JISEA Joint Institute for Strategic Energy Analysis

2023 JISEA Annual Meeting: Addressing Real Life Data Challenges and Novel Solutions for Applied Science Projects

Moderator: Debbie Brodt-Giles, JISEA

Panelists: Grant Buster (NREL), Meghan Mooney (NREL), Megan Day (NREL), David Rojas (CSU)

NREL/PR-6A50-86710

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JISEA Joint Institute for Strategic Energy Analysis

NREL Data Resources for Energy System Planning

Grant Buster

JISEA Annual Meeting

April 27th, 2023

NREL Transforming ENERGY | Colorado School of Mines | Colorado State University | Howard University Office of Research | Massachusetts Institute of Technology | Stanford University | University of Colorado Boulder

So you’re planning an energy system…

What questions might you have?

1. What wind and solar resources are available in my area?
2. What will be the cost of such systems?
3. Where should I put my generators?
4. What local land use ordinances are present in my area?
5. How will my future energy system operate?
6. How does climate change affect these systems?

What is the wind and solar resource in my area?

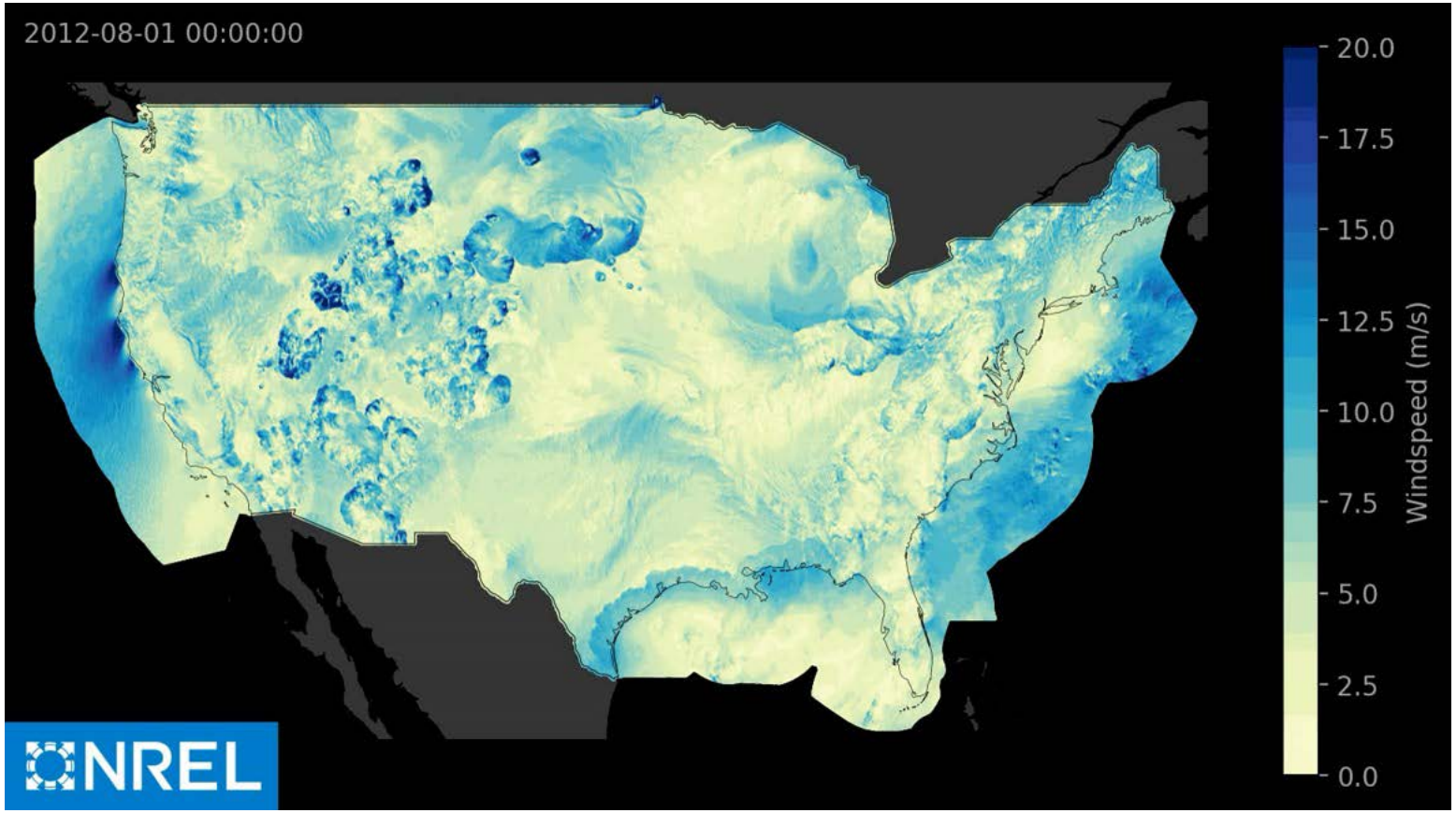
The National Solar Radiation Database (NSRDB)

- Historical record of solar irradiance over the Western hemisphere
- Satellite-derived solar irradiance data
- Machine learning techniques for satellite image processing
- Historically accurate
- 1998-present
- Now global!
- https://nsrdb.nrel.gov/

What is the wind and solar resource in my area?

The Wind Integration National Dataset (WIND Toolkit)

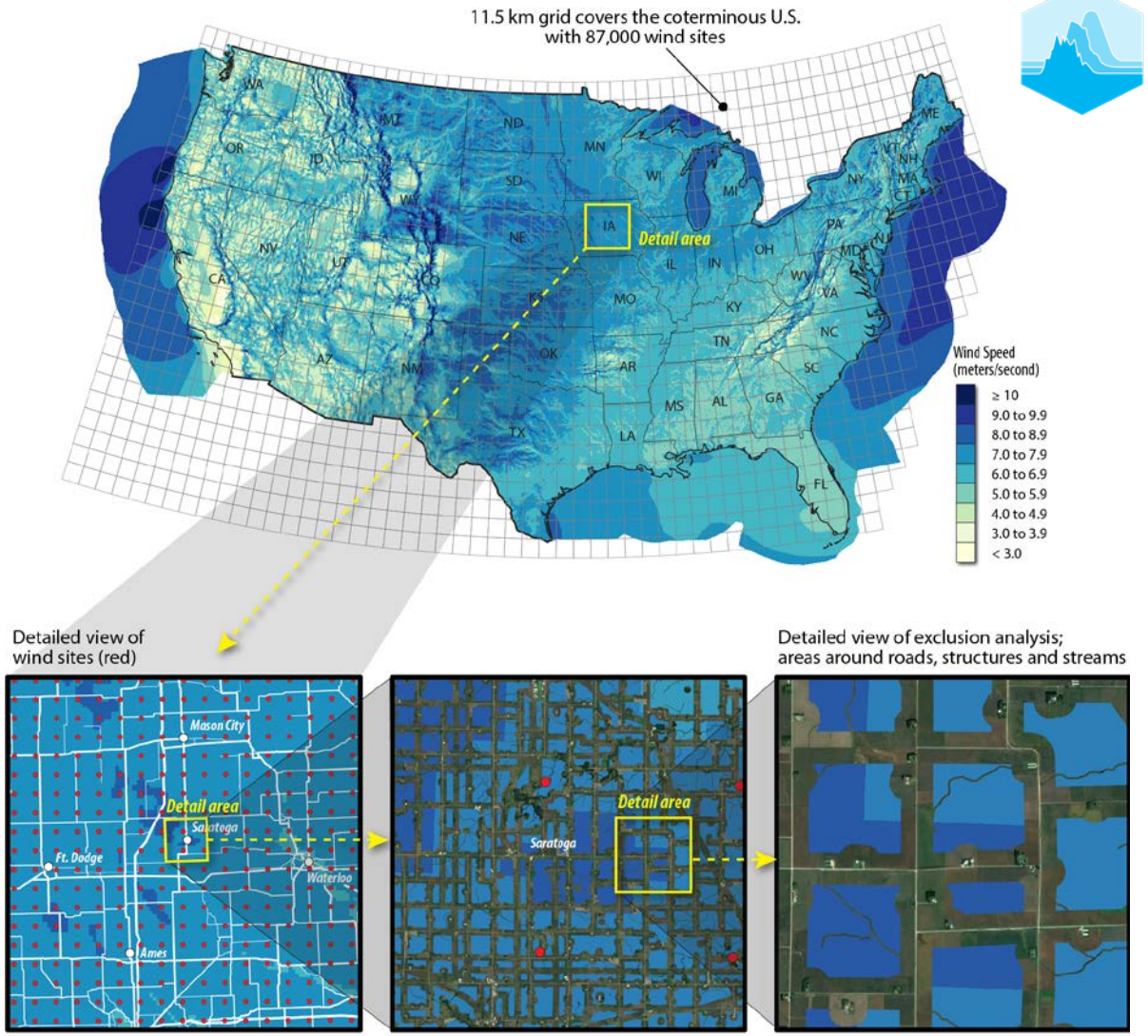
- Numerical weather prediction of historical wind resource
- Historically accurate
- 2007-2014
- Some global data
- New years of data, coming soon!
- https://www.nrel.gov/grid/wind-toolkit.html



Where should I put my generators?

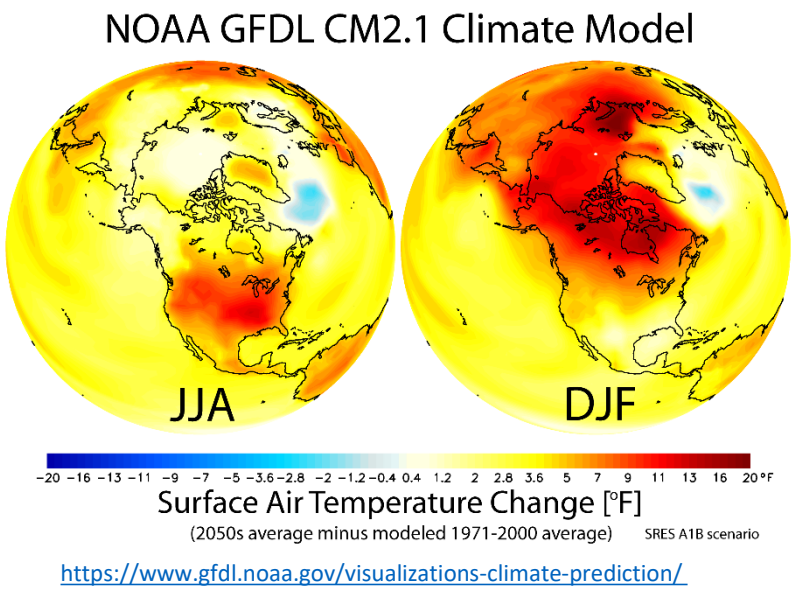
The Renewable Energy Potential Model (reV)

1. Continental-scale renewable energy siting
2. Cost and time-series modeling
3. Local ordinances and land use constraints
4. Fully integrated with NSRDB and WIND Toolkit
5. Anyone can run reV on the cloud
6. https://nrel.github.io/reV/



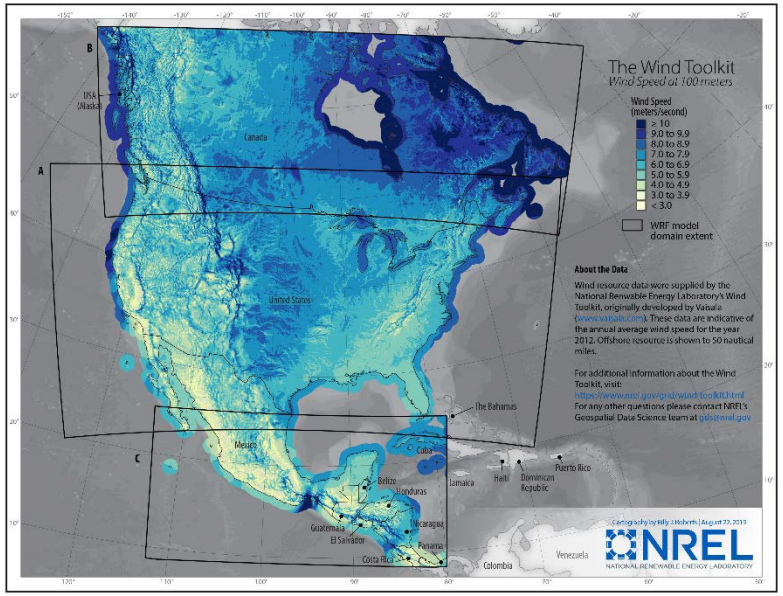
How does climate change affect my energy system?

Global Climate Models (GCMs)



https://www.gfdl.noaa.gov/visualizations-climate-prediction/

Mesoscale NREL Datasets (WTK, NSRDB)



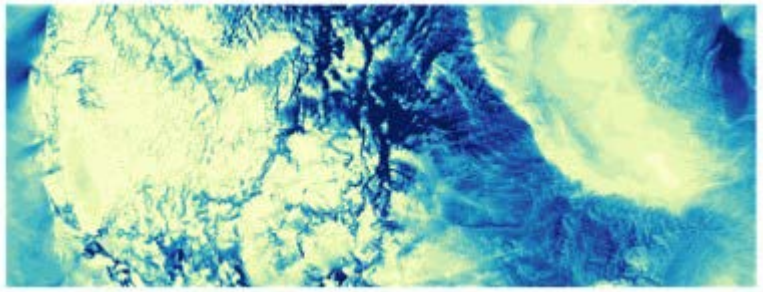
~100 km grid resolution
daily average data
2000-2100

How do we bridge this gap?

~4 km grid resolution
hourly data
Historical

Super-Resolution for Renewable Energy Resource Data with Climate Change Impacts (Sup3rCC)

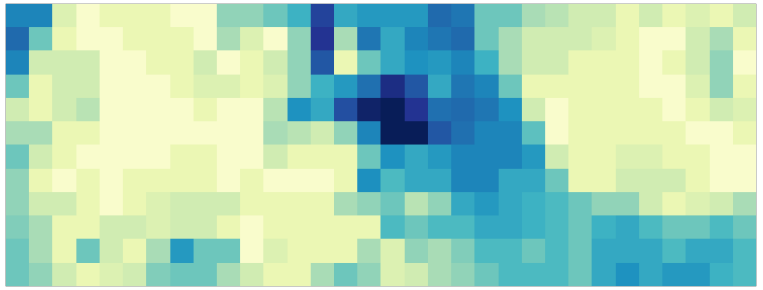
True High Res (WTK or NSRDB)



4km Hourly

Coarsen high res to create training data

Low Res (WTK, NSRDB, GCM)

