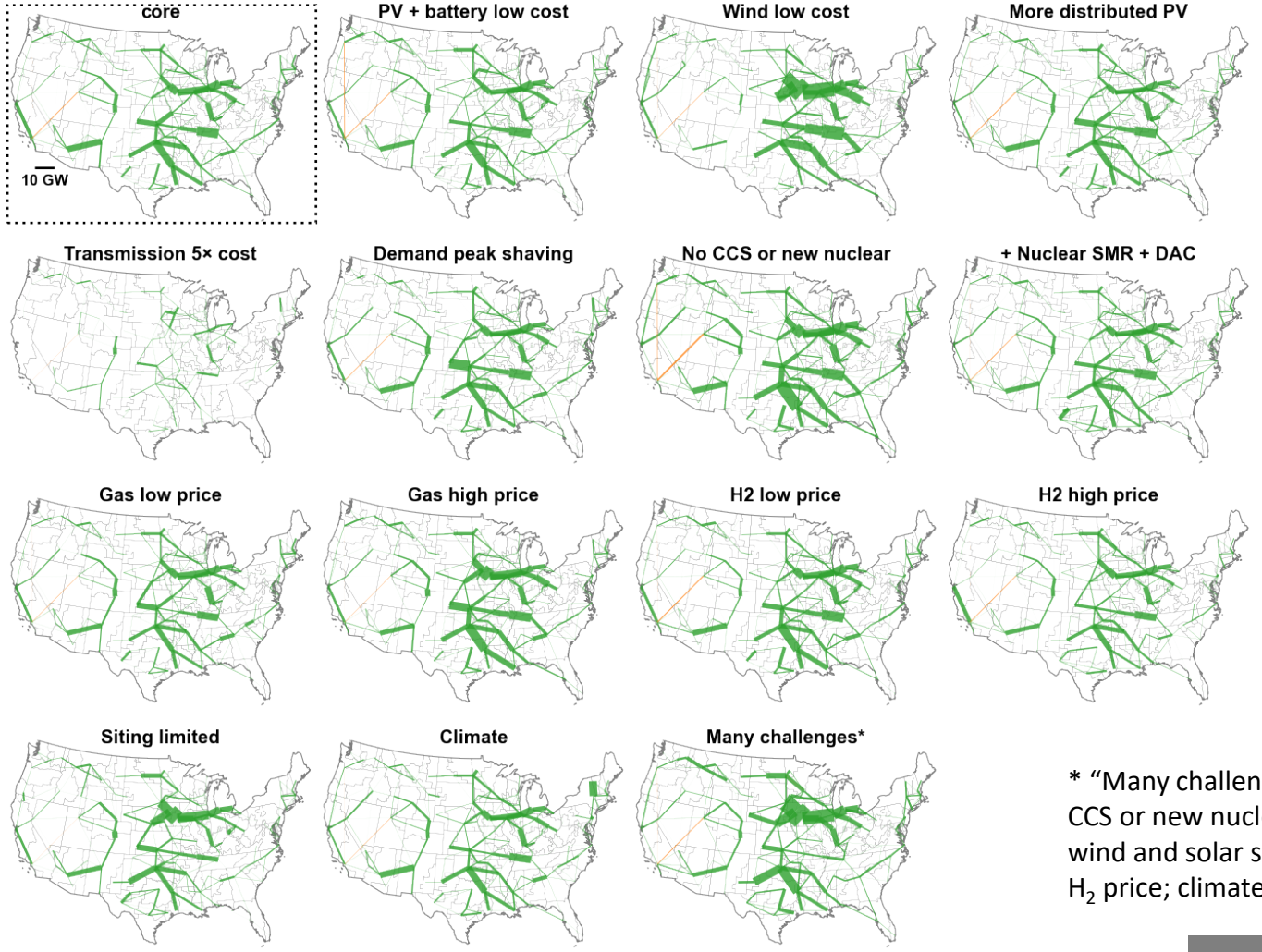


erim results
Do not cite

Preliminary Finding #5

100% by 2035, High demand





The **geographic distribution** of transmission additions is **robust** across many sensitivities, although the total capacity (TW-miles) can vary.

The highest density of transmission additions occurs **between the wind belt and eastern interconnection demand centers**, but increased transmission occurs in all regions of the country.

* "Many challenges" = No CCS or new nuclear; limited wind and solar siting; high H_2 price; climate

Next Steps

- Identify *initial draft* of **high priority transmission options** based on the full suite of Candidate Scenarios
- **Down-select scenarios** for more detailed analysis
  - Production Cost Modeling and Resource Adequacy analysis (zonal)
  - Production Cost Modeling and power flow analysis (nodal)
  - Economic Analysis
  - Resilience Analysis
- **Refined capacity expansion modeling** for Candidate Scenarios v2
  - Climate change informed input data
  - Demand updates
  - Other updates…

Timing and success of planned model improvements still TBD

Economic Analysis Coming Up

Objective

- Inform transmission planning and cost allocation through demonstrated evaluations of transmission benefits for interregional lines
- Identify which transmission benefits are key drivers for investments in interregional lines
- Evaluate how transmission benefits are anticipated to change over time.

