National Transmission Planning Study

Land Use and Environmental Exclusions Subcommittee Meeting

June 24, 2022

Project Overview

Objectives of the study

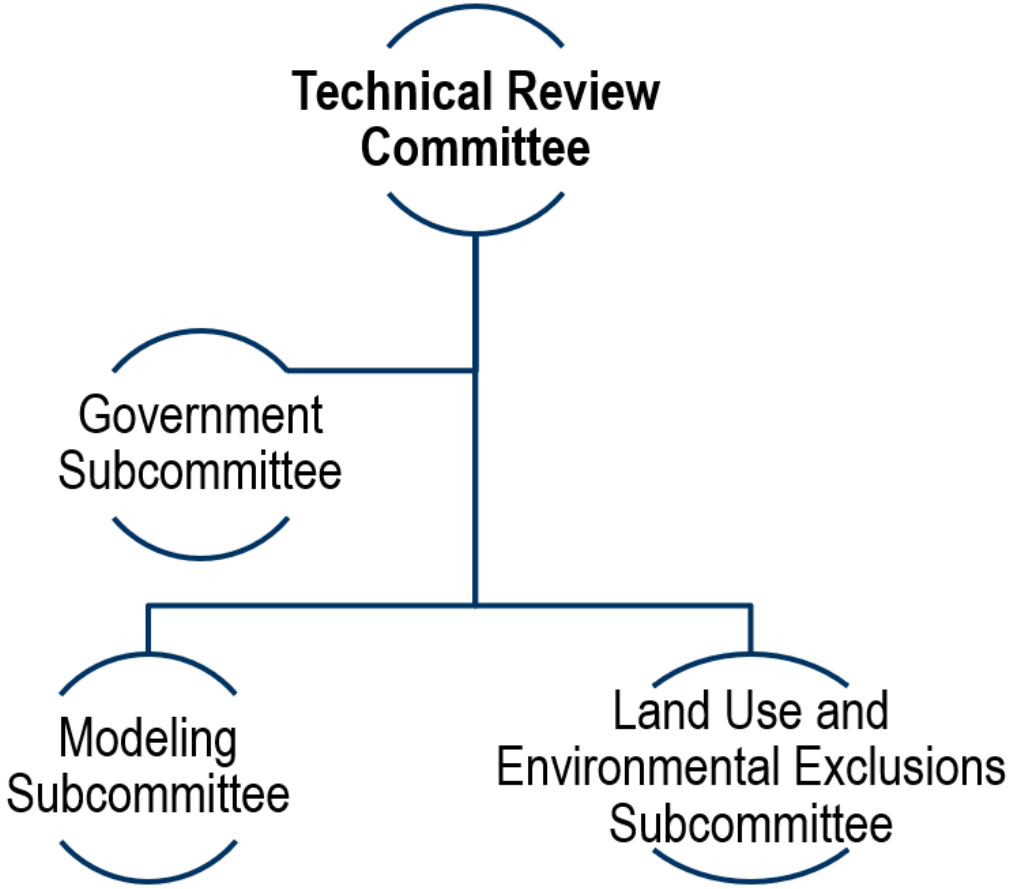
1. Identify interregional and national strategies to accelerate cost-effective decarbonization while maintaining system reliability

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

3. Identify viable and efficient transmission options that will provide broad-scale benefits to electric customers

Technical Review Committee

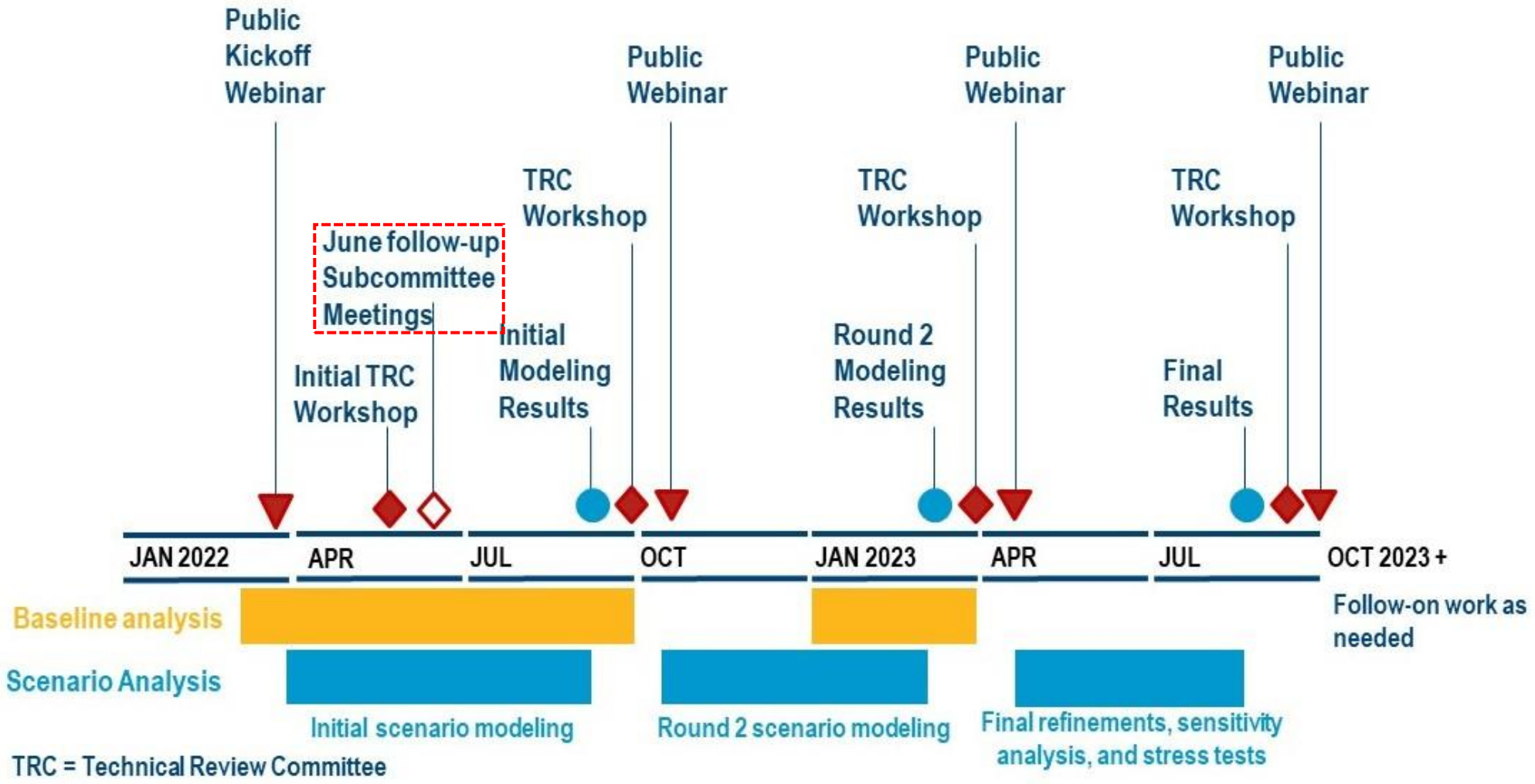
- **Technical Review Committee** (TRC) will constructively scrutinize and review the overall project and, where needed, will provide a forum for integrating input from all three subcommittees.
- **Government Subcommittee** will provide feedback on how to reflect federal and state policy and regulatory issues in the analysis.
- **Modeling Subcommittee** will provide technical feedback on assumptions, modeling, and data.
- **Land Use and Environmental Exclusions Subcommittee** will provide feedback on generalized issues related to constraints on locating new transmission and generation.



Follow-up June subcommittee meetings

- Follow-up June subcommittee meetings designed to provide an opportunity for smaller-group dialogue and questions based on material presented during the May 20 TRC meeting
  - **Modeling Subcommittee** – June 7th
  - **Government Subcommittee** – June 10th
  - **Land Use and Environmental Exclusions Subcommittee** – today
- Future TRC meeting information will be posted on the public project website: https://www.energy.gov/oe/national-transmission-planning-study

Public Engagement: Timeline



Survey of state policies

- Lab team needs to confirm assumptions for and representation of:
  - Existing state policies for clean energy, emission reductions
  - Annual and peak demand under scenarios representing different possibilities for electrification, etc.
- Next month, Government Subcommittee members will receive a spreadsheet tool that lists modeling assumptions state-by-state, year-by-year
  - Will be circulated to Government Subcommittee for review and comment (July)
  - Full survey will be circulated to states through NARUC, NASEO (July)
- Some demand data sets may be sent to TRC members for review on a separate timetable

Baseline Analysis and relationship to Scenario Analysis

Baseline and Scenario Tasks and Interactions

Baseline Assessment Task

- Estimate range of decarbonization potential without major changes to the planned transmission system
- Explore level of system decarbonization enabled by select transmission projects for greater decarbonization
  - Projects will not be assessed individually
- Reference point for the decarbonization gap the Scenario task must address

Scenario Task

- Assumes concerted effort to decarbonize the power system
- Investigate the tradeoffs (e.g., generation mix, cost, operations, risks to system stressors) between different transmission expansion scenarios to enable deeper decarbonization
- Identify high priority transmission pathways that demonstrate robustness across many scenarios and unique value to system economics, reliability, and decarbonization

Tools and Methods Used in Each Task

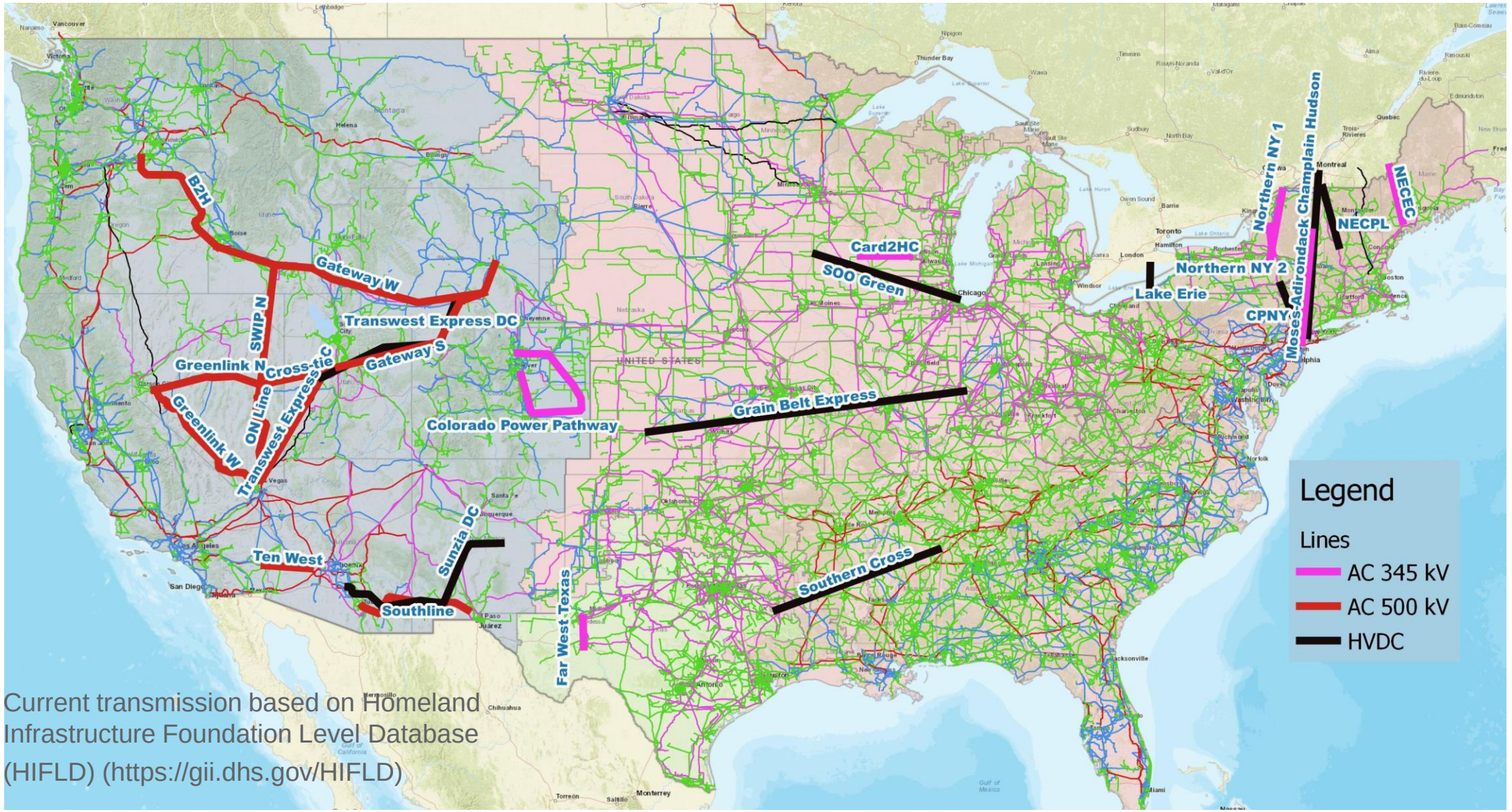
Baseline Assessment Task

- Production Cost and Powerflow Modeling only
- Nodal transmission topology
- Transmission and generation fleet determined by best available industry plans with minor tweaks to push limits of wind and solar the planned system could accommodate

Scenario Task

- Co-optimized transmission, generation, and storage
- Zonal and nodal modeling
- Wider dimension of inputs considered (e.g., electrification levels, etc.)

