JISEA Joint Institute for Strategic Energy Analysis

Intersections of Disadvantaged Communities and Renewable Energy Potential: Analyses to Inform Equitable Investment Prioritization

Presenters* and authors:

Megan Day*, Sustainable Communities Catalyzer PI
Liz Ross*, Sustainable Communities Catalyzer Intern
Christiana Ivanova
Akua McLeod
Jane Lockshin

NREL Transforming ENERGY | COLORADOSCHOOLOFMINES EARTH • ENERGY • ENVIRONMENT | COLORADO STATE UNIVERSITY | Massachusetts Institute of Technology | Stanford University | University of Colorado Boulder

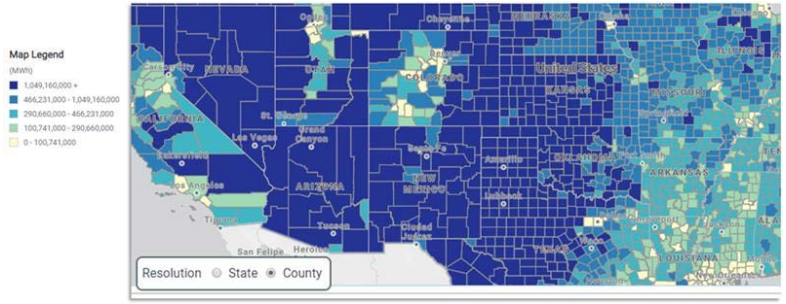
JISEA's Sustainable Communities Catalyzer

Advance understanding of social, economic, environmental, and land use impacts of clean energy transition and map pathways for sustainable, equitable transitions, with a focus on rural and disadvantaged communities

Lead PI: Megan Day

Importance: Scaling clean energy integration, electrifying economies, and transforming energy systems will have major impacts on land use, economies, people, and the environment. NREL is uniquely positioned to apply and integrate world-class modeling, visualization, and computation capabilities to sustainable communities' analysis. *NREL should lead quantitative analysis on impacts and opportunities associated with attaining subnational clean energy transformation and sustainability goals across multiple sectors.*

Aligns with NREL's strategic plans in Integrated Energy Pathways and Electrons to Molecules; Administration prioritization of climate and environmental justice



Success Metrics:

- Codify research needs in coordination with NREL Directorates and partners
- Engage with external practitioners and researchers to include NREL in this community of practice and provide a feedback mechanism for NREL sustainable communities work
- Publications on thought-leadership analysis
- Incubate a Clean Energy Communities group to build capabilities and train existing and new staff in evidence-based best practices in engaging with communities on equitable clean energy planning

Sustainable Communities

Sustainable Communities means attention to people, profit, planet and just and equitable energy transitions

*What are the community-level impacts and **opportunities of clean energy transitions**?*

Focus communities:

- Rural communities
- Disadvantaged communities

Equitable Energy Investment Prioritization Research

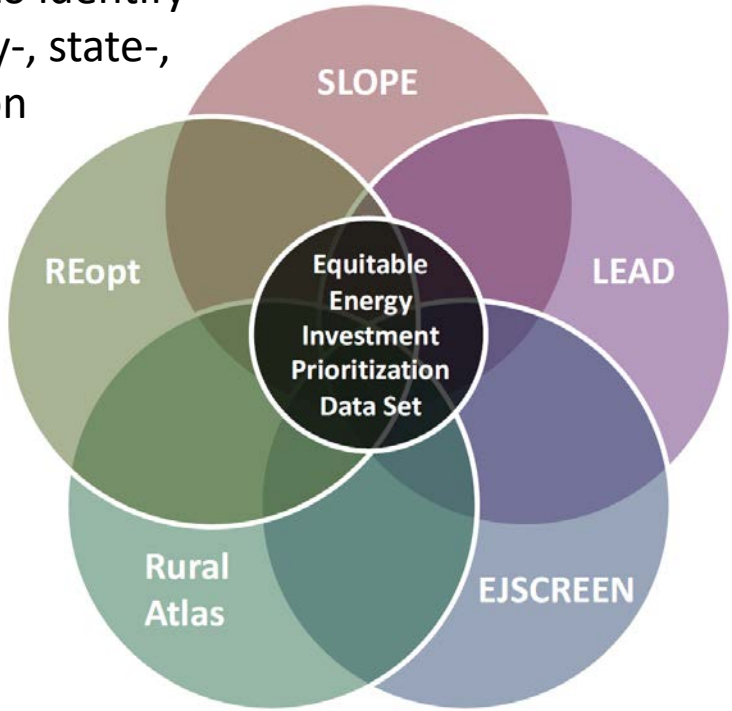
Goal: Intersect **disadvantaged community (DAC) metrics** with **renewable energy (RE) deployment potential metrics** to identify local clean energy opportunities and inform community-, state-, and national-level clean energy investment prioritization

Data set to aid in analysis

- "Equitable Energy Investment Prioritization" data set
- *Published in NREL's Data Catalog*
  - https://data.nrel.gov/submissions/175

Paper with initial analyses

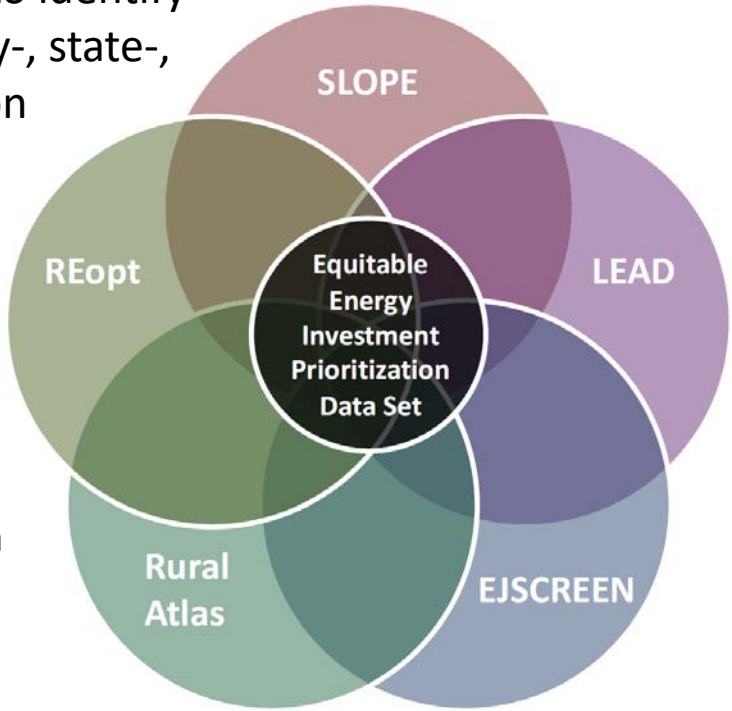
- "Intersections of Disadvantaged Communities and Renewable Energy Potential: Analyses to Inform Equitable Investment Prioritization"
- *Publication pending- submitted to journal on 9/1/21*