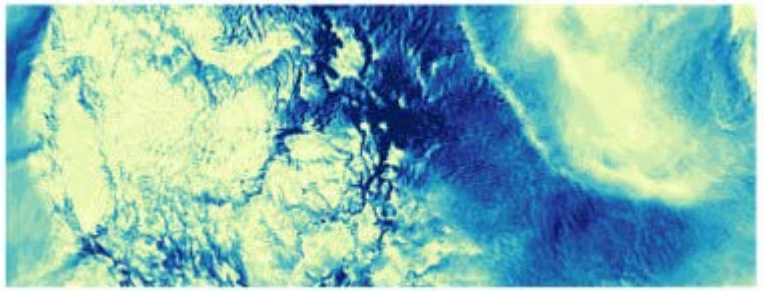


100km Daily

Discriminative Model

Generative Model

Synthetic High-Res Output



4km Hourly

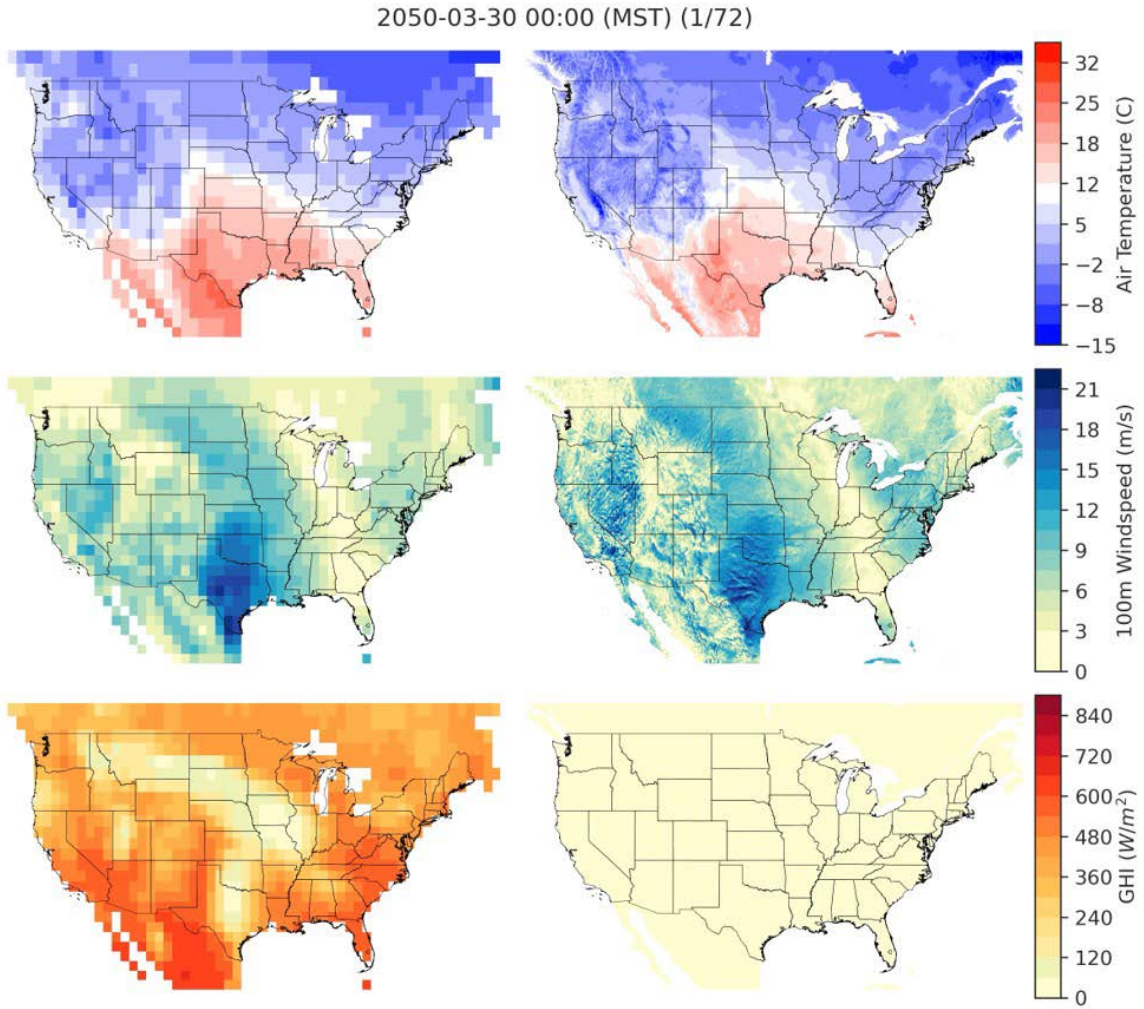
Benefits of Downscaling with ML:

1. Computational efficiency (40-200x faster than WRF)
2. Designed for renewables (wind, solar, temp, humidity)
3. Fully integrated into energy analysis software
4. Open-source: https://nrel.github.io/sup3r/

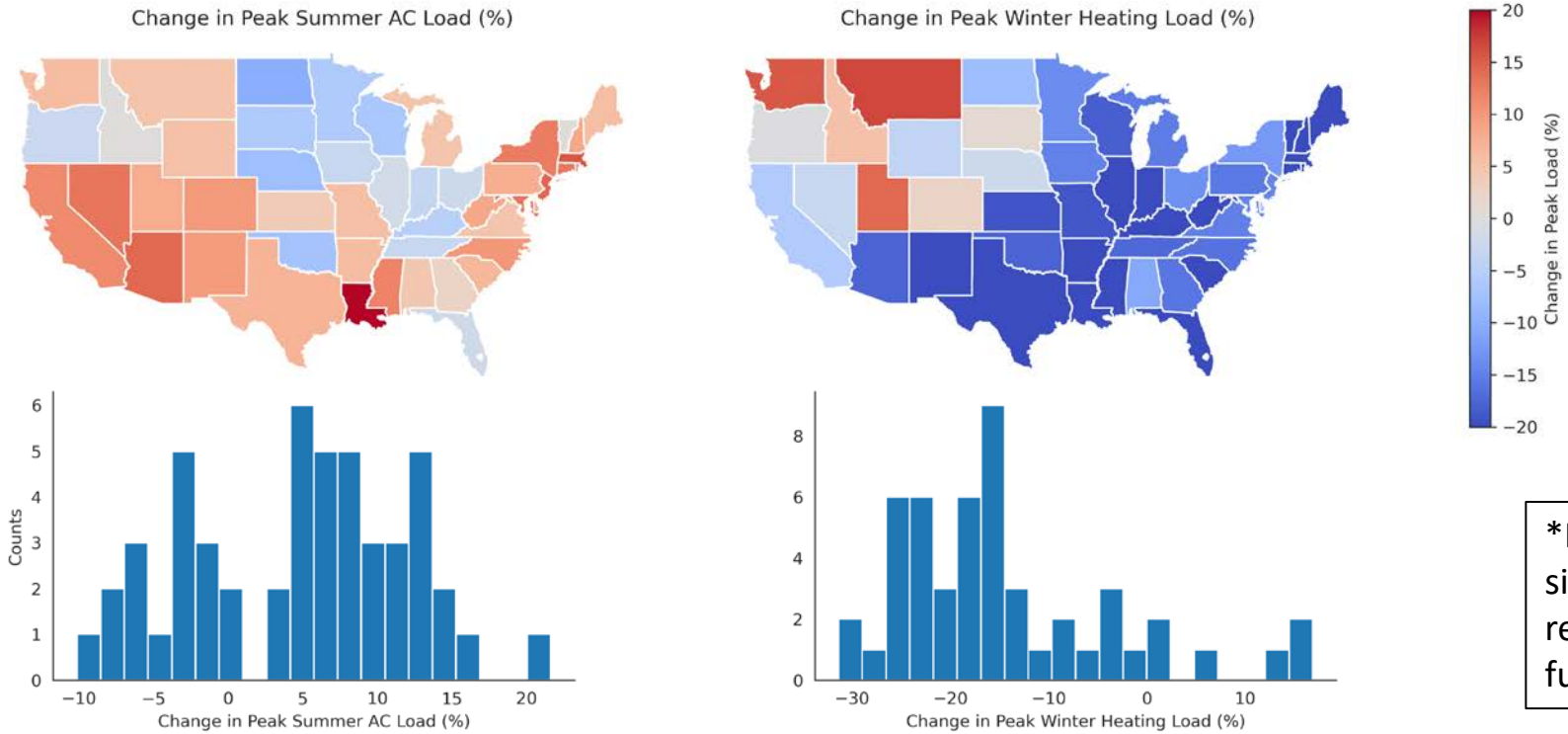
Super-Resolution for Renewable Energy Resource Data with Climate Change Impacts (Sup3rCC)

Sup3rCC enables us to:

1. Generate high-resolution synchronous wind, solar, and temperature data for the whole 21st century
2. Estimate the impacts of climate change on energy supply and demand
3. Explore extreme heat and cold events
4. Study human-climate-energy system dynamics
5. Plan a future energy systems that are resilient to climate change
6. https://data.openei.org/submissions/5839



Impacts on Energy Demand

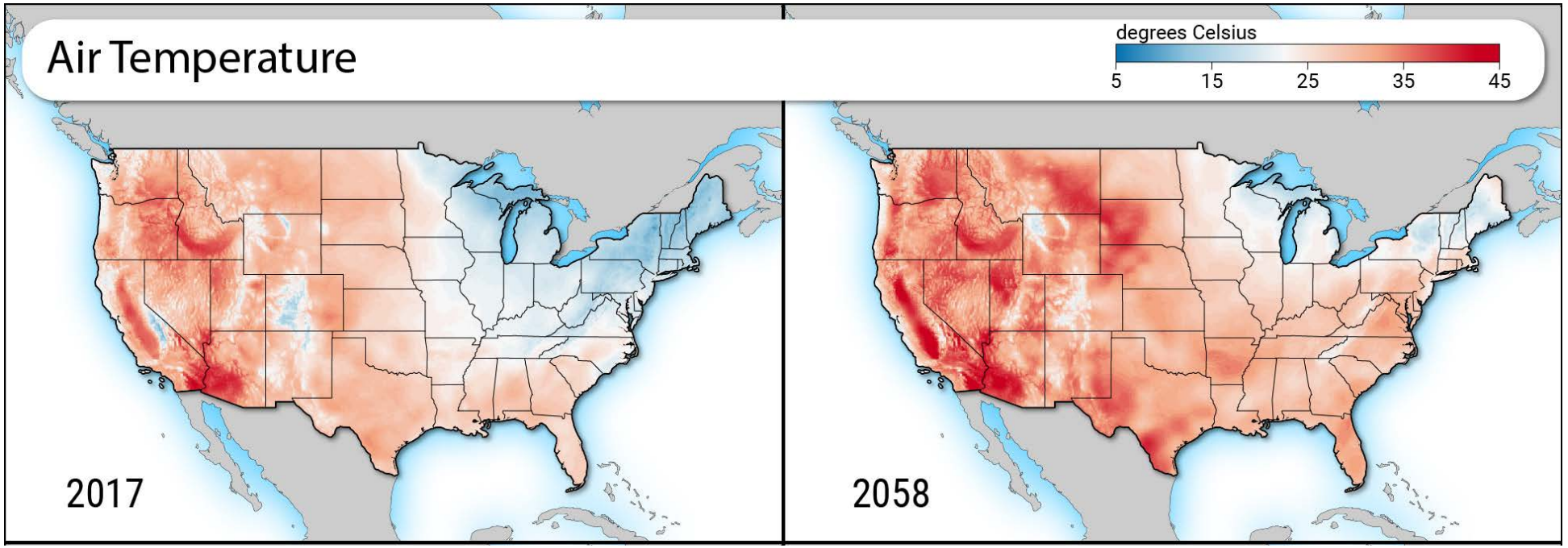


*Results are from a single GCM and only represent one possible future climate

- We can use Sup3rCC to quantify how 2050 HVAC electricity demand estimates might change based on historical versus future meteorology
- The load data above is based on bottom-up electrical load modeling from Evolved Energy Research for a hypothetical net-zero 2050 electrified infrastructure

PRELIMINARY RESULTS - DO NOT FOR DISTRIBUTE, QUOTE, OR CITE.

Wind + Solar + Temperature Compound Events



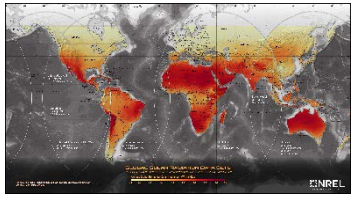
- The maps above show snapshots during the hottest days in the West during unseasonably low wind + solar events (more than 1 stdev from baseline values) from the 2015-2024 and 2050-2059 periods
- Future event is +1.6ºC hotter in the West (widespread, population weighted) and up to +3.4ºC hotter (localized temperature increase in Los Angeles)

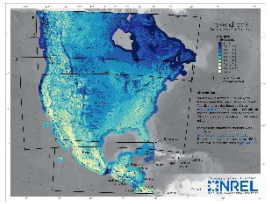
*Results are from a single GCM and only represent one possible future climate

PRELIMINARY RESULTS - DO NOT FOR DISTRIBUTE, QUOTE, OR CITE.

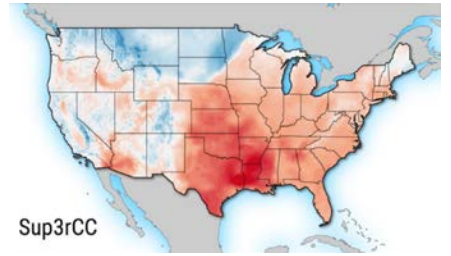
How does this all fit together?

Renewable Energy Resource Data (NSRDB, WTK)





Climate Change Data



rev

Power System Modeling

- Capacity Expansion Model (CEM)
- Production Cost Model (PCM)
- Resource Adequacy (RA)

Load Data

Results and Insights!

What are some challenges we're dealing with?

Uncertainty!

1. There is uncertainty in historical meteorology
2. There is *massive* uncertainty in future meteorology

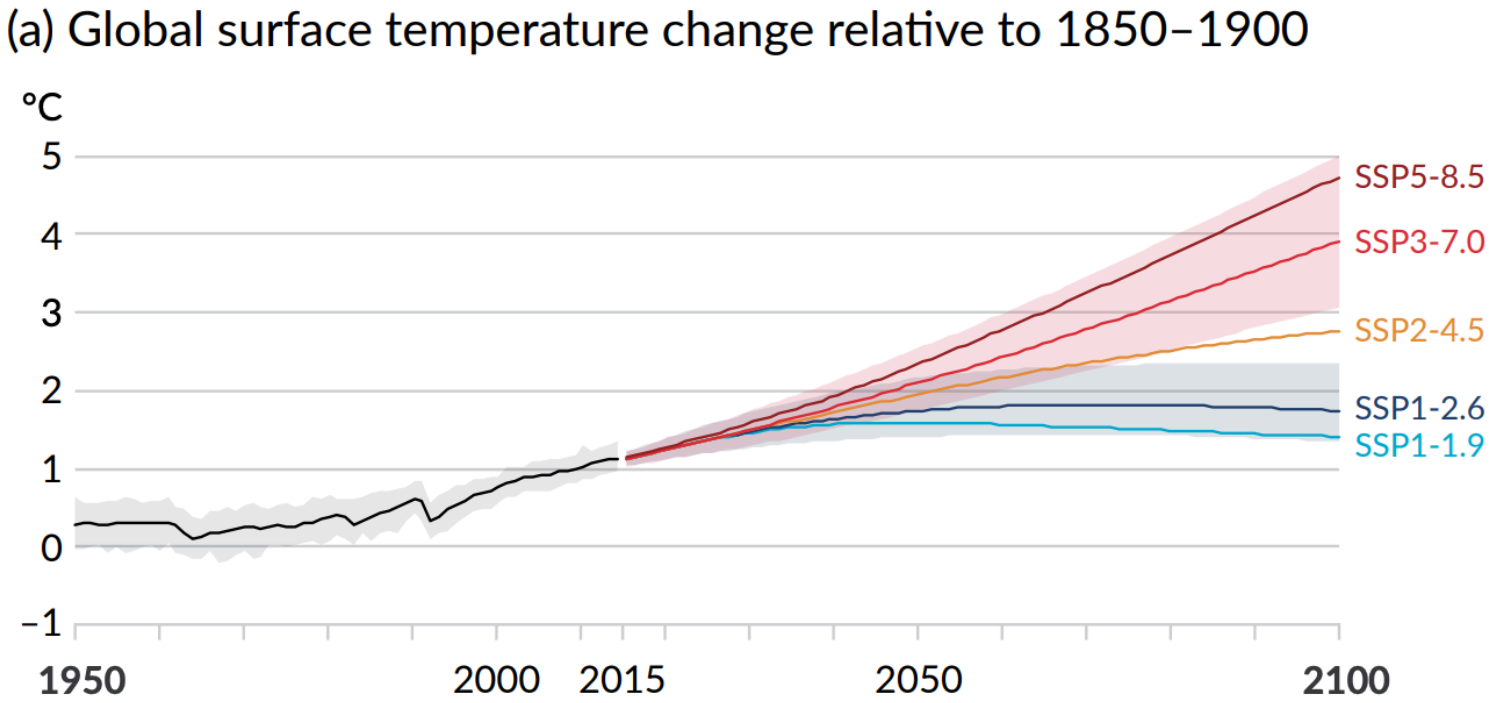


Figure from the IPCC (link)

What are some challenges we're dealing with?

Data volume!

1. NSRDB – 341 TB
2. WIND Toolkit – 900 TB
3. Sup3rCC – 5 TB

"We are drowning in information but starved for knowledge"

- John Naisbitt (1982)

What are some challenges we're dealing with?

Interfacing with industry + academia!

Is this 1,200+ TB of data valuable??

What data do we need to continue the clean energy transition?

What data do *you* need that NREL is not currently serving?

Thank You!

