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WEBINAR
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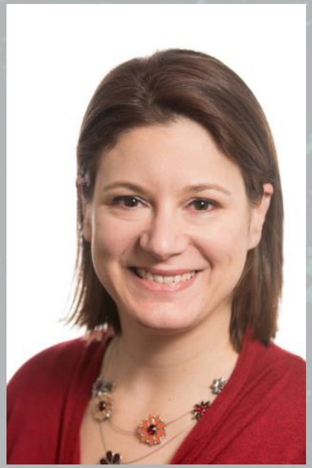

DEEP DIVE TWO: Incorporating Socioeconomic and Natural Resources Impacts into New Infrastructure Siting

Hosted by: Nathalie Voisin
Panelists: Kendall Mongird, Konstantinos Oikonomou, and Stefan Rose
July 10, 2023

Pacific Northwest
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GODEEEP
Grid Operations, Decarbonization, Environmental and Energy Equity Platform
@PNNL

Incorporating Socioeconomic and Natural Resources Impacts into New Infrastructure Siting

Kendall Mongird, Konstantinos Oikonomou, Stefan Rose, and the GODEEEP team

Mongird K., K. Oikonomou, and S.A. Rose. 07/10/2023. "Incorporating Socioeconomic and Natural Resources Impacts into New Infrastructure Siting." Online, United States. PNNL-SA-187250.

U.S. DEPARTMENT OF ENERGY BATTELLE

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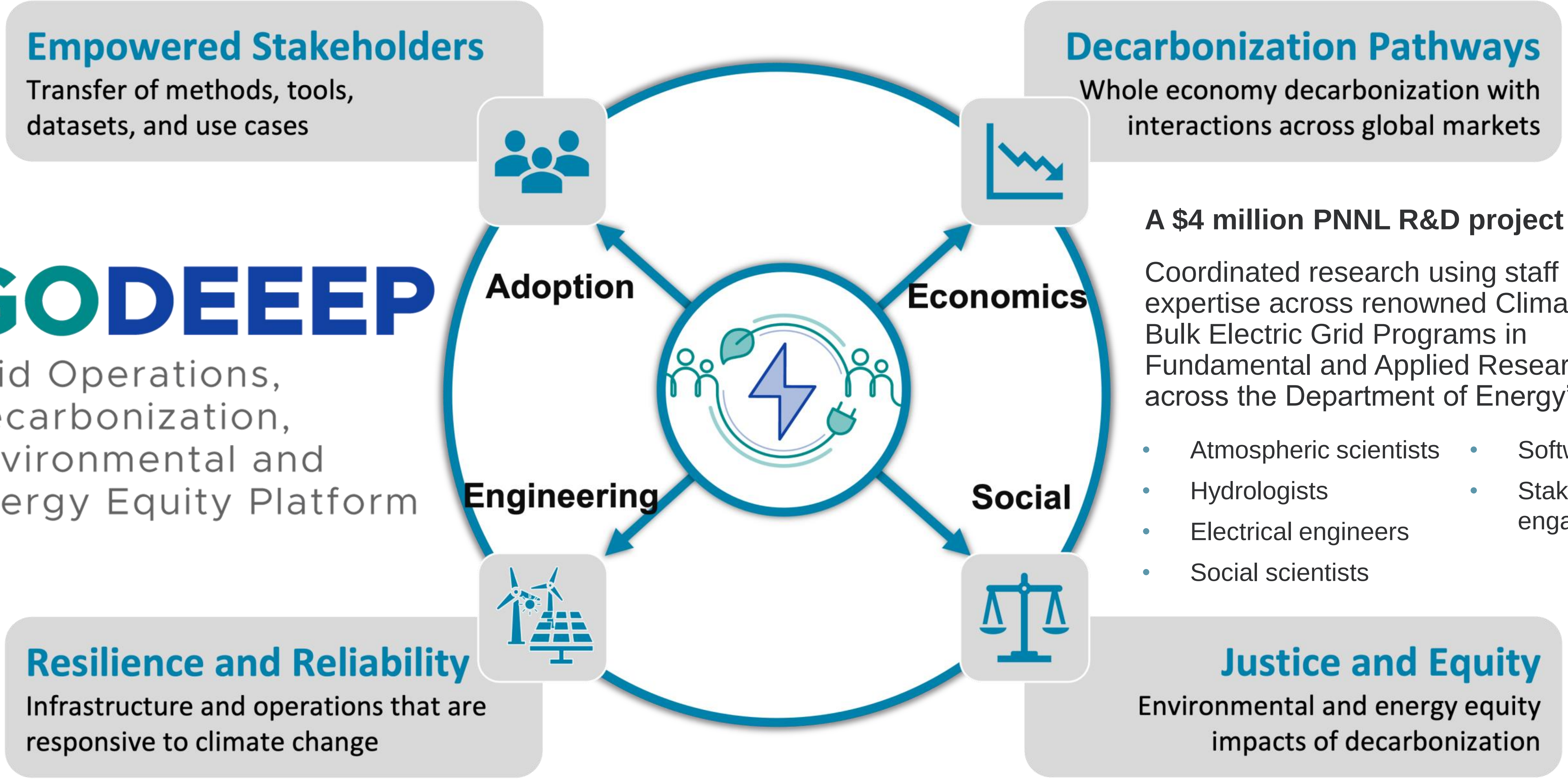
GODEEEP uses PNNL’s expertise working across fundamental and operational research in climate, power grid, and multisector dynamics



Empowered Stakeholders
Transfer of methods, tools, datasets, and use cases

Decarbonization Pathways
Whole economy decarbonization with interactions across global markets

Resilience and Reliability
Infrastructure and operations that are responsive to climate change

Justice and Equity
Environmental and energy equity impacts of decarbonization

GODEEEP

Grid Operations, Decarbonization, Environmental and Energy Equity Platform

A $4 million PNNL R&D project

Coordinated research using staff expertise across renowned Climate and Bulk Electric Grid Programs in Fundamental and Applied Research across the Department of Energy’s offices

- Atmospheric scientists
- Hydrologists
- Electrical engineers
- Social scientists
- Software engineers
- Stakeholder engagement experts

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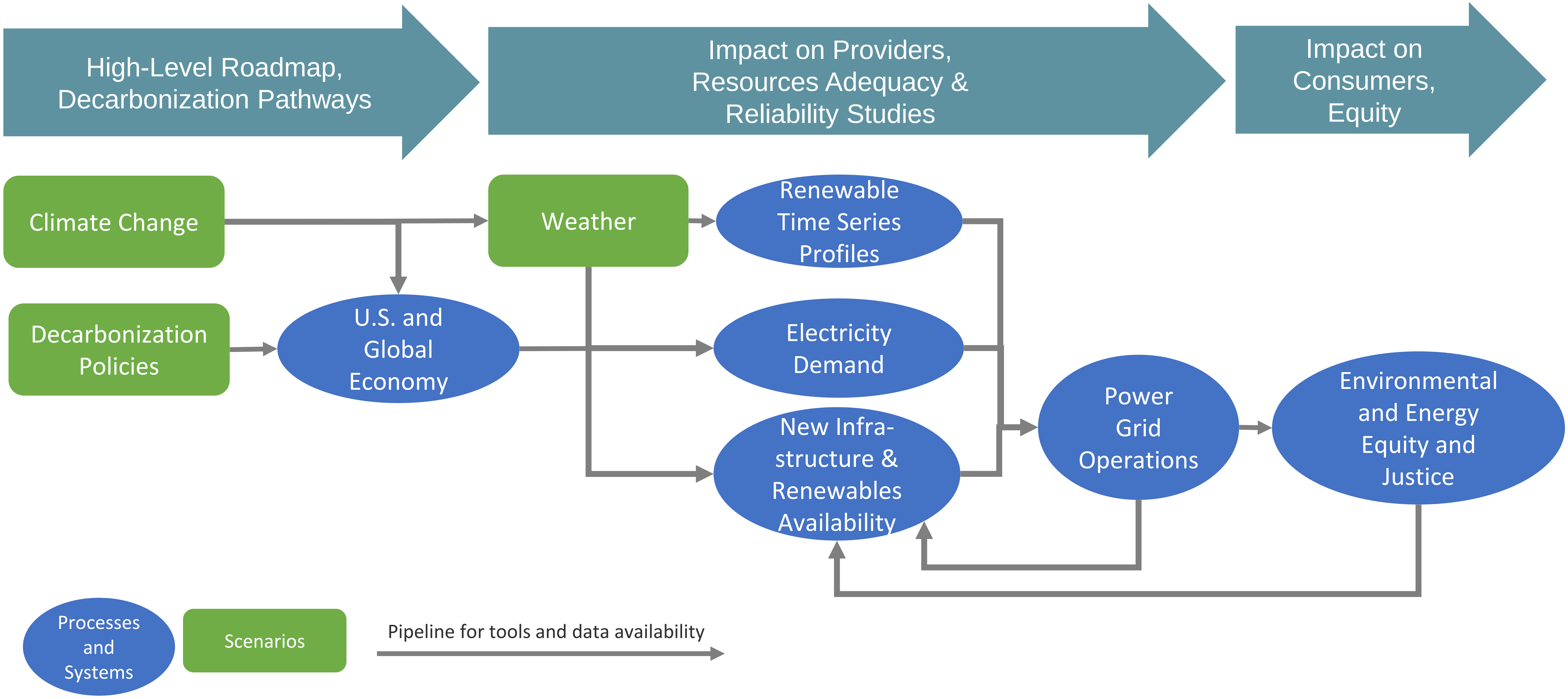
Consistent, open-source, end-to-end framework with intermediate datasets and tools for flexible customization



High-Level Roadmap, Decarbonization Pathways

Impact on Providers, Resources Adequacy & Reliability Studies

Impact on Consumers, Equity

Climate Change

Weather

Renewable Time Series Profiles

Decarbonization Policies

U.S. and Global Economy

Electricity Demand

New Infra-structure & Renewables Availability

Power Grid Operations

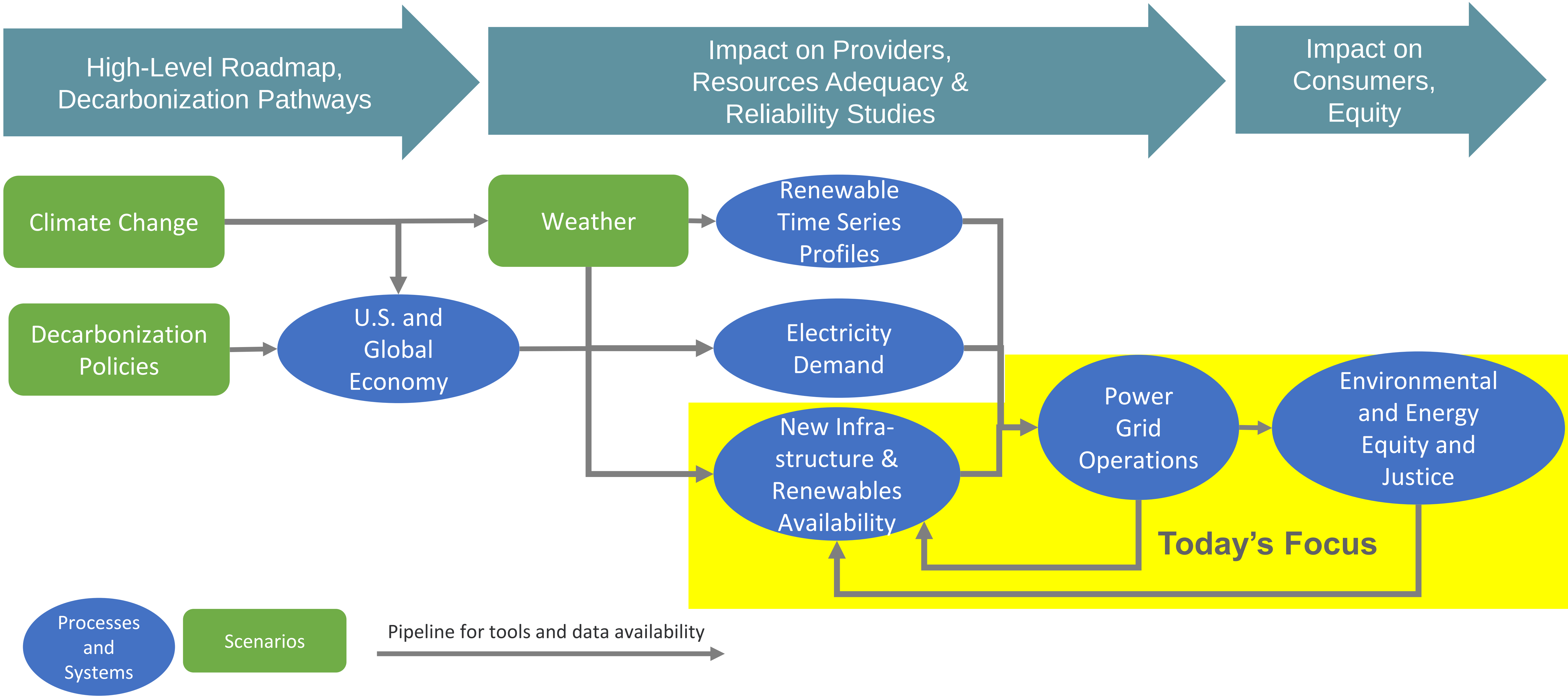
Environmental and Energy Equity and Justice

Processes and Systems

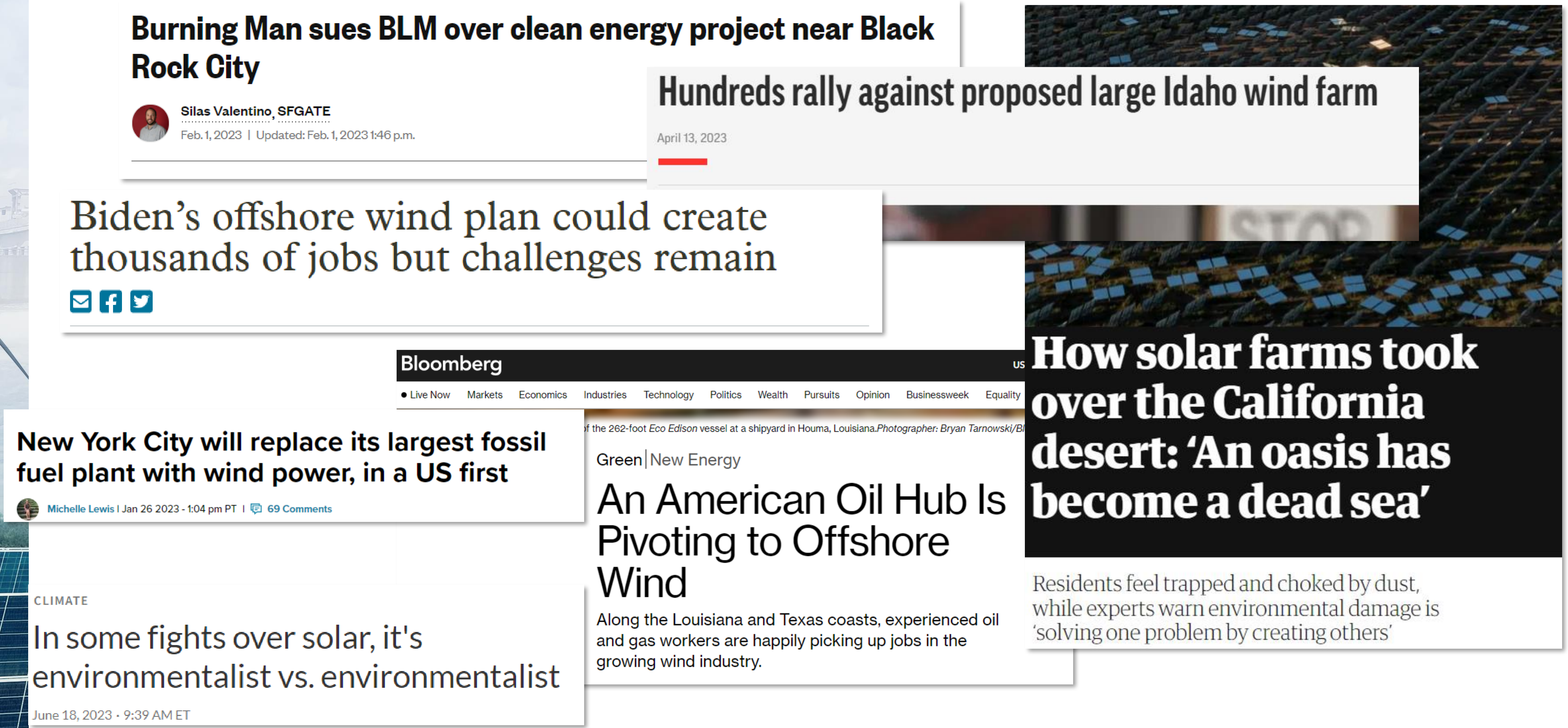
Scenarios

Pipeline for tools and data availability

Consistent, open-source, end-to-end framework with intermediate datasets and tools for flexible customization



Siting Power Plants under Decarbonization: Conflicting Impacts and Opinions



Burning Man sues BLM over clean energy project near Black Rock City

Silas Valentino, SFGATE
Feb. 1, 2023 | Updated: Feb. 1, 2023 1:46 p.m.

Hundreds rally against proposed large Idaho wind farm

April 13, 2023

Biden's offshore wind plan could create thousands of jobs but challenges remain

New York City will replace its largest fossil fuel plant with wind power, in a US first

Michelle Lewis | Jan 26 2023 - 1:04 pm PT | 69 Comments

f the 262-foot *Eco Edison* vessel at a shipyard in Houma, Louisiana.*Photographer: Bryan Tarnowski/Bl*

Green | New Energy

An American Oil Hub Is Pivoting to Offshore Wind

Along the Louisiana and Texas coasts, experienced oil and gas workers are happily picking up jobs in the growing wind industry.