Activities

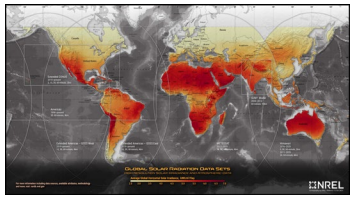
- Identify and develop methodologies to evaluate quantifiable economic benefits associated with transmission development
- Disaggregate economic benefits in the national modeling into regional values
- Develop knowledge base to inform cost allocation of interregional projects.

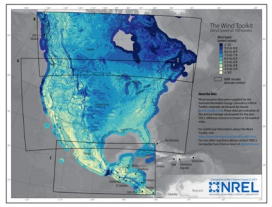
Outcomes

- Methodologies to quantify and regionally disaggregate a range of economic benefits of interregional transmission
- Distribution of transmission benefits for interregional lines identified in the NTP to inform future planning and coordination
- Insights into how transmission benefits are anticipated to change over time to inform future planning practices.

Climate Analysis for Next Round

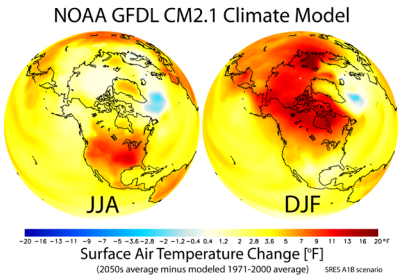
Renewable Energy Resource Data (NSRDB, WTK)





CC data to be used for sensitivities and stress tests

Climate Change Data (GCMs)



rev

Power System Modeling Ecosystem

PCM (nodal)

CEM (zonal)

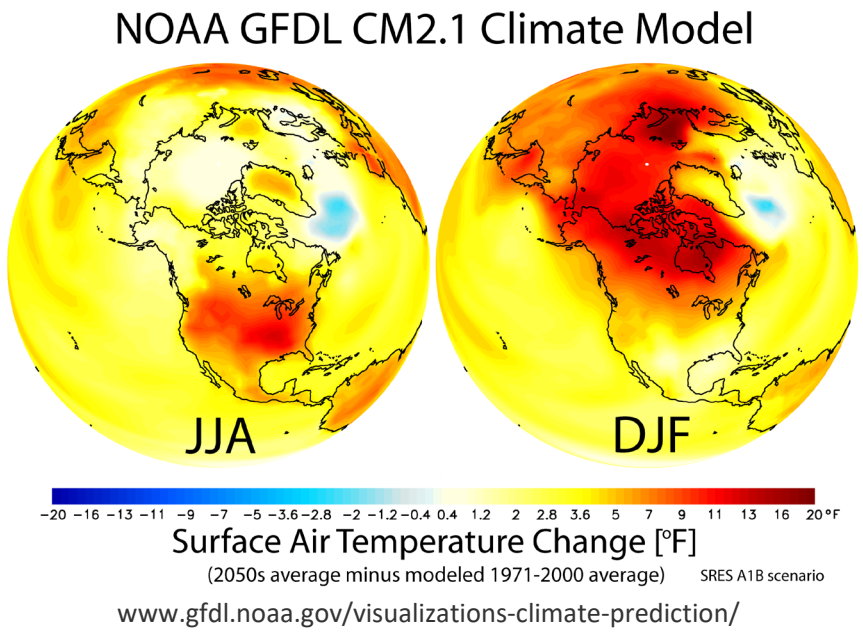
RA (zonal)

Load Data

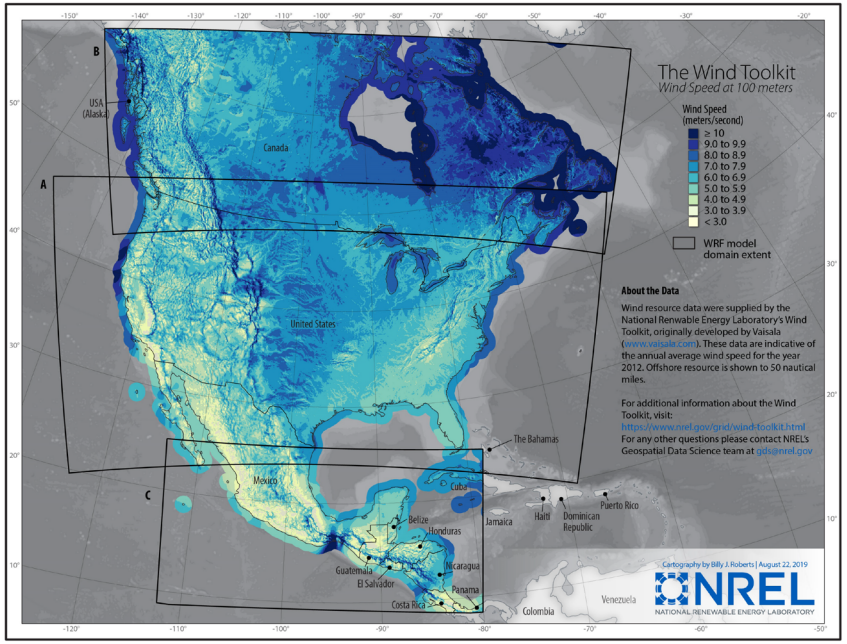
Results and Insights!