Equitable Energy Investment Prioritization Research

Goal: Intersect **disadvantaged community (DAC) metrics** with **renewable energy (RE) deployment potential metrics** to identify local clean energy opportunities and inform community-, state-, and national-level clean energy investment prioritization

- **Top-down** applications
  - Identify broad patterns across RE and DAC metrics
  - Guide investment that prioritizes DACs
- **Bottom-up** applications
  - Provide communities with information to help them identify their needs and their comparative potential for RE development



Equitable Energy Investment Prioritization Research

Goal: Intersect **disadvantaged community (DAC) metrics** with **renewable energy (RE) deployment potential metrics** to identify local clean energy opportunities and inform community-, state-, and national-level clean energy investment prioritization

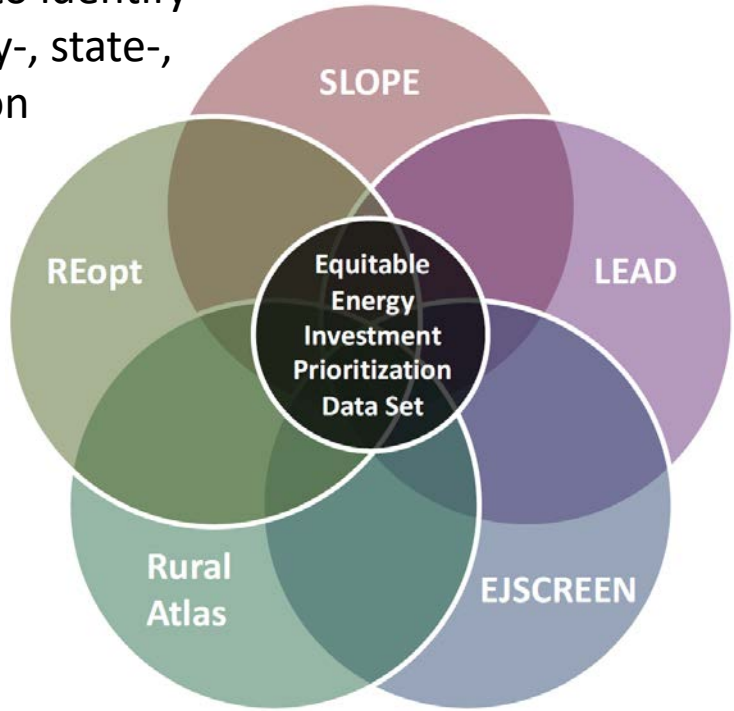
SLOPE: State and Local Planning for Energy platform