How solar farms took over the California desert: 'An oasis has become a dead sea'

Residents feel trapped and choked by dust, while experts warn environmental damage is 'solving one problem by creating others'

CLIMATE

In some fights over solar, it's environmentalist vs. environmentalist

June 18, 2023 · 9:39 AM ET

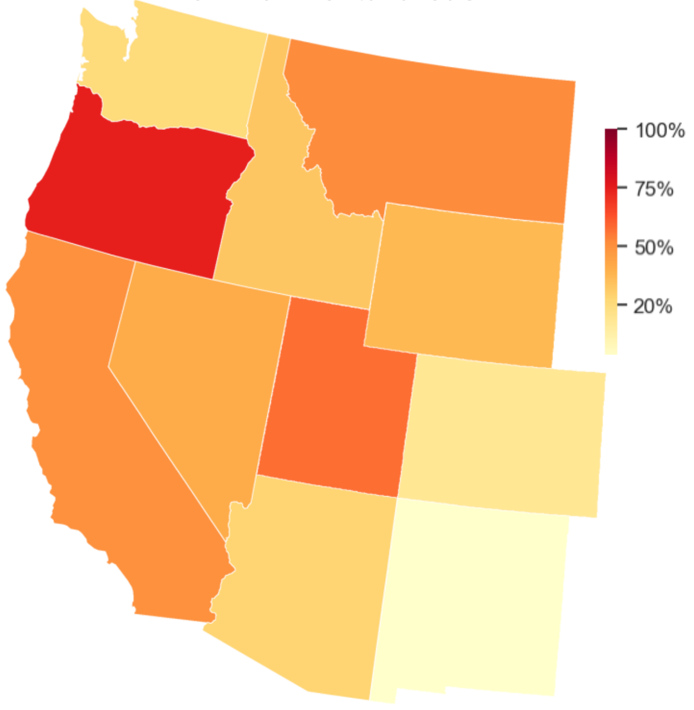
Evaluation of a 2035 clean electricity infrastructure scenario under climate change conditions over the Western US: Key Findings

46% of the land required for new infrastructure is projected to be located on federally identified Disadvantaged Communities (DACs).

12% of the land required for new infrastructure is projected to be located on important farmland. This is equivalent to about 2,100 km^2 (~800 mi^2) with the highest percentages in Oregon and Washington.

60% of the land required for new infrastructure is projected to be located within 5 km of environmental or protected areas, with potential impact on conservation goals.

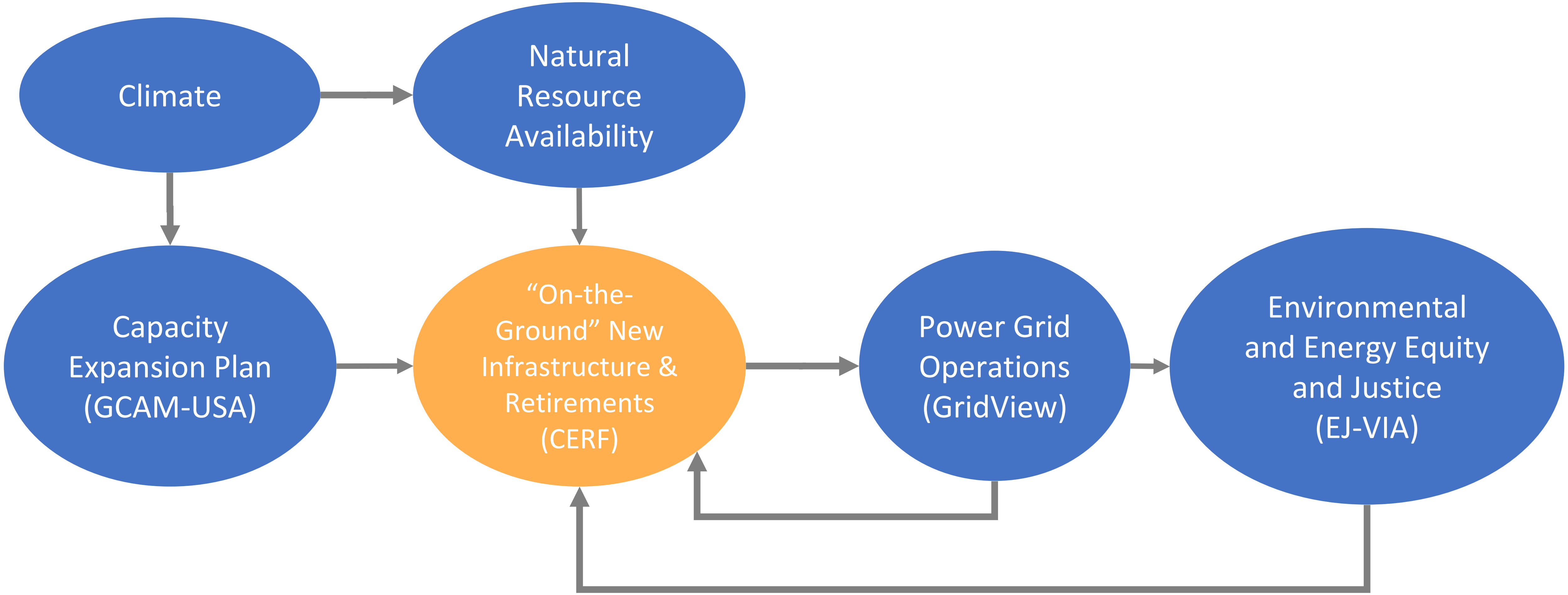
Percent of sitings under decarbonization within 5 km of environmental areas



Solar and onshore wind in Oregon, Utah, and California require further local studies to evaluate the direct and proximate impacts of the decarbonized infrastructure and its operations on social and environmental justice.

Our current projections of decarbonized grid infrastructure and operations installations will soon be made available at godeeep.pnnl.gov

GODEEEP Platform – Detail for Modeling Infrastructure Siting



Climate

Natural Resource Availability

Capacity Expansion Plan (GCAM-USA)

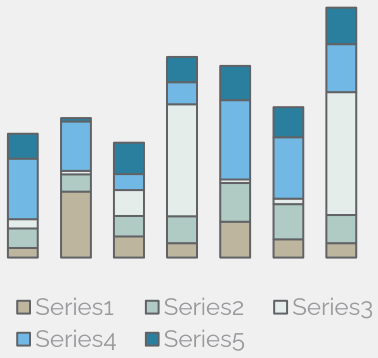
“On-the-Ground” New Infrastructure & Retirements (CERF)

Power Grid Operations (GridView)

Environmental and Energy Equity and Justice (EJ-VIA)

Infrastructure Siting Workflow

GCAM-USA



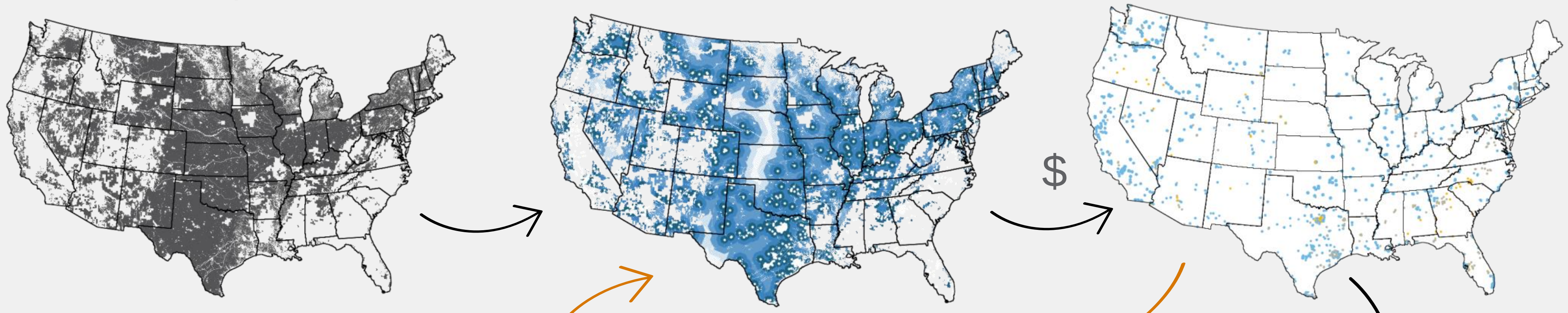
Ingest state-scale capacity expansion plan

5-year timestep

CERF

Apply geospatial constraints specific to each technology (renewables and non-renewables)

Emulate power plant developer and ISO/RTO planning decisions. Technologies compete for feasible siting locations based on interconnection costs and locational marginal prices



5-year timestep

Provide the new power plant coordinates to GridView

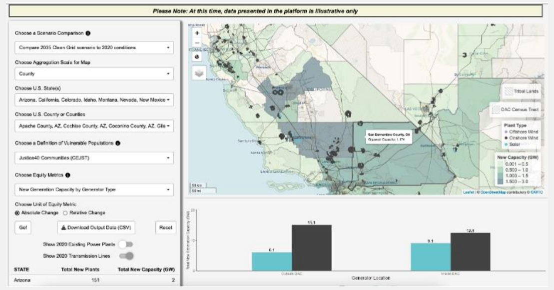
Evaluate siting challenges and opportunities

GridView

Ingest nodal energy prices and substation infrastructure from GridView

EJ-VIA

Disadvantaged communities by census tract



Iterative 5-year timestep process

CERF Methodology: Siting Algorithm

How does CERF determine the best place among the available locations to site each power plant?

Net Locational Cost (NLC)

- CERF employs an economic algorithm to compete power plant technologies per grid cell.
- This is done by calculating a new metric developed for CERF called the net locational cost (NLC). The NLC represents the tradeoff between interconnection costs and operational value to the grid.
- The NLC is based on:
    1. Distance-based cost to connect to the nearest electric grid interconnection point,
    2. Technology-specific marginal operating costs, and
    3. Locational marginal prices (LMPs) to determine the value of energy generation at a specific location

$$\mathbf{NLC(annualized)} = \mathbf{Interconnection\ Cost} - \mathbf{Net\ Operating\ Value}$$

$$= \mathbf{Interconnection\ Cost} - [\mathbf{Locational\ Marginal\ Value} - \mathbf{Operating\ Costs}]$$

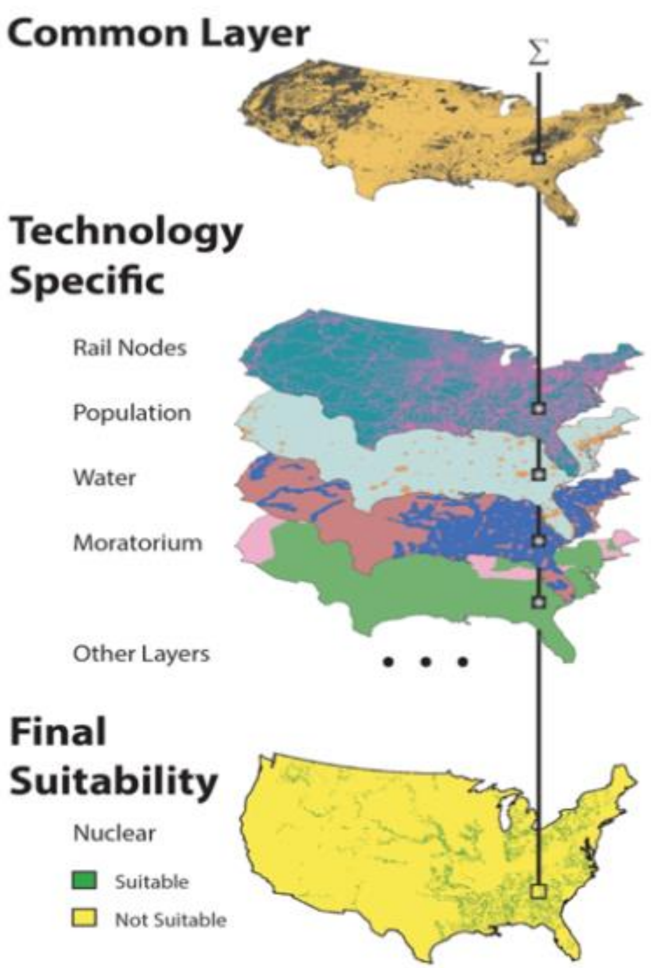
CERF Methodology: Geospatial Suitability

- CERF begins the siting process by determining which areas are suitable for development for each individual technology using rasterized geospatial data.
- These include:
    - Legally protected environmental areas
    - Cooling water availability
    - Renewable resource potential
    - Population density
    - + many more
- The siting suitability for each technology is determined by the aggregate of various siting exclusions.
- These geospatial layers are intended to emulate the social, land, and policy-based constraints faced by developers in the US
- 3

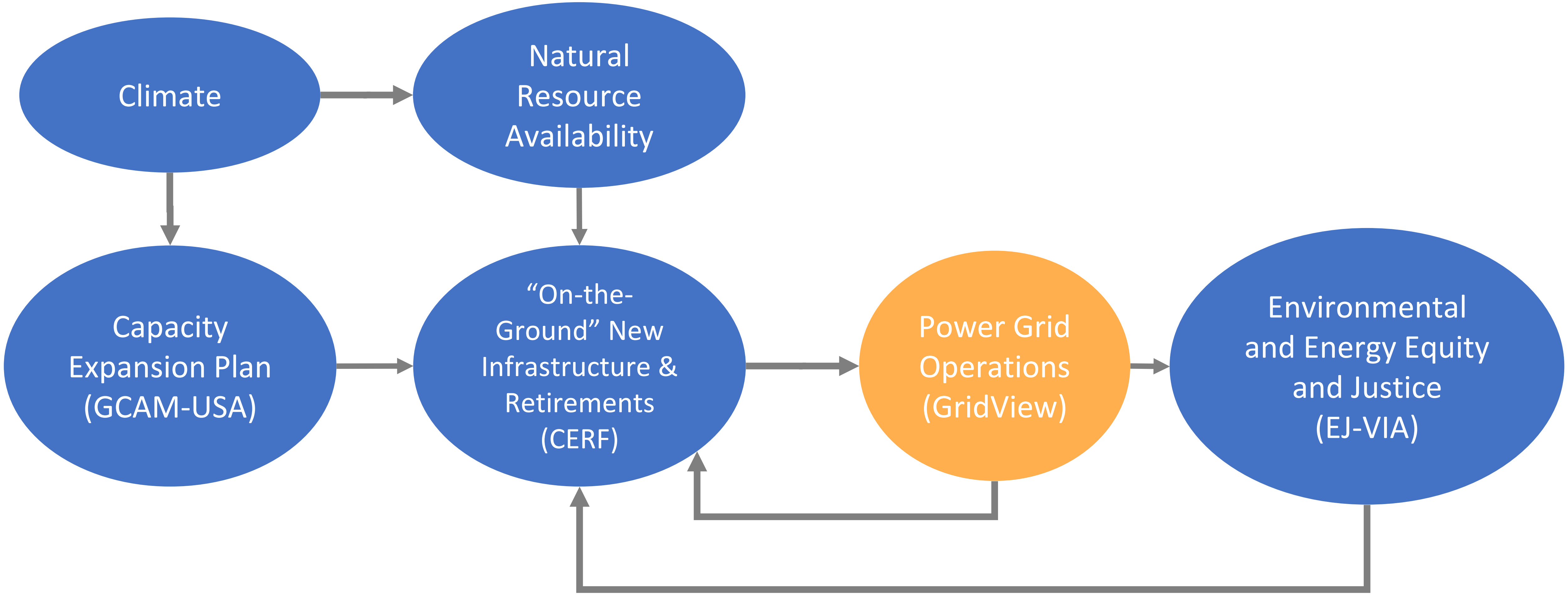
Geospatial layers for siting suitability

CERF Methodology: Geospatial Suitability

- We've built 80+ unique geospatial suitability layers, a subset of which are also temporally-, shared socioeconomic pathway (SSP)-, and/or resource-dynamic, leading to over 300+ layers in total.
- And have the capability to site 79 different power plant technology configurations considering various cooling technologies, turbine types, etc.
  - Biomass (Conventional & IGCC, with and without CCS)
  - Coal (Conventional & IGCC, with and without CCS)
  - Natural Gas (CC & CT, with and without CCS)
  - Solar (PV & CSP)
  - Geothermal
  - Nuclear (Gen2 LWR, Gen3 SMR, & Gen3 AP1000)
  - Refined Liquids (Steam & CT)
  - Wind (Onshore & Offshore, each at various hub heights)
  - + various cooling types: recirculating, pond, dry, dry-hybrid, once-through, seawater
- In addition to our base case geospatial layers, we have additional layers that we can use for sensitivity analysis and scenario exploration such as DAC areas