Grant.Buster@NREL.gov

www.jisea.org

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 DOE Grid Deployment Office (GDO), the DOE Advanced Scientific Computing Research (ASCR) program, the DOE Solar Energy Technologies Office (SETO), and the Laboratory Directed Research and Development (LDRD) program at the National Renewable Energy Laboratory. The research was performed using computational resources sponsored by the DOE Office of Energy Efficiency and Renewable Energy and located at the National Renewable Energy Laboratory. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

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Data Challenges in Scaling up Community Energy Transformation Efforts

Meghan Mooney, NREL

JISEA Annual Meeting

April 27th, 2023

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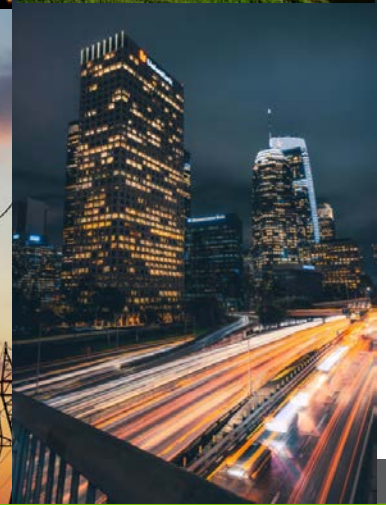


LA100

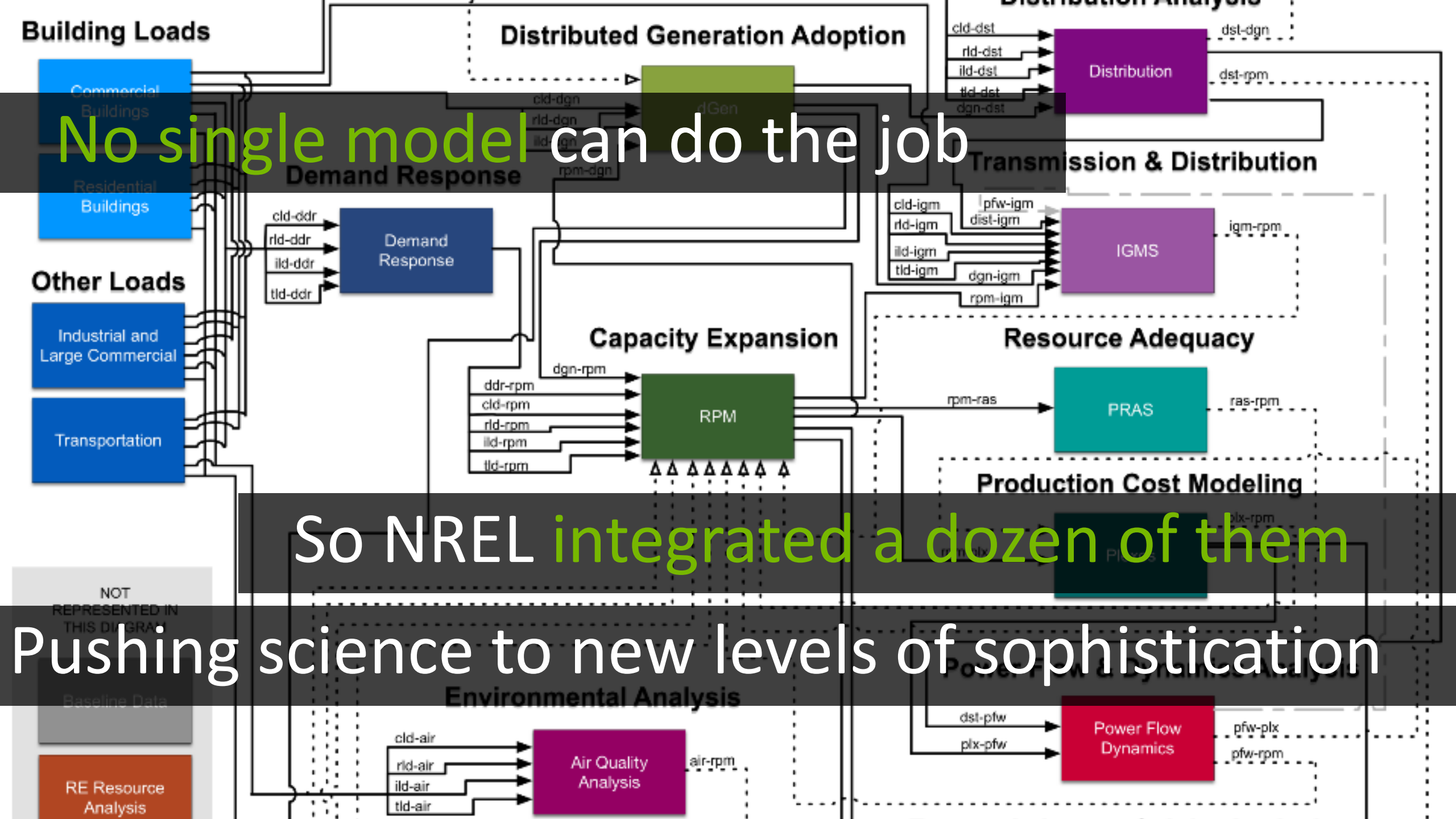
The Los Angeles 100% Renewable Energy Study

LA City Council motions directed LADWP to evaluate:

- What are the **pathways and costs to achieve a 100% renewable electricity supply** while electrifying key end uses and maintaining the current high degree of reliability?
- What are the potential benefits to **the environment** and **health**?
- How might **local jobs** and the **economy** change?
- How can communities shape these changes to prioritize **environmental justice?**

Underpinning LA100 were big models

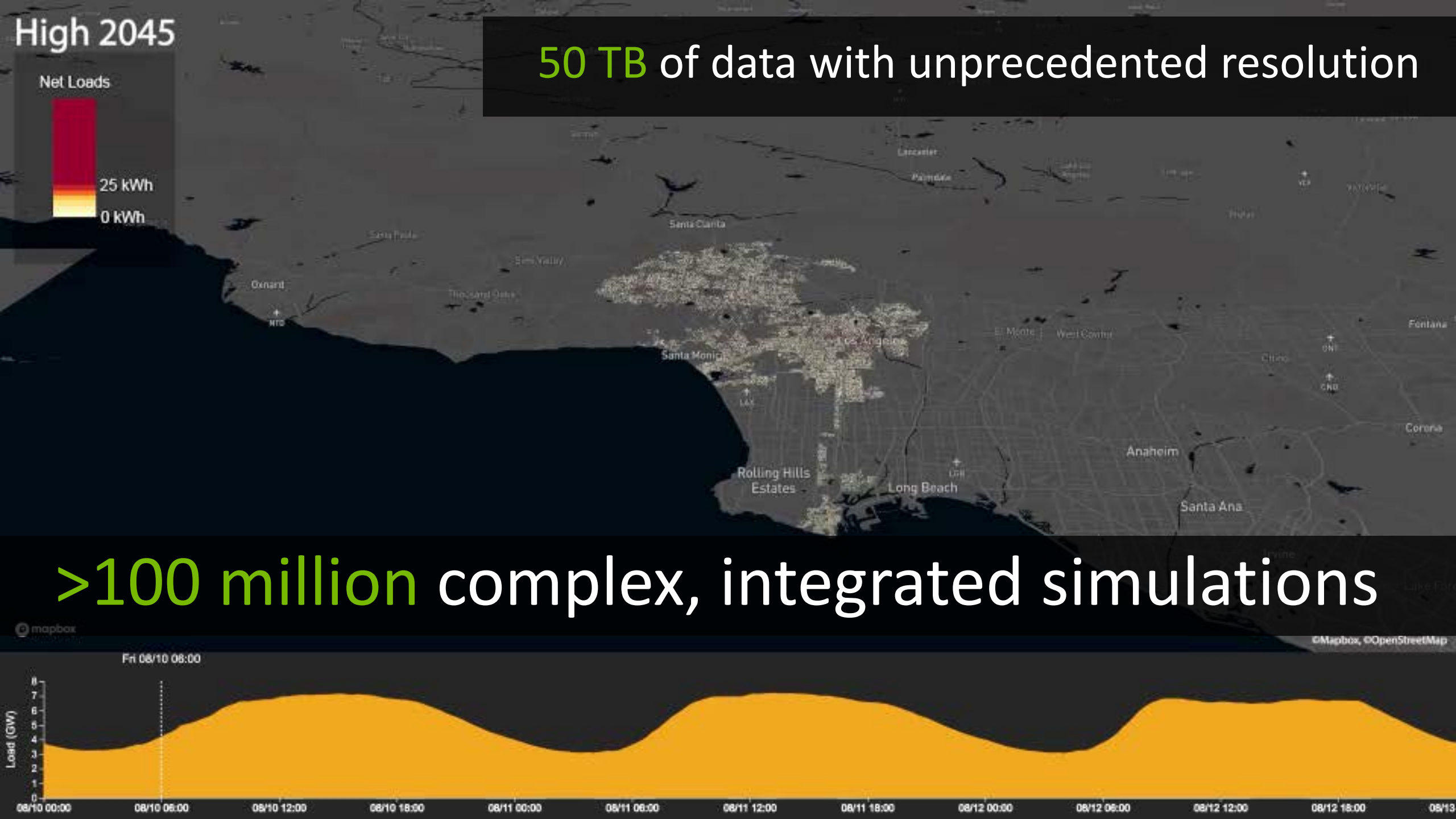
And big data



No single model can do the job

So NREL integrated a dozen of them

Pushing science to new levels of sophistication


High 2045
Net Loads
25 kWh
0 kWh
50 TB of data with unprecedented resolution
Lancaster
Palmdale
Santa Clarita
Oxnard
Santa Monica
Los Angeles
Fontana
Rolling Hills Estates
Long Beach
Anaheim
Corona
Santa Ana
>100 million complex, integrated simulations
mapbox
©Mapbox, ©OpenStreetMap
Fri 08/10 08:00
Load (GW)
0
1
2
3
4
5
6
7
8
08/10 00:00
08/10 06:00
08/10 12:00
08/10 18:00
08/11 00:00
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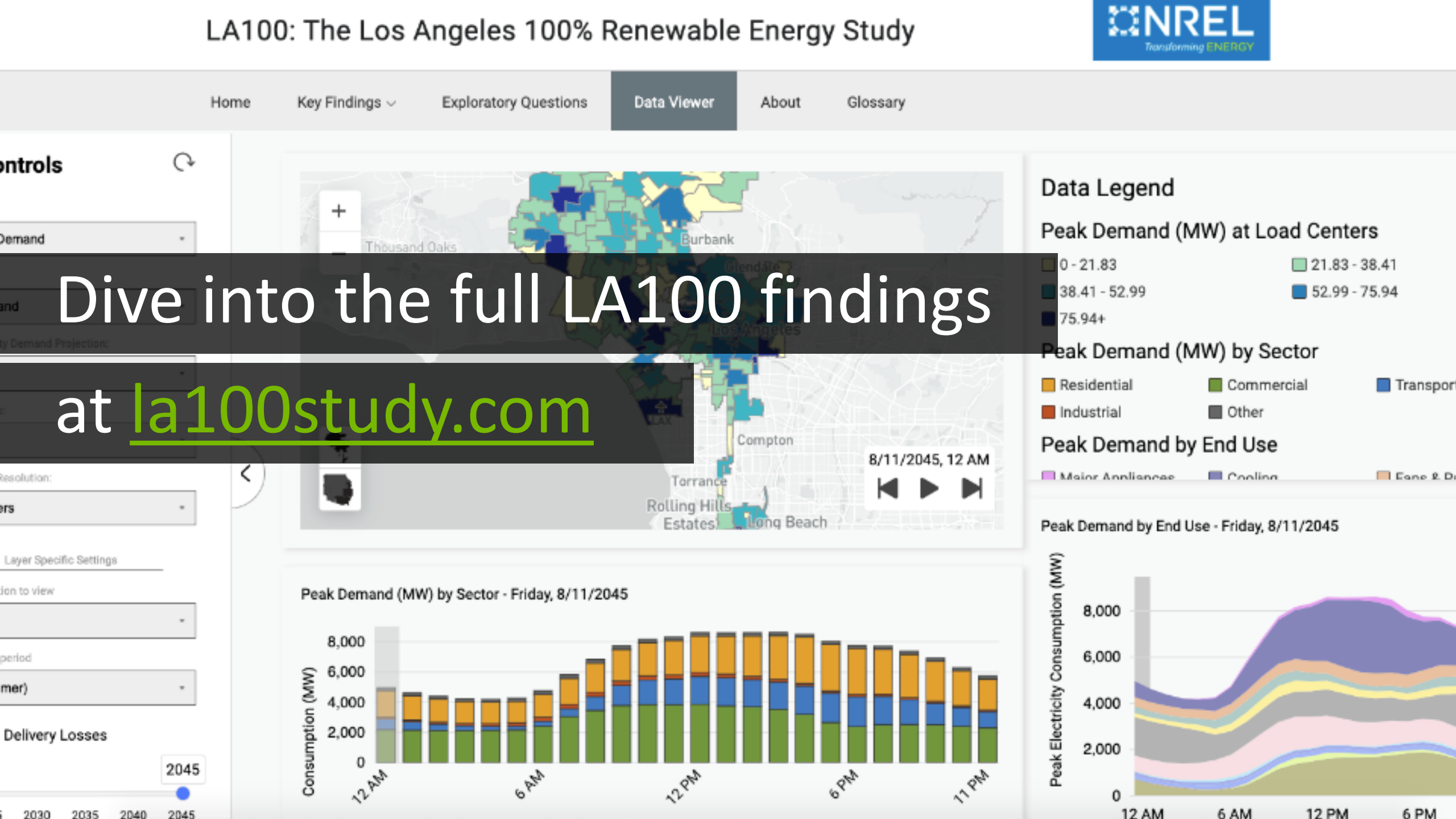
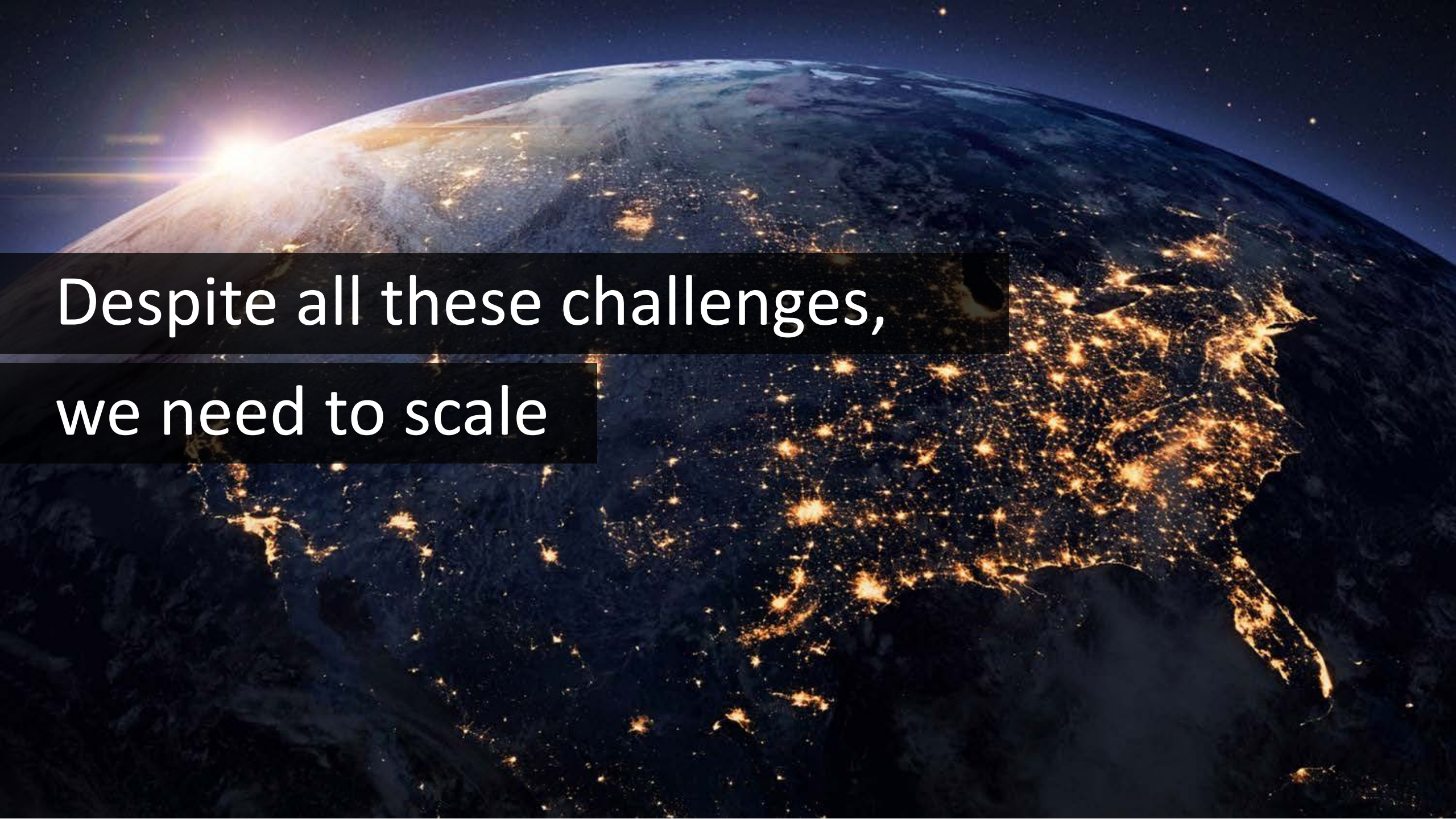