Baseline transmission projects at advanced development stage



Current transmission based on Homeland Infrastructure Foundation Level Database (HIFLD) (https://gii.dhs.gov/HIFLD)

Most of them have the objective of connecting renewable resources with load centers

Select items from TRC feedback received to date

Clarifications on the Purpose of the Baseline Case

- Provides an optimistic business as usual prediction of decarbonization progress.
- Provides reference point for the scenarios analysis

Data sets to be used

- Industry planning cases and opportunity for review

Baseline Transmission Criteria

- Line length and voltage requirement
- Criteria for Advanced Development Stage
- Power flow / dynamic data availability

Approach

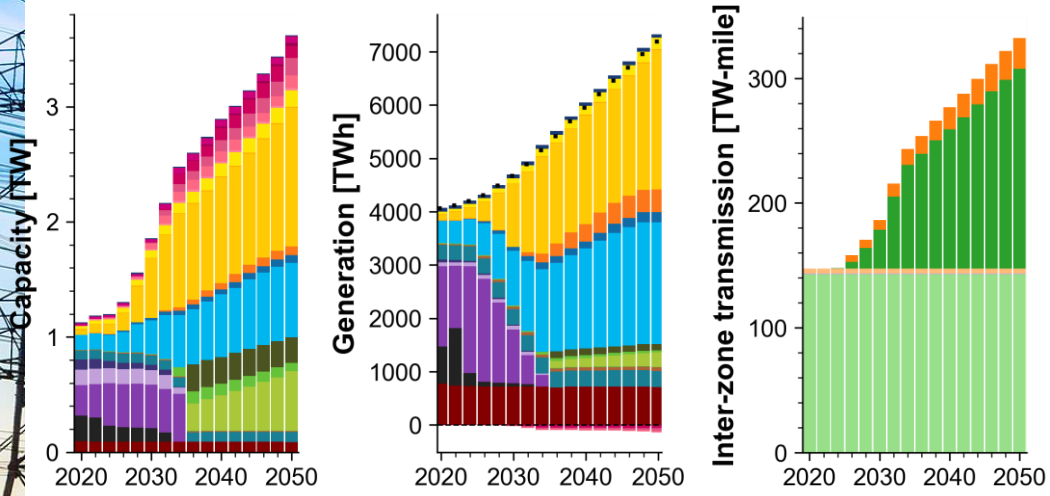
- Methods for new wind and solar additions
- Solar vs. Hybrid solar+storage project

Open discussion for other feedback

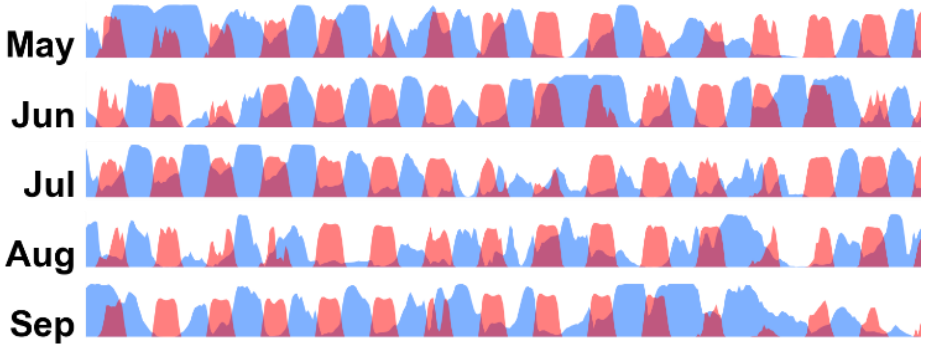
Scenario Framework & Capacity Expansion Modeling

ReEDS: Key Takeaways

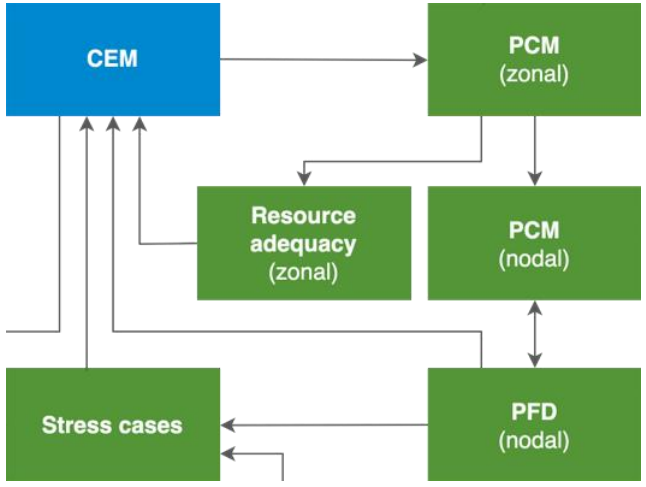
Co-optimizes generation, storage, and transmission capacity nationwide over the next 3+ decades



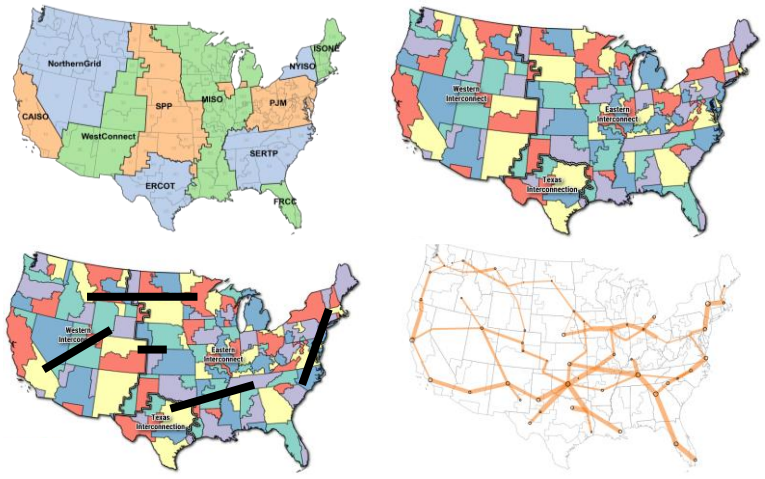
Explicit treatment of issues related to **VRE and storage**; flexible tradeoff of spatial vs. temporal resolution; 2007–2013 weather



Provides **starting point** for more detailed operational models



Capable of covering a **broad range** of scenario designs & transmission frameworks



Clarifications

- ***ReEDS capacity expansion model will be used to model ~100+ Candidate Scenarios, a subset of which will be further examined using more-solved modeling and zonal-to-nodal linkages.***
- Transmission, generation, storage are co-optimized.
  - Transmission is an output of the model. Topologies represent constraints applied to transmission (e.g., inter-regional or not)
- Carbon constraints and electrification levels are not forecasts
- CEM is zonal (134 zones) only, but zonal-to-nodal linkage process is part of the study.
- Grid-enhancing technologies are not part of CEM but will be considered in the study
- Retirements: announced, age, and economic
- Demand assumptions and coordination with other studies (AOWTS)

Key scenario framework questions for the TRC

1. Does the proposed scenario framework capture the main drivers relevant for national transmission planning? Are there any missing or extraneous drivers?

4 transmission topologies

x

9 emissions variants = 3 grid decarbonization X 3 electrification

+

14 sensitivities = 2 emissions variants X 7 other drivers

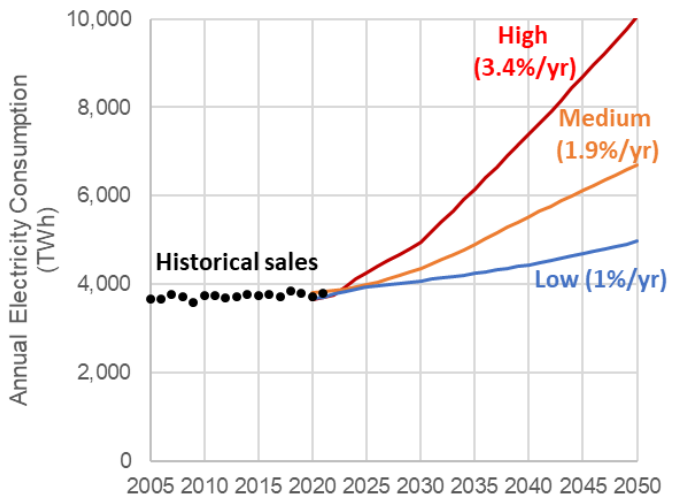
+

model formulation sensitivities

=

~100 total sensitivities from CEM

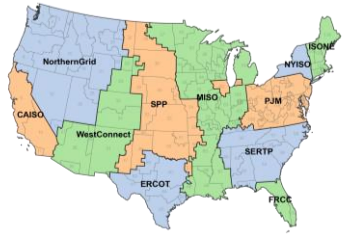
1. High transmission costs → 2–10x default assumptions
2. High distributed PV adoption → 170 GW in 2035 (default = 93 GW)
3. Low solar & storage costs → ATB Advanced
4. Low wind costs → ATB Advanced
5. Constrained renewable energy siting → Limited Access *(see next slide)*
6. Limited non-RE techs → no CCS, no new nuclear
7. Expanded non-RE techs → incl. CO_2 removal, nuclear-SMR

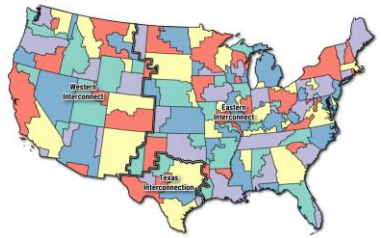


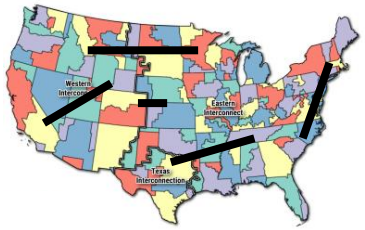
2. Do the range of assumptions appropriately bound expectations - especially within the lens of decarbonization?

Reactions to the electrification and demand growth assumptions would be most helpful.