REopt®: Renewable Energy Integration and Optimization model

LEAD: Low-Income Energy Affordability Data Tool

EJSCREEN: Environmental Justice Screening and Mapping tool

Rural Atlas: Atlas of Rural and Small-Town America

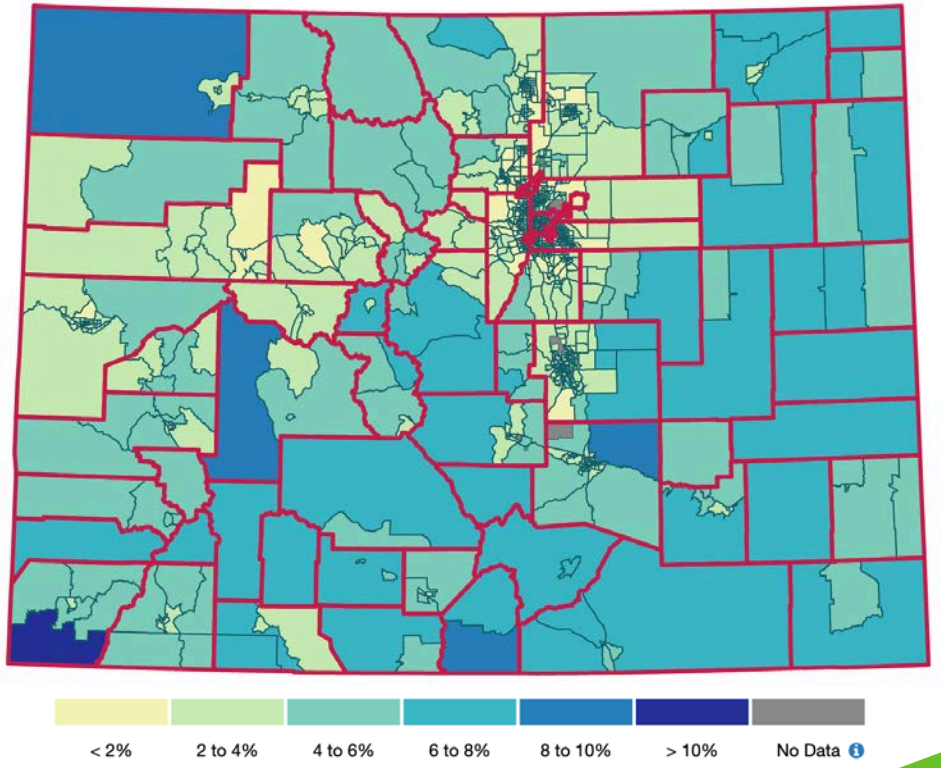


LEAD: Energy Burden

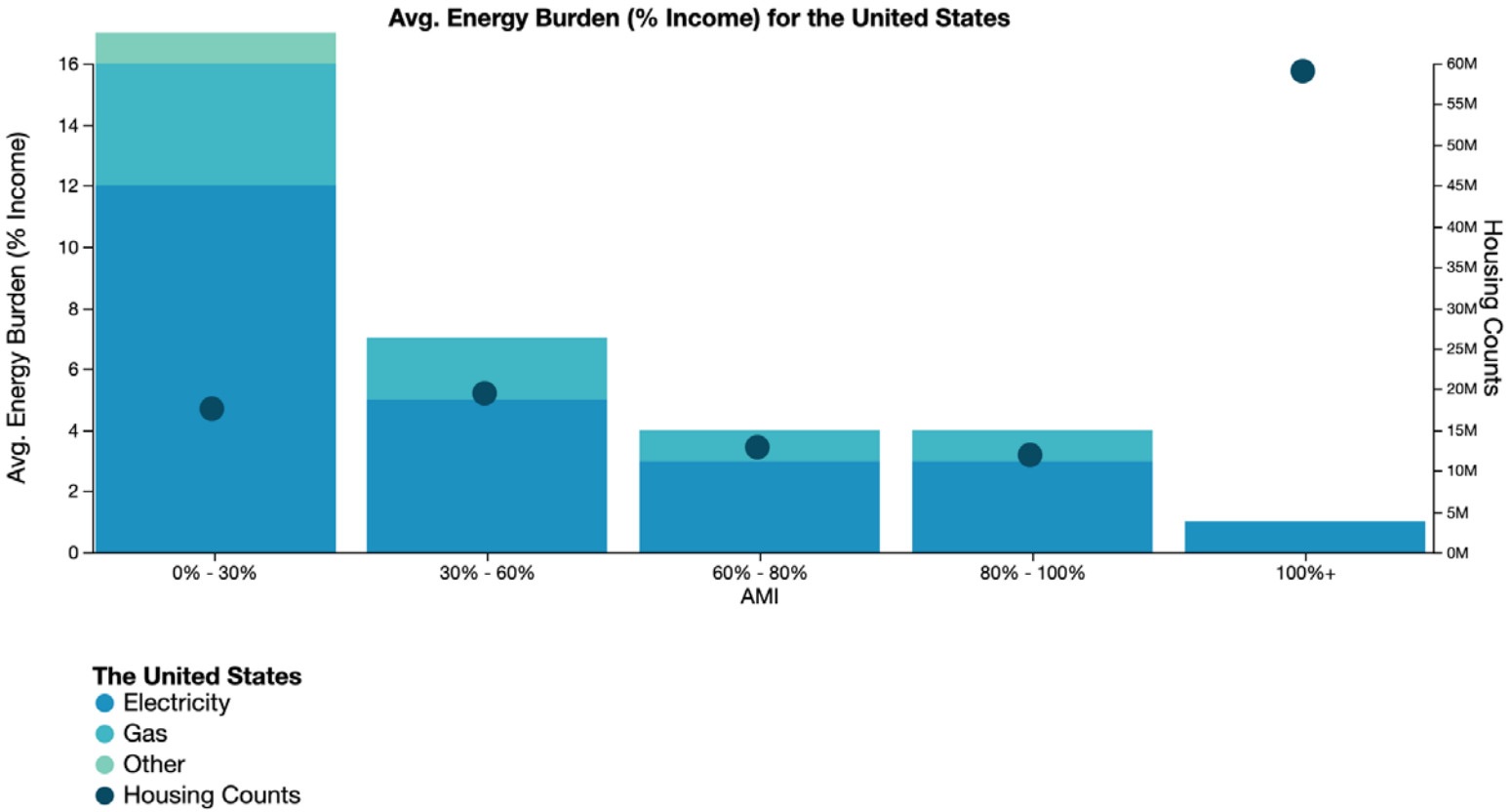
Energy Burden: the percentage of household income spent on household energy costs.

Households spending more than 6% of gross annual income are typically considered energy burdened.

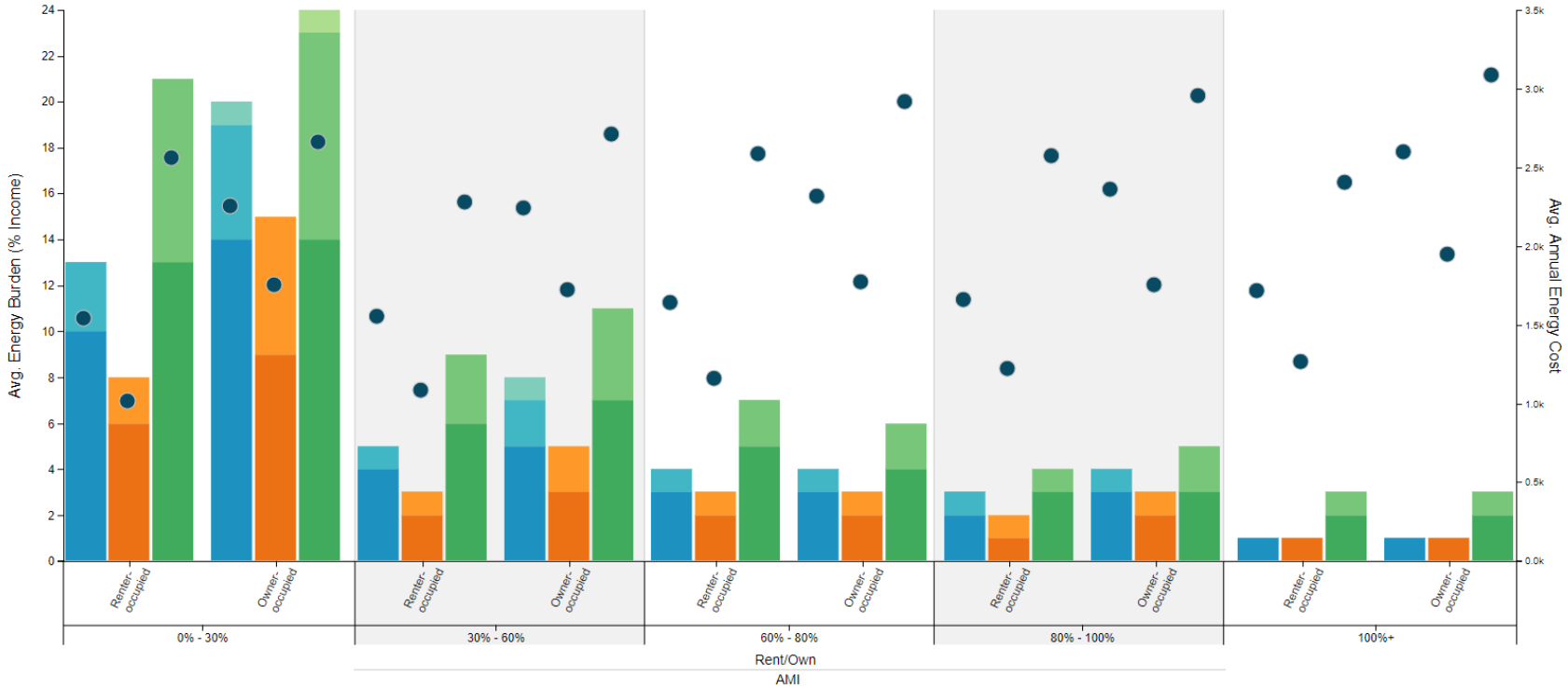
Energy burden by census tract in Colorado