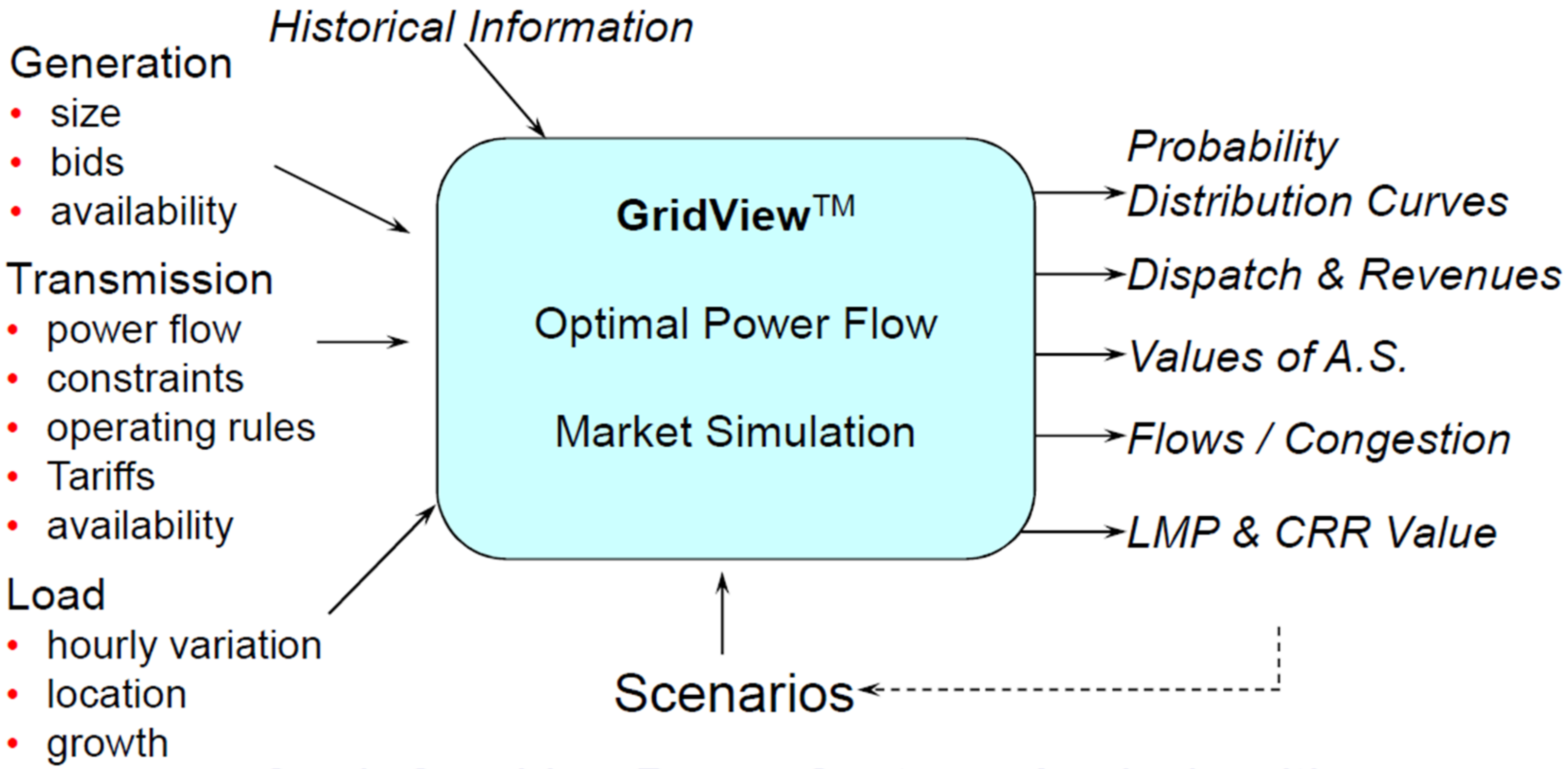


GODEEEP Platform – Detail for Modeling Infrastructure Siting



GridView – a high resolution operational production cost model used by the WECC for reliability studies (commercial tool developed by Hitachi)

- **GridView features**:
  - Co-optimization of Energy and Ancillary Services
  - Detailed and Flexible Transmission (Transmission Outages, PAR / HVDC model)
  - Detailed and Flexible Generator Modeling (Steam/CC/GT/Nuclear/Wind/HY/PS/Geo/ Storage)
  - Hydro-Thermal Optimization
  - Marginal Losses including Losses in DC Links and Distributed Reference Buses
  - Multi-interval Optimization & look ahead logic (1-week)



Historical Information

Generation
- size
- bids
- availability

Transmission
- power flow
- constraints
- operating rules
- Tariffs
- availability

Load
- hourly variation
- location
- growth

GridView™

Optimal Power Flow

Market Simulation

Probability Distribution Curves

Dispatch & Revenues

Values of A.S.

Flows / Congestion

LMP & CRR Value

Scenarios

Goal: Combine Power Systems Analysis with Accurate Economic Models

https://www.hitachienergy.com/products-and-solutions/energy-portfolio-management/enterprise/gridview

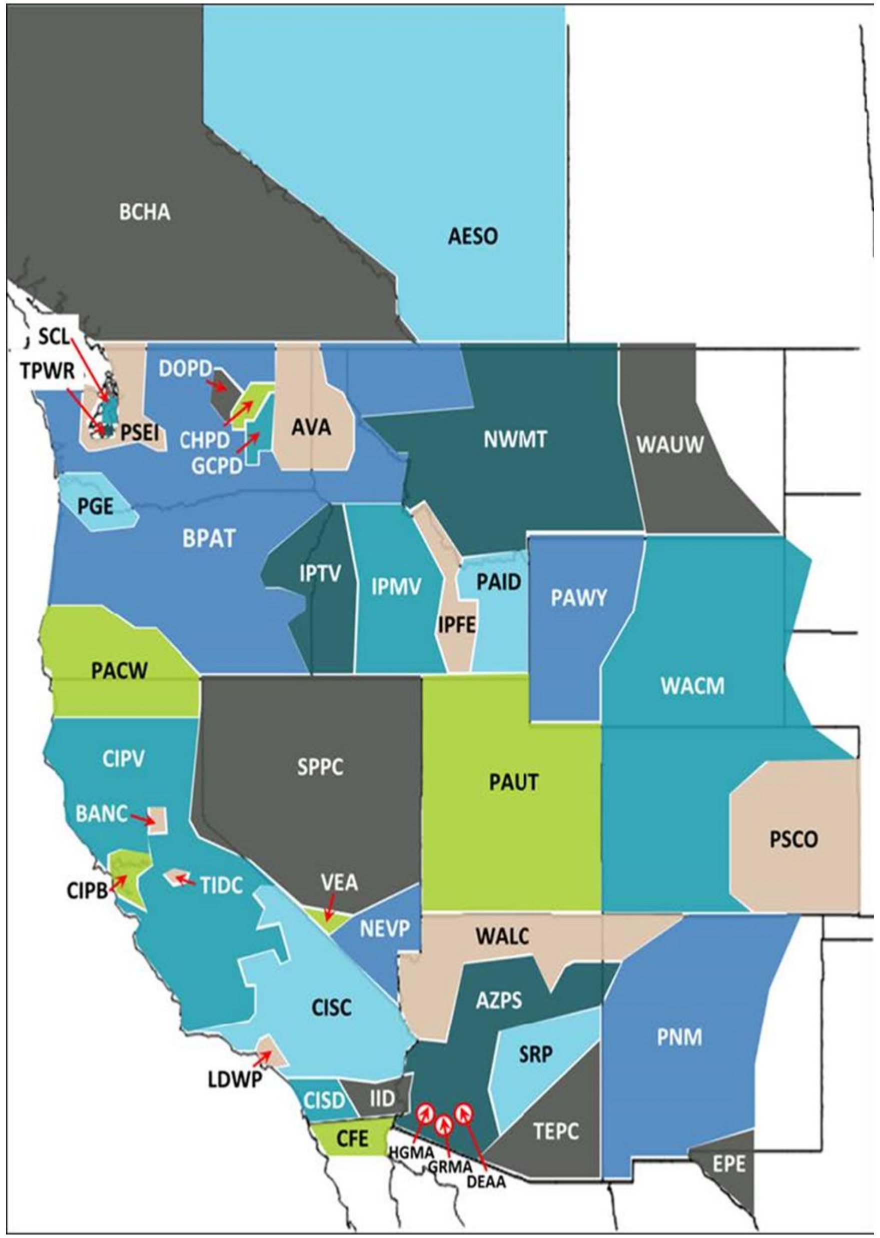
Intermediate GridView simulations provide the economic incentives for siting along with reliability constraints checks

Industry Planning WECC Case: 2020 backcast used as benchmark for siting under decarbonization scenarios

- Best available data for the western interconnection (WI): The WECC 2030 Anchor Data Set (ADS)
    - We created a 2020 Backcast case to harmonize with 2020 GCAMs generation mix
    - The 2020 Backcast is used as the first time point

- There are **38 functional Balancing Authorities** (BA) in the Western Interconnection.

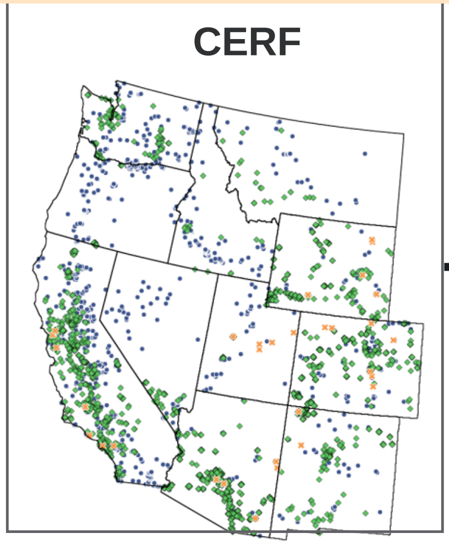
- The 2020 Backcast provides a detailed nodal representation of the WI power grid topology:
  ~22k nodes and ~26k transmission lines



https://www.wecc.org/Pages/home.aspx

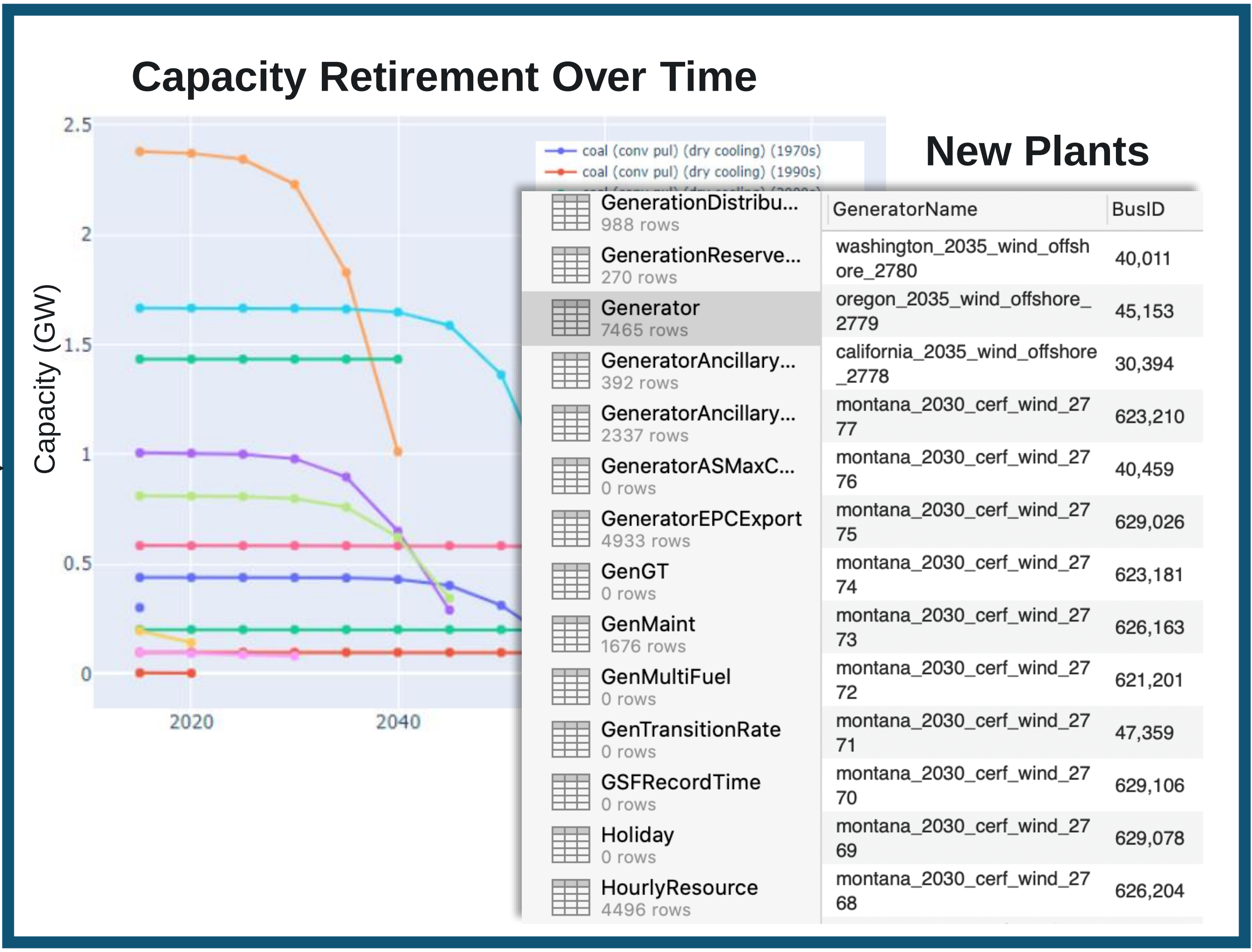
CERF to GridView

Infrastructure Siting & Retirements (2025, 2030, 2045)



CERF

Update GridView's database



Capacity Retirement Over Time

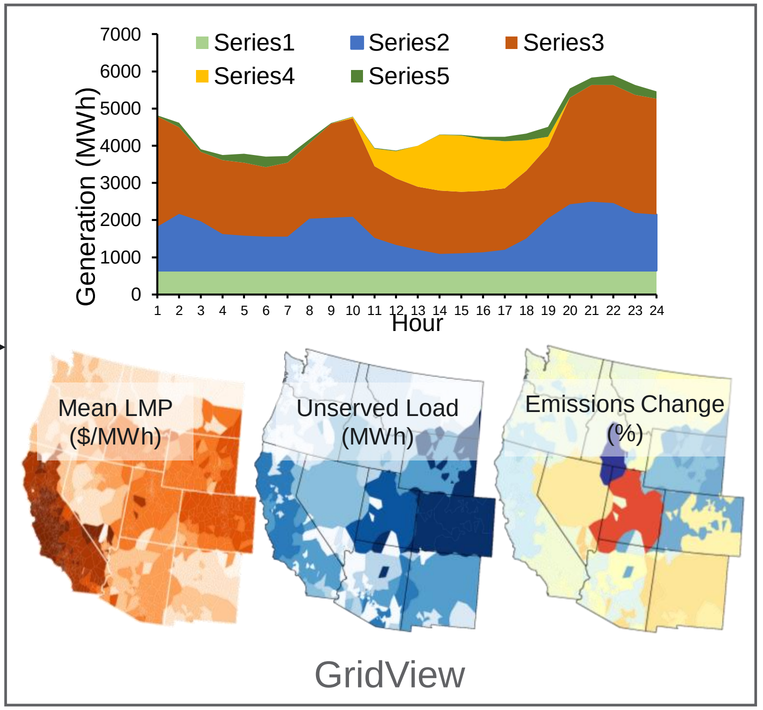
New Plants

GenerationDistribu...	988 rows
GenerationReserve...	270 rows
Generator	7465 rows
GeneratorAncillary...	392 rows
GeneratorAncillary...	2337 rows
GeneratorASMaxC...	0 rows
GeneratorEPCExport	4933 rows
GenGT	0 rows
GenMaint	1676 rows
GenMultiFuel	0 rows
GenTransitionRate	0 rows
GSFRecordTime	0 rows
Holiday	0 rows
HourlyResource	4496 rows

GeneratorName	BusID
washington_2035_wind_offshore_2780	40,011
oregon_2035_wind_offshore_2779	45,153
california_2035_wind_offshore_2778	30,394
montana_2030_cerf_wind_2777	623,210
montana_2030_cerf_wind_2776	40,459
montana_2030_cerf_wind_2775	629,026
montana_2030_cerf_wind_2774	623,181
montana_2030_cerf_wind_2773	626,163
montana_2030_cerf_wind_2772	621,201
montana_2030_cerf_wind_2771	47,359
montana_2030_cerf_wind_2770	629,106
montana_2030_cerf_wind_2769	629,078
montana_2030_cerf_wind_2768	626,204

GridView Outputs:

- Generation schedules
- LMP (energy + congestion)
- Unserved energy
- Curtailment
- Power Flows



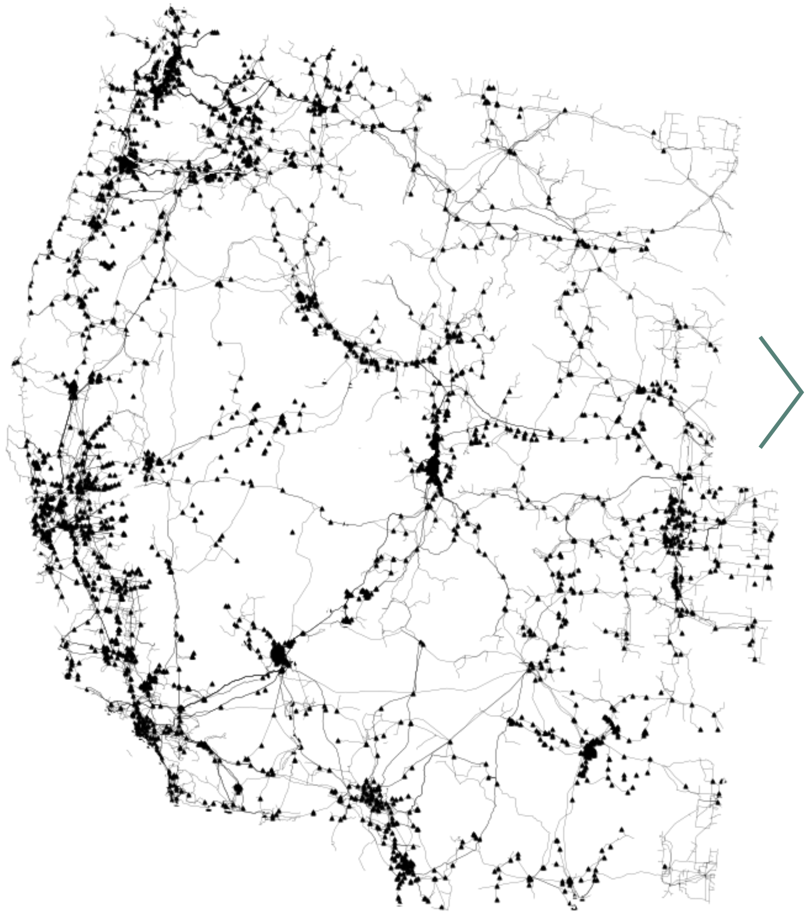
GridView

Challenges:

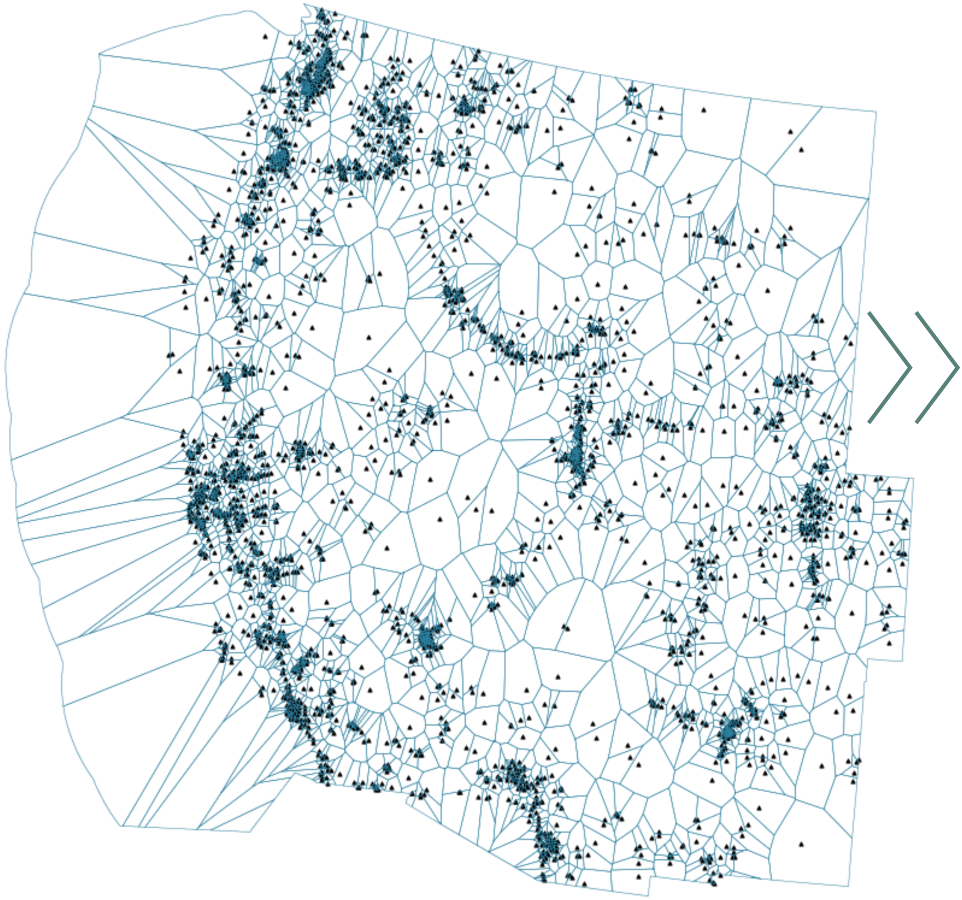
- GridView's network database is vast, complex, and sensitive to small errors in data formatting
- GCAM-USA reports retirements as a state-level change in capacity which needs to be connected to specific power plants in GridView's database

GridView <-> CERF mapping

1. We begin with a set of substations from GridView

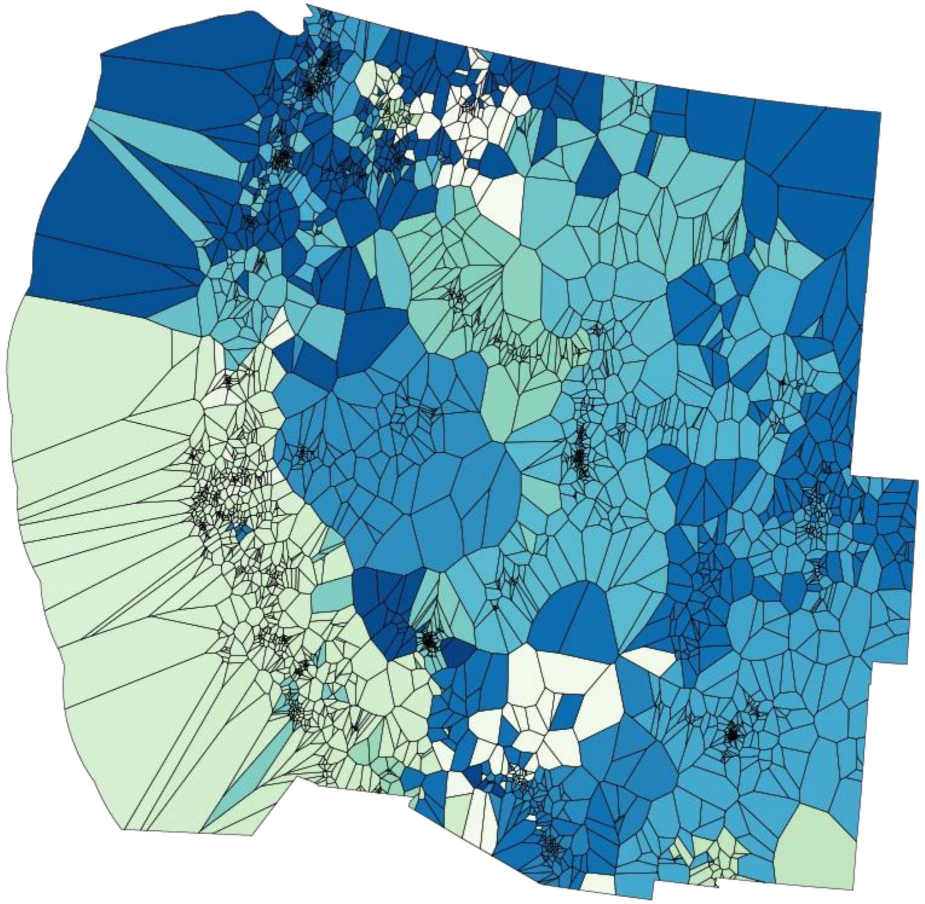


2. Voronoi polygons are calculated for each substation point



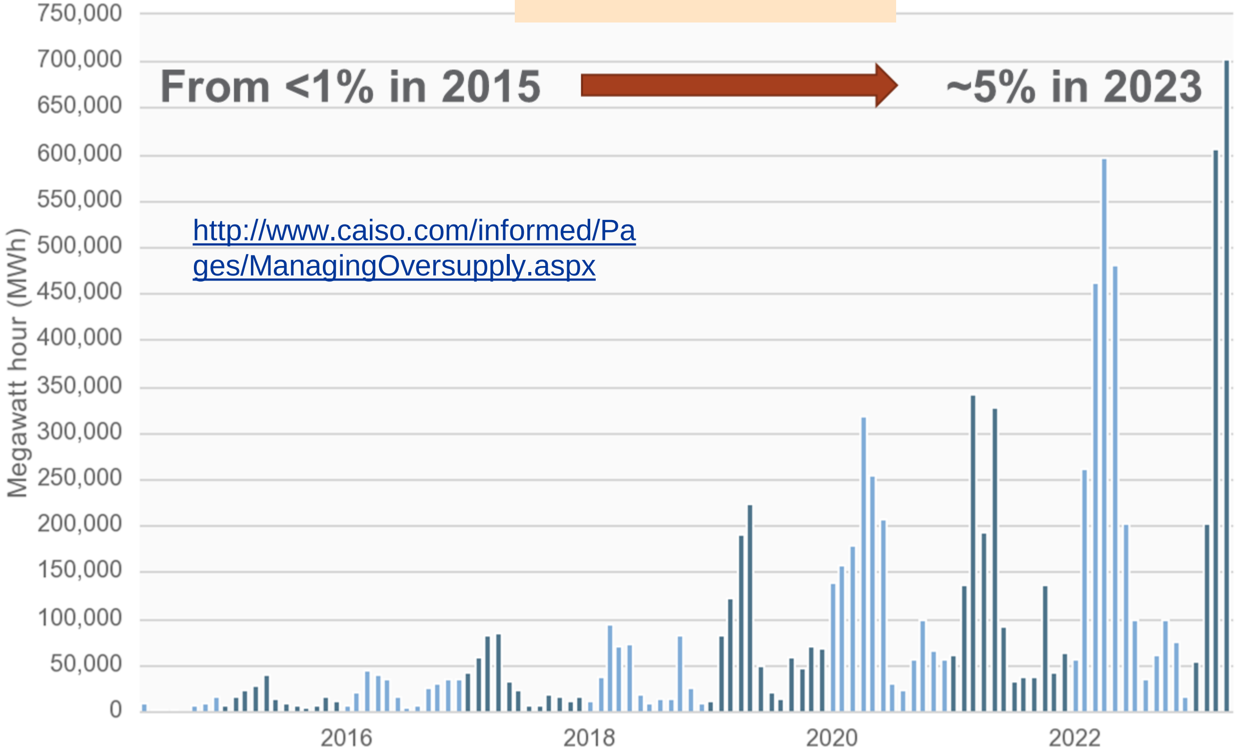
3. The CERF sitings located in the polygons are then mapped to GridView nodes for updating GridView database.

4. The resulting geospatial areas represent “LMP Zones” that allows us to map nodal energy prices to geospatial areas



Ensuring Reliability while Decarbonizing the Grid

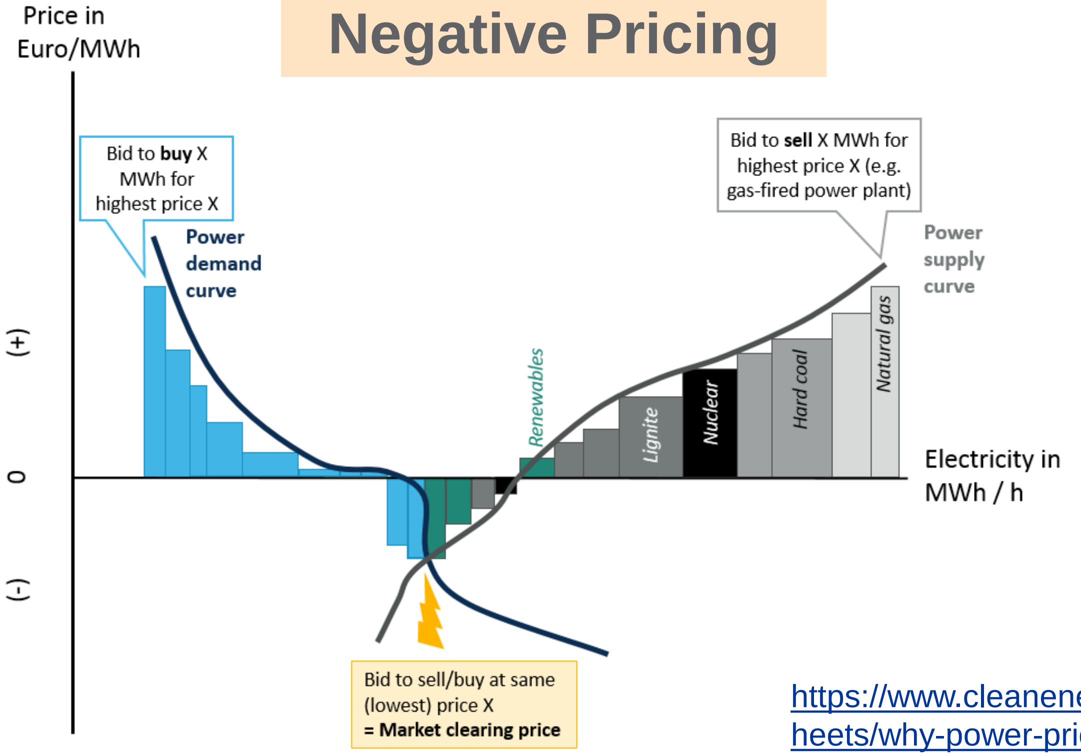
Curtailment



From <1% in 2015 → ~5% in 2023

http://www.caiso.com/informed/Pages/ManagingOversupply.aspx

Negative Pricing



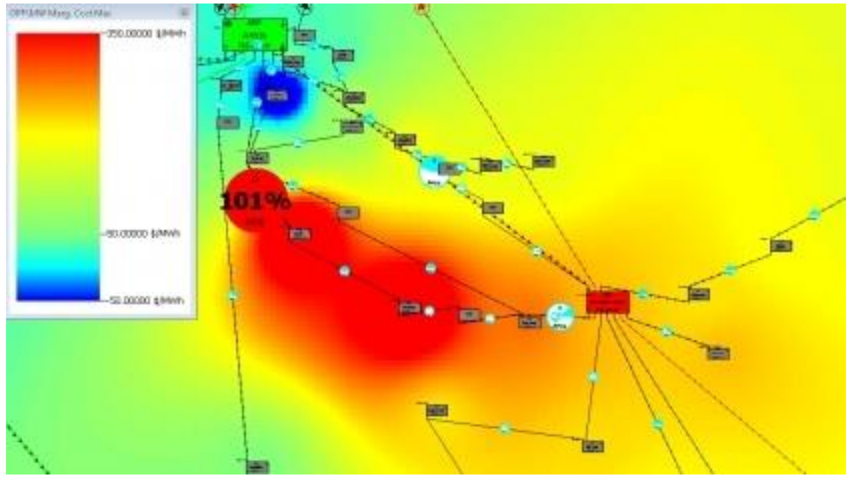
Bid to **buy** X MWh for highest price X

Bid to **sell** X MWh for highest price X (e.g. gas-fired power plant)

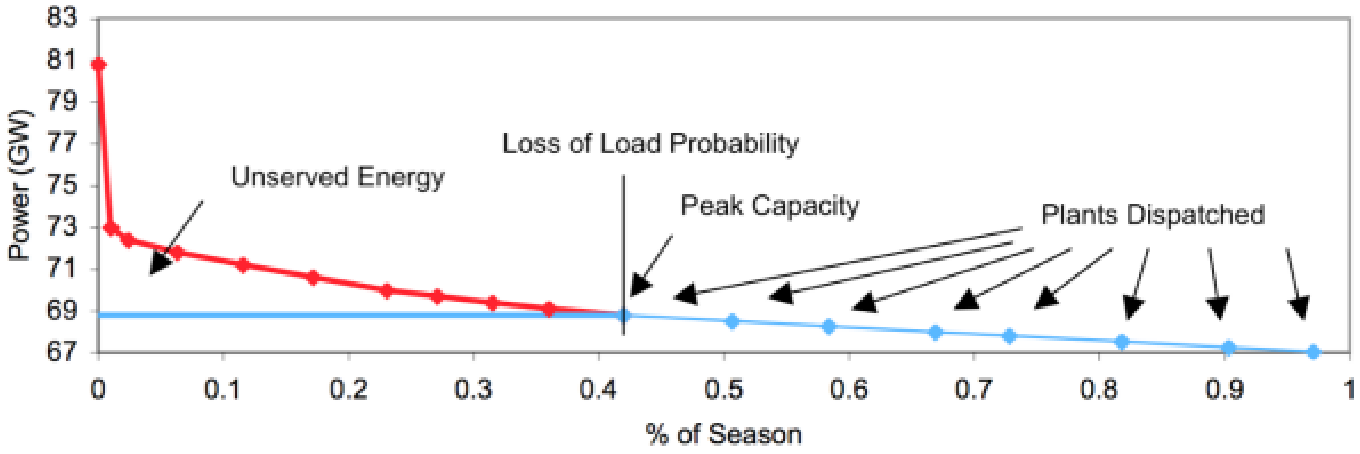
Bid to sell/buy at same (lowest) price X
= Market clearing price

https://www.cleanenergywire.org/factsheets/why-power-prices-turn-negative

Transmission Congestion



Unserved Energy

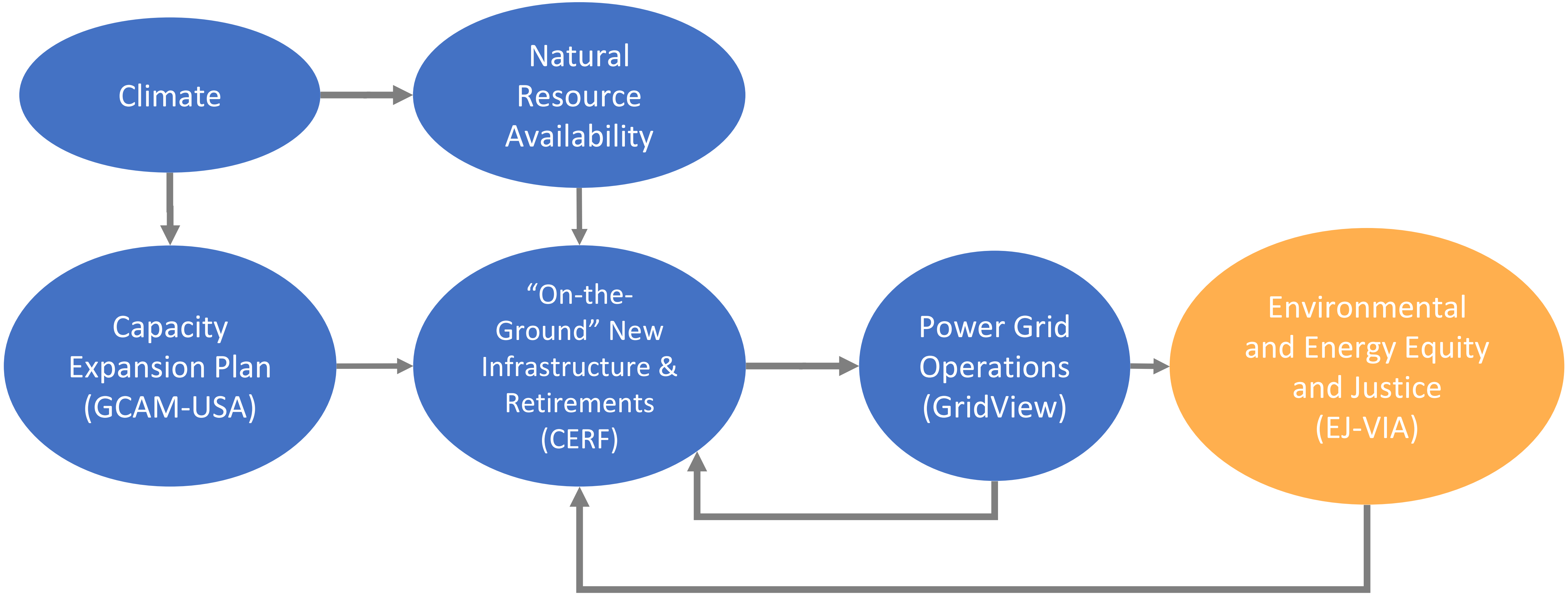


Reliability Check and Fine Tuning

Technology	Market Design Reforms	Out of Market Policies
Storage and hybrid energy storage systems	Flexible loads for energy and AS services	Power purchase agreements
Transmission Upgrades (conventional upgrades, MTDC, DLR, FACTS, etc)	Longer Horizon Markets (than day-ahead and real-time)	Carbon pricing
Zero Carbon dispatchable resources (Carbon Capture, Hydrogen, SMR)	Energy Imbalance Market	
	Opportunity costs for non-power commodities (water, hydrogen)	

Multiple fine tunings should be considered. GODEEEP focuses on climate-informed storage and hybrid systems over multiple horizons.