3. Are there specific variations to the transmission topologies that should be prioritized?







Select items from TRC feedback received to date

Scenarios and sensitivities

- Demand-side flexibility and distributed resources
- Reserve margin and extreme weather
- Fuel price variations
- Energy justice (generator and transmission siting)
- Clean gas
- Low-cost storage
- Constraints on new transmission due to siting and environmental challenges

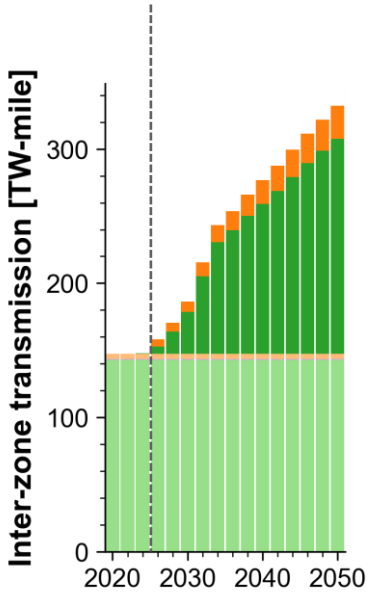
Range of parameters

- 100% by 2035 and high electrification may be ambitious

Transmission topologies

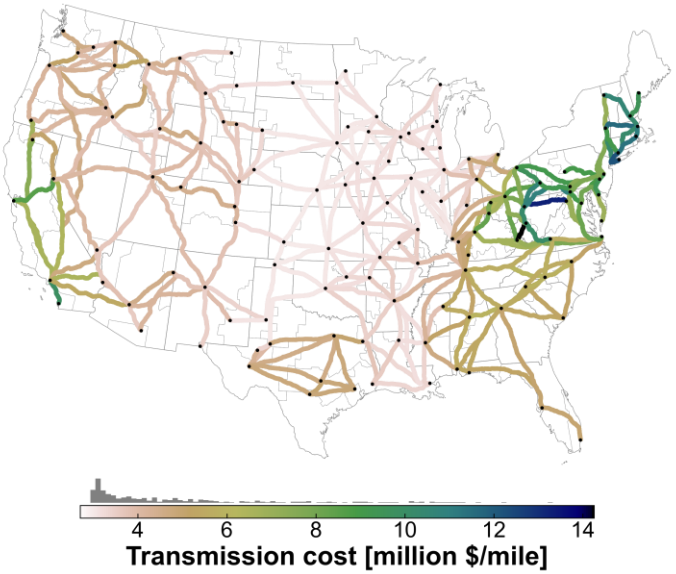
- More constraints on intra-regional expansions
- Trade-offs between inter- vs. intra-regional transmission
- Prioritize inter-interconnection and macrogrid, less interest in intra-interconnection one

Key capacity-expansion questions for the TRC



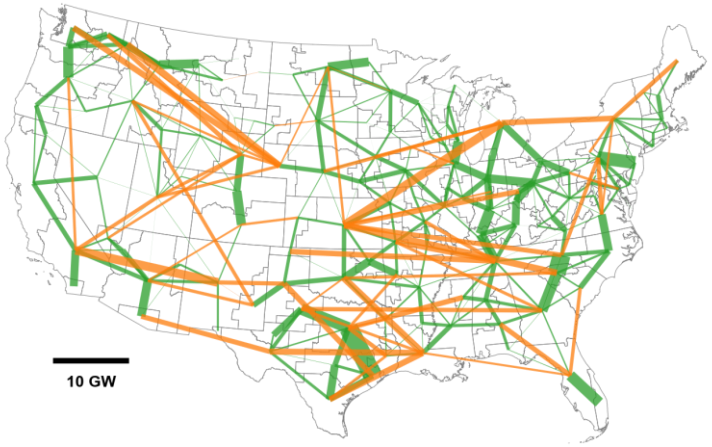
1. In what year should new, **currently unplanned** transmission capacity additions start to be allowed?

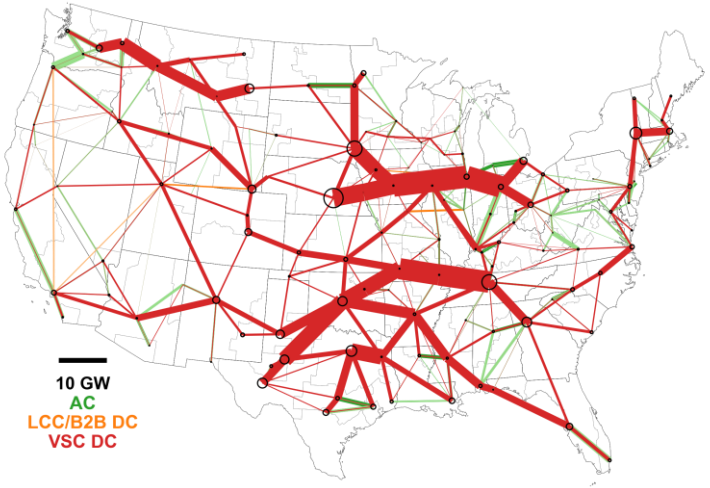
Should it depend on technology, location, or other factors?



2. Are the assumed **cost and performance** characteristics appropriate?

Are there other characteristics that should be considered?





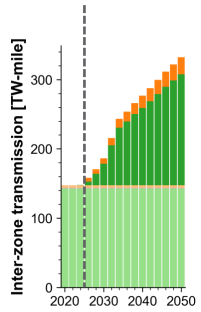
3. Is it worthwhile to consider both **LCC** and **VSC** DC, or other high-capacity options?

4. **What geographic resolution** for transmission construction is needed for actionable findings? (Total TW-miles, inter-region capacities, individual lines…?)

Select items from TRC feedback received to date

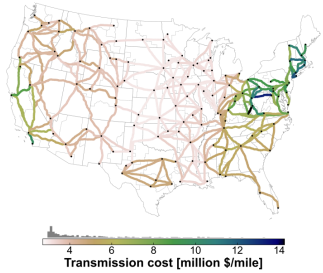
First year for new transmission builds

- Predominantly > 10 years [2026 (1), 2028 (3), 2030 (4), 2033 = 10 years (4), 2035 (1)]
- Depends on multiple factors (technology, land type, regulatory environment, population)



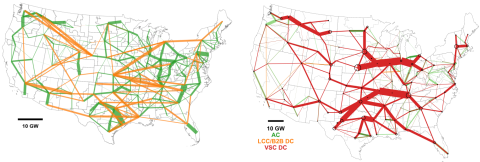
Transmission costs and performance

- Reasonable process and assumptions, though some specific regions may differ
- Different voltages (& costs & ROW widths) for new AC in different regions?
- Impact of ROW width on cost



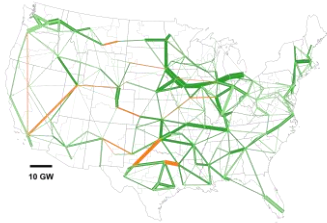
LCC vs. VSC

- Mixed opinions, but more support for considering both LCC and VSC
- Concern about HVDC breakers (& other features not in CEM); suggestion to discuss with HVDC vendors



Geographic resolution

- Need more than TW-miles; mixed opinions on individual lines vs. inter-regional capacities



Interregional Renewable Energy Zones (IREZs)

What is an IREZ?

- A tool for siting transmission, not for siting renewable energy projects
  - Site transmission based on the likelihood of maximizing its utilization
  - Development of renewable energy projects will follow the transmission
- Conceptual collection point for a high volume of low-cost renewable energy
  - Treatment as a single collection point enables comparison with other zones and makes cost analyses more understandable
  - A subsequent transmission development plan for an IREZ may include multiple lines and substations, taking into account network characteristics that do not enter into the IREZ analysis
- No geographic perimeter to an IREZ
  - Not useful
  - Misleading, because it would falsely imply a distinction between potential sites on either side of the boundary

Criteria for IREZ Resources

- Market demand for the technology is already robust (and pent-up due to insufficient transmission access)
- Productivity of the technology is site-dependent
- Technology can be developed in concentrations that allow economies of scale with respect to transmission ("supersizing" new lines)

Steps to identifying IREZs

- Apply resource data (NREL WIND Toolkit, National Solar Resource Database)
- Apply land use exclusions
- Determine weights for encouraging or discouraging development in certain areas
- Conduct a cluster analysis to identify optimal collection points
- Characterize the resources capable of connecting to the IREZ collection point
  - Supply curve that includes estimated busbar cost and gen-tie costs
- Compare supply curve with average cost of generation
  - By region
  - Combining regions to test the value of interregional transmission from IREZ to load

Timeline

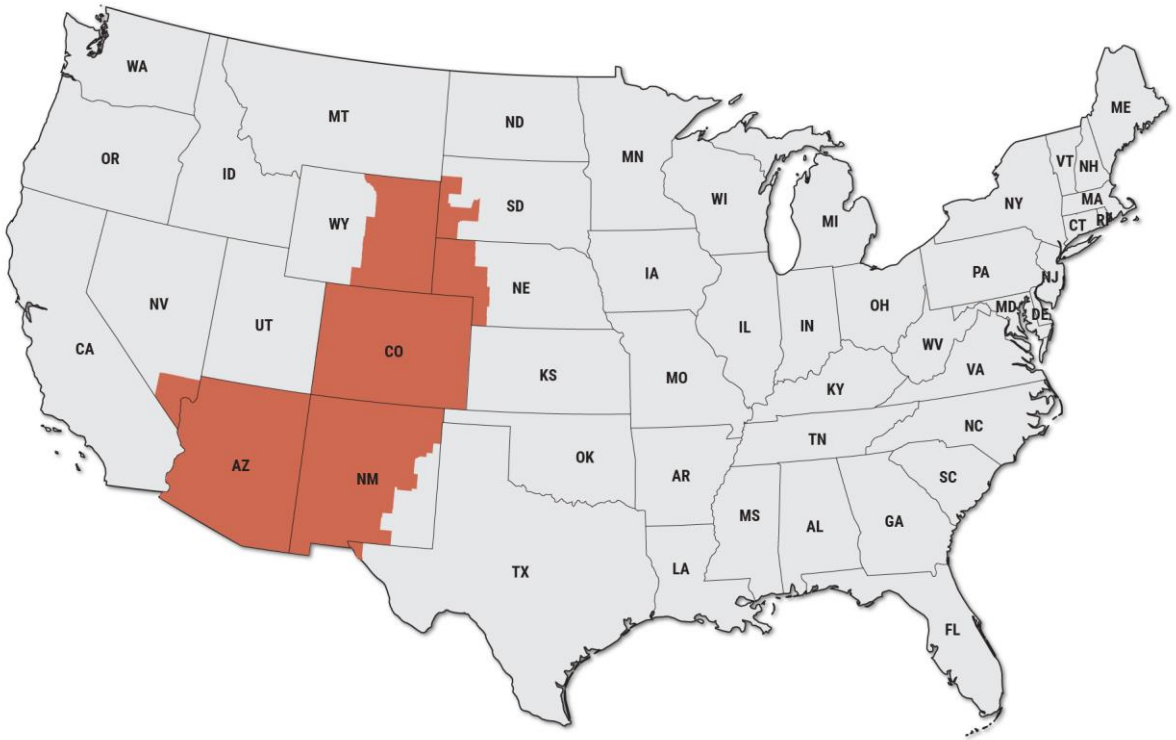
- Preliminary methodology introduced today
- Revised methodology and results will be presented to the Government Subcommittee

	Milestones
June	For a test region (WestConnect): implement spatial exclusions, apply resource overlays for wind and solar, conduct clustering analysis
Today	Present preliminary methodology and results for WestConnect to TRC Land Use Subcommittee for review and comment
July	Conduct TRC preferences survey
July 11	Post on TRC website technical memorandum describing revised methodology
Early August	Apply revised methodology to CONUS. Post IREZ map on TRC website.
Late August	Conduct load-matching analysis, present results to TRC (government and land use subcommittees) for review and comment.
Sept. 30	Finalize IREZ methodology documentation; solicit interest from TRC (government subcommittee) in customizing analysis for specific regions

Input and comment requested today

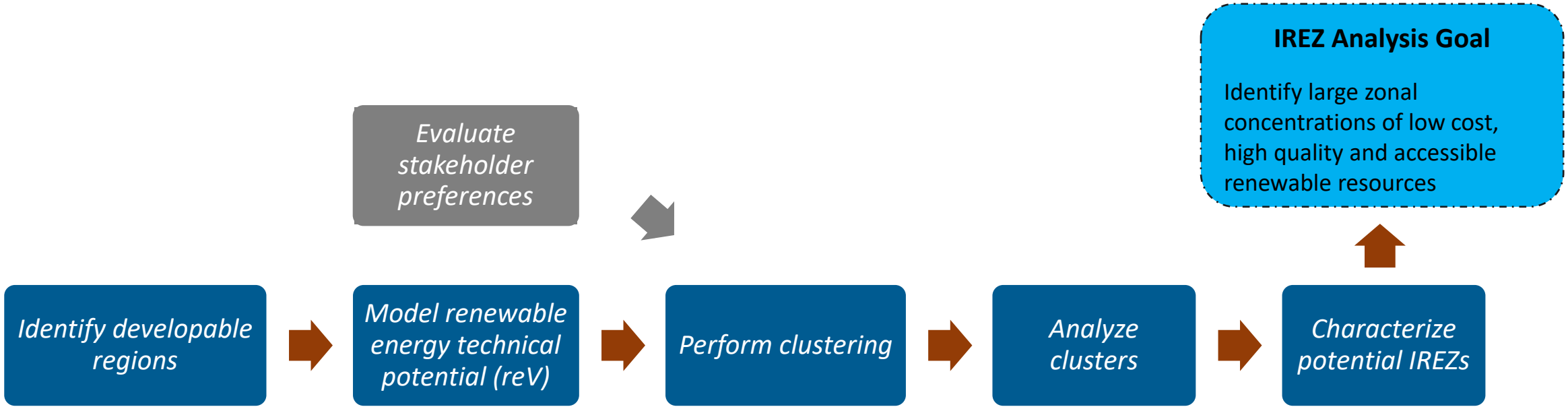
- Feedback on IREZ framework
  - Do the results of the test analysis for WestConnect make sense?
- Items to add in the survey of preferences for geospatially weighting developable areas