Lower Income Households and Energy Burden

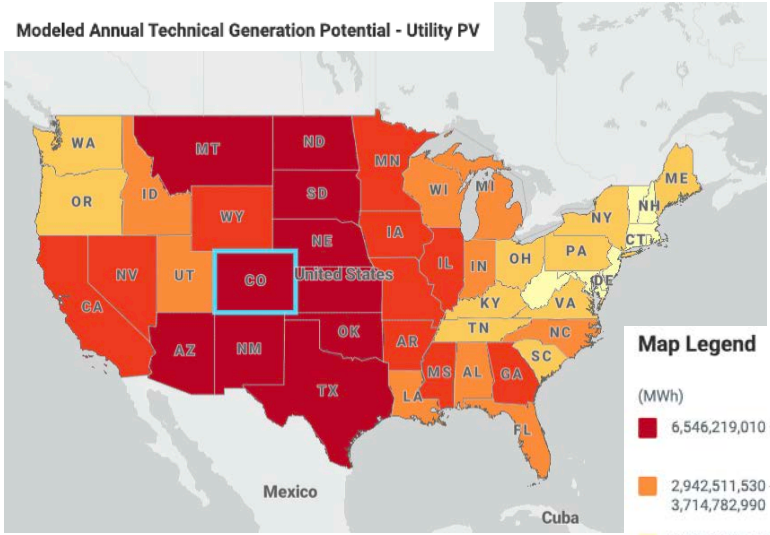


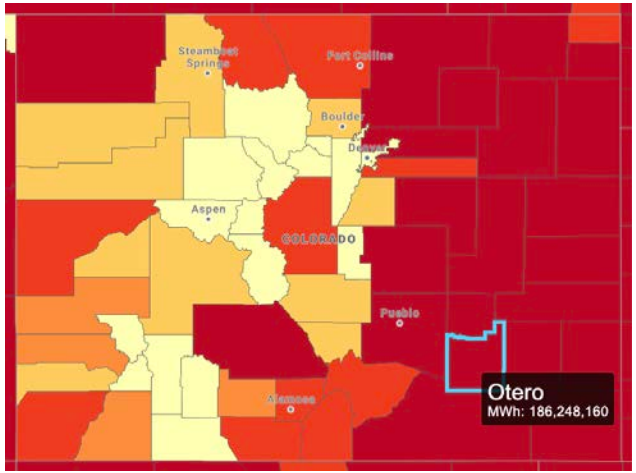
Lower Income Households and Energy Burden



Utility PV: Modeled Annual Technical Potential

In eastern Colorado, technical potential for **utility-scale photovoltaic** (PV) is among the highest in the nation.

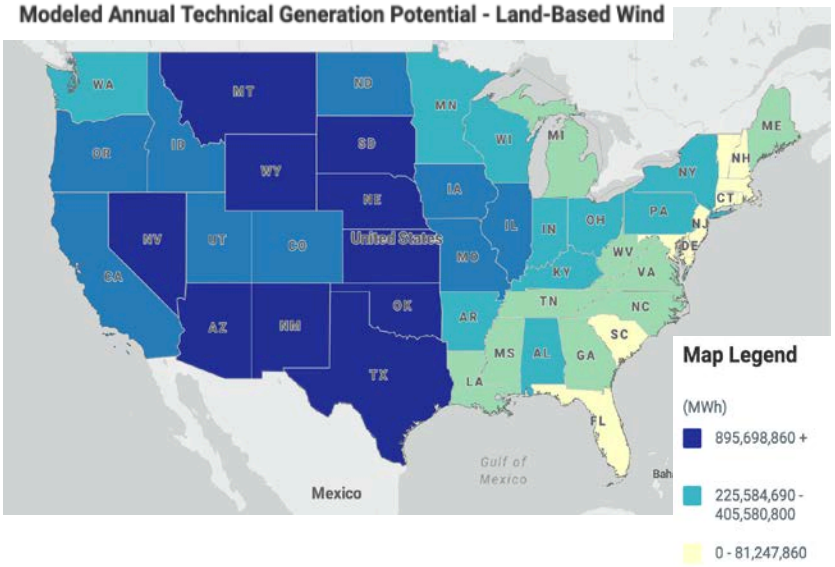


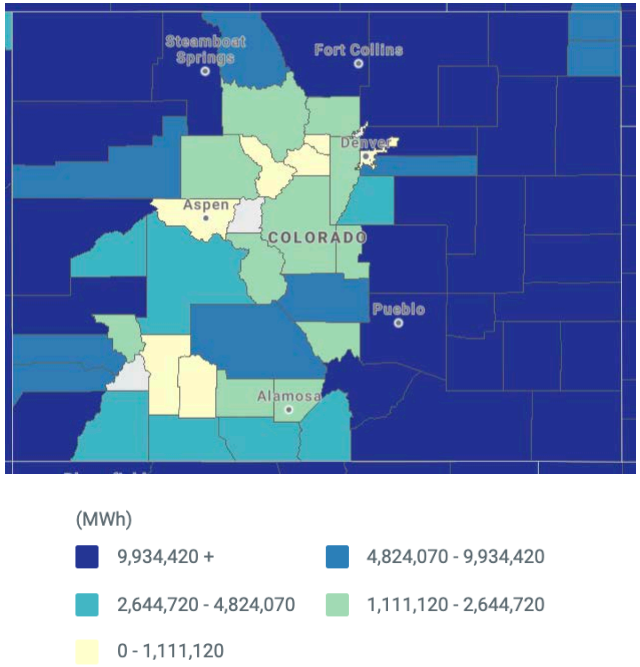


Note: Utility-scale PV generation potential is estimated using the Renewable Energy Potential (reV) Model based on single-axis tracking, 20 MW capacity systems, with performance and pricing characteristics in line with a 1.34 DC-to-AC ratio or inverter loading ratio, consistent with Annual Technology Baseline representative technology.

Land-Based Wind: Modeled Annual Technical Potential

In eastern Colorado, technical potential for **land-based wind** is among the highest in Colorado and high compared to the nation.