GODEEEP Platform – Detail for Modeling Infrastructure Siting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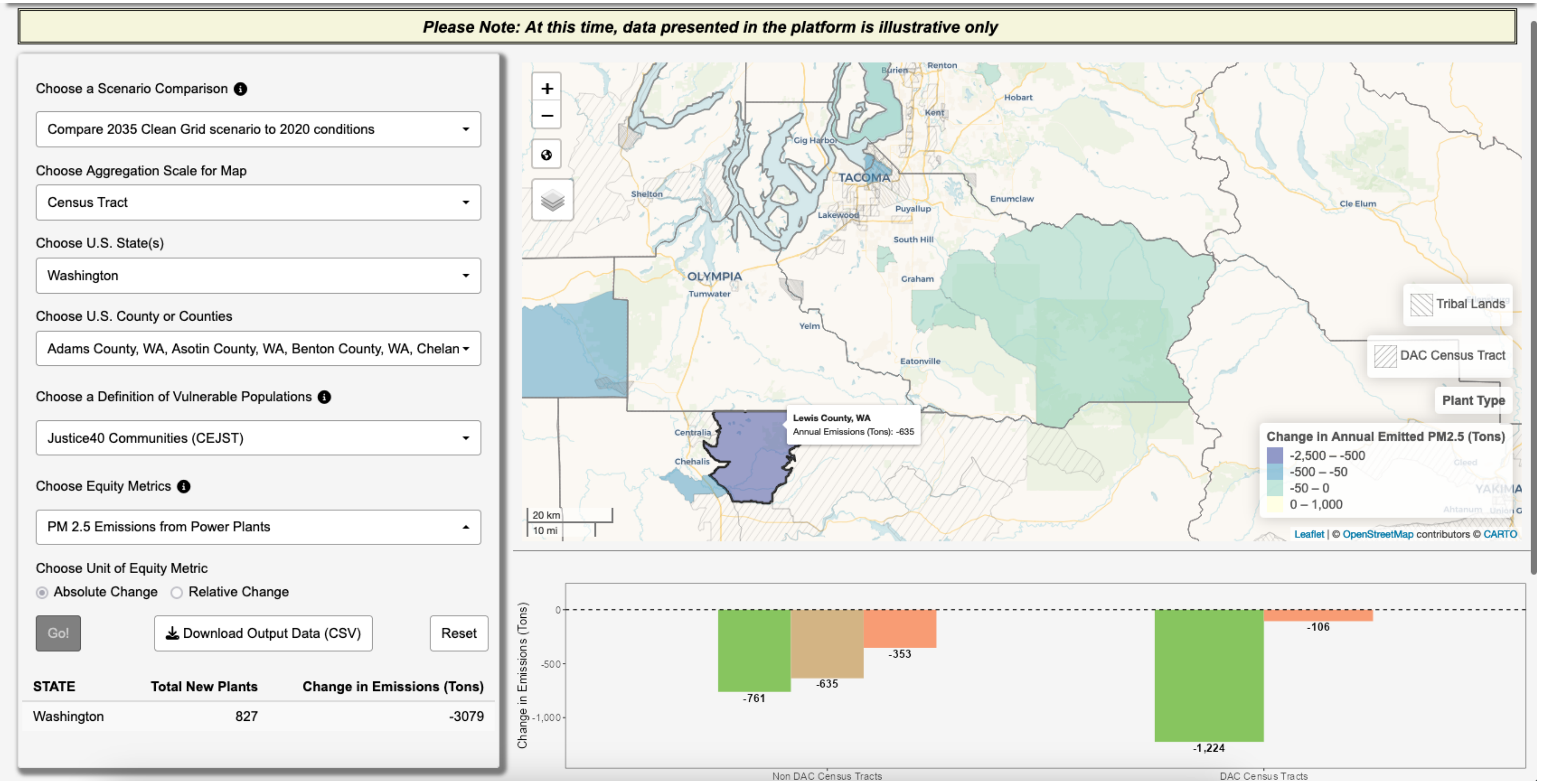
Energy Justice-Visualization and Impact Analysis (EJ-VIA) Tool

- Forthcoming GODEEEP geospatial analysis tool
- Visualize and analyze equity metrics and DACs across decarbonization scenarios, geographic scales
- Filter and download datasets based on user inputs



Please Note: At this time, data presented in the platform is illustrative only

Choose a Scenario Comparison: Compare 2035 Clean Grid scenario to 2020 conditions

Choose Aggregation Scale for Map: Census Tract

Choose U.S. State(s): Washington

Choose U.S. County or Counties: Adams County, WA, Asotin County, WA, Benton County, WA, Chelan

Choose a Definition of Vulnerable Populations: Justice40 Communities (CEJST)

Choose Equity Metrics: PM 2.5 Emissions from Power Plants

Choose Unit of Equity Metric: ● Absolute Change ○ Relative Change

STATE	Total New Plants	Change in Emissions (Tons)
Washington	827	-3079

Lewis County, WA
Annual Emissions (Tons): -635

Change in Annual Emitted PM2.5 (Tons)

■	-2,500 – -500
■	-500 – -50
■	-50 – 0
□	0 – 1,000

Disadvantaged Communities (DACs)

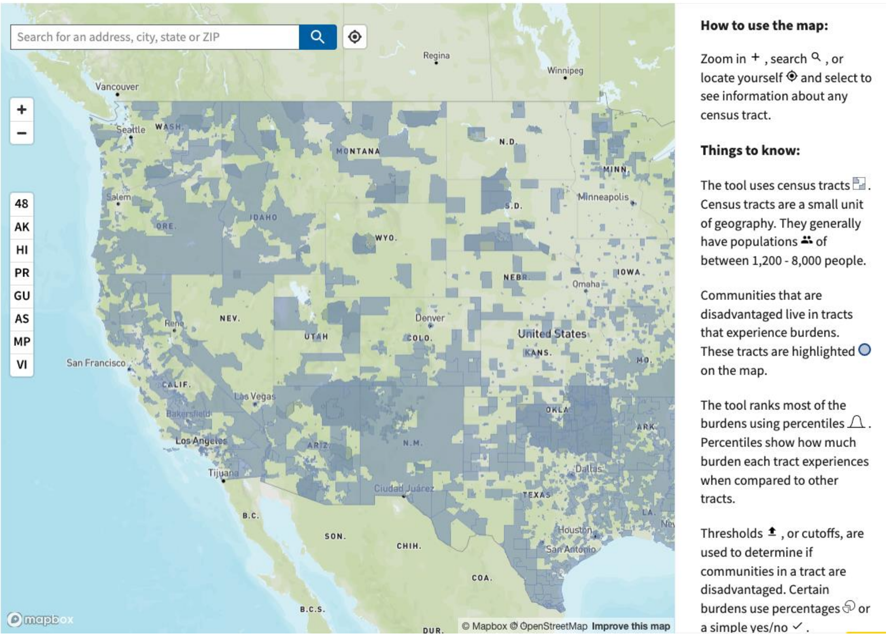
- Geographic areas designated by federal, state or local agencies as marginalized, underserved, and overburdened by a combination of economic, health, and environmental factors
- Definitions and methodologies of determining DAC status vary by regions and agencies
- Implications of differing methods and definitions need to be explored

Entity	Agency	Scale	Resolution	Name
Federal	White House Council on Environmental Quality	All U.S. States and Territories	Census Tract*	Climate & Economic Justice Screening Tool (CEJST)
State	CalEPA	California		CalEnviroScreen
	CO Dept. of Public Health & Environment	Colorado		COEnviroScreen
	WA Dept. of Health	Washington		WA Environmental Health Disparities

*COEnviroscreen data is also available at the Census Block Group and County scales

DAC Methodologies – Climate & Economic Justice Screening Tool (CEJST)

- Created as part of the Justice40 Initiative
- Threshold approach to DAC designation
- Communities considered as DAC if:
    - Located in tract that exceeds thresholds in 1 (or more) of 8 categories of burden
    - On land within Federally Recognized Tribes
    - Located in Census Tract surrounded by DACs IF below low-income threshold
- Over 30 indicators of burden normalized to a common resolution (Census Tract) to address the objective of developing consistent and publicly available equity information



How to use the map:

Zoom in +, search 🔍, or locate yourself ⊙ and select to see information about any census tract.

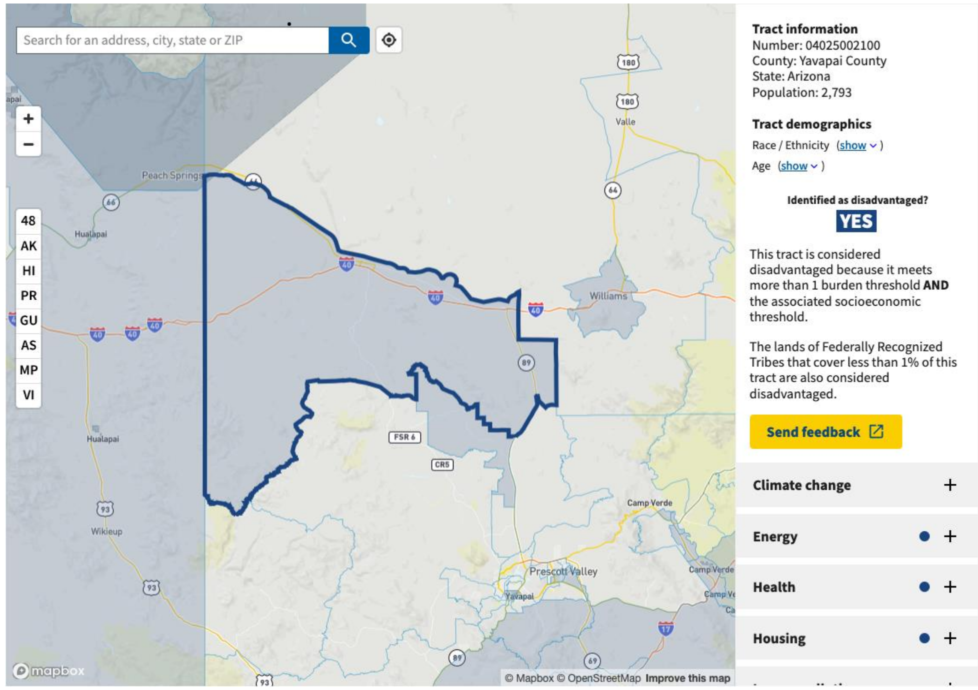
Things to know:

The tool uses census tracts. Census tracts are a small unit of geography. They generally have populations of between 1,200 - 8,000 people.

Communities that are disadvantaged live in tracts that experience burdens. These tracts are highlighted ○ on the map.

The tool ranks most of the burdens using percentiles. Percentiles show how much burden each tract experiences when compared to other tracts.

Thresholds, or cutoffs, are used to determine if communities in a tract are disadvantaged. Certain burdens use percentages or a simple yes/no ✓.



Tract information
Number: 04025002100
County: Yavapai County
State: Arizona
Population: 2,793

Tract demographics
Race / Ethnicity (show)
Age (show)

Identified as disadvantaged?
YES

This tract is considered disadvantaged because it meets more than 1 burden threshold **AND** the associated socioeconomic threshold.

The lands of Federally Recognized Tribes that cover less than 1% of this tract are also considered disadvantaged.

Source: https://static-data-screeningtool.geoplatform.gov/data-versions/1.0/data/score/downloadable/1.0-cejst-technical-support-document.pdf

DAC Methodologies – WA Environment Health Disparities

- Indexing (formulaic) approach
- Effort to evaluate cumulative impacts of environmental health risks
- Indicators values are ranked and normalized into deciles
- Decile ranks are averaged within categories and plugged into formula
- Formula product is a final composite score assigned to each census tract

Washington Environmental Health Disparities

Threat x Vulnerability = Risk

THREAT X **VULNERABILITY** = **RISK**

THREAT

Environmental Exposures
- Diesel emissions
- Ozone concentration
- PM2.5 concentration
- Proximity to heavy traffic roadways
- Toxic releases from facilities

Environmental Effects
- Lead risk from housing
- Proximity to hazardous waste treatment, storage, and disposal facilities
- Proximity to Superfund sites
- Proximity to risk management plan facilities
- Wastewater discharge

VULNERABILITY

Socioeconomic Factors
- Limited English
- No high school diploma
- People of color
- Population living in poverty
- Transportation expense
- Unaffordable housing
- Unemployment

Sensitive Populations
- Populations with high death rates from cardiovascular disease
- Populations with high percentages of low birth weight

RISK

Environmental Health Disparities

Communities experiencing a disproportionate share of environmental health burdens that will need more assistance to reach equitable outcomes

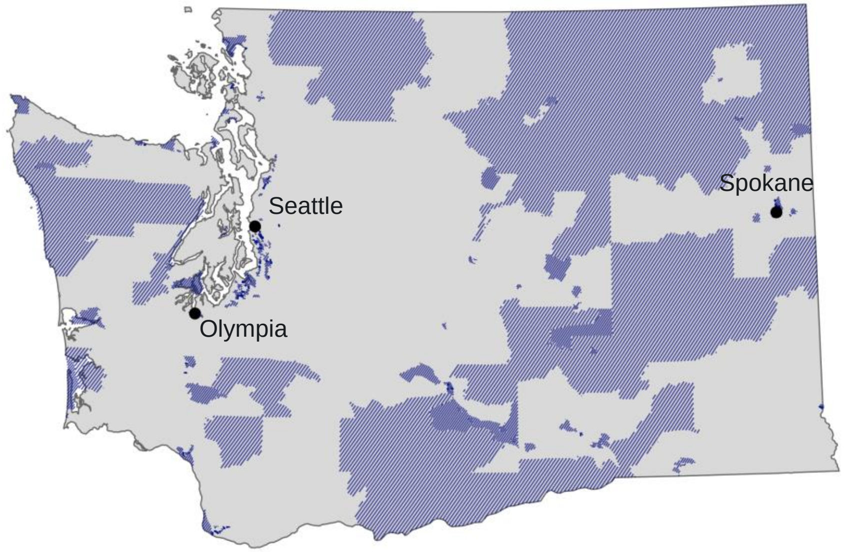
Least impacted — Most impacted

1	2	3	4	5	6	7	8	9	10
10% of communities	10% of communities	10% of communities	10% of communities	10% of communities	10% of communities	10% of communities	10% of communities	10% of communities	10% of communities
70% of communities are less impacted							are similarly impacted	20% of communities are more impacted	

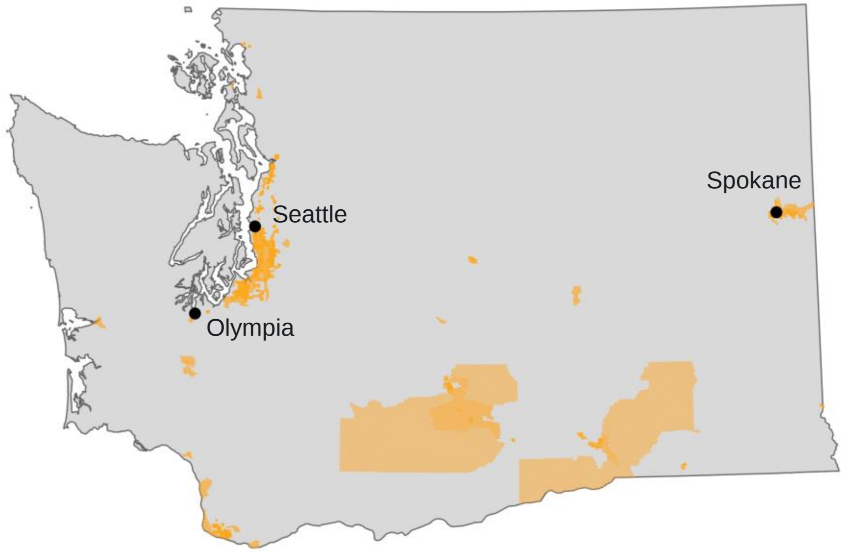
Source: https://doh.wa.gov/sites/default/files/2022-07/311-011-EHD-Map-Tech-Report_0.pdf?uid=649b3fedb6d12

DAC Methodologies - Comparison

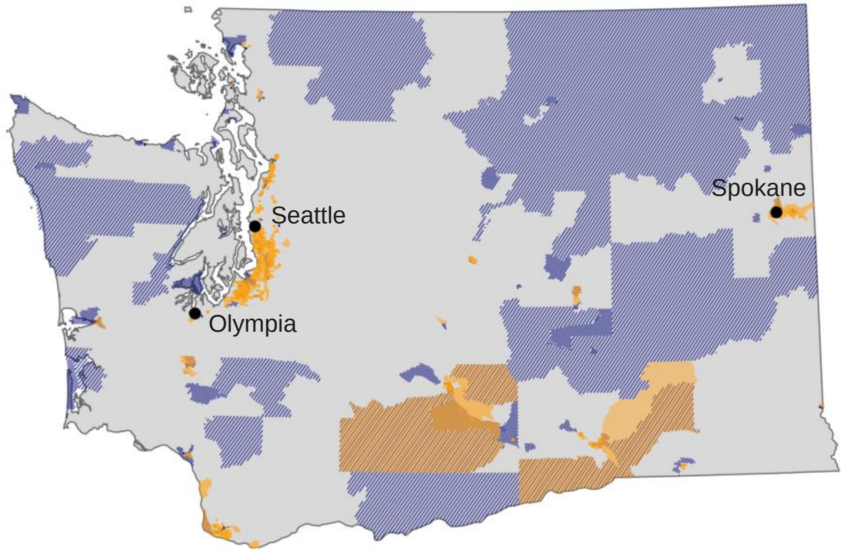
CEJST



WA Environmental Health Disparities*



CEJST & WA Env. Health Disparities



State	Total Census Tracts	DAC Definition	# of DAC Census Tracts Identified	# of DAC Census Tracts in Common	% of DAC Census Tracts in Common	# of Unique DAC Census Tracts
California	9,129	CalEnviroScreen	2,310	1,844	80%	466
		CEJST	3,107		59%	1,263
Colorado	1,447	COEnviroScreen	250	147	59%	103
		CEJST	279		53%	132
Washington	1,784	WA Env Health Disparities	443	186	42%	257
		CEJST	319		58%	133

*Note: WA Env. Health Disparities ranks all census tracts on 1-10 scale from least burdened to most burdened. It does not designate a threshold for which tracts should be considered DAC and for purposes of this analysis tracts scoring 8,9, and 10 were considered DAC.