WestConnect Test Region



Application of preliminary IREZ methodology to WestConnect

Workflow Schematic



Key datasets and technology assumptions

National Solar Radiation Database (NSRDB)

- High fidelity solar resource data spanning CONUS and beyond
- 4 km spatial resolution
- Half-hourly temporal resolution for key solar radiation variables
  - Global horizontal, direct normal and diffuse horizontal irradiance

PV System 2030 Moderate

- 1-Axis Tracking (Non-bifacial)
- Azimuth : 180 Degrees (due South)
- Inverter Efficiency: 96%
- Losses : 14.1%
- Capacity Density: 32 MW/km^2
- DC:AC ratio: 1.3

Wind Integration National Dataset (WIND) Toolkit

- High fidelity modeled wind resource data spanning CONUS and beyond
- 2 km spatial resolution
- Hourly temporal resolution for wind speed/direction/atmospheric variables at multiple hub heights

Wind 2030 Moderate

- Turbine Capacity: 5.5 MW
- Hub Height: 120 m
- Rotor Diameter: 175 m
- Losses: 11.8%
- Capacity Density: 3 MW/km^2

Note: We modeled potential wind and solar generation using hourly data for the period spanning 2007-2013

Spatial exclusions

Wind

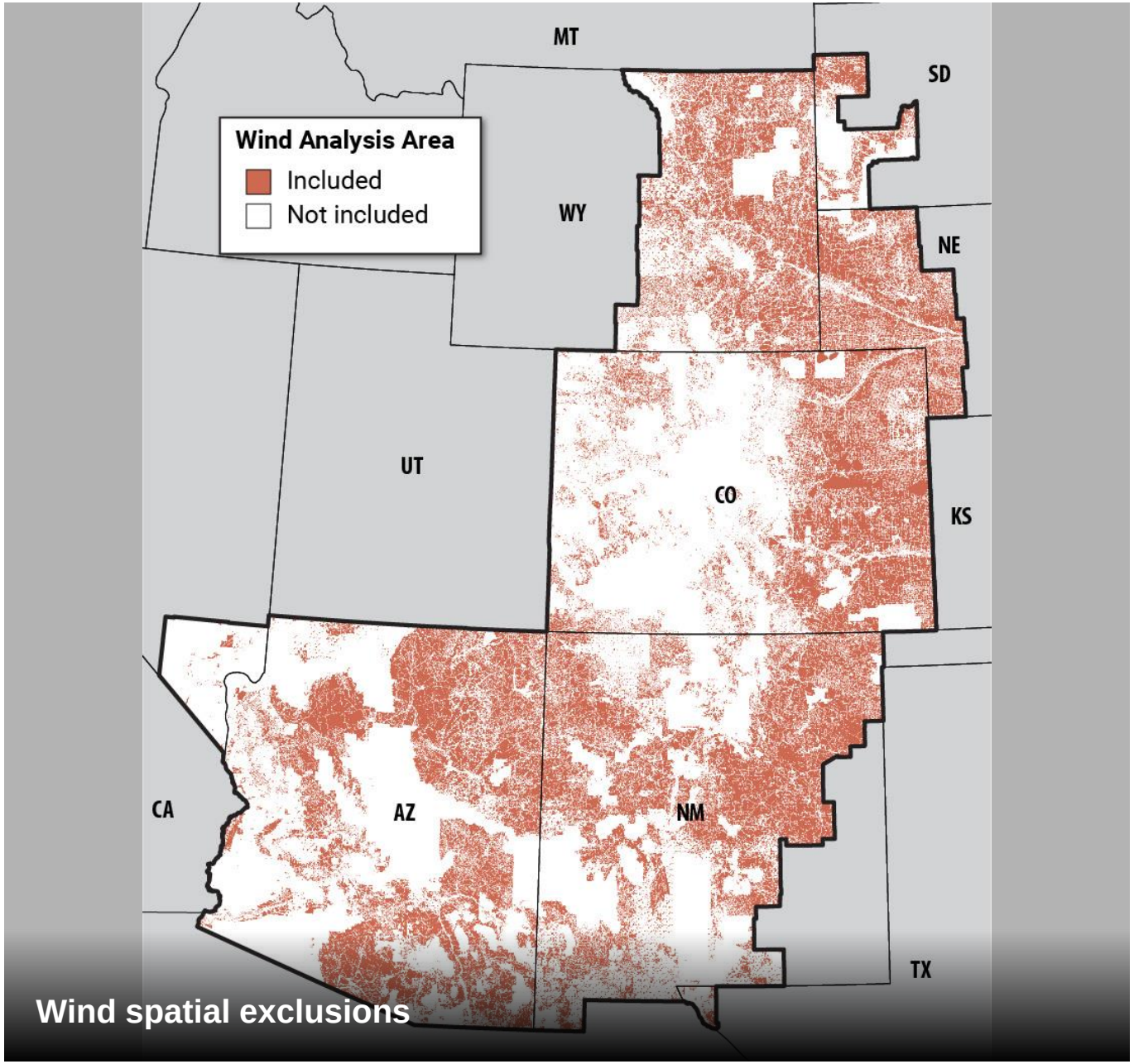
Category	Variable
Federal Land	Areas of Critical Environmental Concern (BLM)
	Inventoried Roadless Areas (USFS)
	National Battlefield
	National Conservation Area
	National Fish Hatchery
	National Monument
	National Park
	National Recreation Area
	National Scenic Area
	National Wilderness Area
	National Wildlife Refuge
	Wild and Scenic River
	Wildlife Management Area
Natural Landscapes	Water bodies
	Woody Wetlands 1,000ft buffer
	Herbaceous Wetlands 1,000ft buffer
Existing Structures and Setbacks	Airports
	Existing Moratoriums
	Height Limits
	Rail Setbacks (existing plus extrapolated 1.1x tip-height)
	River Setbacks (existing plus extrapolated 1.1x tip-height)
	Road Setbacks (existing plus extrapolated 1.1x tip-height)
	Structure Setbacks (existing plus extrapolated 1.1x tip-height)
	Transmission Setbacks (existing plus extrapolated 1.1x tip-height)
	Existing Rail
	Existing Roads
	Existing Structures
	Existing Transmission right-of-way
	Existing Wind Facilities (used as inclusion layer)
	Urbanized Areas (GHSL SMOD)
Physical Land Characteristics	Include land mass only (no barrier islands, keys, etc.)
	High Mountains
	Radar (NEXRAD 4km)
	Radar (DoD 9km)
	Shadow Flicker - Over 30 hours exposure per year for 120m hub height turbine
	Slope
Protected Areas	Land Managed for Biodiversity (NCED)
	Land Managed for Biodiversity (PAD-US)

Solar

Category	Variable
Federal Land	National Battlefield
	National Fish Hatchery
	National Monument
	National Park
	National Recreation Area
	National Scenic Area
	National Wilderness Area
	National Wildlife Refuge
	Wild and Scenic River
	Wildlife Management Area
Natural Landscapes	Waterbodies
	Woody Wetlands
	Herbaceous Wetlands
	'Existing' Prime / Important Farmlands on Current Croplands
Land Use	Buildings
	Airports
	Railways
	Transmission Right-of-Ways
	Roadways
	Landmarks
	Parks
	Urban Areas
	Suburban Areas
	NG HGL Petroleum Crude Pipelines
Physical Land Characteristics	High Mountains
	Slope Threshold
Protected Areas	USFS Inventoried Roadless Areas
	Land Managed for Biodiversity
	Areas of Critical Environ. Concern
	Land Managed for Biodiversity

Exclusions are based on the reference access siting regime, which represents best current understanding of best practices for renewable energy siting.

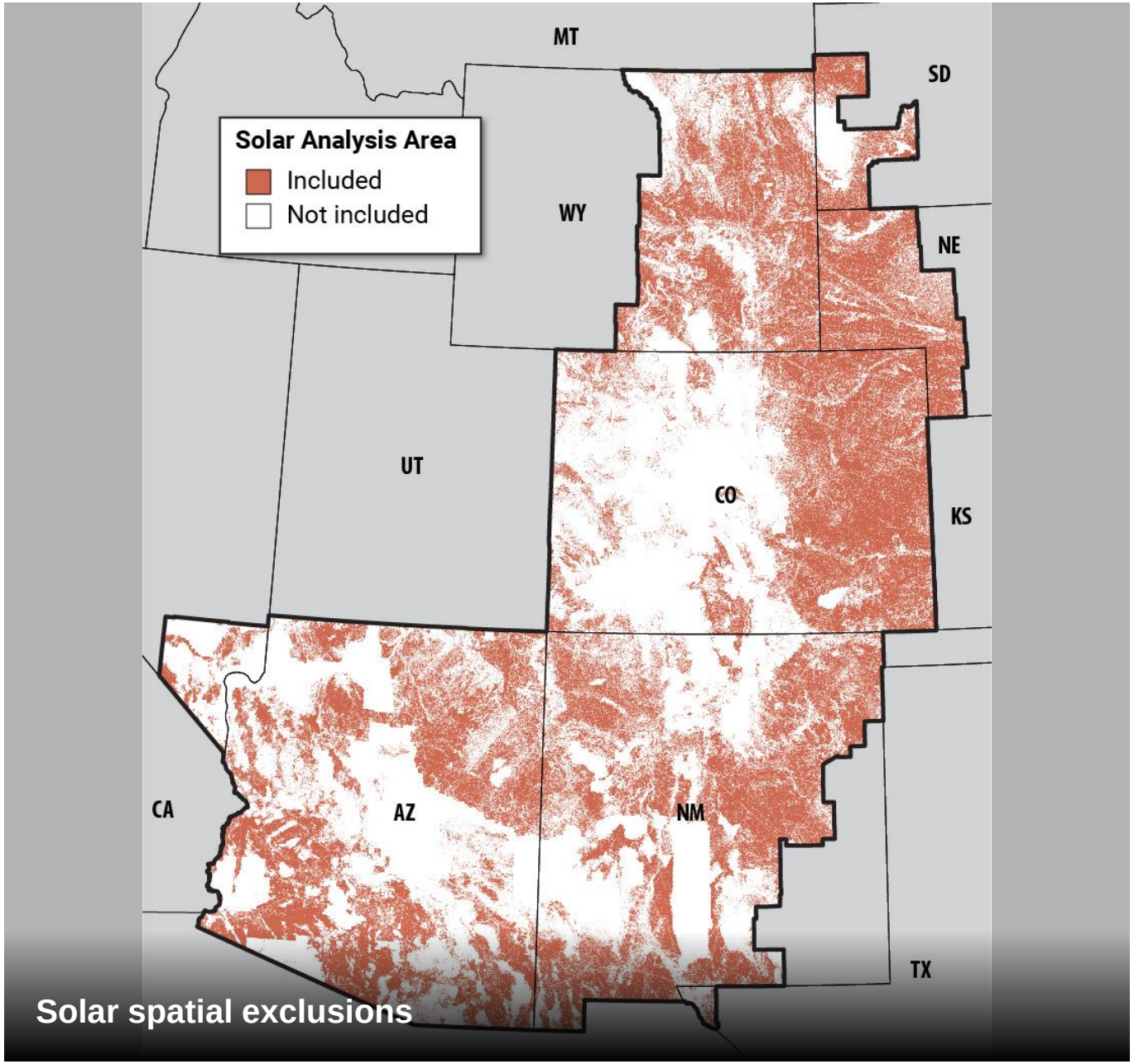
Wind exclusions



Wind spatial exclusions

Note that the test region analysis currently excludes federal lands. <u>These lands will not be excluded</u> in the national IREZ assessment per the exclusions slide.