LA100: The Los Angeles 100% Renewable Energy Study
NREL
Transforming ENERGY
Home
Key Findings
Exploratory Questions
Data Viewer
About
Glossary
Dive into the full LA100 findings
at la100study.com
Data Legend
Peak Demand (MW) at Load Centers
0 - 21.83
21.83 - 38.41
38.41 - 52.99
52.99 - 75.94
75.94+
Peak Demand (MW) by Sector
Residential
Commercial
Industrial
Other
Peak Demand by End Use
8/11/2045, 12 AM
Peak Demand (MW) by Sector - Friday, 8/11/2045
Consumption (MW)
8,000
6,000
4,000
2,000
0
12 AM
6 AM
12 PM
6 PM
11 PM
Peak Demand by End Use - Friday, 8/11/2045
Peak Electricity Consumption (MW)
Delivery Losses
2045
2030
2035
2040
2045

But all this awesome came with its own set of data challenges

Selected LA100 Data Challenges:

- Data Quantity
  - Too much or too little data can be a challenge
    - Is 50 TBs of data too much?
    - Lack of geographically resolved demographic and building data
- Managing integrated modeling pipelines
  - Aligning models and data can be time-consuming
  - Lack of standardization and software support for version control, quality control, data visualizations, etc.
  - Limited support for data collaboration


Despite all these challenges,
we need to scale

Inspired by LA100, C2C enhanced capabilities—ARIES validation—will scale technical innovation

One utility
over 3 years

LA100
The Los Angeles 100% Renewable Energy Study

Pathway analysis

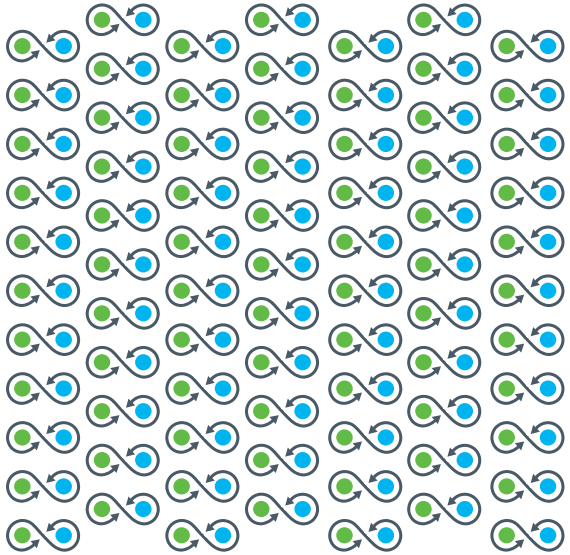
\+ ☑ ARIES Validation

C2C: Clean Energy *to* Communities

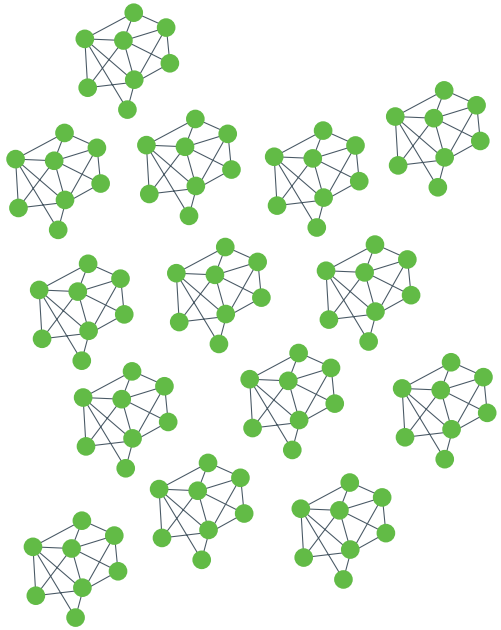
U.S. DEPARTMENT OF ENERGY

Multiple teams of utilities, local governments, and community- based organizations in the **first 3 years**

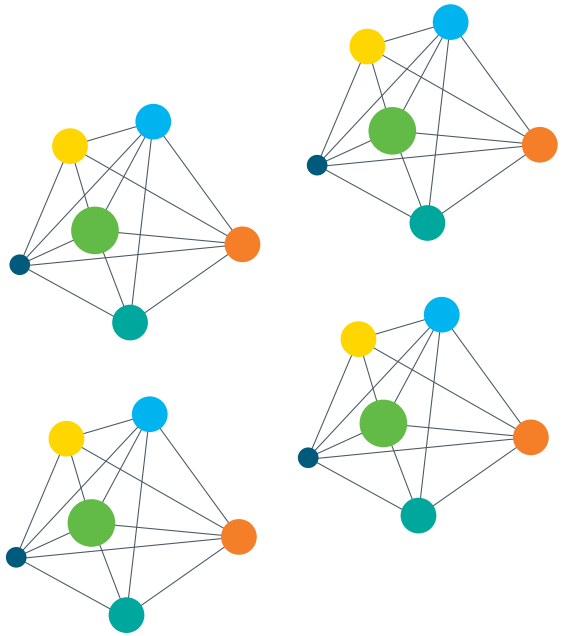
C2C Program designed to meet communities where they are at



Expert match



Cohort



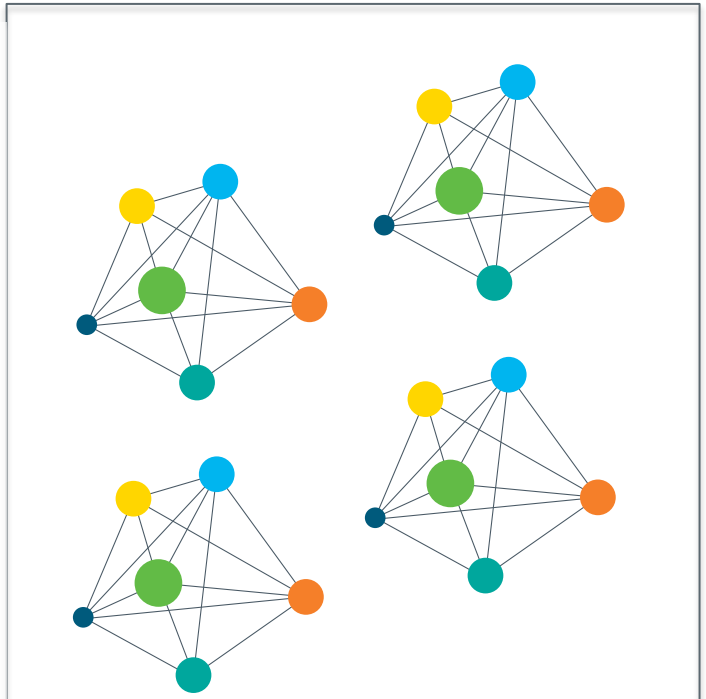
In-depth partnership

~2 months | ~1 year | ~3 years

Length of engagement

C2C Program designed to meet communities where they are at

C2C In-Depth Partnerships require us to solve data challenges in order to scale our community impact



In-depth partnership

~3 years

Expert match

~2 months

Cohort

~1 year

Length of engagement

What are the scaling data challenges?

#1 Tension between national coverage and representing community detail

National Coverage
(i.e., Tract or County level data for the nation)

- Improve engagement turn-around speed
- Extends our reach to all communities despite existing data resource

Community Detail
(i.e., Custom, tailored data likely curated for the project)

- Improve representation of community nuances
- Real and perceived quality improvements
  - May improve community buy-in
- Matching utility system improves utility buy-in

Solutions:

- Leverage national datasets where possible and supplement with community detail where needed
  - Invest in development of more national datasets
- Manage buy-in from community and utility in creative ways

What are the scaling data challenges?

#2 Dealing with the paradox of having too much and too little data

Too much

- Big data can be expensive to store and compute
- Increased risk of uncaught errors
- What value is the data providing? Do we really use all of the detail?
- Hard to share with communities

Too little

- Lacking resolved demographic data needed to represent equity in the way we traditionally conduct modeling
- Lack of data fidelity could lead to unintentional bias in modeling

Solutions:

- Decoupling models may reduce data dimension explosion
- Finding creative ways to fill in data gaps, e.g., ML approaches (related to Issue #4)
- Opportunities to build free cloud-based methods to disseminate large data to communities

What are the scaling challenges?

#3 Managing even more complex data pipelines

- Data requirements and standards vary across different organizations, utilities, communities, government agencies and their national laboratories
- Managing pipelines from planning models & ARIES
- Ensuring data quality, access, security, and availability across communities can be a challenge
- Integration of visualizations in an automated and collaborative platform is critical to engage communities throughout the process

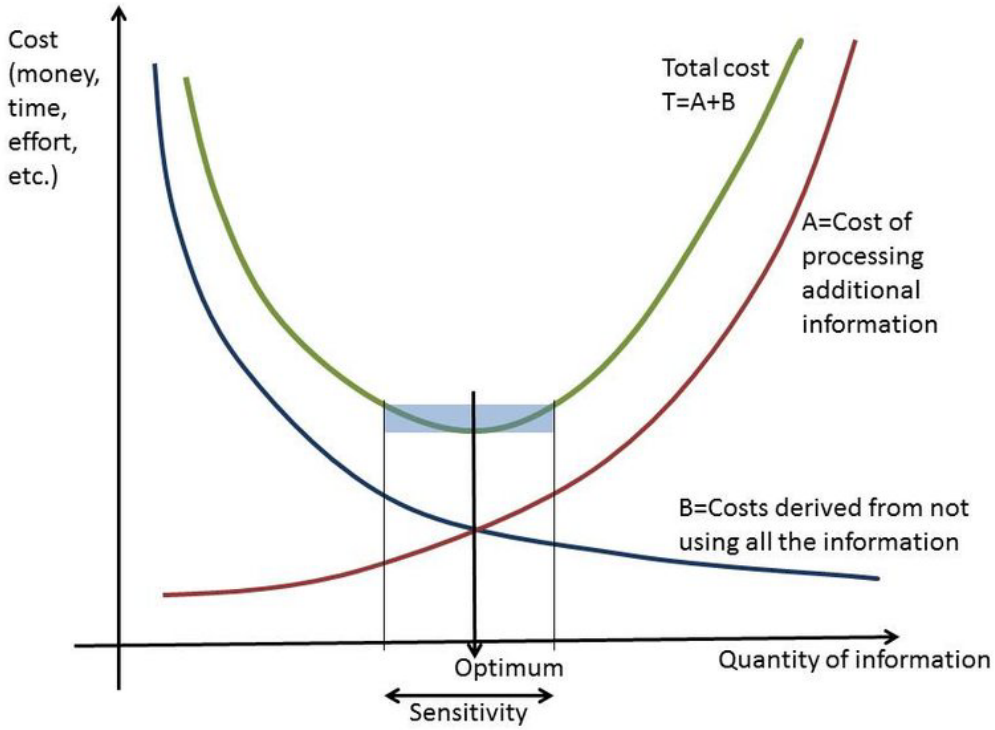
Solutions:

- Invest in software solutions for data pipeline management for integrated modeling
- Opportunities for future tech to do accelerate pipeline management (related to Issue #6)

What are the scaling data challenges?

#4 Managing the tradeoff between improving the quality and fidelity of our data versus using faster, "good enough" approaches that may yield the same conclusions

What is the optimal balance? Will this convince the utility? The community?



Solutions:

- Challenge the narrative, think critically, and get creative
- Never sacrifice getting the community and utility onboard (related to #1)

What are the scaling challenges?

#5 Community engagement takes time and the process limits data modeling windows

Solutions:

- Plug and play planning models built on pre-generated national datasets speed up modeling turn around (related to Issue #1)
- Potential for advancements in computing and AI to further reduce modeling simulation times (related to Issue #6)
- Don’t sacrifice community engagement, but be creative

What are the scaling challenges?

#6 Designing and investing in forward looking data solutions today in a rapidly evolving technology landscape

- Are the data solutions we are investing in today going to be replaced by a near-term advancements in AI?
- How will emerging technologies solve current data challenges? In what ways will they introduce new challenges?
- Can we use AI and other emerging technologies to accelerate community transitions?

Solutions:

- Design solutions today that can be flexible and adaptable to future technologies
- Do our best to keep our fingers on the pulse

Thank You!

Meghan.Mooney@NREL.gov

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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 DOE Grid Deployment Office (GDO), the DOE Advanced Scientific Computing Research (ASCR) program, the DOE Solar Energy Technologies Office (SETO), and the Laboratory Directed Research and Development (LDRD) program at the National Renewable Energy Laboratory. The research was performed using computational resources sponsored by the DOE Office of Energy Efficiency and Renewable Energy and located at the National Renewable Energy Laboratory. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

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COLORADO STATE UNIVERSITY

Massachusetts Institute of Technology

Stanford University

University of Colorado Boulder

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Data Challenges & Solutions
State and Local Planning for Energy (SLOPE)
JISEA Sustainable Communities Catalyzer

Megan Day, NREL

JISEA Annual Meeting

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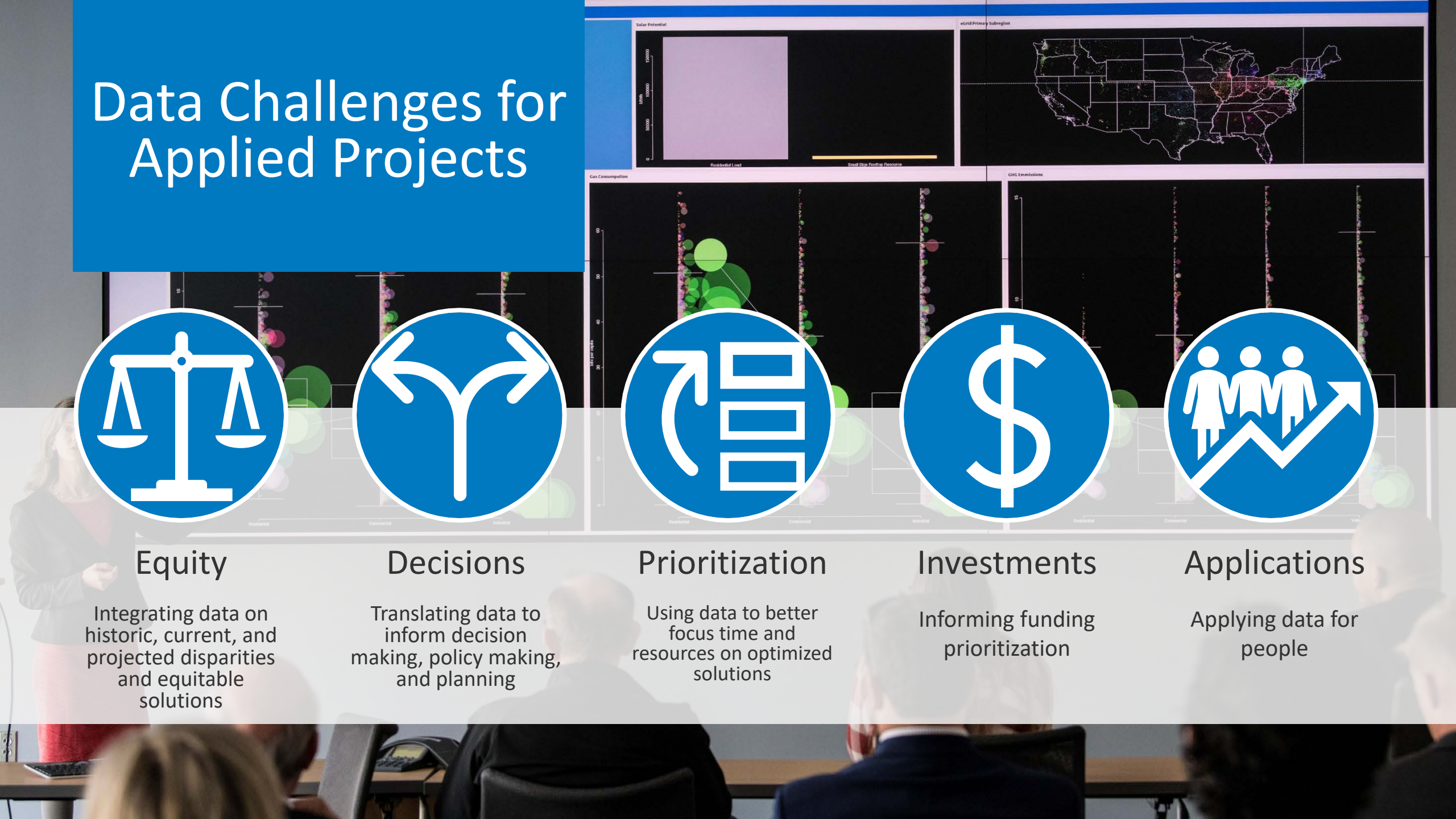
Data Challenges for Applied Projects