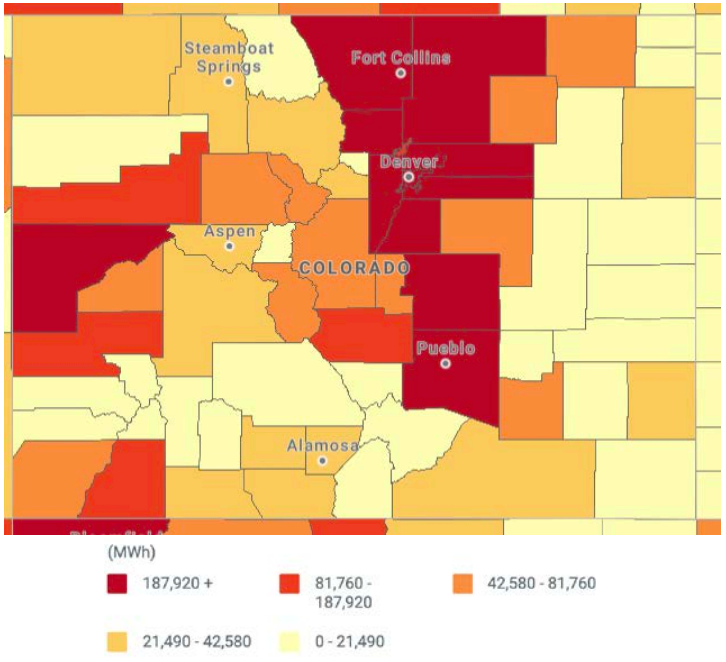




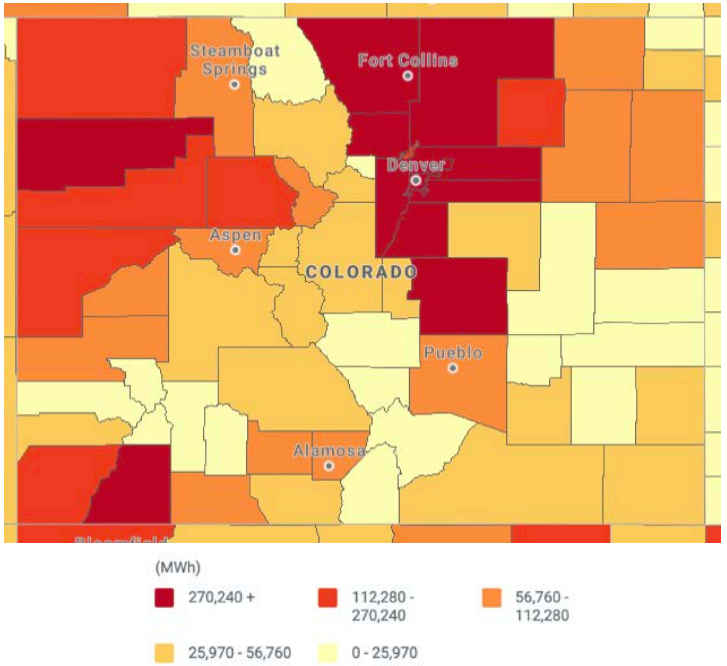
Note: Land-based wind generation potential is estimated using the Renewable Energy Potential (reV) Model and reflects representative technology consistent with Annual Technology Baseline assumptions.

Rooftop Solar: Modeled Annual Technical Potential

Residential Rooftop Solar



Commercial Rooftop Solar



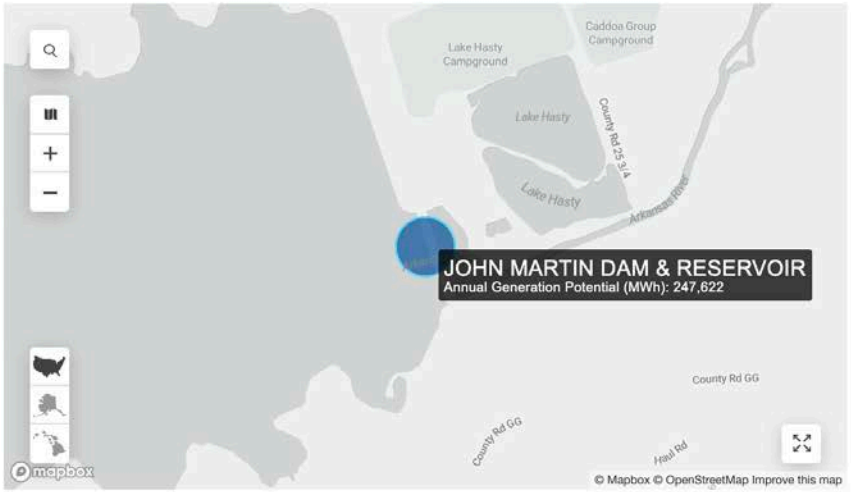
NOTE: The technical generation potential of residential and commercial rooftop PV is estimated by combining modeled suitable rooftop area with solar resource availability and quality and system performance data through a methodology described here. Technical potential does not account for existing systems and does not consider economic or market feasibility. Additional solar information resources are available here.

Hydropower: Modeled Annual Technical Potential

Bent County, CO

Bent County

Hydropower - Non-Powered Dams



Current Map & Graph Resolution: Point Location

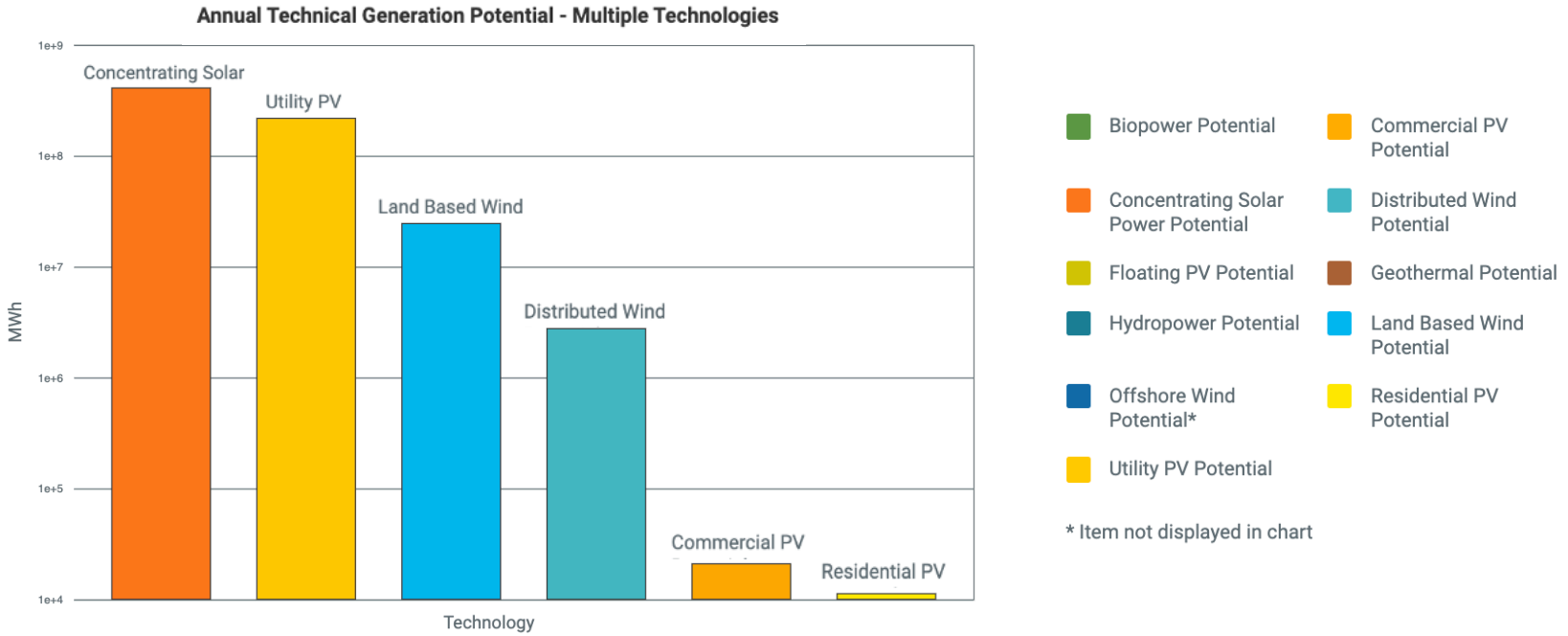
Hydropower - Non-Powered Dams

Month	Generation Potential - MWh	Capacity - MW
Annual	247622	79
January	10192	
February	9162	
March	12060	
April	16896	
May	43705	
June	52064	
July	32779	
August	27364	
September	12141	
October	11353	
November	10349	
December	9557	

NOTE: Non-powered dams (NPD) are those that do not produce electricity but provide services ranging from water supply to inland navigation and other water conveyance infrastructures such as irrigation canals. Estimates factor technical characteristics described in the Department of Energy/Oak Ridge National Laboratory Assessment of Energy Potential at Non-Powered Dams in the United States report.