Solar exclusions



Solar spatial exclusions

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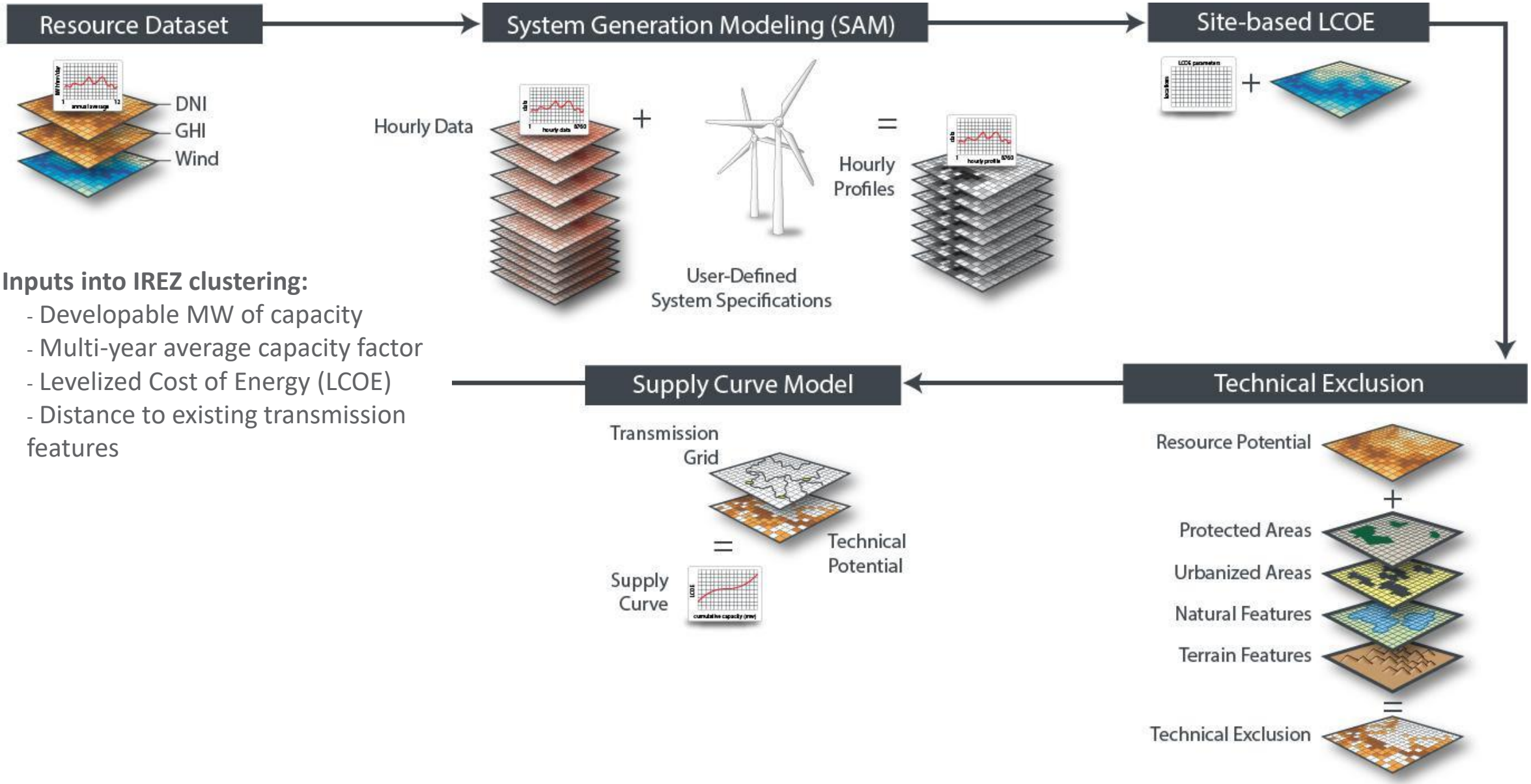
Renewable Energy Potential Model (reV)



Inputs into IREZ clustering:

- Developable MW of capacity
- Multi-year average capacity factor
- Levelized Cost of Energy (LCOE)
- Distance to existing transmission features

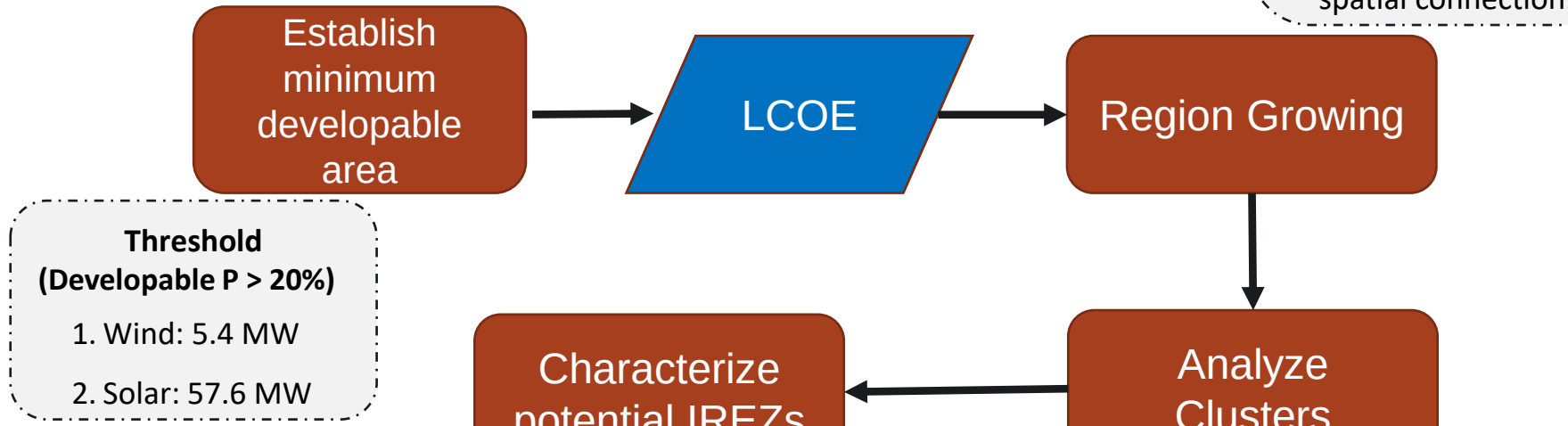
Clustering methodology

We use a data-driven approach to identify potential IREZs based on available capacity, site-LCOE and spatial connectivity. *The feature space will be expanded to include stakeholder friction based on the AHP survey.*

Key Criteria

1. Identify sites within the top 10% of regional site-LCOE values
2. Expand cluster if comparable sites are within 25 km
3. Balanced results based on LCOE and spatial connection.

Spatial resolution: 3 km * 3 km



Threshold (Developable P > 20%)

1. Wind: 5.4 MW
2. Solar: 57.6 MW

1. Total Capacity
2. Supply Curve (i.e., cumulative capacity below LCOE price point)

Refine Clusters

1. 10 Clusters
2. Remove small & isolated clusters (Total capacity < 1GW)

Should the clustering account for other features beyond capacity and site-LCOE?

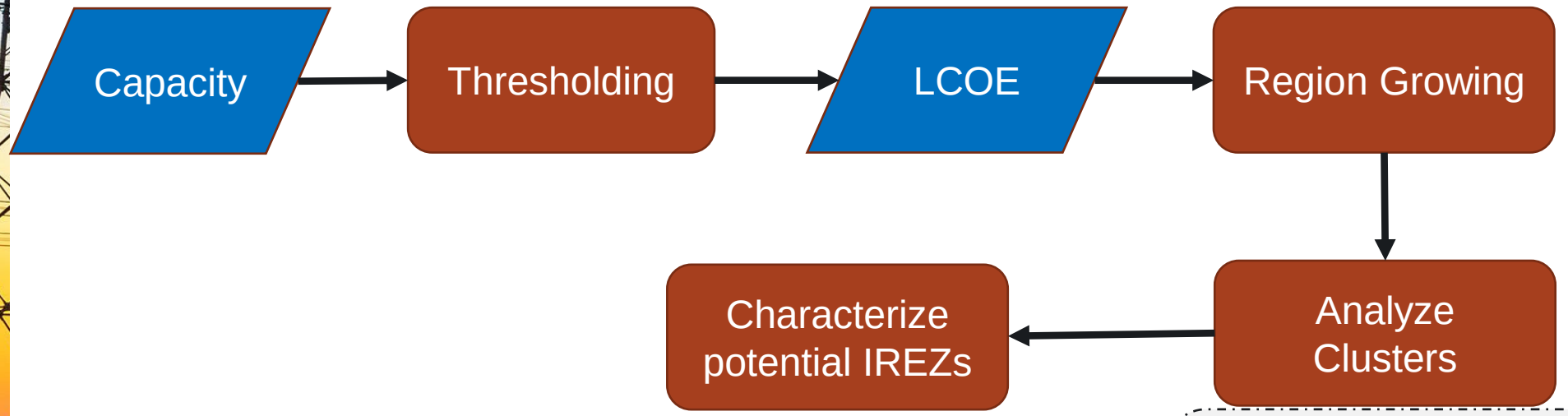
Clustering methodology

Threshold (Developable P > 20%)

1. Wind: 5.4 MW
2. Solar: 57.6 MW

Key Criteria

1. Lowest 10% LCOE
2. Spatial connectivity: closest neighboring <= 25km
3. Balanced results based on LCOE and spatial connection.