Equity

Integrating data on historic, current, and projected disparities and equitable solutions

Decisions

Translating data to inform decision making, policy making, and planning

Prioritization

Using data to better focus time and resources on optimized solutions

Investments

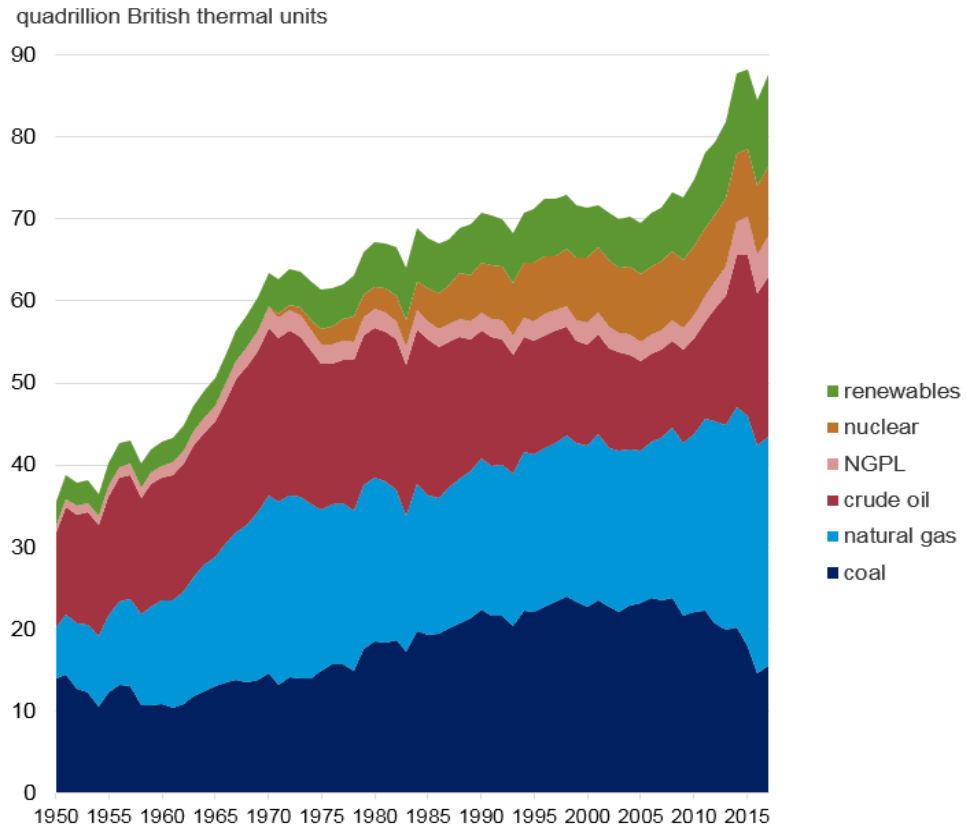
Informing funding prioritization

Applications

Applying data for people

Clean energy is growing

U.S. primary energy production by major sources, 1950-2017

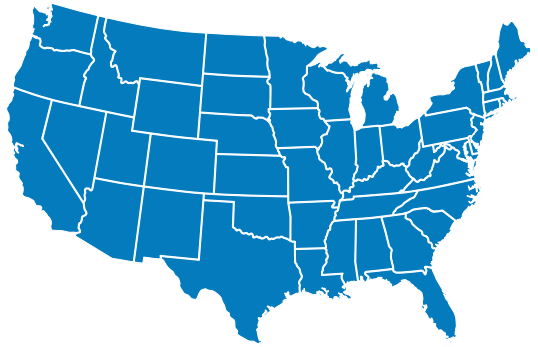


Note: NGPL is natural gas plant liquids.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.2, April 2018

eia

100%

Clean Energy Goals



180+ US cities,
10 counties, 8 states, DC,
and Puerto Rico*

*As of 2/14/22 https://www.sierraclub.org/ready-for-100/commitments

…but not for everyone

- Households earning more than **120% of area median income made up 70%** or higher of **new residential PV systems** between 2010 and 2018 (Barbose et al. 2020)
- Nearly **90% of solar adopters** in 2018 had **prime or super prime credit scores** (Barbose et al. 2020)
- **Black-majority Census Tracts installed 69% less rooftop PV** than no-majority tracts of same household income (Sunter et al. 2019)
- Only **5% of U.S. community solar projects include more than 10% low-income subscribers** (Gallucci 2019).

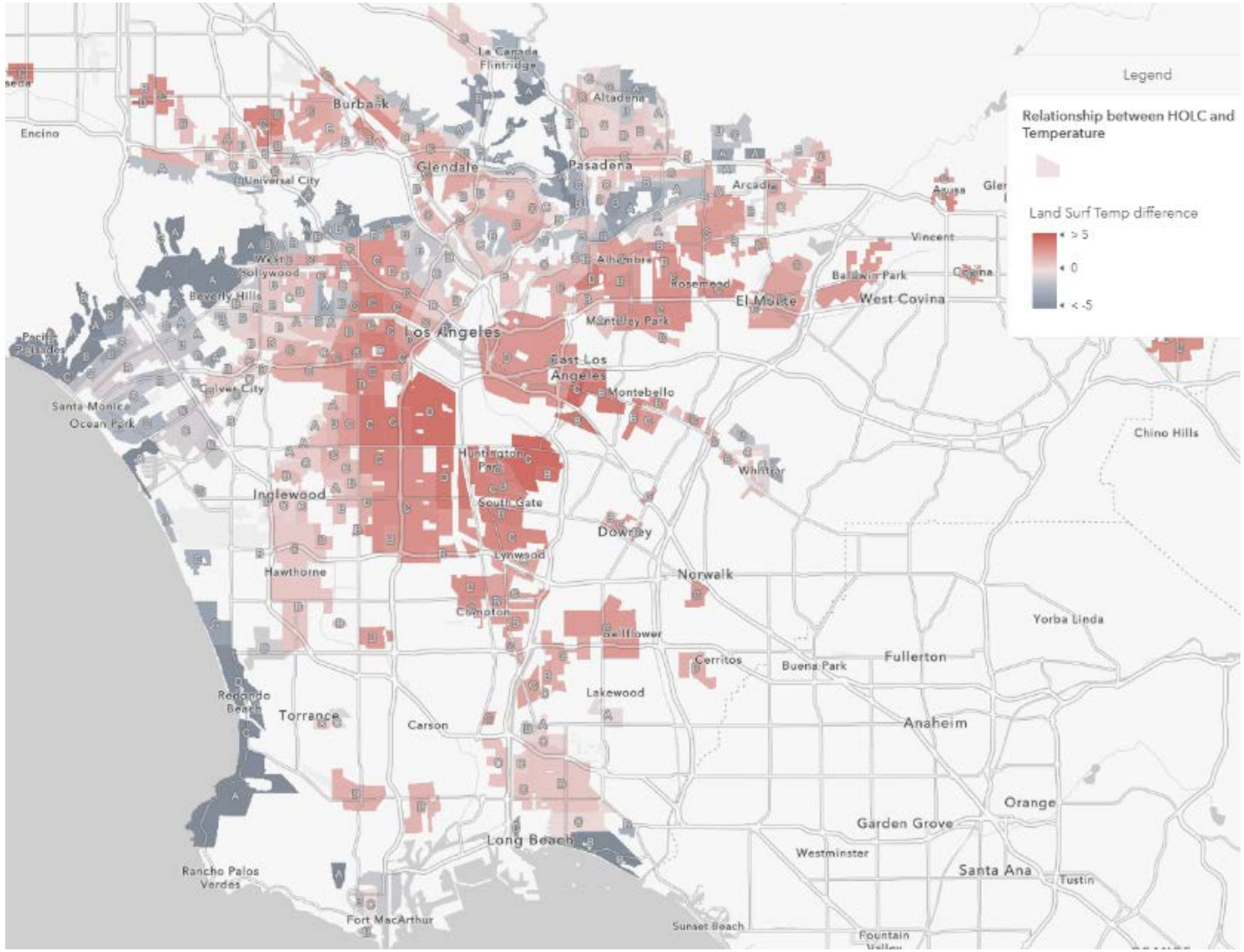
- Between 2006 and 2015, **90% of electric vehicle income credits were received by the top fifth in household income** (Borenstein & Davis 2016)
- **Renters and those living in multi-family housing often lack access to home charging locations**, where 80% of electric vehicle charging occurs
- **37% of rental housing units have a garage or carport** compared to 78% of owner-occupied housing (DOE 2017).

Research shows inequity in access to benefits from clean energy

https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-power/a-p-cleanenergyfuture/a-p-la100equitystrategies

Subsidizing residential rooftop solar and privately-owned EVs and charging stations results in inequitable outcomes

Redlining and Energy



Redlining, a 1930s federal government practice of identifying high mortgage lending risk based in part on the racial composition of neighborhood, limited investments in ways still felt today.

Recent research indicates formerly redlined neighborhoods have ***higher than average summer temperatures.*** Higher temperatures can lead to *higher mortality risk* during heat waves and higher cooling costs.

On the date measured (2017), red-lined neighborhoods (Grade D) in LA were on average **7.58 F°** (4.21 C°) hotter than those neighborhoods deemed "Best“ (Grade A) by the Home-Owners' Loan Corporation in the 1930s.

*Source: The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A S*tudy of 108 US Urban Areas. https://www.mdpi.com/2225-1154/8/1/12/htm
Map: https://www.arcgis.com/apps/dashboards/73e329457b6644e7aeff13ecce43c8d8

State and Local Planning for Energy (SLOPE)

Addressing Data Access and Resolution Challenges

"SLOPE is helping account for carbon reduction potential across transportation and buildings."

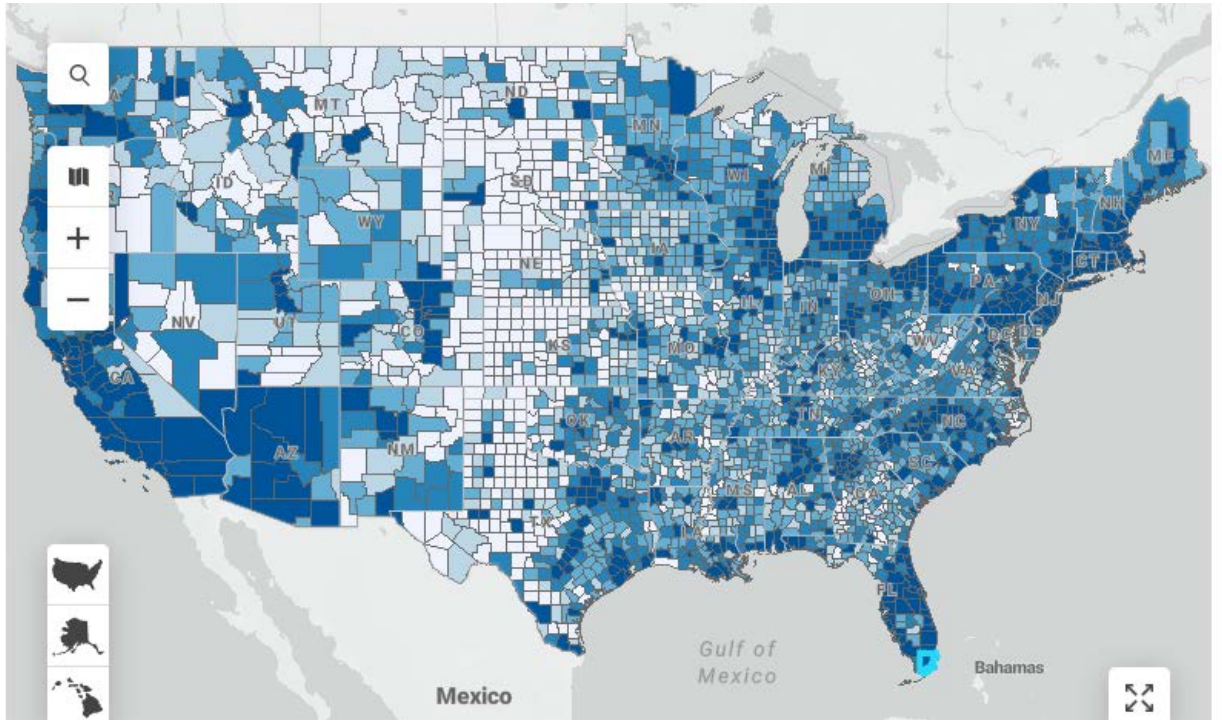
-- Kofi Wakhisi, Planning Administrator, Atlanta Regional Commission

State and Local Planning for Energy (SLOPE)

SLOPE is a free and easy-to-access online platform that helps energy planners at state and local levels make data-driven decisions to achieve their communities' energy goals.

- **Scenario Planner:** Explore the impacts of different energy transition scenarios on the energy consumption, CO_2 emissions, and system costs at county, state, and national scales.
- **Data Viewer:** Dive into city, county, and state data on renewable energy, energy efficiency, and sustainable transportation potential and projections.

SLOPE is a SCEP-led, cross-DOE collaboration.