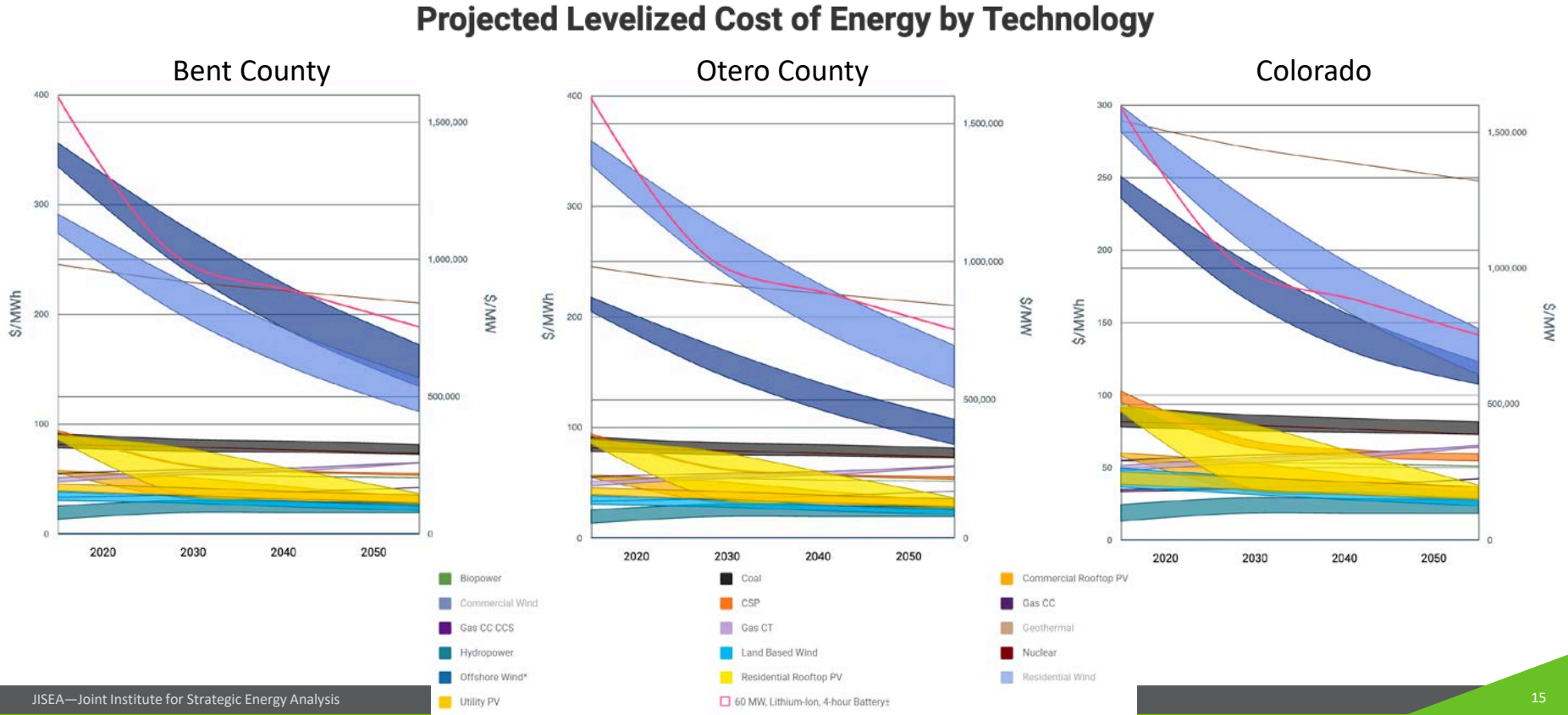
Technical Potential Across Multiple Technologies

Bent County, CO



NOTE: This graph uses a logarithmic axis.

Hydropower, Wind, & Solar Have Lowest LCOE



SLOPE: Renewable Energy Technologies Considered

Metric	Description	Indicator
Commercial PV*	Uses commercial and industrial building roof-mounted, fixed tilt, medium-capacity systems to convert solar energy into electricity	Technical generation potential, levelized cost of energy (LCOE); quintiles based on national data
Residential PV	Uses residential building roof-mounted, fixed tilt, small-capacity systems to convert solar energy into electricity	Technical generation potential, LCOE; quintiles based on national data
Utility PV	Uses ground-mounted, tracking, large-capacity systems to convert solar energy into electricity	Technical generation potential, LCOE; quintiles based on national data
Land-based wind	Uses utility-scale, large-capacity onshore wind turbines to convert energy from wind spinning the turbine blades into electricity	Technical generation potential, LCOE; quintiles based on national data
Geothermal	Converts energy from naturally occurring underground reservoirs of hot water spinning a turbine into electricity	LCOE, capital costs; quintiles based on national data
Hydropower	Converts potential energy from flowing water into electricity; costs consider development of new stream reach and non-powered dams–not upgrades to existing facilities	LCOE, capital costs; quintiles based on national data

*Photovoltaics

REopt: Solar-Plus-Storage

Metric	Description	Indicator
Solar-plus-storage	Battery energy storage systems with solar PV	Cost savings estimates reaggregated* from utility subdivisions to county-level

*Reaggregation occurred by intersecting REopt data with US county shapefiles & calculating percent overlap between reference sites and counties and scaling the cost savings for each site within the county by percent overlap

LEAD: Energy Burden

Metric	Description	Indicator
Energy burden	% of household income spent on household energy use	Weighted average of energy burdened and energy impoverished percents by county*

**Energy burdened* defined as an energy burden of ≥ 7% and ≤ 10%; *energy impoverished* defined as an energy burden of > 10% (Cook & Shah, 2018).