1. Total Capacity
2. Supply Curve (i.e., cumulative capacity below LCOE price point)

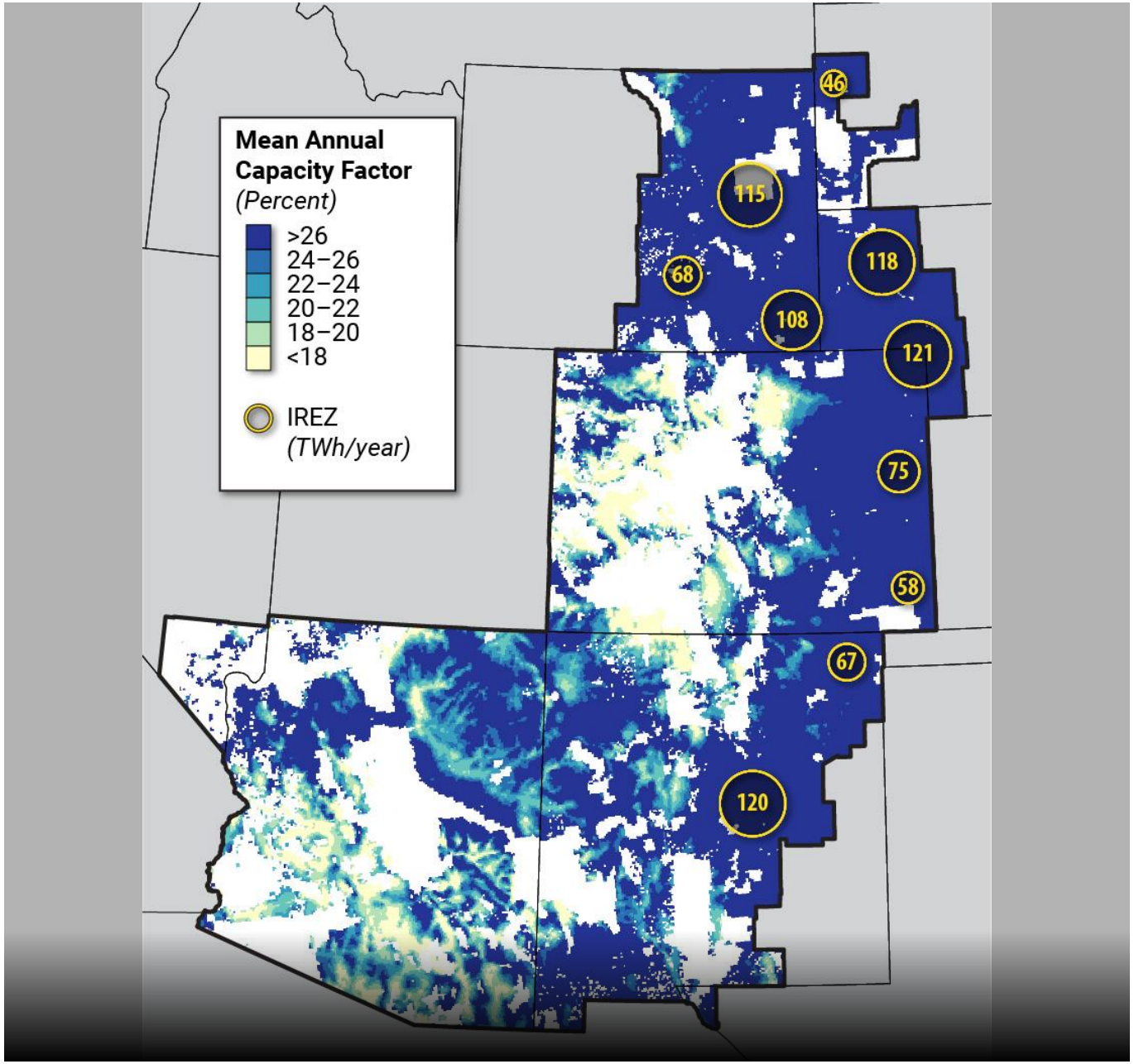
Refine Clusters

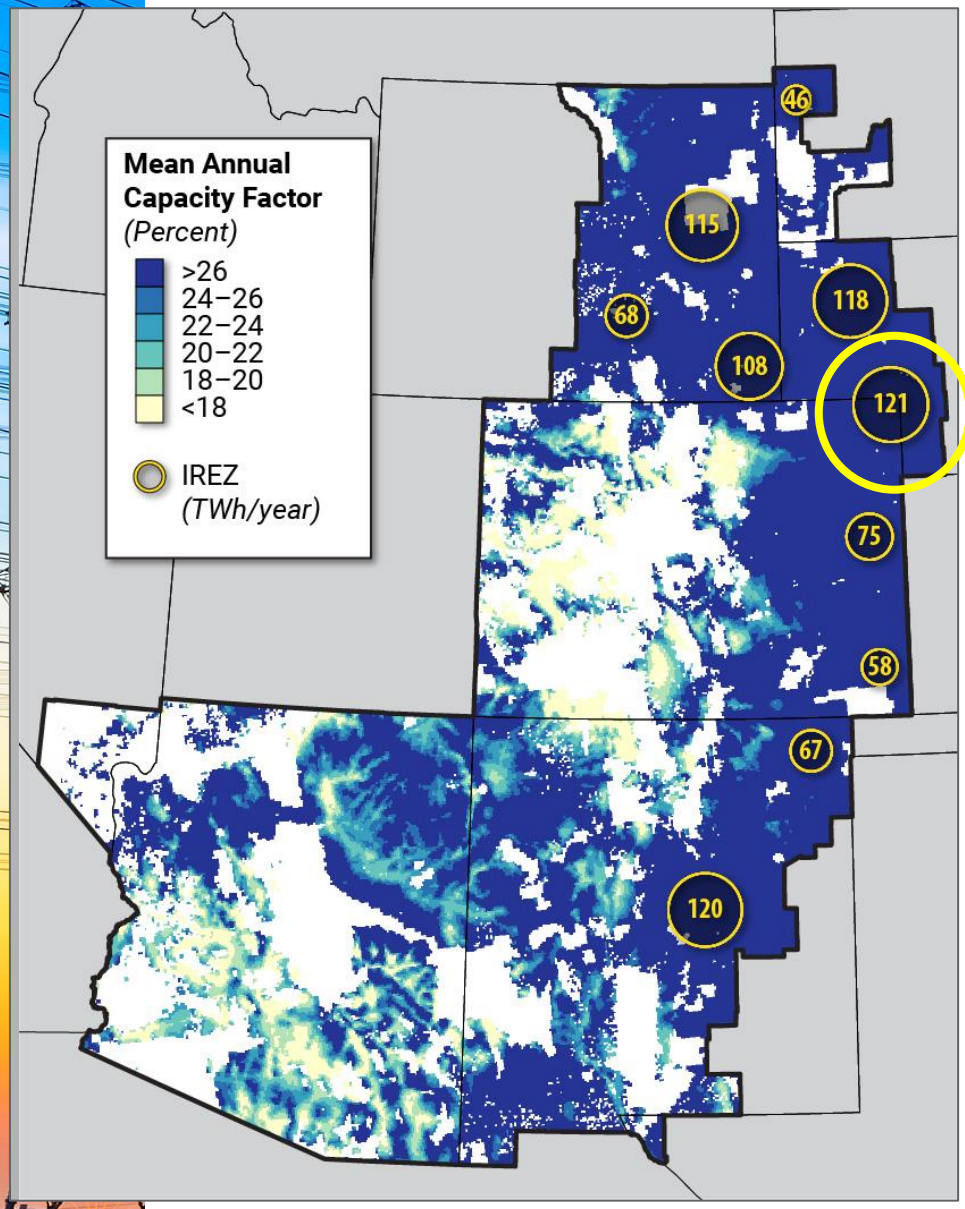
1. 10 Clusters
2. Remove small & isolated clusters (Total capacity < 1GW)

Spatial resolution: 3 km * 3 km

Wind results

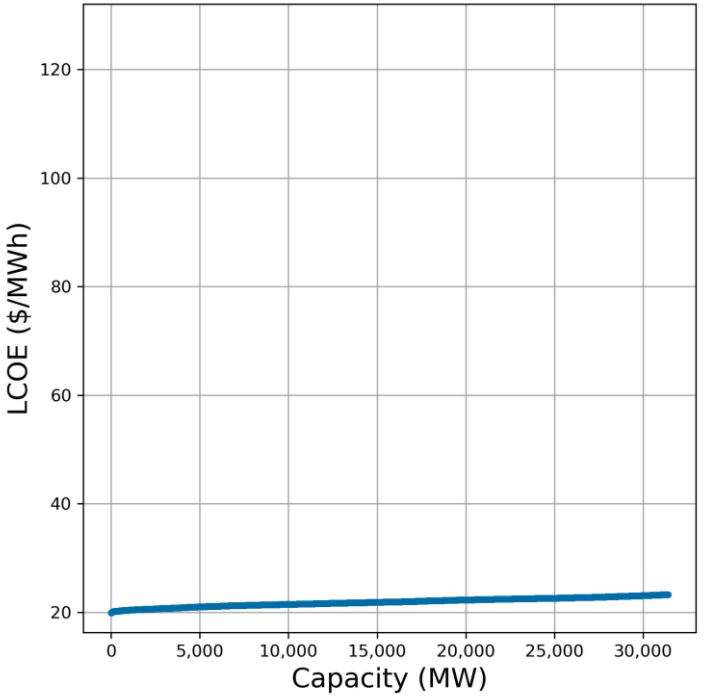
- Map of nodes with proportional sizing



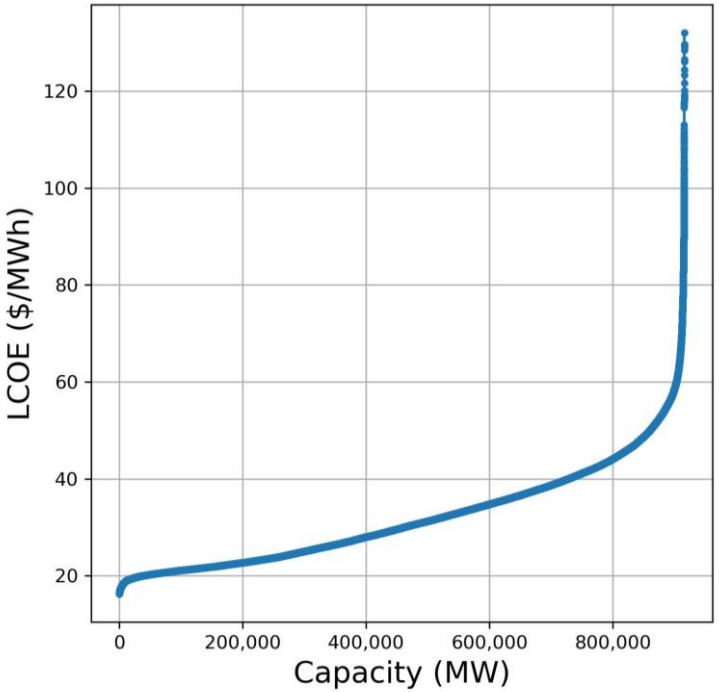


ID	Total Capacity (GW)	Average LCOE ($/MWh)	Annual Energy (TWh/year)	Average CF
1	12	21.83	46	0.44
2	14	20.98	58	0.44
3	16	20.07	68	0.44
4	17	21.27	67	0.44
5	19	22.18	75	0.44
6	26	20.39	108	0.44
7	29	21.22	115	0.44
8	29	21.19	118	0.44
9	30	21.23	120	0.44
10	31	21.88	121	0.44
TOTAL	223	/	896	/