Data Viewer: Personally Owned Light Duty Vehicle Fuel Consumption - High Electrification Scenario (2030)

SCEP STATE & COMMUNITY ENERGY PROGRAMS

BIOENERGY TECHNOLOGIES OFFICE (BETO) | STRATEGIC ANALYSIS (SA) | BUILDING TECHNOLOGIES OFFICE (BTO) | GEOTHERMAL TECHNOLOGIES OFFICE (GTO) | SOLAR ENERGY TECHNOLOGIES OFFICE (SETO) | VEHICLE TECHNOLOGIES OFFICE (VTO) | WATER POWER TECHNOLOGIES OFFICE (WPTO) | WIND ENERGY TECHNOLOGIES OFFICE (WETO)

slope@nrel.gov maps.nrel.gov/slope

NREL Transforming ENERGY

Transforming Energy Planning for Counties

To deliver county-level scenario results, the SLOPE team integrated results from five of NREL's flagship models, along with scenarios from two of NREL's innovative energy sector analyses:

ReEDS

Regional Energy Deployment System (ReEDS)

dGen

Distributed Generation Market Demand (dGen™)

ResStock

ResStock™

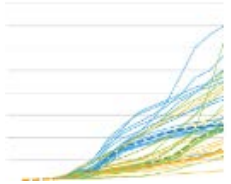
ComStock

ComStock™

TEMPO

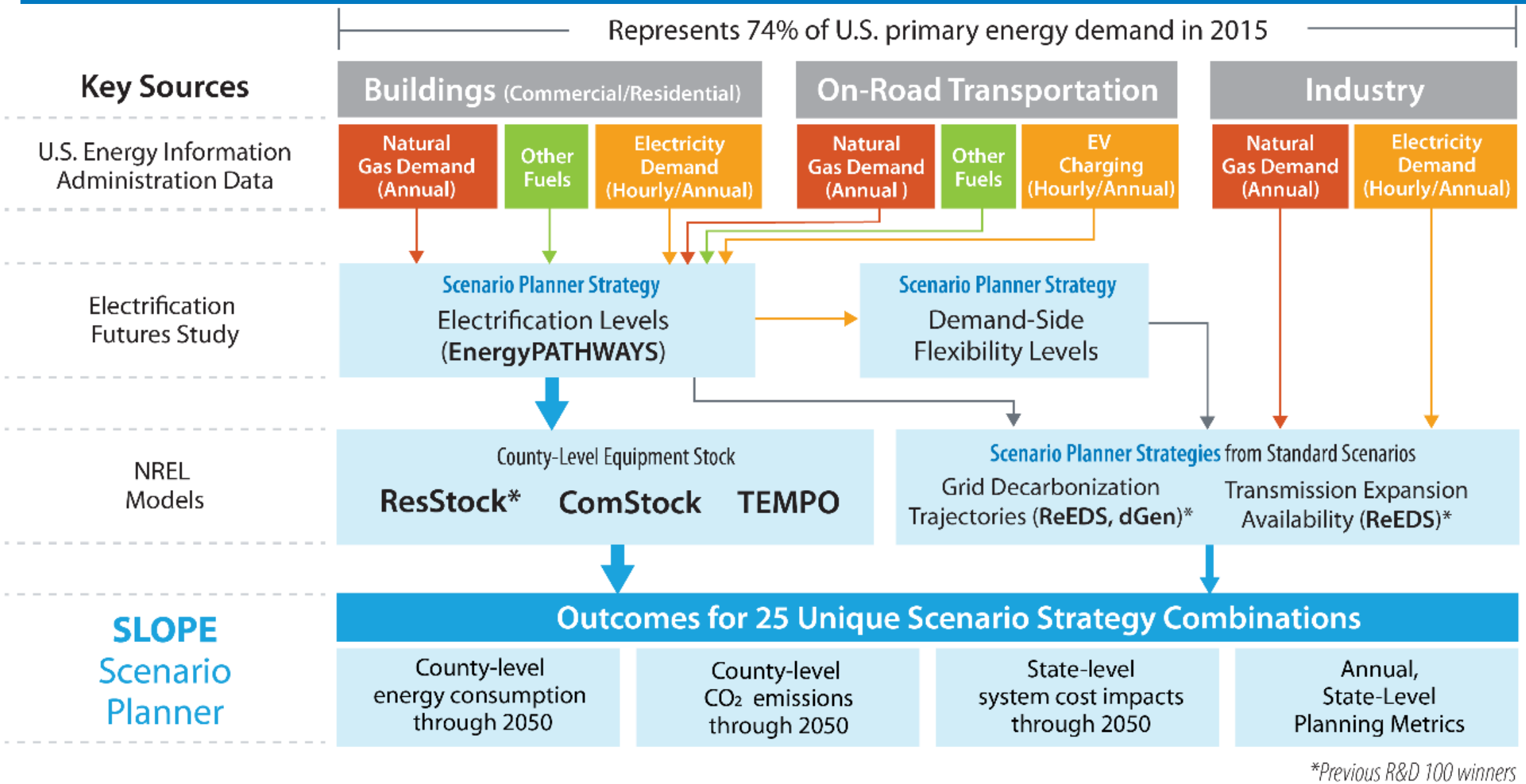
Transportation Energy & Mobillity Pathway Options™ (TEMPO)

Electrification Futures Study



2021 Standard Scenarios

Scenario Planner: Analysis Architecture



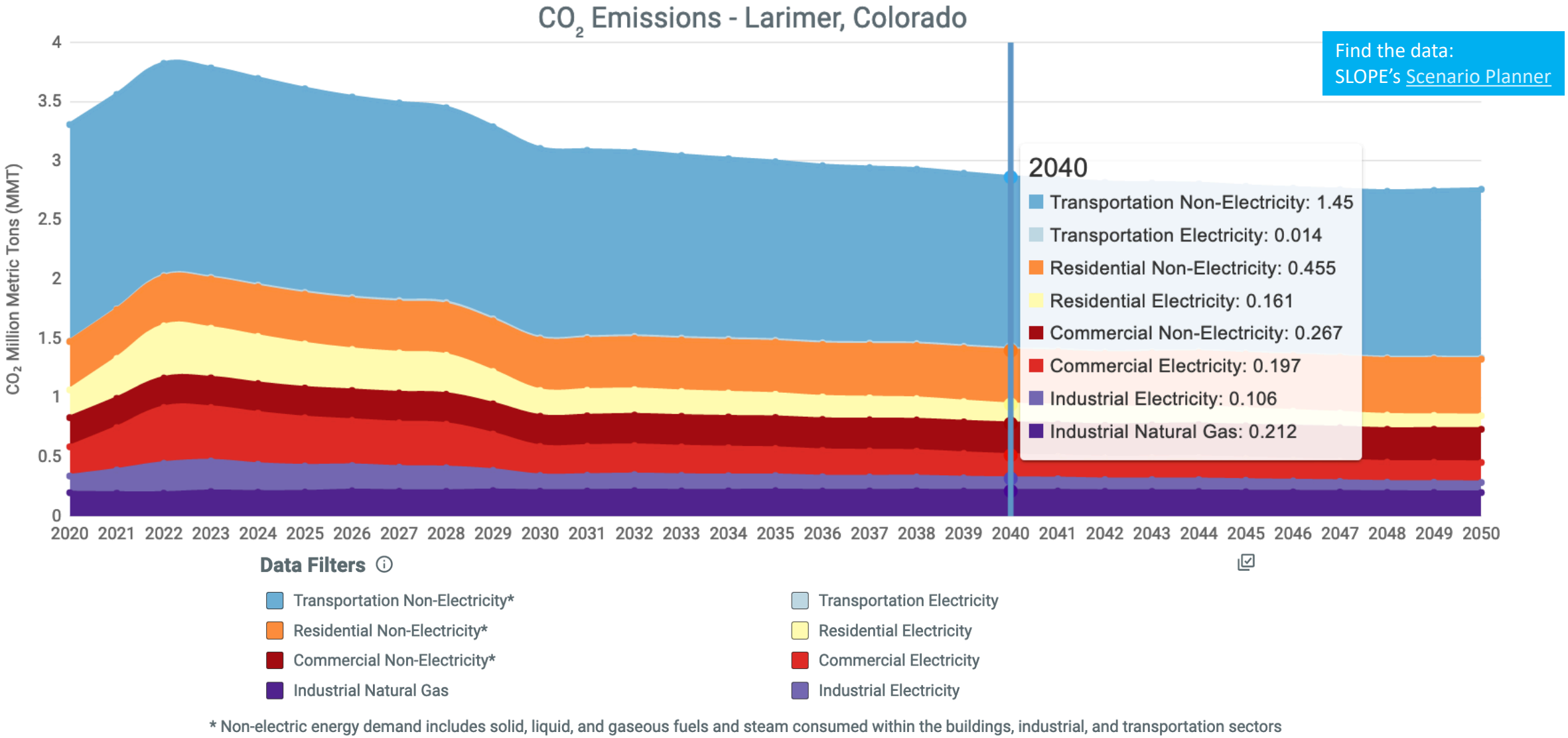
Larimer County, CO

SLOPE Data on Savings Potential from
Energy Efficiency Upgrades

Energy Planning/Investment Prioritization/Goal Setting

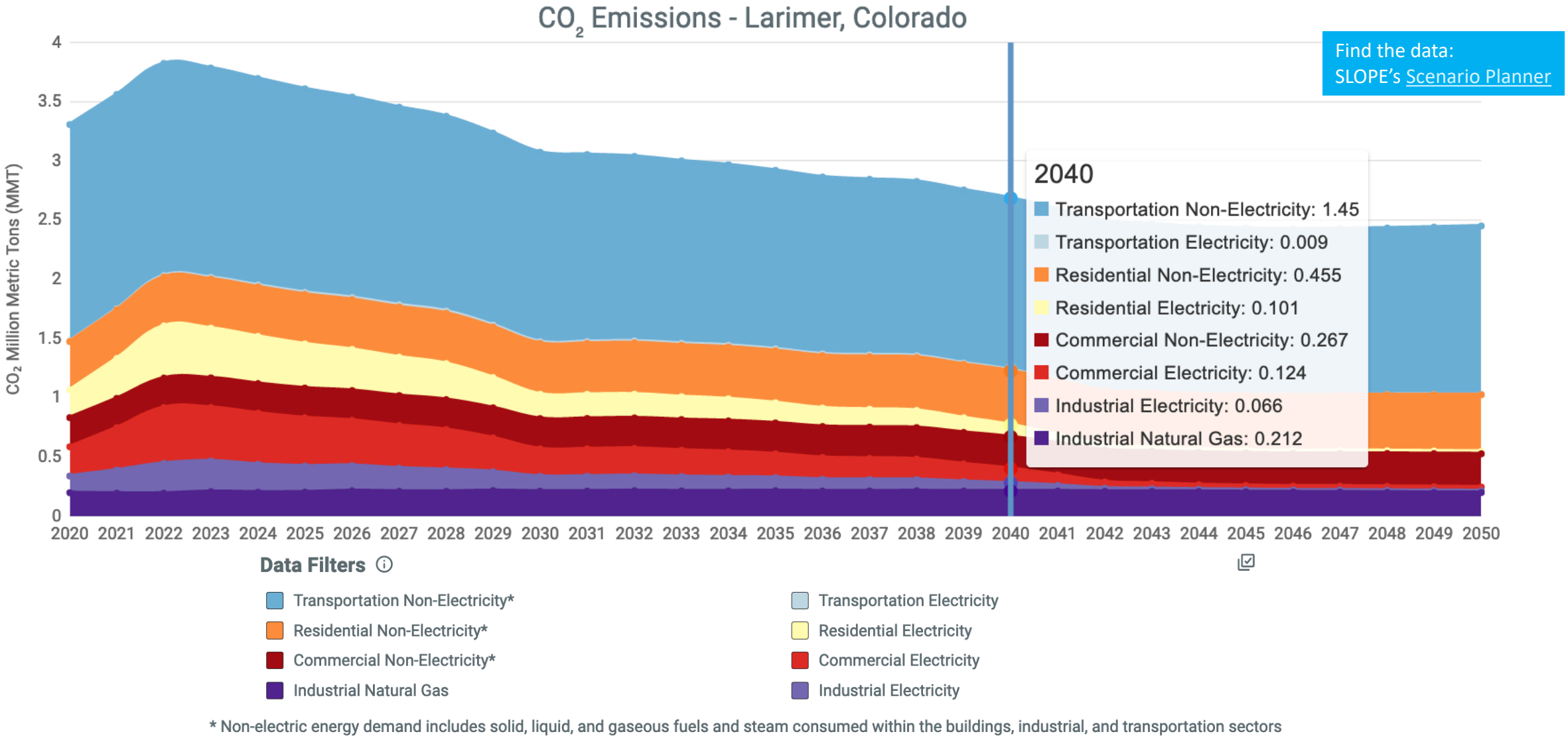
How do **greenhouse gas emissions** compare if our county focuses on grid decarbonization, building efficiency, electrification, or a combination of approaches?

Reference Scenario: How much CO_2 are we projected to emit in 2040?



Under business-as-usual development, Larimer County is expected to emit 2.86 CO_2 MMT in 2040, with non-electric transportation constituting over 50% of those emissions.

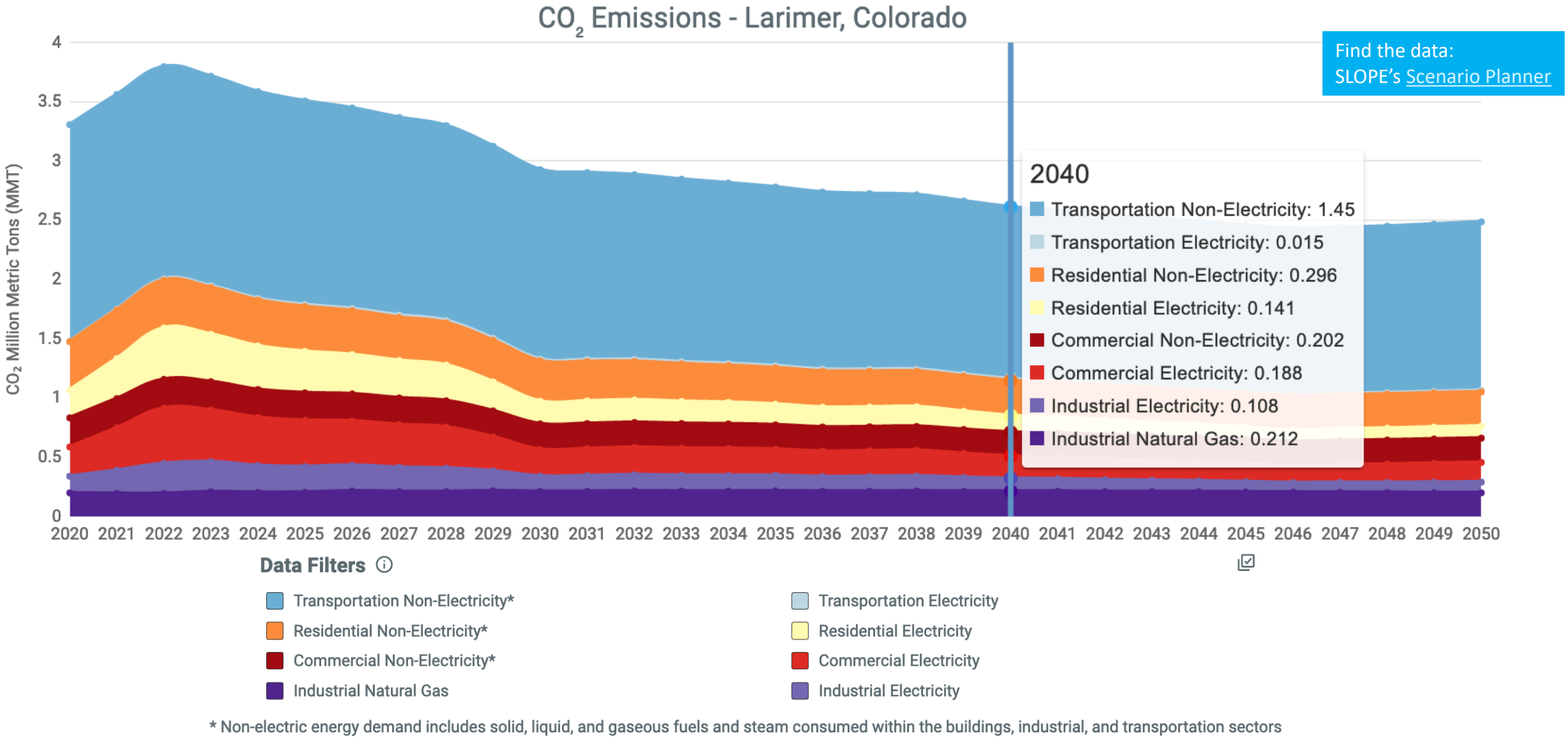
95% Grid Decarbonization: How will grid decarbonization impact emissions?



* Non-electric energy demand includes solid, liquid, and gaseous fuels and steam consumed within the buildings, industrial, and transportation sectors

Grid decarbonization of 95% by 2050 could reduce county-wide emissions by 6% compared to the reference scenario.