Scores assigned based on energy burden scale[a]

Not burdened: < 4%
Energy stressed: 4–7%
Energy burdened: 7–10%
Energy impoverished: > 10%

→ Count of the census tract scores, by county and by score

→ Percent of census tracts with each score, by county

→ Weighted average of *energy burdened* and *energy impoverished* percents by county

[a]Cook & Shah, 2018

Rural Atlas: Sociodemographic Indicators

Metric	Description	Indicator
Mining, quarrying, and oil & gas jobs	% of labor force employed in mining, quarrying, and oil & gas extraction	Quintile based on national data
Rural-urban code	Rural-urban classifications	Ranges from 1 (most urban) to 9 (most rural)
Unemployment	% of unemployed individuals	Quintile based on national data

EJSCREEN: Sociodemographic Indicators

Metric	Description	Indicator
Less than HS	% of individuals with less than a high school education	Weighted sum of proportion of block groups in the fourth and fifth quintile in excess of 20% by county
Low-income	% of households that make less than or equal to twice the federal poverty level	
Minority	% of non-white, non-Hispanic/Latinx individuals	

Scores assigned for each block group based on national quintiles → Count of the block group scores, by county and by score → Percent of block groups with each score, by county → Subtract 20% from the fourth and fifth quintile percentage and take a weighted sum of the values

EJSCREEN: Environmental Hazard Indicators

Metric	Description	Indicator
Cancer risk	Due to inhalation of outdoor air toxics	Percent of block groups in the fifth quintile in excess of 20% by county
Diesel PM	Concentration of hazardous air pollutants	
Lead paint	% of occupied housing units built before 1960	
NPL proximity	Superfund sites where remediation is needed	
Ozone	Concentrations from summer averages	
$PM_{2.5}$	Concentrations of fine particles in the air	
Respiratory hazard	Due to air toxics	
RMP proximity	Facilities that house hazardous materials for which a risk management plan is needed	
TSDF proximity	Hazardous waste disposal sites	
Traffic proximity	Average annual daily vehicle counts divided by distance	
Wastewater discharge	Water pollutant concentrations divided by the distance	

Initial Analyses: Broad Patterns between DACs and REs

- **Rural areas** tend to have better opportunity for **land-based wind** development.
- **Mining and oil & gas communities** tend to have better opportunity for **utility PV** and **land-based wind** development.
- **Rooftop PV** has higher potential in urban areas, areas with higher minority populations, and areas exposed to certain environmental hazards.
- **Communities with higher ozone concentrations** tend to have better opportunity for **utility, commercial, and residential PV** and for **land-based wind** development.

	Technology												
	Commercial PV		Residential PV		Utility PV		Land-based wind		Geothermal		Hydro		Solar + storage
Indicator	Technical potential	LCOE	Technical potential	LCOE	Technical potential	LCOE	Technical potential	LCOE	Capital costs	LCOE	Capital costs	LCOE	Cost savings
Energy burden	-.07***	.02	-.08***	.02	.02	.04*	.04*	-.01	.08	.07	.07***	.07***	-.04*
Less than HS	-.08***	-.24***	-.12***	-.22***	.06***	-.32***	-.01	.22***	-.11^{+}	-.10^{+}	-.18***	-.09***	.01
Low-income	-.12***	-.17***	-.15***	-.16***	.04*	-.26***	-.01	.20***	.10^{+}	.11^{+}	-.13***	-.05*	-.04*
Minority	.15***	-.37***	.13***	-.35***	.23***	-.25***	.12***	.10***	-.09	-.10^{+}	-.08***	-.06**	.14***
Mining, quarrying, and O&G employment	-.07***	-.25***	-.09***	-.25***	.29***	-.25***	.31***	-.15***	-.09	-.10^{+}	-.07***	-.02	-.03^{+}
Rural	-.29***	-.10***	-.35***	-.11***	.14***	-.12***	.22***	-.24***	.11^{+}	.11^{+}	.11***	.10***	-.11***
Unemployment	.18***	.21***	.17***	.23***	-.11***	.16***	-.19***	.24***	-.23***	-.23***	-.10***	-.04*	.17***
Cancer risk	.07***	-.07***	.07***	-.06***	-.07***	-.12***	-.15***	.39***	-.18**	-.18**	.01	.07***	.04*
Diesel PM	.33***	.02	.29***	.02	-.06**	.09***	-.07***	.12***	.09	.08	-.06**	-.06***	.01
Lead paint	.14***	.12***	.10***	.12***	-.05**	.15***	-.02	-.15***	.00	.00	.04*	.01	-.02
NPL proximity	.16***	.08***	.16***	.07***	-.06***	.12***	-.08***	.03^{+}	.05	.04	.00	-.03^{+}	.04*
Ozone	.06***	-.42***	.07***	-.45***	.39***	-.22***	.37***	.01	.23***	.23***	.08***	.04*	.14***
$PM_{2.5}$	.22***	.00	.22***	.00	-.06**	.12***	-.08***	.25***	-.19***	-.18**	-.02	-.05***	.14***
Respiratory hazard	.08***	-.09***	.06***	-.09***	-.07***	-.09***	-.16***	.43***	-.33***	-.33***	.03	.08***	.12***
RMP proximity	.04*	-.10***	.03	-.10***	.08***	-.08***	.10***	-.22***	-.11*	-.12*	.17***	.15***	-.01
TSDF proximity	.43***	.04*	.32***	.04*	-.08***	.15***	-.08***	.08***	-.24***	-.24***	-.04*	-.06***	.15***
Traffic proximity	.49***	-.02	.37***	-.02	-.08***	.12***	-.08***	.09***	-.24***	-.24***	-.03	-.04*	.21***
Wastewater discharge	.08***	-.02	.08***	-.03^{+}	.04^{+}	.02	.02	.04*	.00	-.01	.04^{+}	.03	.03

Note: Blue shades indicate positive correlations, with darker blue indicating a stronger positive correlation. Pink shades indicate negative correlations, with darker pink indicating a stronger negative correlation. The lightest shade indicates a correlation between ±.10 and ±.30, and the darkest shade indicates a correlation greater than ±.30. White indicates either a negligible correlation (r < .10) or a correlation with p > .10. A p-value less than .05 indicates a significant relationship, and a p-value greater than or equal to .10 indicates a nonsignificant relationship. A p-value greater than or equal to .05 and less than .10 is considered marginally significant.