Supply Curve for Cluster 10

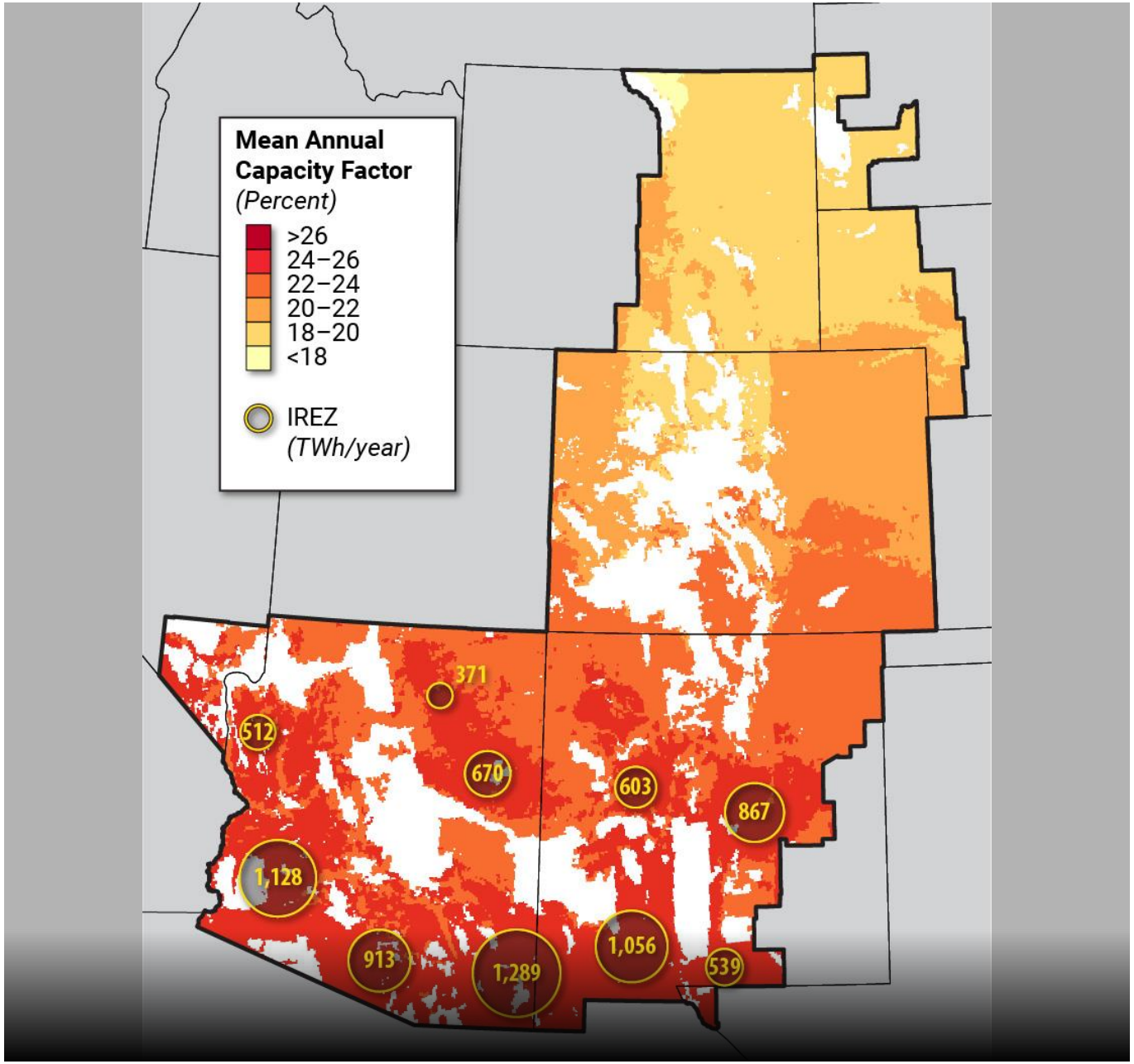


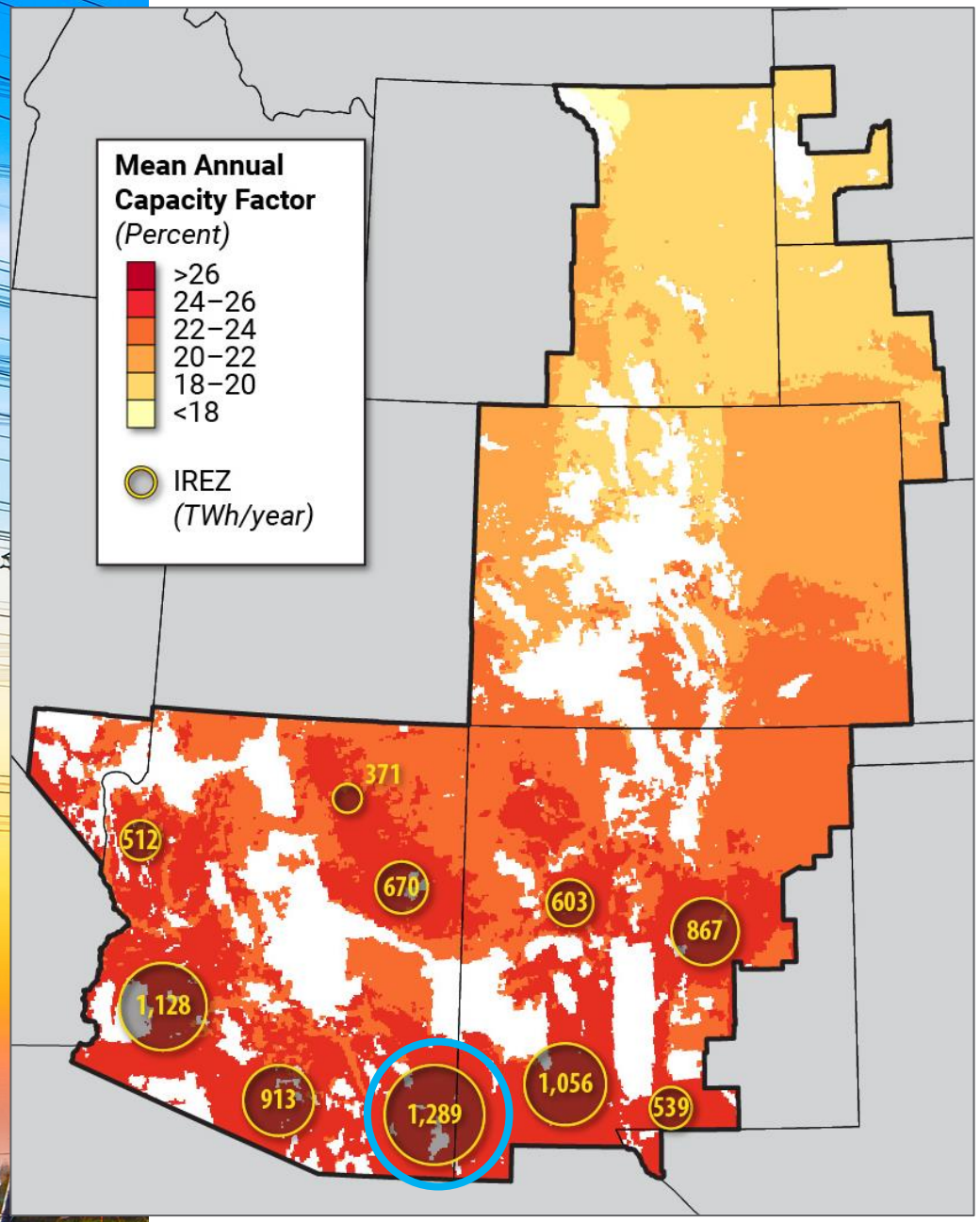
Supply Curve for Non-excluded Area



PV results

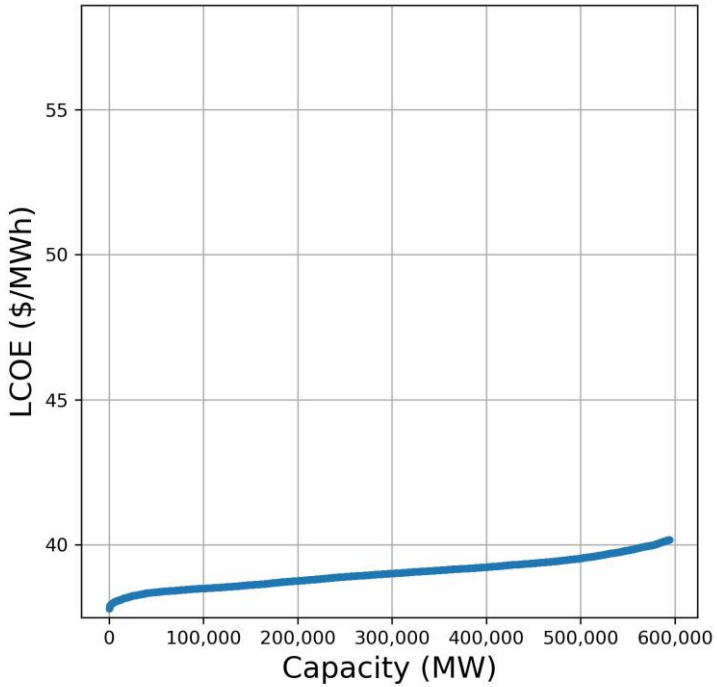
- Map of nodes with proportional sizing



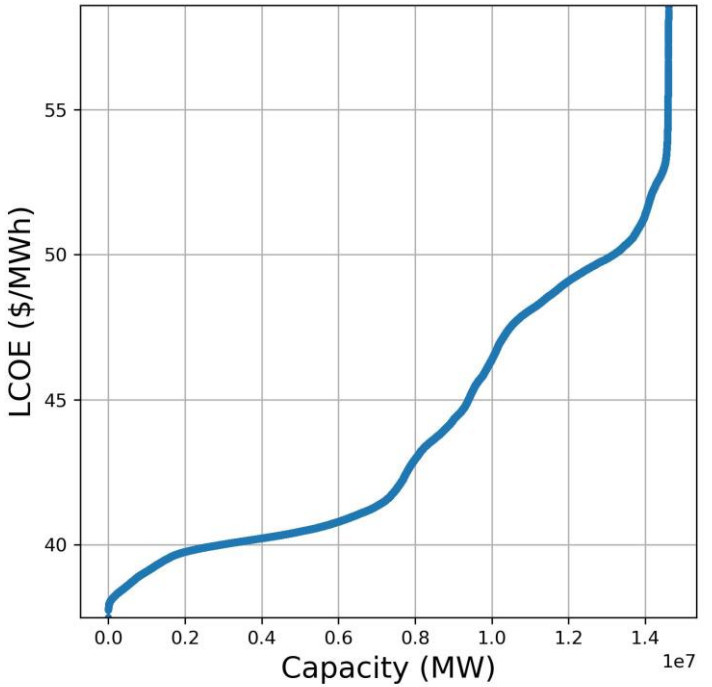


ID	Total Capacity (GW)	Average LCOE ($/MWh)	Annual Energy (TWh/year)	Average CF
1	175	39.98	371	0.25
2	240	39.84	512	0.25
3	247	38.92	539	0.25
4	284	39.97	603	0.25
5	315	39.92	670	0.25
6	408	39.95	867	0.25
7	425	39.61	913	0.25
8	480	38.71	1056	0.25
9	527	39.7	1128	0.25
10	592	39.06	1289	0.25
TOTAL	3692		7946	

Supply Curve for Cluster 10



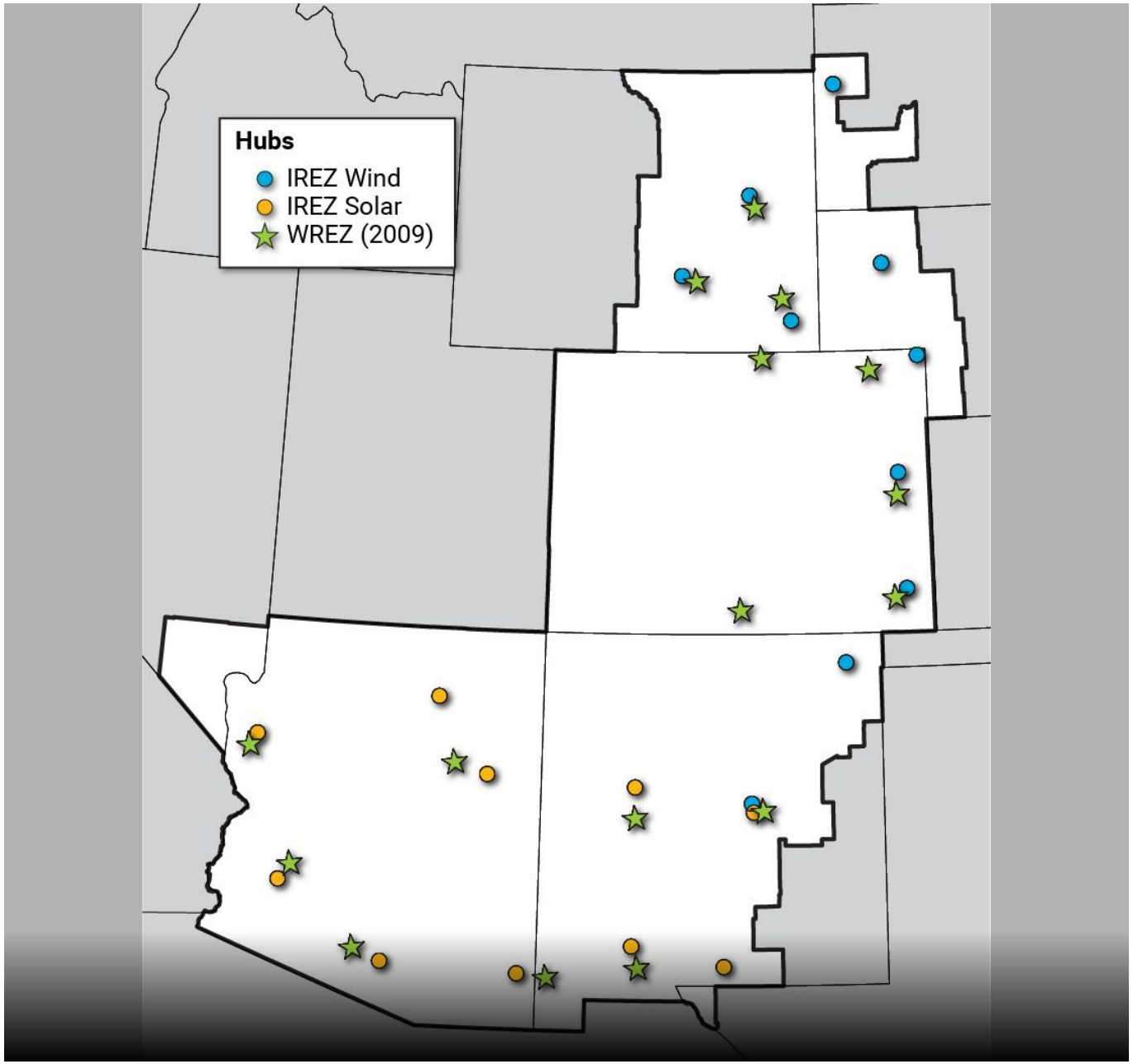
Supply Curve for Non-excluded Area



Comparison with WREZ hubs

- Test: Does the initial IREZ methodology for national application calibrate with zones identified in 2009 for Western Interconnection (Western Renewable Energy Zone Initiative)

Are these interim results intuitive?
Are there any major surprises?