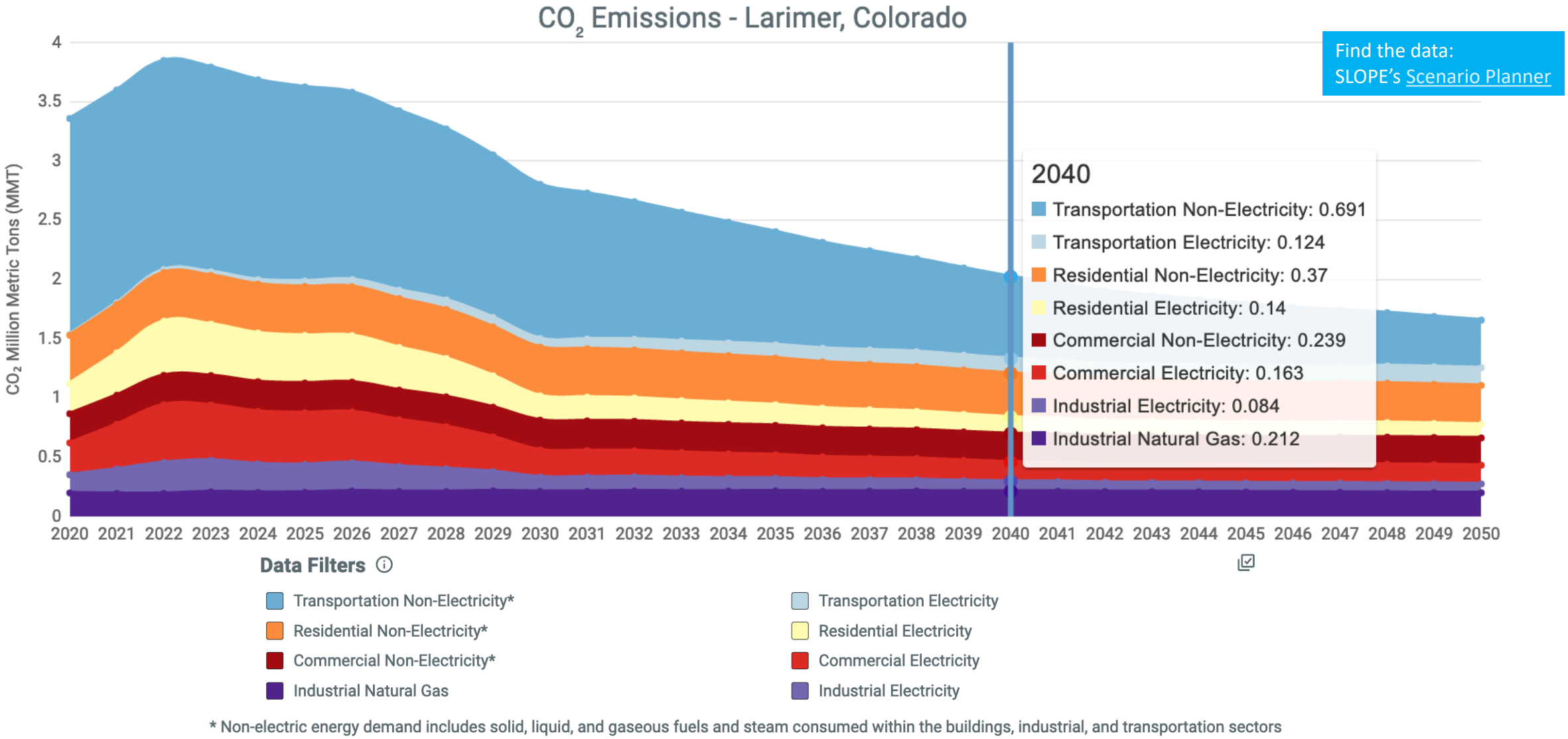
High Efficiency Scenario: How will building energy efficiency impact emissions?



* Non-electric energy demand includes solid, liquid, and gaseous fuels and steam consumed within the buildings, industrial, and transportation sectors

Best-available energy efficiency upgrades in buildings could cut total county-wide emissions by 9% compared to the reference scenario.

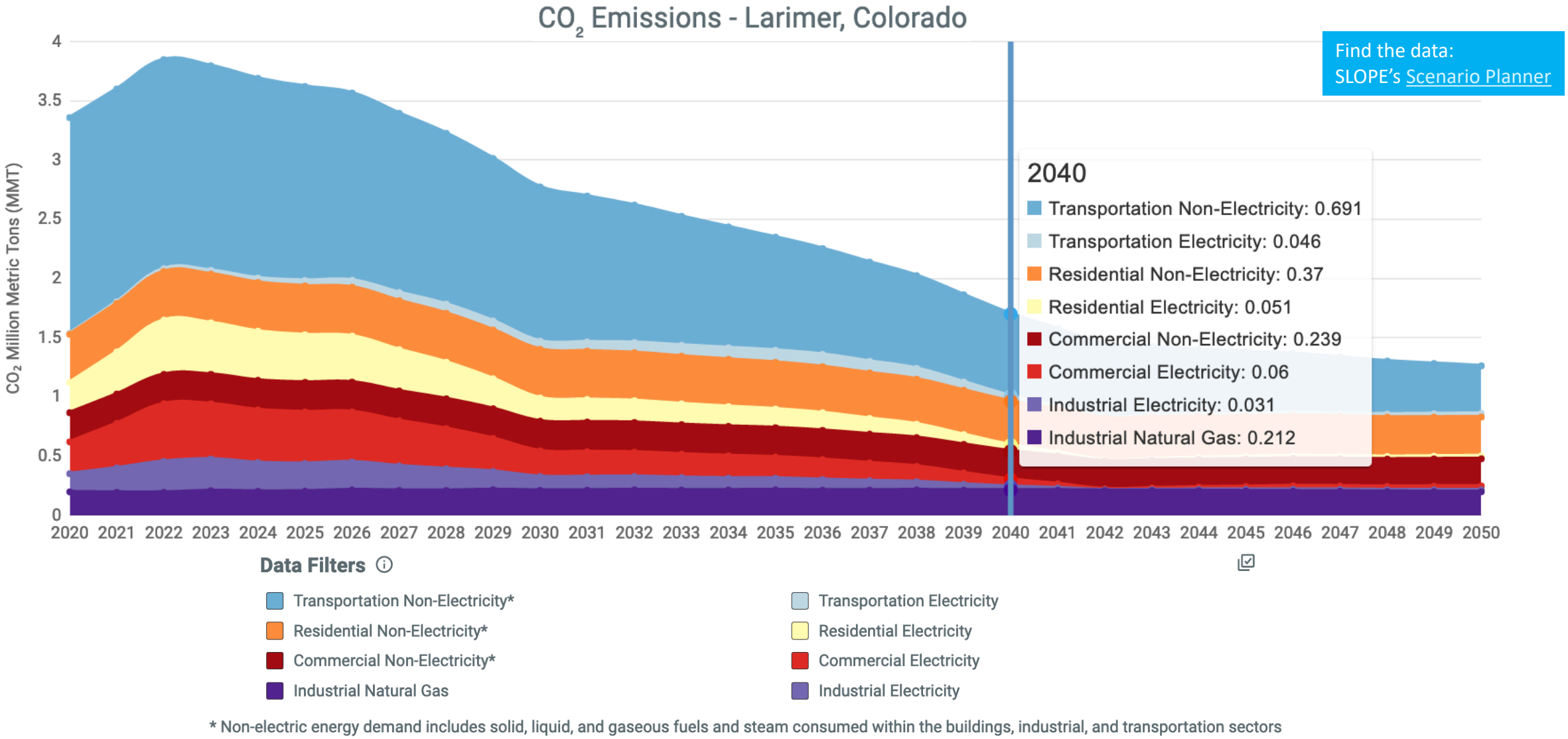
Widespread Electrification: How will building & transportation electrification impact emissions?



* Non-electric energy demand includes solid, liquid, and gaseous fuels and steam consumed within the buildings, industrial, and transportation sectors

With 64% BEV and PHEV penetration and 34% electric space heating penetration in 2040, total county-wide emissions could be cut by 29% compared to the reference scenario, mostly coming from the transportation sector.

Decarbonization & Electrification: How will a combination of strategies impact emissions?



A combination of strategies (widespread electrification and 95% grid decarbonization by 2050) could reduce total county-wide emissions by 1.16 CO_2 MMT in 2040, a reduction of 41% compared to the reference scenario.

Philadelphia, PA

SLOPE Data on Savings Potential from Energy Efficiency Upgrades

Philadelphia, PA Questions:

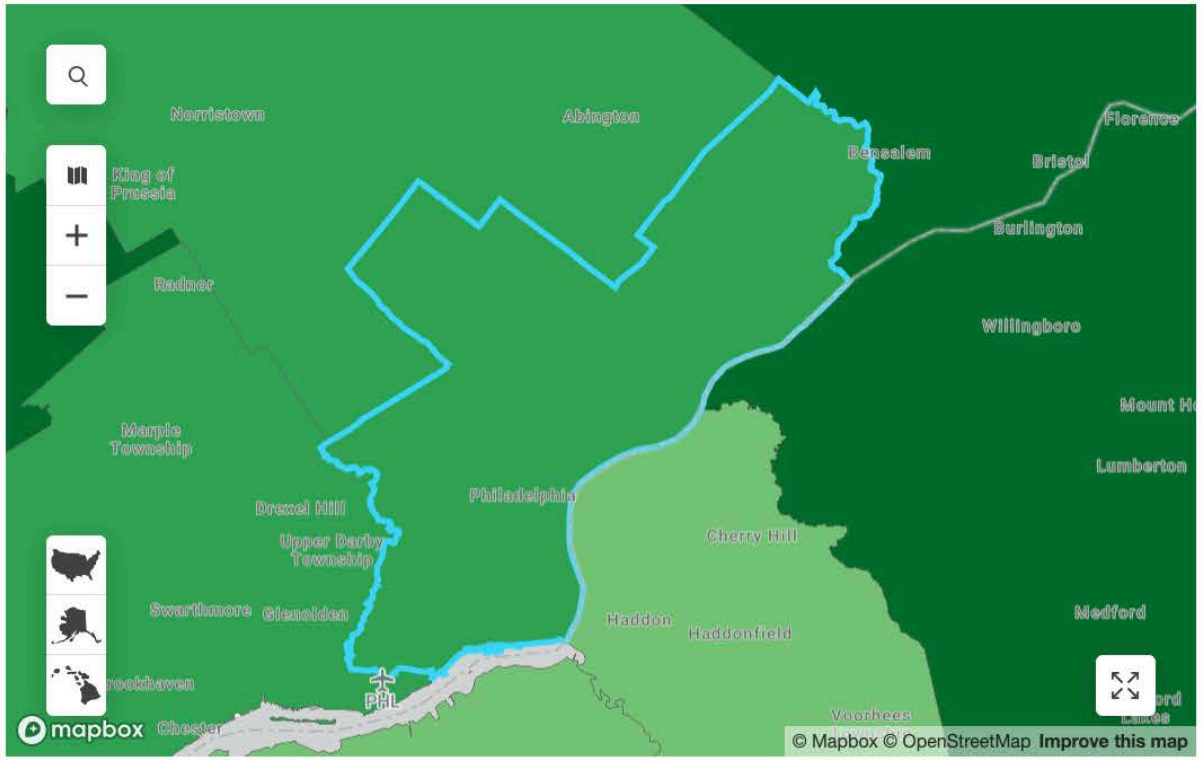
- As the city shift from a focus on reducing emissions from large commercial buildings to **alleviating energy poverty**:
  - How can the city **segment** the overwhelming needs and prioritize the most impactful residential efficiency and electrification strategies?
  - How can strategies be **tailored** to Philadelphia's older, smaller, inefficient housing stock?
- Can we quantify cost savings to help with **education and outreach** to residents?
- Can we **map equity** to identify building stock intersections and number of homes?

Residential Efficiency Upgrades

What is the **energy bill savings potential** of efficiency measures for low- to moderate-income (LMI) households in my county?

What is the energy bill savings potential of efficiency measures for LMI households?

Average % Bill Savings from Efficiency Upgrade Package for LMI Households



Map & Graph Resolution: County **State:** Pennsylvania **County:** Philadelphia

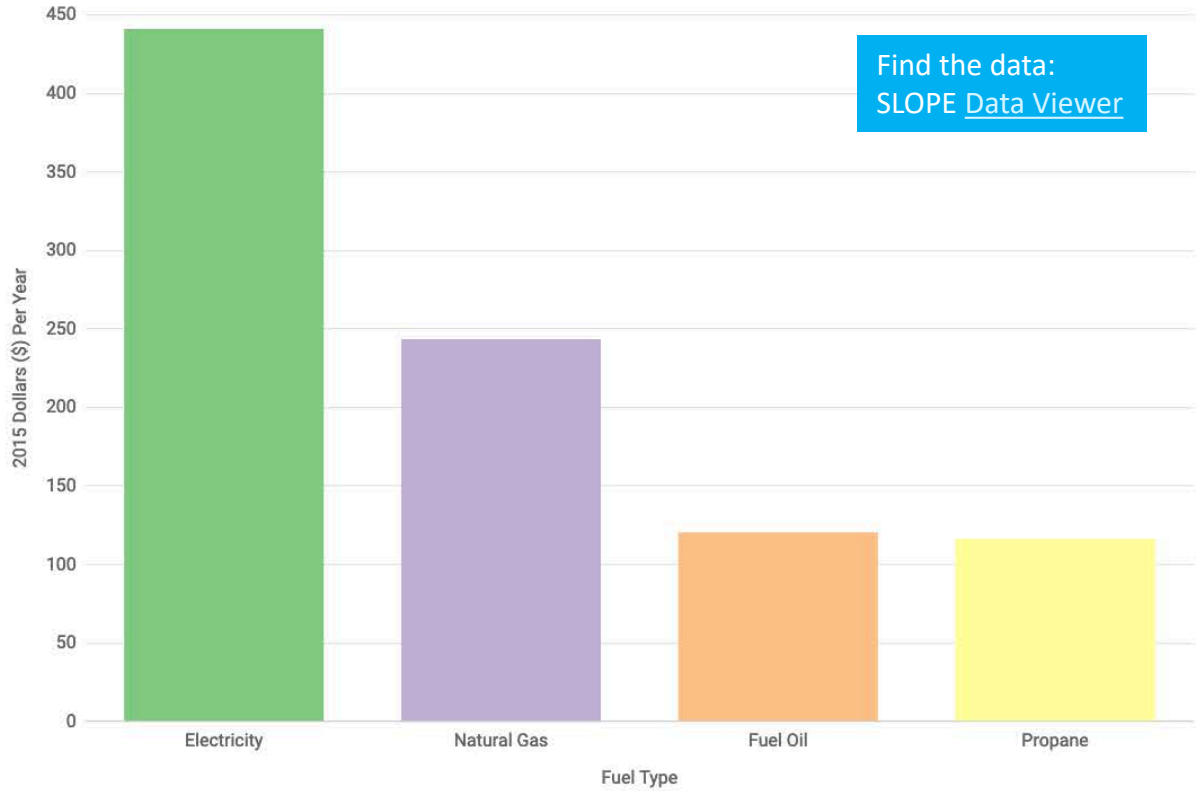
Map Legend

(Average % Energy Bill Savings)

- 51%+
- 45 - 51%
- 40 - 45%
- 35 - 40%
- 0 - 35%

Average Annual Energy Bill Savings Per LMI Single Family Home - Philadelphia

Find the data:
SLOPE Data Viewer



Data Filters

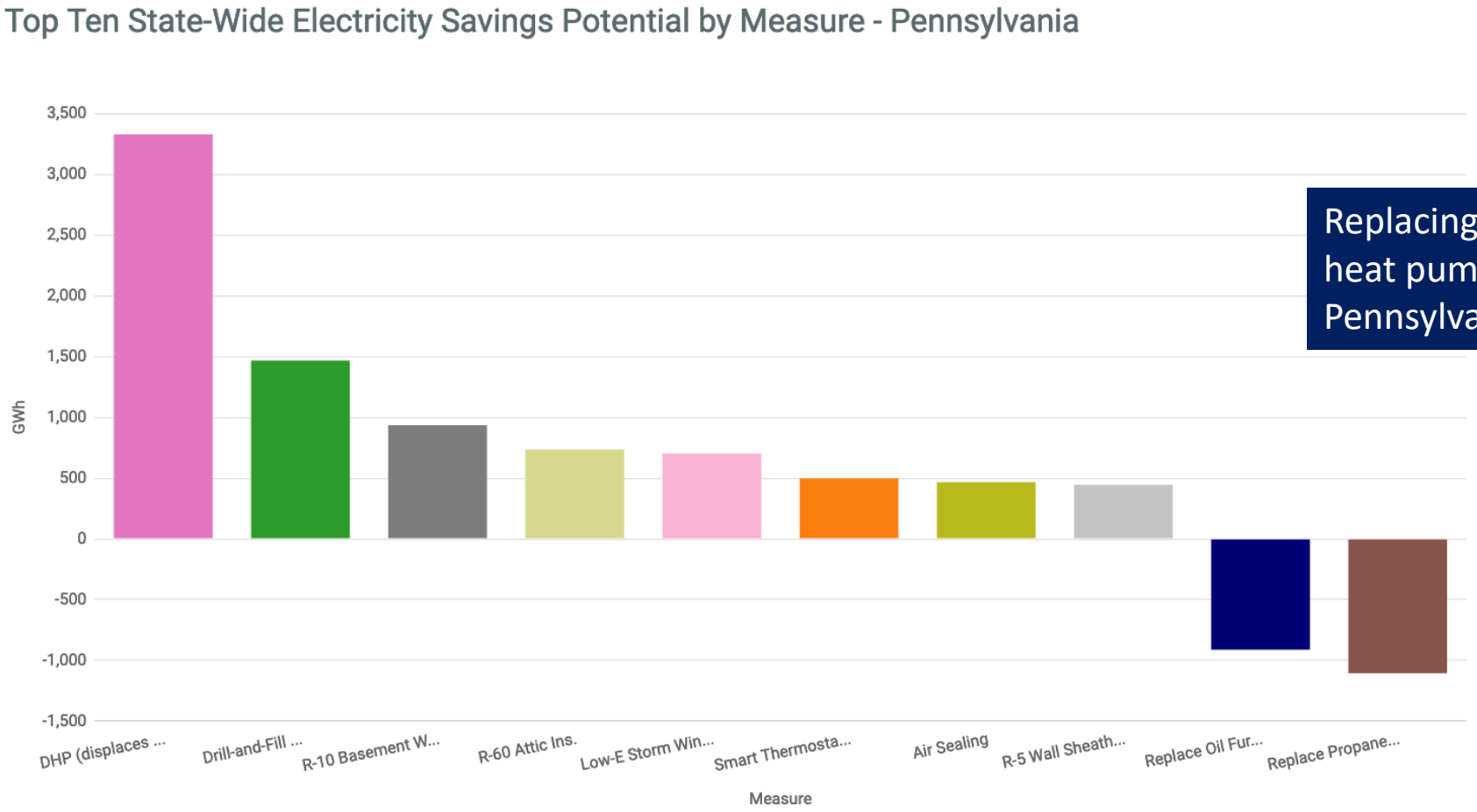
- Electricity
- Natural Gas
- Fuel Oil
- Propane

With efficiency upgrades* in Philadelphia County, low- to moderate-income (LMI) households can expect to save $441 on their electricity bills, $243 on their natural gas bills, $120 on their fuel oil bills, and $116 on their propane bills on average annually.