Table from Linck et al. (in preparation)

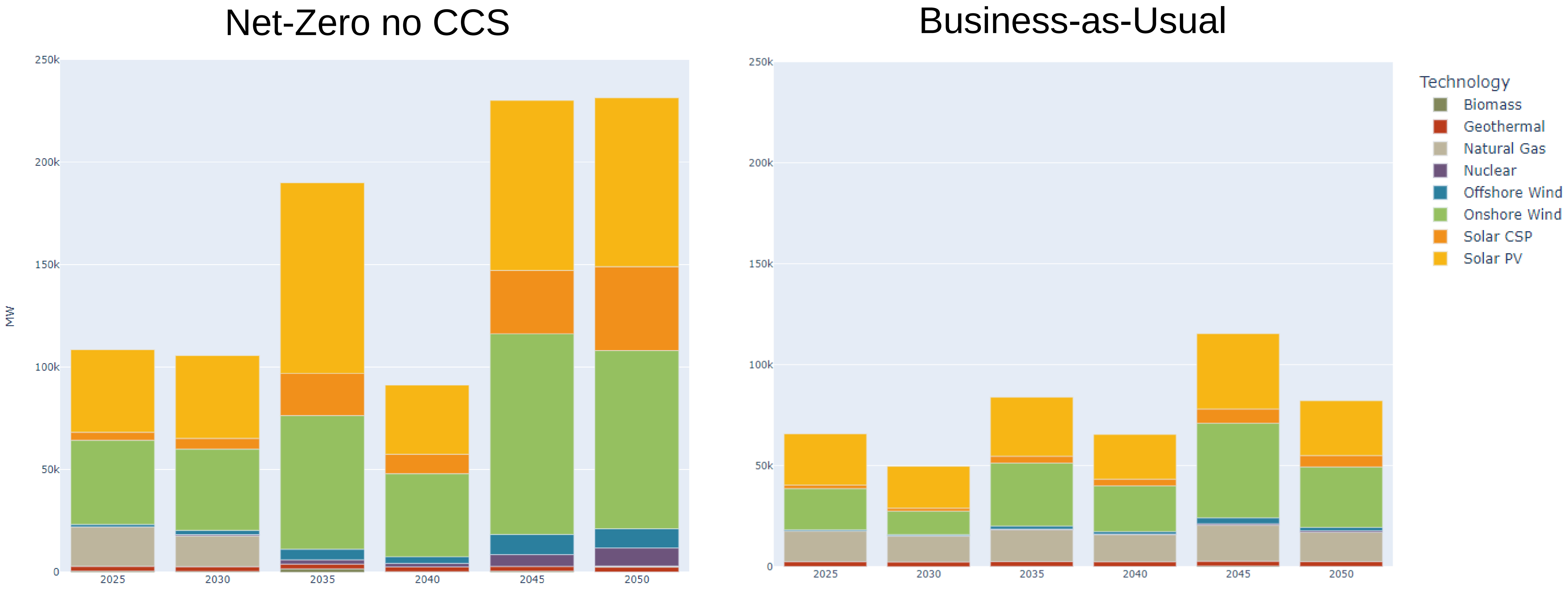
Short Q&A Break

Up Next:

GODEEEP Decarbonization Siting Results & Analysis

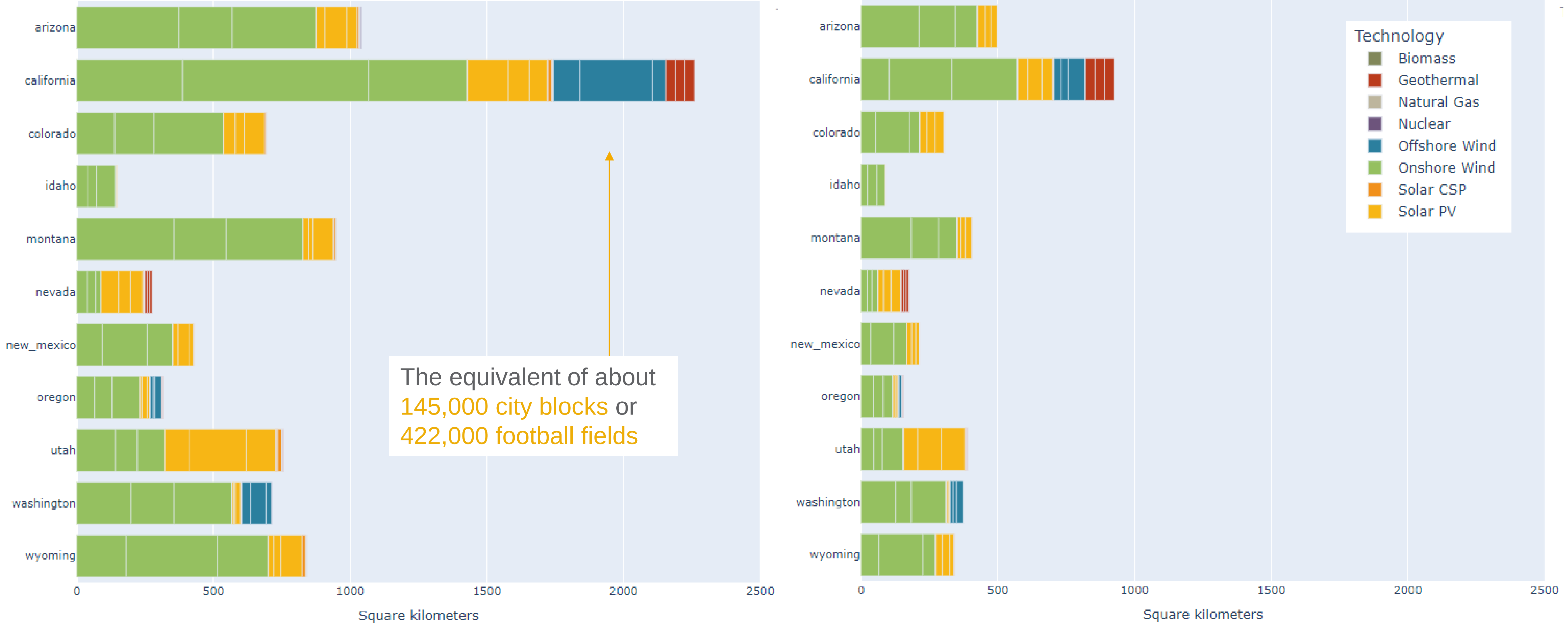
Decarbonization vs. Business-as-Usual Scenario

GCAM-USA new capacity additions across the west



How much land will it take?

Square kilometers of land required for new generation by 2035:

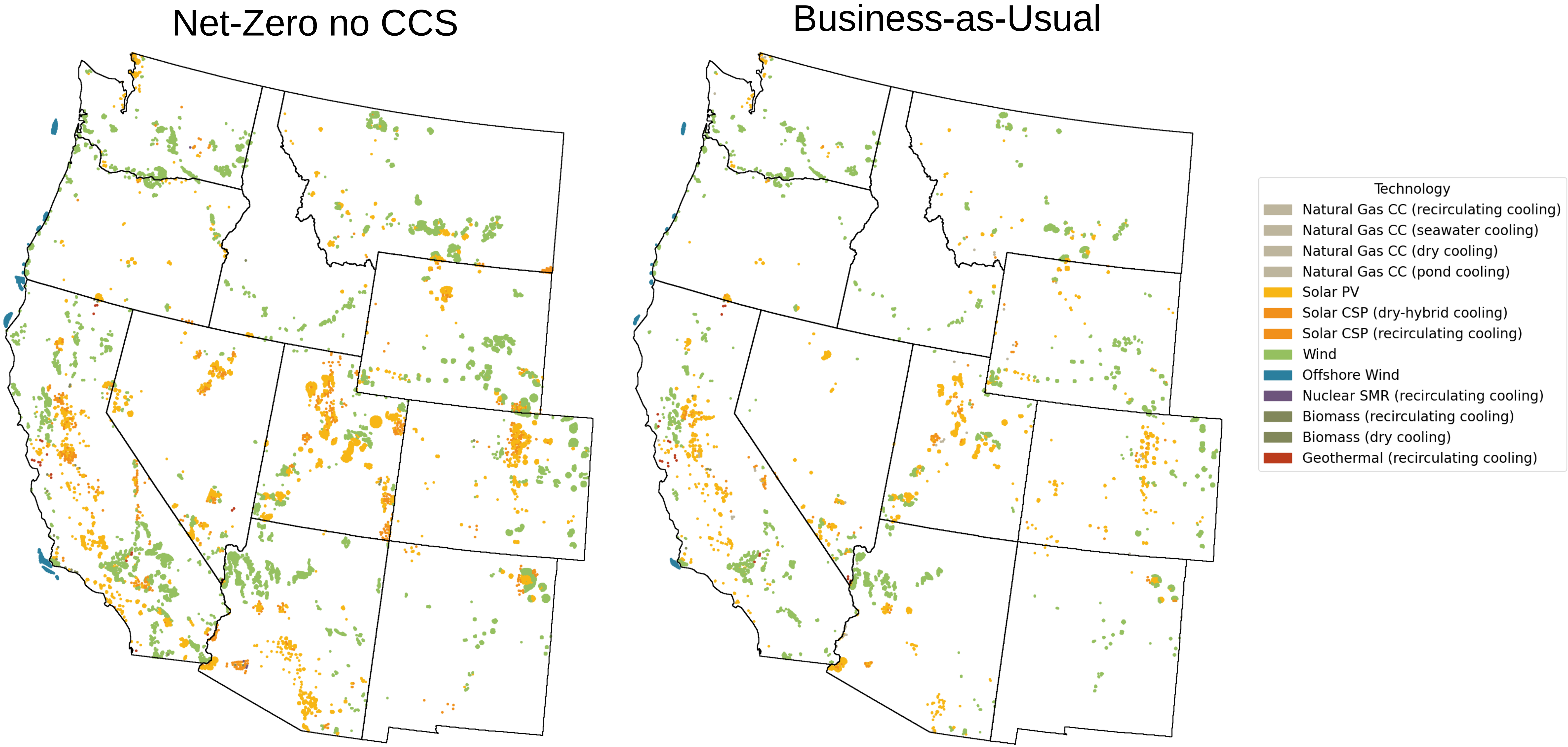


Net-Zero no CCS

Business-as-Usual

The equivalent of about 145,000 city blocks or 422,000 football fields

Projected New Power Plant Sitings by 2035



Net-Zero no CCS

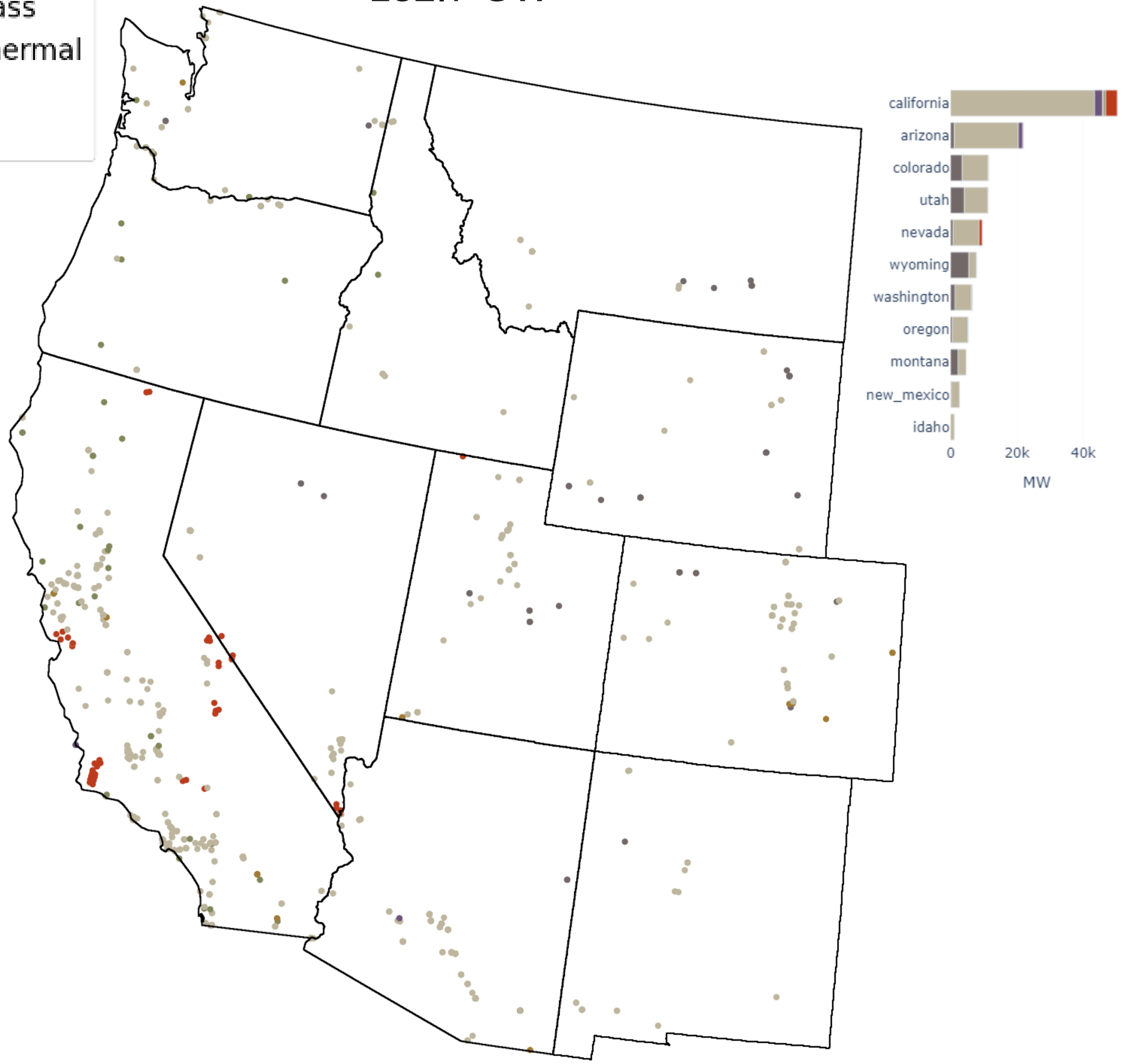
Business-as-Usual

Projected Power Plant Retirements by 2035

Technology
- 🟫 Natural Gas
- 🟪 Nuclear
- 🟩 Biomass
- 🟥 Geothermal
- ⬛ Coal
- 🟧 Oil