TRC survey of siting preferences

Challenges in Spatial Energy Planning

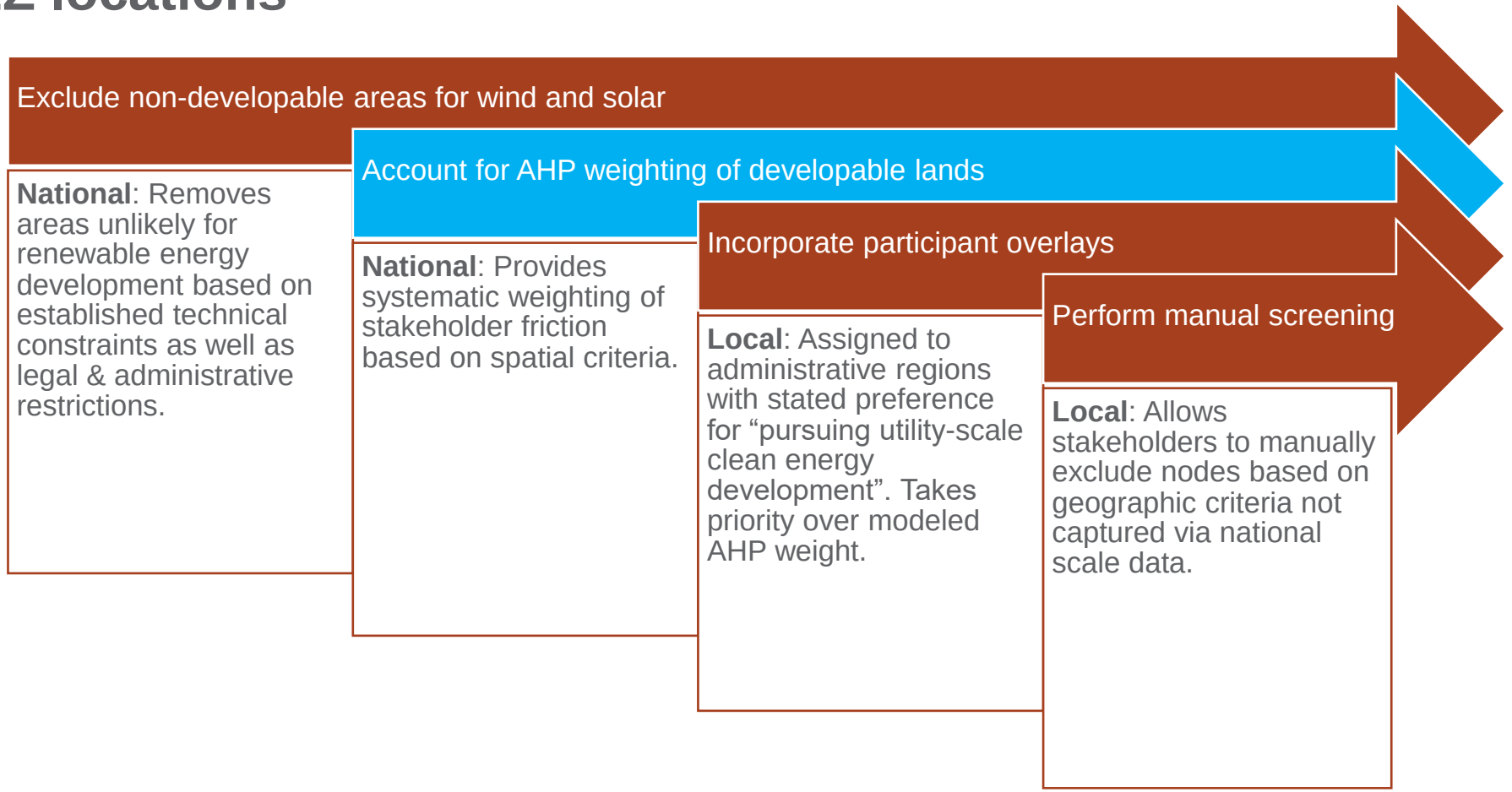
- Energy planning involves complex decision making across many objectives
- Given the multi-use and multi-faceted nature of lands potentially available for energy development, approaches that can be used to gather and robustly evaluate stakeholder input are needed along with tools that can readily incorporate this information into the planning process
- Ideally, stakeholder preferences could be portrayed spatially to facilitate integration with other critical forms of information used in evaluating alternative locations

What is the Analytic Hierarchy Process (AHP)?

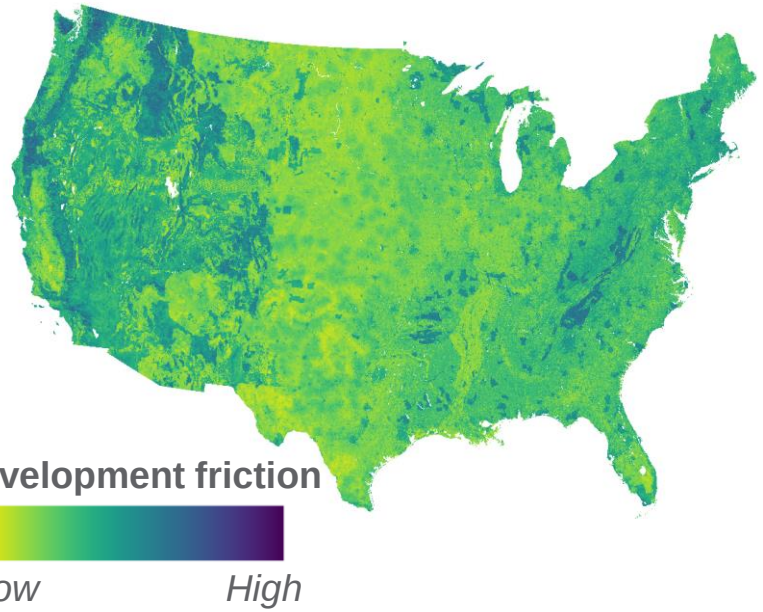
- AHP is a mathematical method for analyzing decisions with multiple attributes
- It works by decomposing a decision problem into a hierarchy of key decision elements
- The hierarchy is composed of top-level objectives, each of which has its own set of criteria
- Preferences for attributes are determined through user input. Users are asked to perform pairwise comparisons among attributes in which they express the intensity of preference on a nine point scale.
- Numerical techniques provide quantitative weights based on these comparisons.
- AHP is a structured and systematic approach that can reveal global priorities and rankings for complex decisions based on acquired preferences

Role of AHP in Informing IREZ locations

AHP plays a complementary role in the spatial assessment of potential IREZ locations



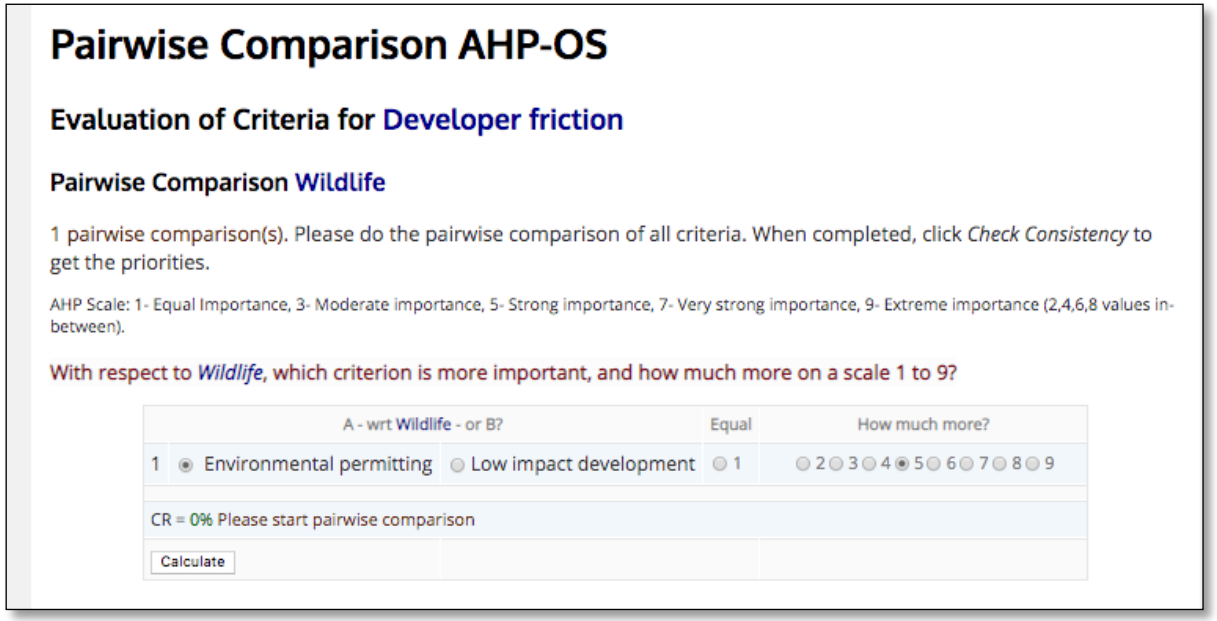
Spatial depiction of AHP weightings



This map offers a visual depiction of a national friction surface developed through AHP. The map is intended to be illustrative and is unrelated to IREZ.

- Each criterion in the decision hierarchy must be accompanied by a spatial indicator that maps out the criteria
- Spatial criteria must be numeric with values transformed such that the ordering of value has consistent meaning within the hierarchy
- Once the AHP weights have been established, they can be applied to generate a national map of stakeholder preferences that can be used to infer relative land "friction" for IREZ planning.
- The resulting map(s) will be used as input into the clustering algorithm such that clusters account for the derived land suitability

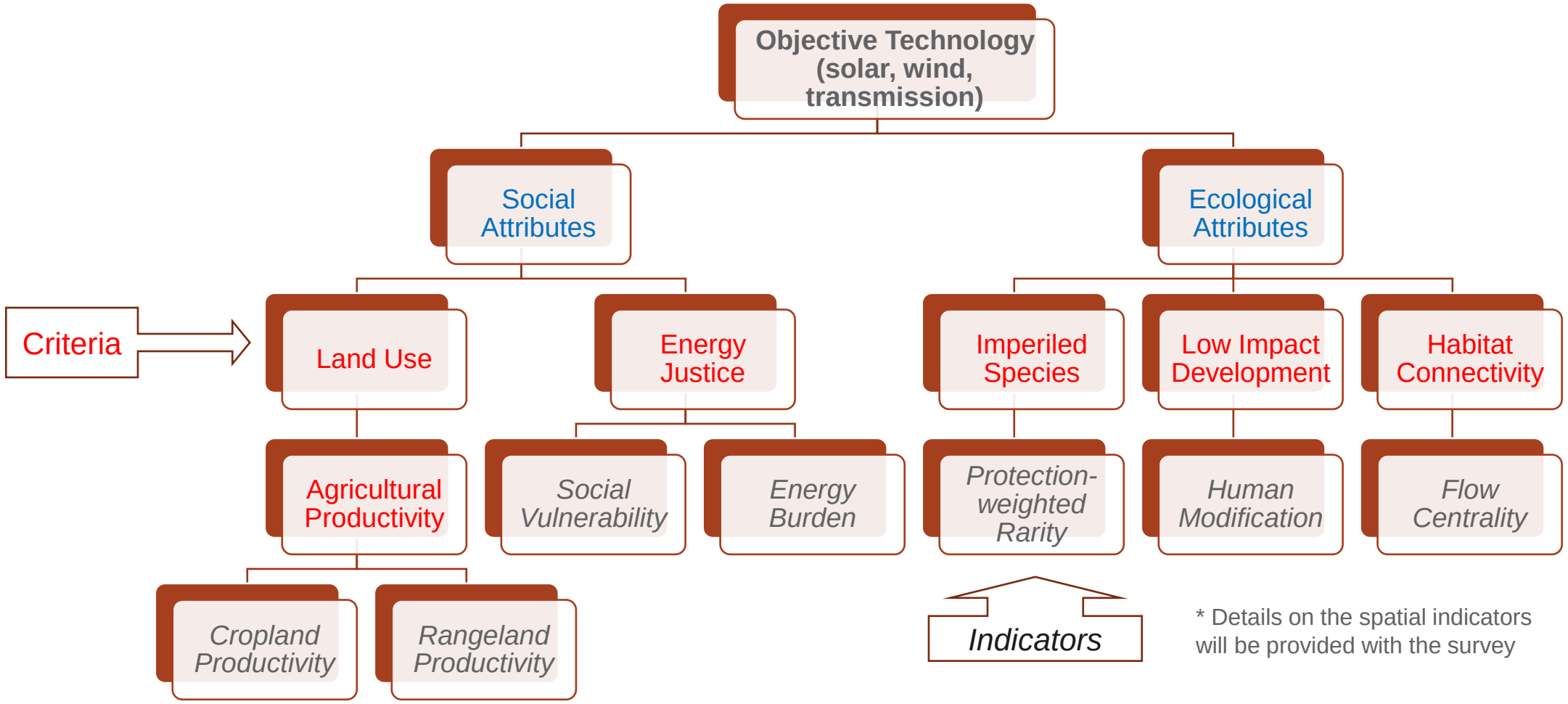
AHP requirements and application



This is an example of the survey interface that will be used to collect AHP weights from the TRC.

- In the coming weeks, TRC members will be asked to complete an online survey in which they evaluate alternatives by completing pairwise comparison of the selected criteria.
- TRC members will be given a tutorial document, providing detailed instructions and an overview of the process including an explanation of the stated objectives, criteria and spatial indicator.

Criteria and indicators to be examined with AHP



* Details on the spatial indicators will be provided with the survey

Do the attributes and criteria make sense?
Are there different criteria or spatial indicators we should consider?

General project, TRC, and timeline Q&A

Next Steps


Pacific Northwest
NATIONAL LABORATORY
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
U.S. DEPARTMENT OF
ENERGY

Next Steps

- Subcommittee members and SMEs complete and submit the feedback form provided
- Lab team will
  - Continue conducting the baseline and scenario analyses
  - Continue to develop IREZ methodology
  - Explore energy justice tools and modeling with DOE Office of EJ Policy and Analysis
- Next TRC meeting - September
- Next public webinar will be in October 2022 to share interim results

https://www.energy.gov/oe/national-transmission-planning-study

- 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**