Climate Data Downscaling

Global Climate Models (GCMs)



Mesoscale NREL Datasets (WTK, NSRDB)



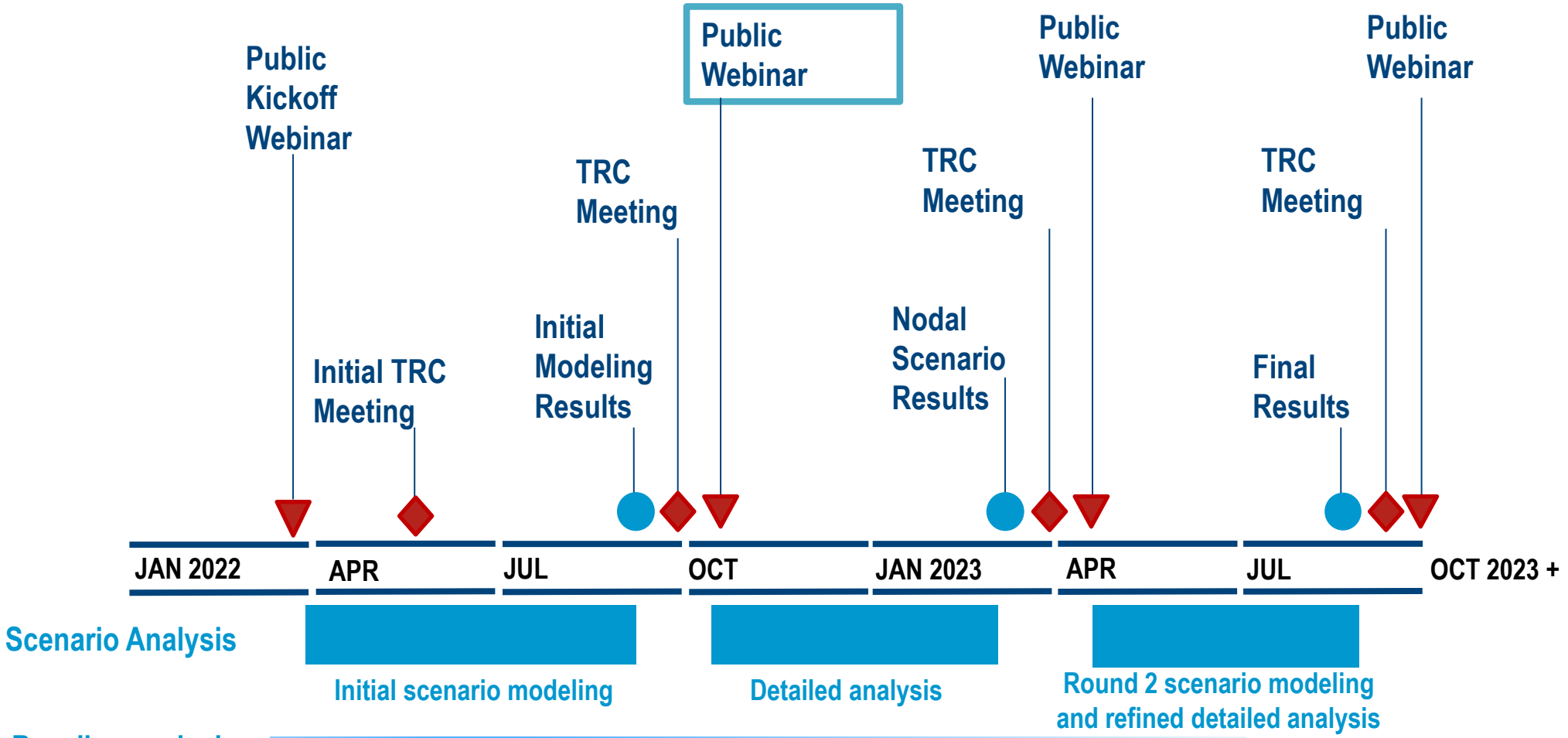
~100 km grid resolution
daily average data
2000-2100

Bridge this Gap

~2-4 km grid resolution
5 min-hourly data
Historical

Our solution needs to be flexible enough to enable researchers to study any GCM/RCP/SSP and to stay current with new climate change research.

NTPS Timeline



TRC = Technical Review Committee

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THANK YOU

- Overview of NTP Study goals and objectives
- Project news and milestone results
- Webinar presentations
- NTP Study mailing list
- TRC meeting schedules and presentation materials
- Public comment form

www.energy.gov/gdo/national-transmission-planning-study

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