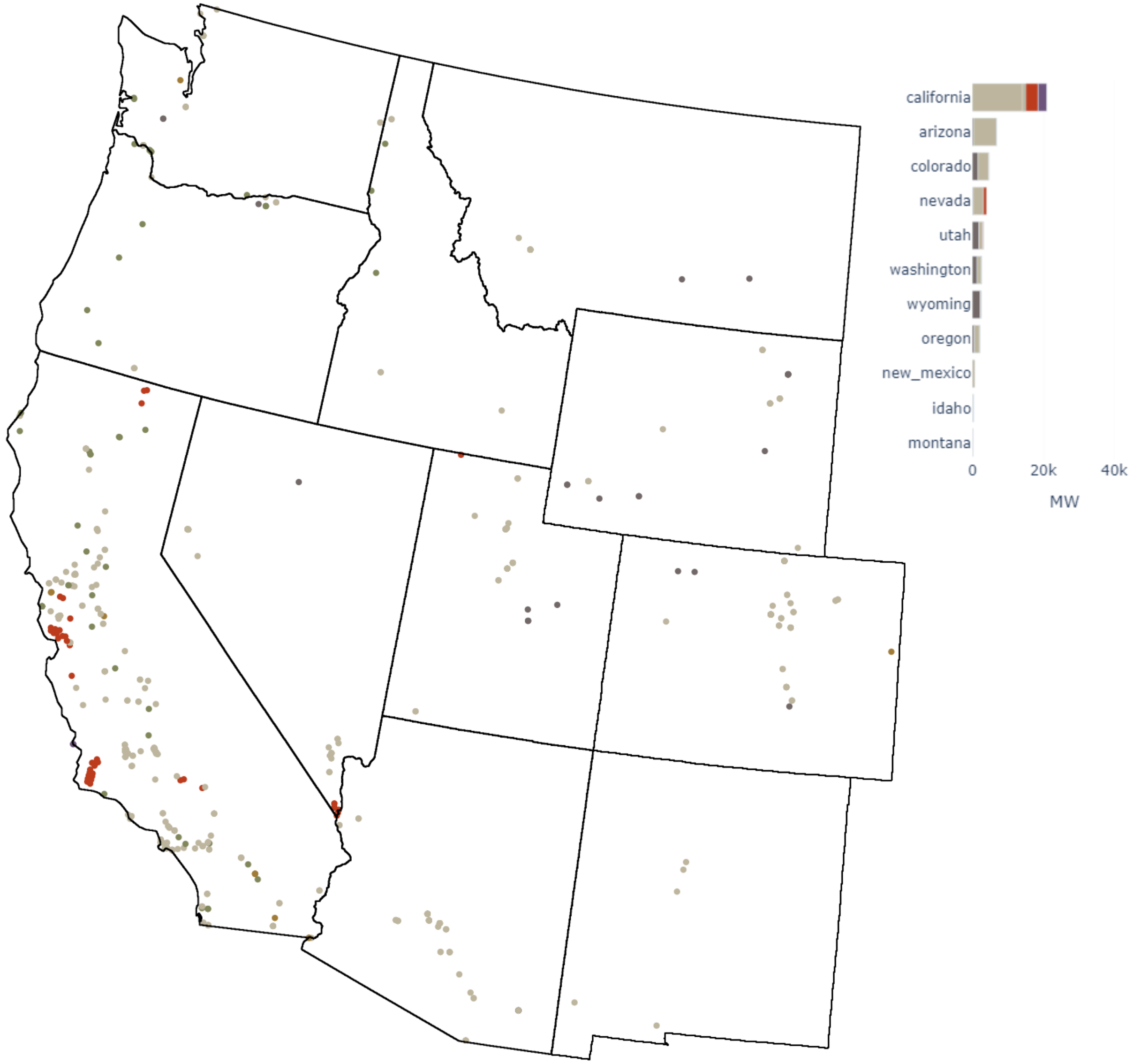
Net-Zero no CCS

132.7 GW



Business-as-Usual

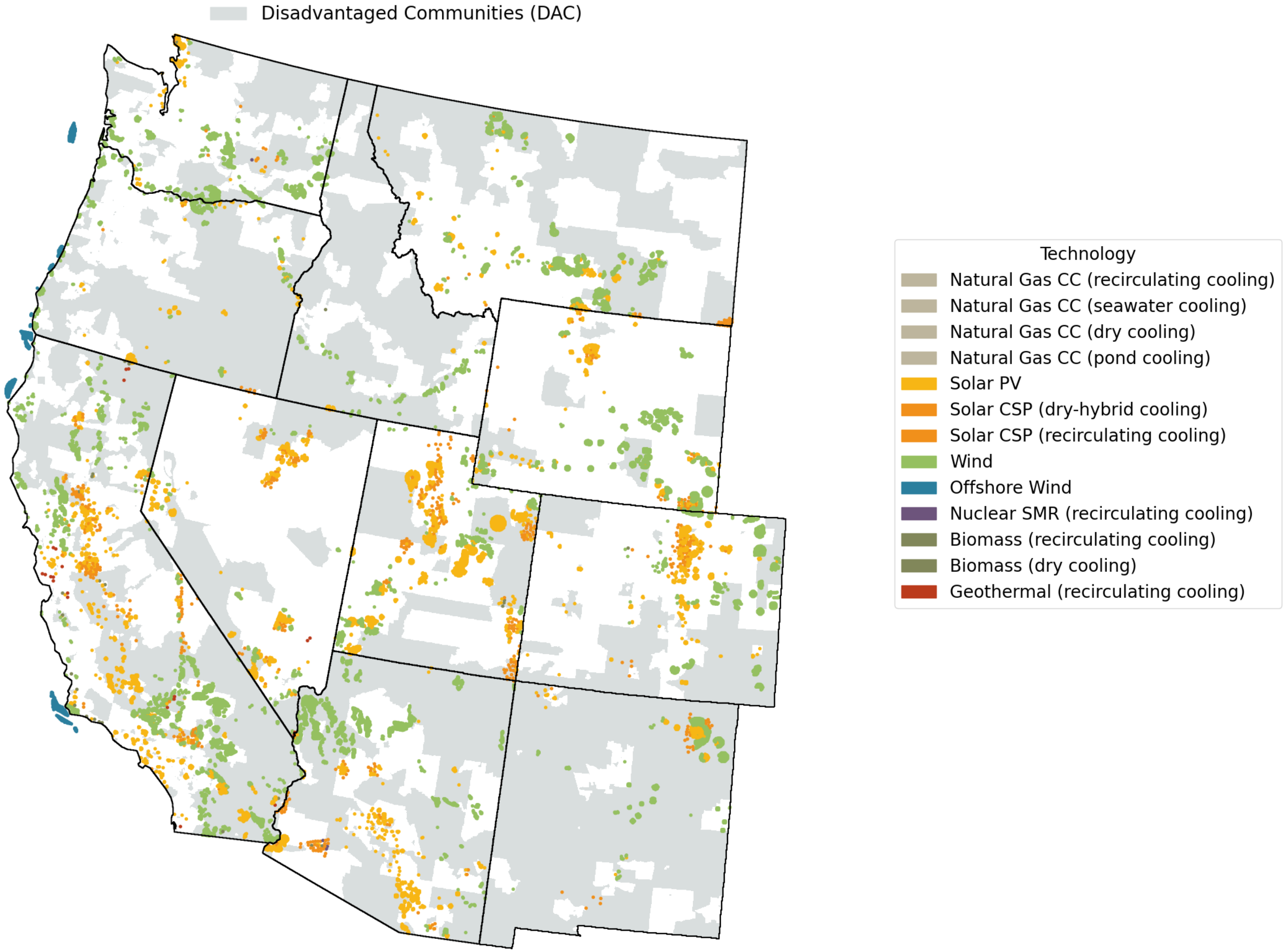
48.1 GW



Sitings & Disadvantaged Communities under Decarbonization

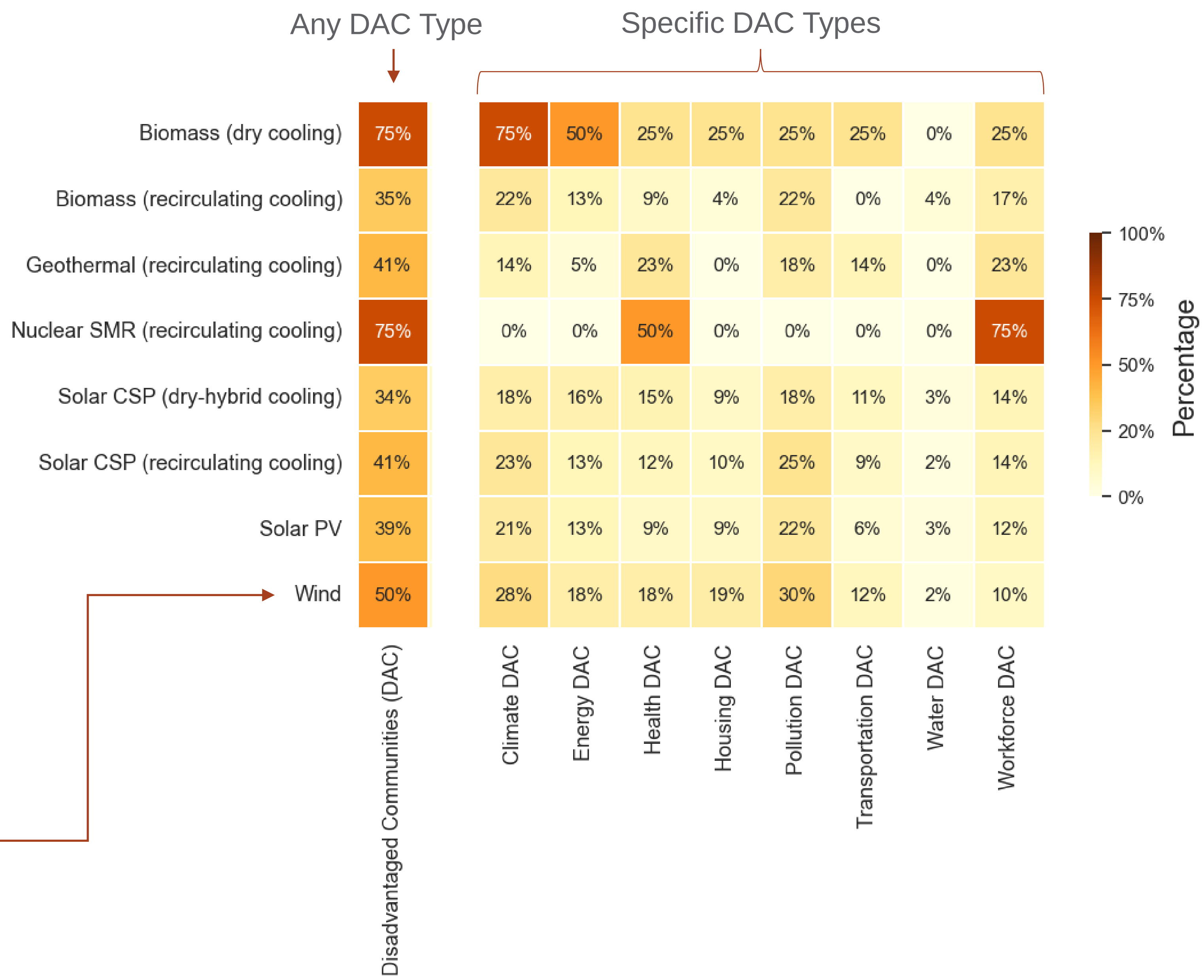
46% of all land used for projected power plant sitings by 2035 under decarbonization is in federally identified DACs

This is equivalent to nearly 8,000 km^2 of land



Sitings & Disadvantaged Communities under Decarbonization

- **50% of the projected wind sitings are in DACs**, mostly within communities that are disadvantaged for climate and pollution reasons.
- **>75% of biomass sitings are in DACs**, mostly within communities that are disadvantaged for climate and energy reasons.
- Though much smaller in terms of number of sitings, **75% of nuclear sitings are in DACs**, mostly within communities that are disadvantaged for workforce and health reasons.
- The amount of projected wind sitings in DACs amounts to approximately **5,300 km^2 of land**.



Percent of Projected New Sitings
in DACs (CEJST Definitions) by Technology

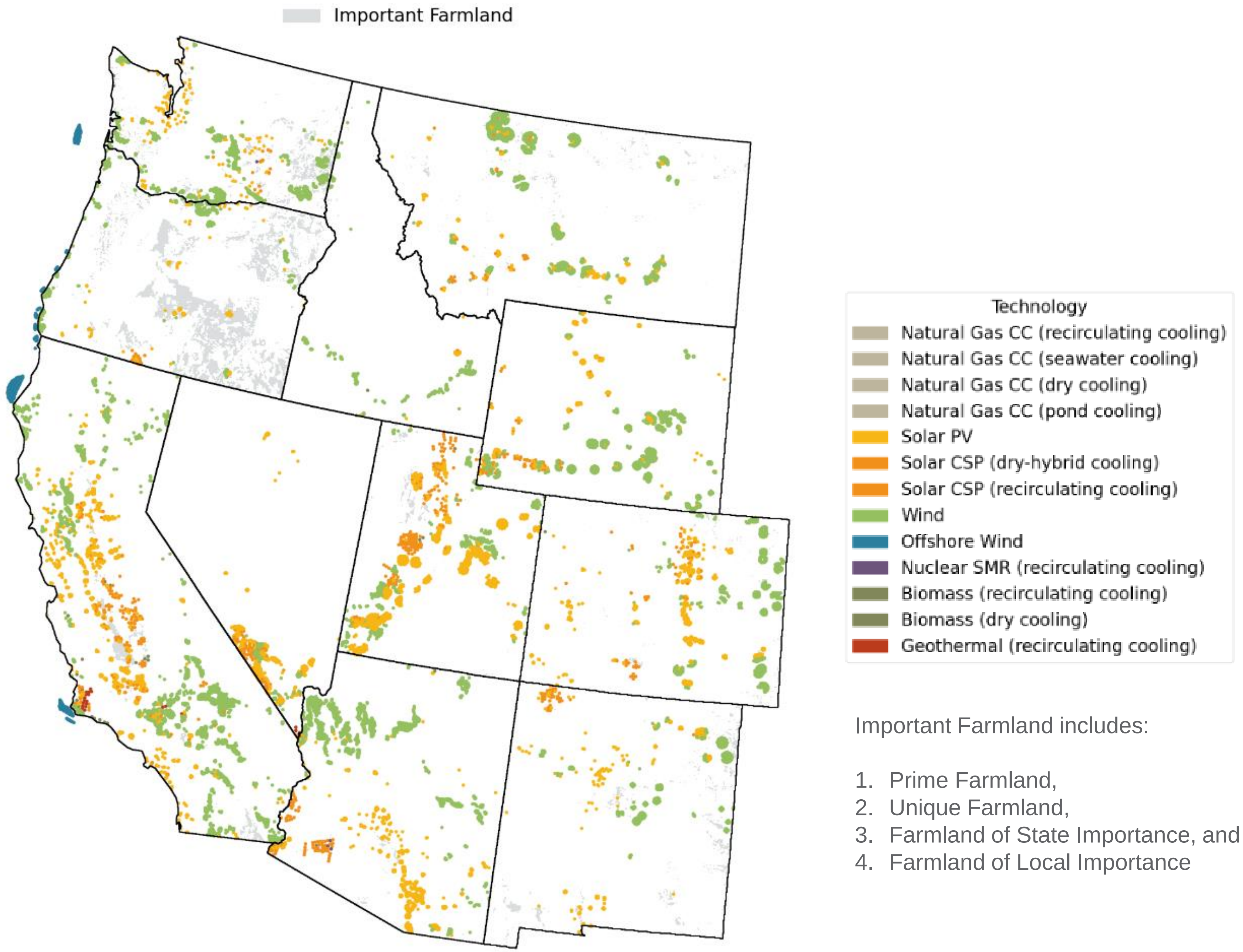
	Disadvantaged Communities (DAC)	Climate DAC	Energy DAC	Health DAC	Housing DAC	Pollution DAC	Transportation DAC	Water DAC	Workforce DAC
Biomass (dry cooling)	75%	75%	50%	25%	25%	25%	25%	0%	25%
Biomass (recirculating cooling)	35%	22%	13%	9%	4%	22%	0%	4%	17%
Geothermal (recirculating cooling)	41%	14%	5%	23%	0%	18%	14%	0%	23%
Nuclear SMR (recirculating cooling)	75%	0%	0%	50%	0%	0%	0%	0%	75%
Solar CSP (dry-hybrid cooling)	34%	18%	16%	15%	9%	18%	11%	3%	14%
Solar CSP (recirculating cooling)	41%	23%	13%	12%	10%	25%	9%	2%	14%
Solar PV	39%	21%	13%	9%	9%	22%	6%	3%	12%
Wind	50%	28%	18%	18%	19%	30%	12%	2%	10%

Sitings & Important Farmland

Using our farmland geospatial data we can determine the percent of power plant sitings that use high value farmland. Those sites will require further evaluation on tradeoffs between agriculture and grid generation.

12% of all land used for projected power plant sitings by 2035 under decarbonization is on important farmland.

The total is equivalent to about 2,100 km^2 of farmland, and predominantly consists of wind and solar technologies



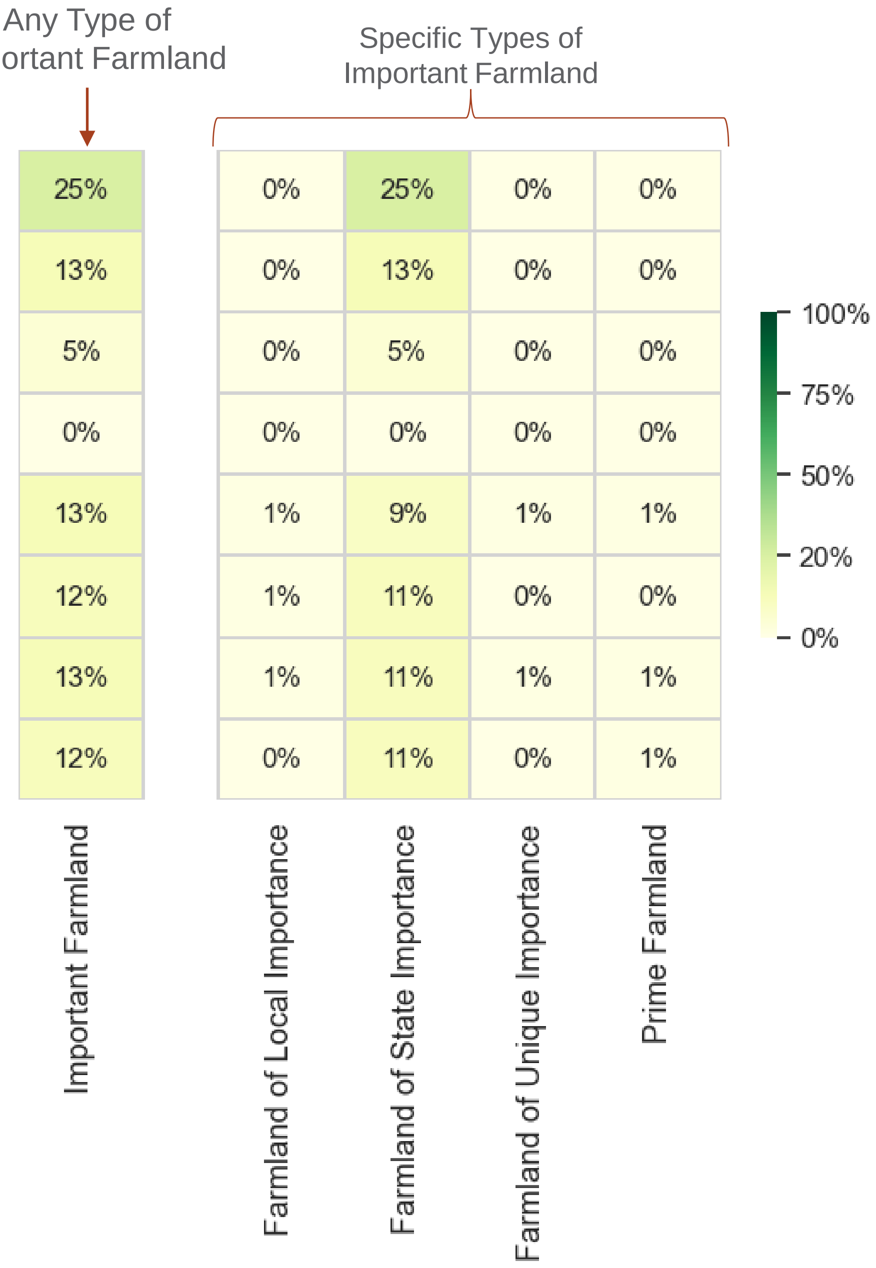
Important Farmland includes:

1. Prime Farmland,
2. Unique Farmland,
3. Farmland of State Importance, and
4. Farmland of Local Importance

Pacific Northwest
NATIONAL LABORATORY

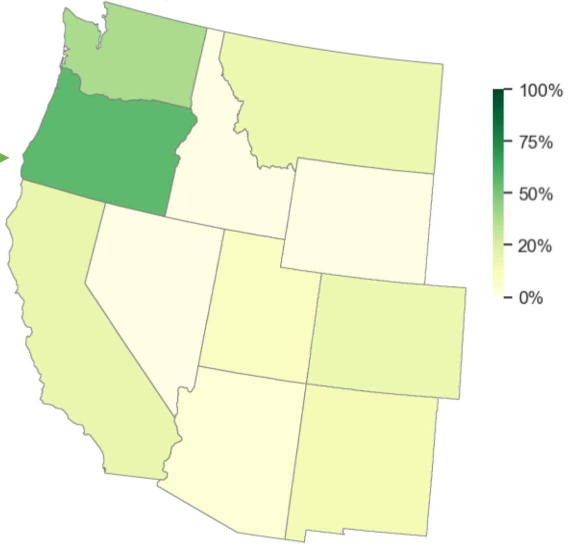
Sitings & Important Farmland

- Though solar and wind have lower percent of installations on important farmland (12-13%) than biomass (25%), the needed land use is highest. The value of services to the grid need to be evaluated with respect to the value of agriculture products.
- **Focusing just on solar:**
  - Across all types, solar is projected to intersect with **817 km^2 of important farmland across the West.**
  - **Oregon** and **Washington** are the states **most likely to receive opposition to solar** siting based on farmland classification
  - **56% of Oregon solar installations** are projected to be on **farmland of state importance**
  - **24% of Washington solar installations** are projected to be on **prime farmland**



	Any Type of Important Farmland	Specific Types of Important Farmland			
	Important Farmland	Farmland of Local Importance	Farmland of State Importance	Farmland of Unique Importance	Prime Farmland
Biomass (dry cooling)	25%	0%	25%	0%	0%
Biomass (recirculating cooling)	13%	0%	13%	0%	0%
Geothermal (recirculating cooling)	5%	0%	5%	0%	0%
Nuclear SMR (recirculating cooling)	0%	0%	0%	0%	0%
Solar CSP (dry-hybrid cooling)	13%	1%	9%	1%	1%
Solar CSP (recirculating cooling)	12%	1%	11%	0%	0%
Solar PV	13%	1%	11%	1%	1%
Wind	12%	0%	11%	0%	1%

Percent of Solar Installations on Important Farmland

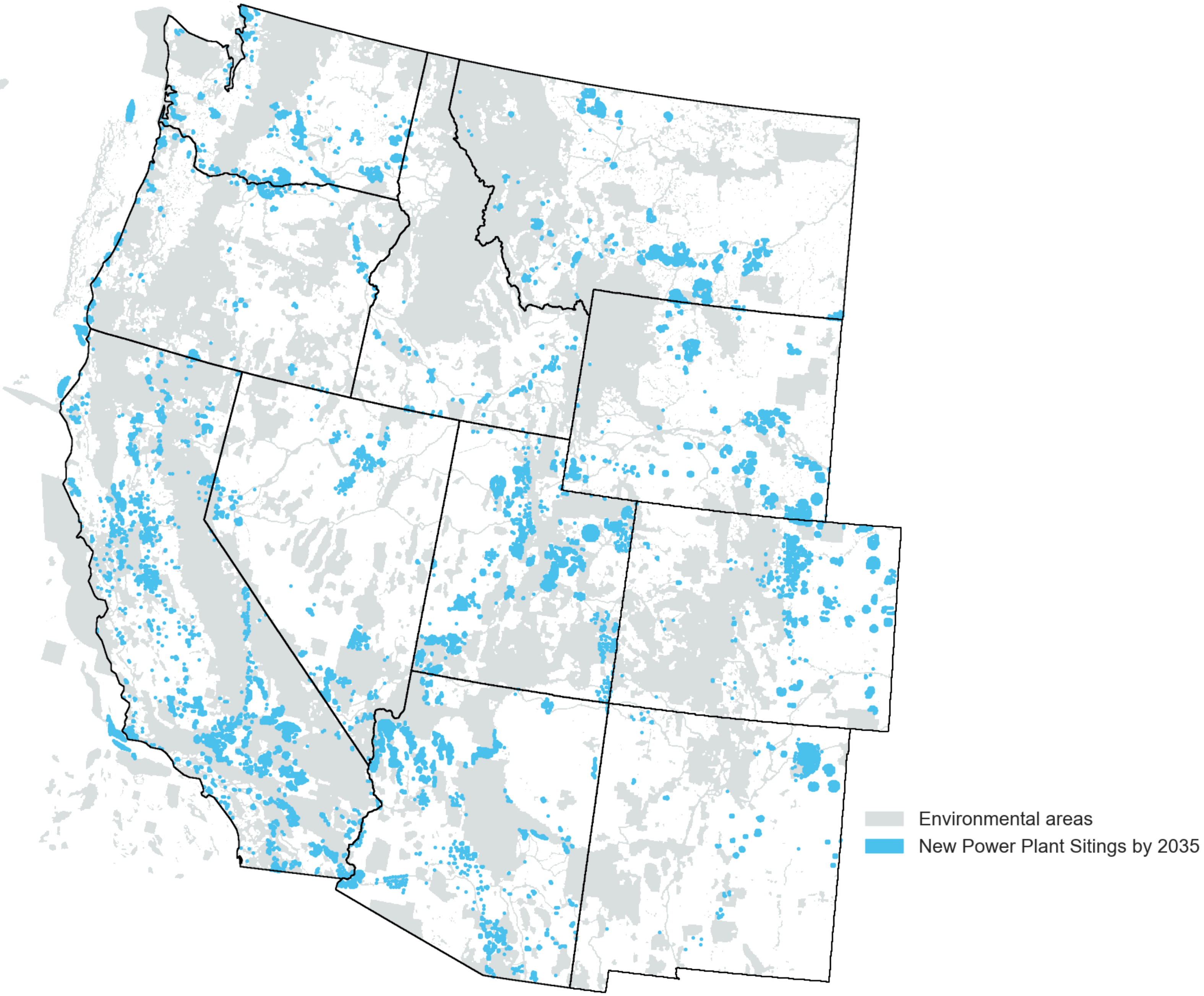


Proximity to Environmental Areas

- By combining geospatial information for various environmental areas, we can determine the fraction of power plant sitings that may receive local opposition for environmental reasons.

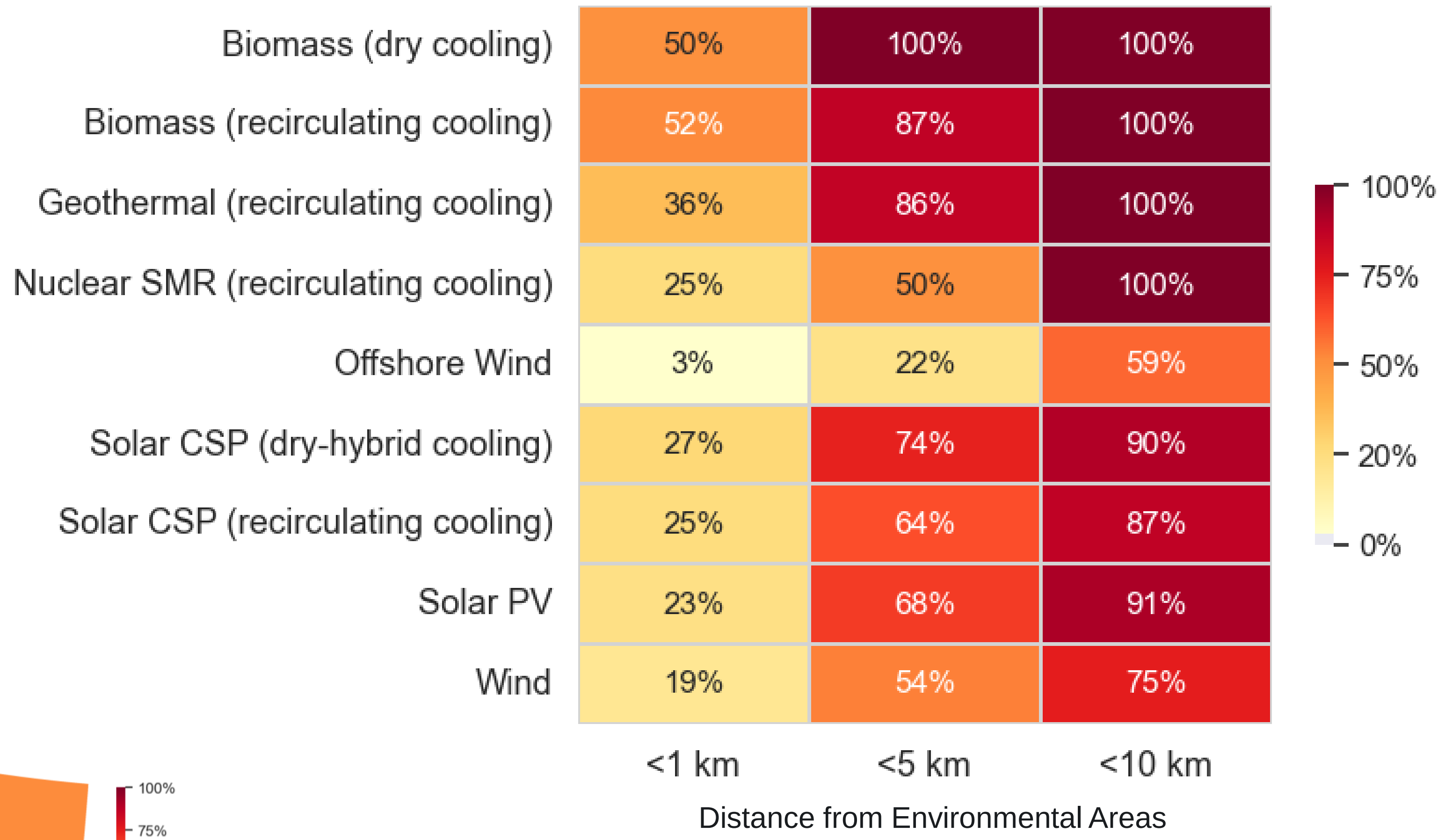
- This can occur even if they are sited in areas that are technically and legally suitable for development but are in proximity to natural areas.

- This combined layer includes areas such as:
    - US National Parks,
    - US Forest Service Lands,
    - Marine Sanctuaries,
    - Outstanding Natural Areas
    - Wetlands
    - State Protected Lands
    - Habitats of Particular Concern
    - Species Designation Areas
    - Wilderness Areas
    - National Monuments
    - + more



Proximity to Environmental Areas

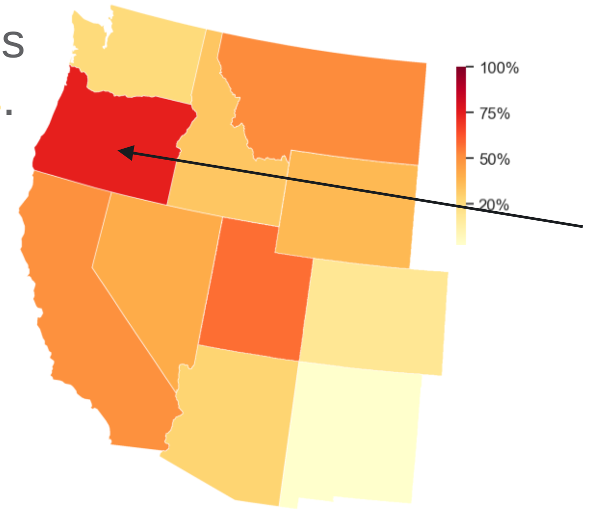
- We evaluated the percent of power plant sitings within 1, 5, and 10 km of environmental areas.
- Approximately **80% of all projected sitings** are **<10 km away** from an environmental or protected area, and **60% <5 km.**
- Wind and solar have a smaller percent of their sitings close to environmental areas, however, they take up most of the land.
- **Oregon (82%)** and **Utah (70%)** have the **highest fraction** of sitings **<5 km from environmental areas**.



Percent of Sitings in Proximity to Environmental Areas

	<1 km	<5 km	<10 km
Biomass (dry cooling)	50%	100%	100%
Biomass (recirculating cooling)	52%	87%	100%
Geothermal (recirculating cooling)	36%	86%	100%
Nuclear SMR (recirculating cooling)	25%	50%	100%
Offshore Wind	3%	22%	59%
Solar CSP (dry-hybrid cooling)	27%	74%	90%
Solar CSP (recirculating cooling)	25%	64%	87%
Solar PV	23%	68%	91%
Wind	19%	54%	75%

Distance from Environmental Areas



Despite having a lower total deployed capacity compared to other states, **Oregon may see highest amount of local opposition to siting.**

Takeaways

1. Evaluating the impacts of decarbonization buildouts requires the complex integration of multiple models of varying types and granularities.

2. Decarbonization will require a significant amount of land for infrastructure buildout. Decarbonization can be successful only if social and environmental equity is considered for the communities those power plants are built in.

3. Our projections show that there may be significant siting in disadvantaged communities identified at the federal level, but future analysis will help us evaluate whether this may be different under state-level definitions.

4. Preliminary siting results show that different states/regions may see varying degrees of socioeconomic and natural resource impacts and opportunities and our analysis can help us understand and identify realistic decarbonization pathways.

Thank you

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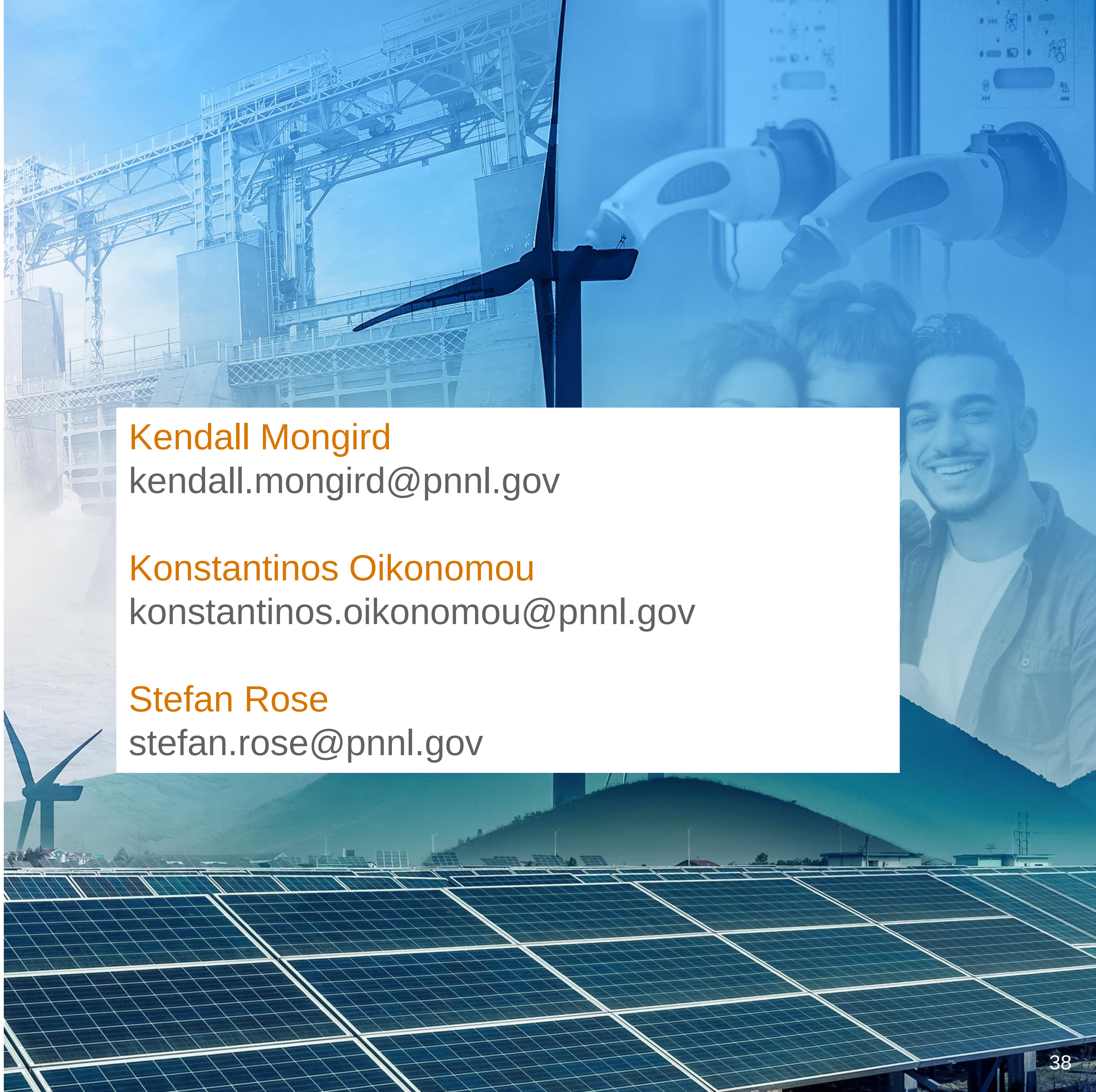

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Mongird K., K. Oikonomou, and S.A. Rose. 07/10/2023. "Incorporating Socioeconomic and Natural Resources Impacts into New Infrastructure Siting." Online, United States. PNNL-SA-187250.

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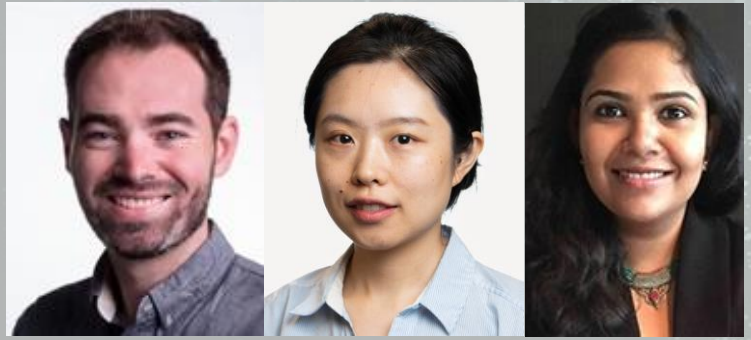

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