*** p < .001, ** p < .01, * p < .05, $^{+}$ p < .10

County Profiles: Top Opportunities for RE Deployment

Top 10 DACs Considering the **Minority Indicator** and **Unemployment Rate** and their Opportunities for Renewable Energy Development

State	County	Minority Indicator Score	Unemploy-ment Rate	Commercial PV Technical Potential (MWh)	Quintile	Residential PV Technical Potential (MWh)	Quintile	Utility PV Technical Potential (MWh)	Quintile	Land-based Wind Technical Potential (MWh)	Quintile
TX	Starr	1.36	17	85,276	3	144,456	4	180,207,812	5	20,975,146	5
WI	Menominee	1.36	15	3,167	1	5,720	1	16,072,767	2	466,696	1
TX	Maverick	1.36	15	70,277	3	135,864	4	180,708,067	5	17,433,906	5
MS	Claiborne	1.36	14	8,762	1	13,649	1	37,011,585	3	3,299,088	2
TX	Zapata	1.36	12	14,122	1	29,708	2	152,028,997	5	15,732,926	5
TX	Duval	1.36	12	34,448	2	29,695	2	262,735,628	5	29,456,452	5
TX	Brooks	1.36	11	16,695	1	16,488	1	140,744,289	5	15,432,380	5
SD	Oglala Lakota	1.36	10	9,328	1	8,150	1	136,741,508	5	32,089,067	5
TX	Jim Hogg	1.36	10	15,066	1	14,511	1	178,341,857	5	24,571,141	5
TX	Webb	1.36	8	349,974	5	466,156	5	492,786,121	5	56,985,634	5

Note. To generate this list, the data set was filtered to include only the counties with the highest score for the minority indicator. The data set was then sorted by highest unemployment rate.

County Profiles: Top Opportunities for RE Deployment

Top 10 DACs Considering the **Minority Indicator** and **Unemployment Rate** and their Opportunities for Renewable Energy Development

State	County	Minority Indicator Score	Unemploy-ment Rate	Commercial PV Technical Potential (MWh)	Quintile	Residential PV Technical Potential (MWh)	Quintile	Utility PV Technical Potential (MWh)	Quintile	Land-based Wind Technical Potential (MWh)	Quintile
TX	Starr	1.36	17	85,276	3	144,456	4	180,207,812	5	20,975,146	5
WI	Menominee	1.36	15	3,167	1	5,720	1	16,072,767	2	466,696	1
TX	Maverick	1.36	15	70,277	3	135,864	4	180,708,067	5	17,433,906	5
MS	Claiborne	1.36	14	8,762	1	13,649	1	37,011,585	3	3,299,088	2
TX	Zapata	1.36	12	14,122	1	29,708	2	152,028,997	5	15,732,926	5
TX	Duval	1.36	12	34,448	2	29,695	2	262,735,628	5	29,456,452	5
TX	Brooks	1.36	11	16,695	1	16,488	1	140,744,289	5	15,432,380	5
SD	Oglala Lakota	1.36	10	9,328	1	8,150	1	136,741,508	5	32,089,067	5
TX	Jim Hogg	1.36	10	15,066	1	14,511	1	178,341,857	5	24,571,141	5
TX	Webb	1.36	8	349,974	5	466,156	5	492,786,121	5	56,985,634	5

Note. To generate this list, the data set was filtered to include only the counties with the highest score for the minority indicator. The data set was then sorted by highest unemployment rate.

County Profiles: Top Opportunities for RE Deployment

Top 10 DACs Considering the **Minority Indicator** and **Unemployment Rate** and their Opportunities for **Land-based Wind Development**

State	County	Minority Indicator	Unemploy-ment Rate	Land-Based Wind Technical Potential (MWh)	Quintile	Land-Based Wind LCOE ($/MWh)	Quintile
TX	Starr	1.36	17	20,975,146	5	35	1
WI	Menominee	1.36	15	466,696	1	39	2
TX	Maverick	1.36	15	17,433,906	5	35	1
MS	Claiborne	1.36	14	3,299,088	2	53	4
TX	Zapata	1.36	12	15,732,926	5	35	1
TX	Duval	1.36	12	29,456,452	5	35	1
TX	Brooks	1.36	11	15,432,380	5	35	1
SD	Oglala Lakota	1.36	10	32,089,067	5	-	-
TX	Jim Hogg	1.36	10	24,571,141	5	35	1
TX	Webb	1.36	8	56,985,634	5	35	1

Note. To generate this list, the data set was filtered to include only the counties with the highest score for the minority indicator. The data set was then sorted by highest unemployment rate.

County Profiles: Top Opportunities for RE Deployment

Top 10 DACs Considering the **Minority Indicator** and **Unemployment Rate** and their Opportunities for **Land-based Wind Development**

State	County	Minority Indicator	Unemploy-ment Rate	Land-Based Wind Technical Potential (MWh)	Quintile	Land-Based Wind LCOE ($/MWh)	Quintile
TX	Starr	1.36	17	20,975,146	5	35	1
WI	Menominee	1.36	15	466,696	1	39	2
TX	Maverick	1.36	15	17,433,906	5	35	1
MS	Claiborne	1.36	14	3,299,088	2	53	4
TX	Zapata	1.36	12	15,732,926	5	35	1
TX	Duval	1.36	12	29,456,452	5	35	1
TX	Brooks	1.36	11	15,432,380	5	35	1
SD	Oglala Lakota	1.36	10	32,089,067	5	-	-
TX	Jim Hogg	1.36	10	24,571,141	5	35	1
TX	Webb	1.36	8	56,985,634	5	35	1

Note. To generate this list, the data set was filtered to include only the counties with the highest score for the minority indicator. The data set was then sorted by highest unemployment rate.

County Profiles: Costilla County, CO

Costilla County

- **Indicators of high need**
  - Rural & farming-dependent
  - High unemployment
  - Low-income, persistent poverty, & energy burdened (7-10%)
- **Indicators of high potential**
  - Land-based wind & Utility PV
    - High technical potential
    - Low cost

DAC and Renewable Energy Deployment Potential Indicators in Costilla County, CO

Metric	Quintile or Indicator Score	Raw value
Utility PV		
Technical potential (MWh)	4th	91,650,546
LCOE ($/MWh)	1st	45
Land-based wind		
Technical potential (MWh)	4th	10,961,518
LCOE ($/MWh)	2nd	38
Solar-plus-storage		
Cost savings ($)	4th	3,363
Unemployment rate (%)	4th	7.2
Mining, quarrying, and O&G employment (%)	4th	.86
Low-income	.88	-
Energy burden	.55	-
Less than high school education	.93	-
Hispanic or nonwhite individuals	.81	-
Ozone concentration	.80	-

Note: Raw value not reported for some metrics because original resolution was not at the county level

Thank you

Megan Day, AICP; Liz Ross

www.jisea.org

NREL/PR-6A50-81527
https://www.nrel.gov/docs/fy22osti/81527.pdf

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the Joint Institute for Strategic Energy Analysis. The views expressed herein do not necessarily represent the views of the DOE, the U.S. Government, or sponsors.

JISEA Joint Institute for Strategic Energy Analysis

NREL Transforming ENERGY | COLORADOSCHOOLOFMINES EARTH • ENERGY • ENVIRONMENT | COLORADO STATE UNIVERSITY | Massachusetts Institute of Technology | Stanford University | University of Colorado Boulder