Residential Efficiency Upgrades

What efficiency measures have the most potential to **reduce energy costs** and consumption in the **residential sector** of my jurisdiction?

Which residential efficiency measures would have the greatest impact on consumption?



Replacing electric baseboard heat with ductless heat pumps (DHP) today can save residences in Pennsylvania over 3,300 GWh in electricity.

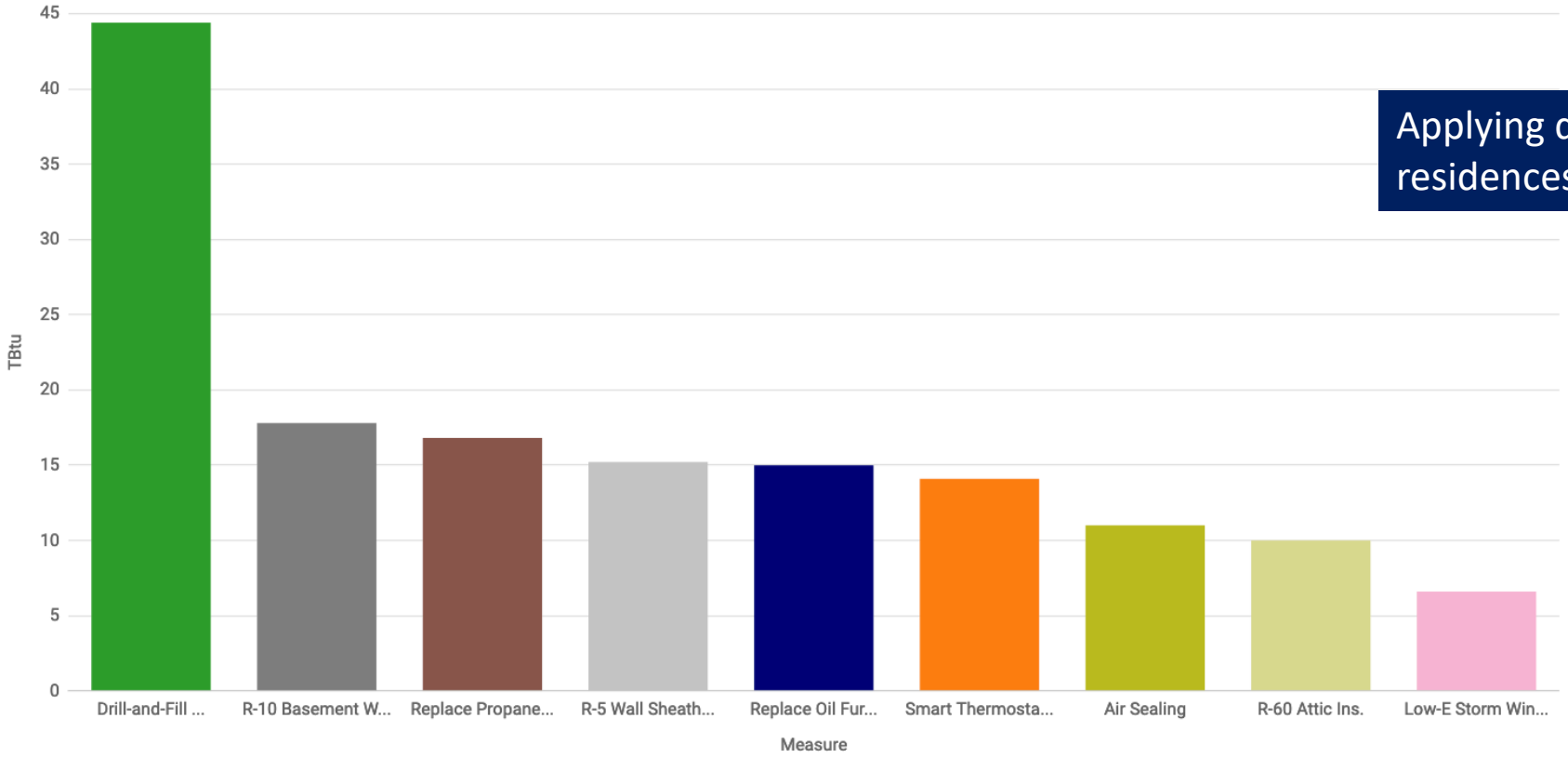
Data Filters

- Smart Thermostat
- Low-E Storm Windows (DIY)
- ~~SEER 18 Central AC*~~
- Drill-and-Fill Wall Insulation
- ~~Duct Sealing*~~
- ~~R-49 Attic Ins.*~~
- ~~LED Lighting*~~
- ~~ENERGY STAR Room AC (EER 12)*~~
- ~~Upgrade Electric WH to HPWH*~~
- ~~R-10 Crawlspace Walls*~~
- Replace Propane Furnace with VSHP
- Air Sealing
- ~~Upgrade ElecFurn to VSHP at Wear Out*~~
- DHP (displaces electric baseboard today)
- R-60 Attic Ins.
- ~~SEER 16 Central AC*~~
- R-5 Wall Sheathing
- R-10 Basement Wall Insulation
- Replace Oil Furnace with VSHP
- ~~ENERGY STAR Boiler - Oil*~~

Find the data:
SLOPE's Data Viewer

Which residential efficiency measures would have the greatest impact on consumption?

Top Ten State-Wide Fuel Savings Potential by Measure - Pennsylvania



Applying drill-and-fill wall insulation can save residences in Pennsylvania nearly 45 TBtu in fuel.

Data Filters

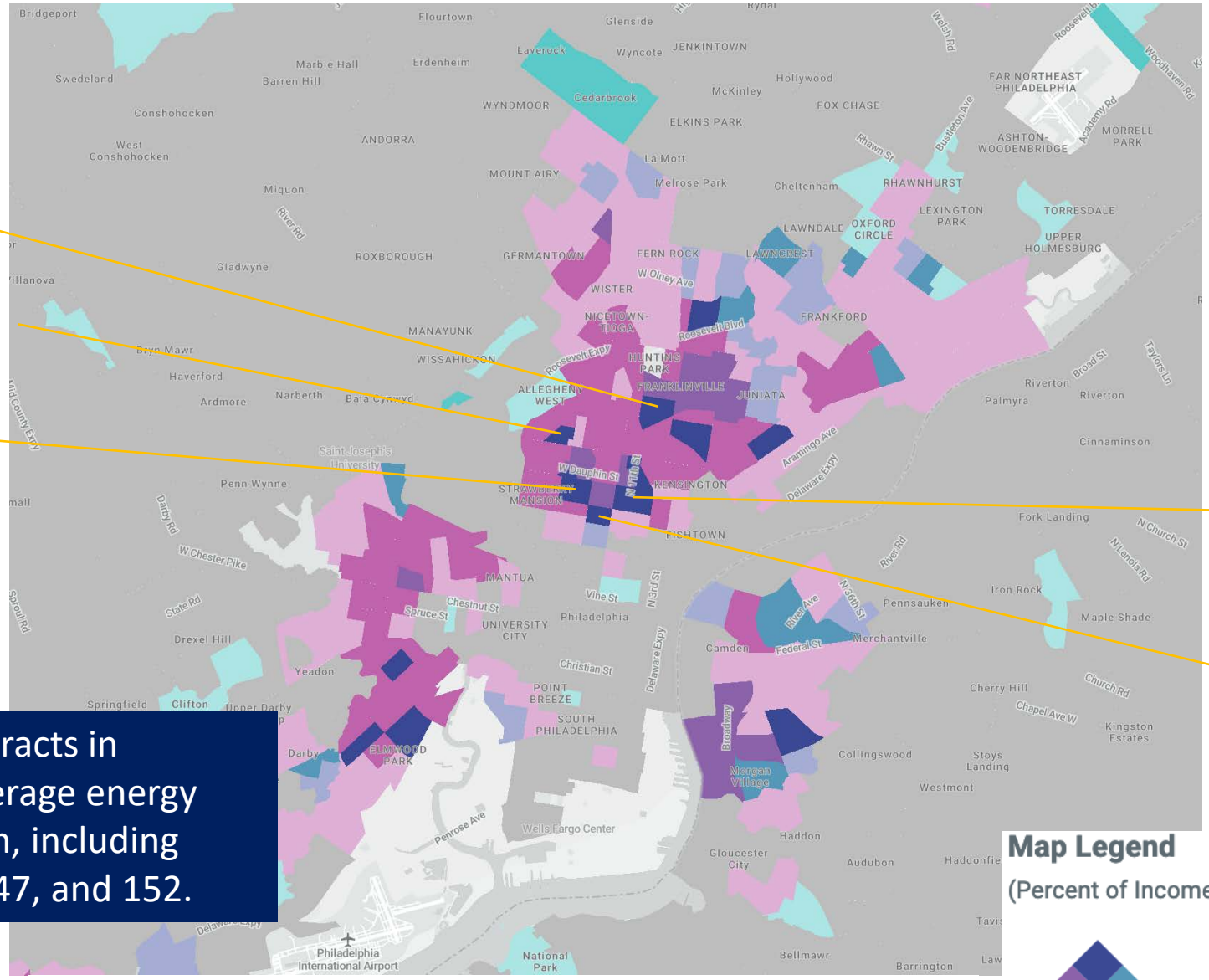
- Smart Thermostat
- Low-E Storm Windows (DIY)
- ~~SEER 18 Central AC*~~
- Drill-and-Fill Wall Insulation
- ~~Duct Sealing*~~
- ~~R-49 Attic Ins.*~~
- ~~LED Lighting*~~
- ~~ENERGY STAR Room AC (EER 12)*~~
- ~~Upgrade Electric WH to HPWH*~~
- ~~R-10 Crawlspace Walls*~~
- Replace Propane Furnace with VSHP
- Air Sealing
- ~~Upgrade ElecFurn to VSHP at Wear Out*~~
- ~~DHP (displaces electric baseboard today)*~~
- R-60 Attic Ins.
- ~~SEER 16 Central AC*~~
- R-5 Wall Sheathing
- R-10 Basement Wall Insulation
- Replace Oil Furnace with VSHP
- ~~ENERGY STAR Boiler - Oil*~~

Find the data:
SLOPE's Data Viewer

Residential Efficiency Upgrades

Which **segments** of the housing stock should we **prioritize** with efficiency investments?

How does energy and transportation burden vary across the jurisdiction's census tracts?



There are several census tracts in Philadelphia with high average energy and transportation burden, including tracts 377, 199, 172.02, 147, and 152.

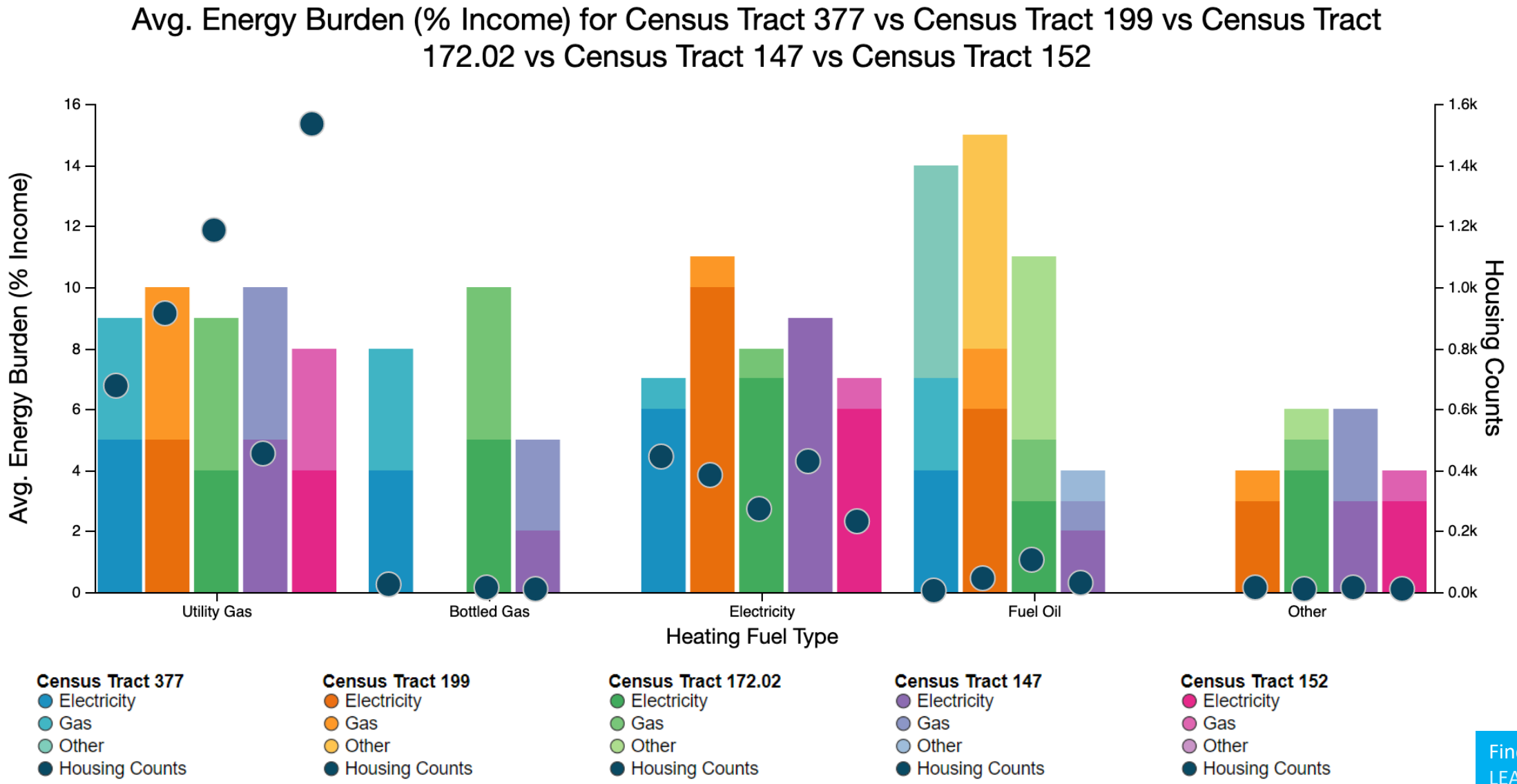
Map Legend

(Percent of Income)

	Low	Medium	High
Housing Energy Burden	< 3.8%	3.8 - 6.0%	> 6.0%
Transportation Burden	< 3.6%	3.6 - 4.2%	> 4.2%

Find the data:
SLOPE's Data Viewer

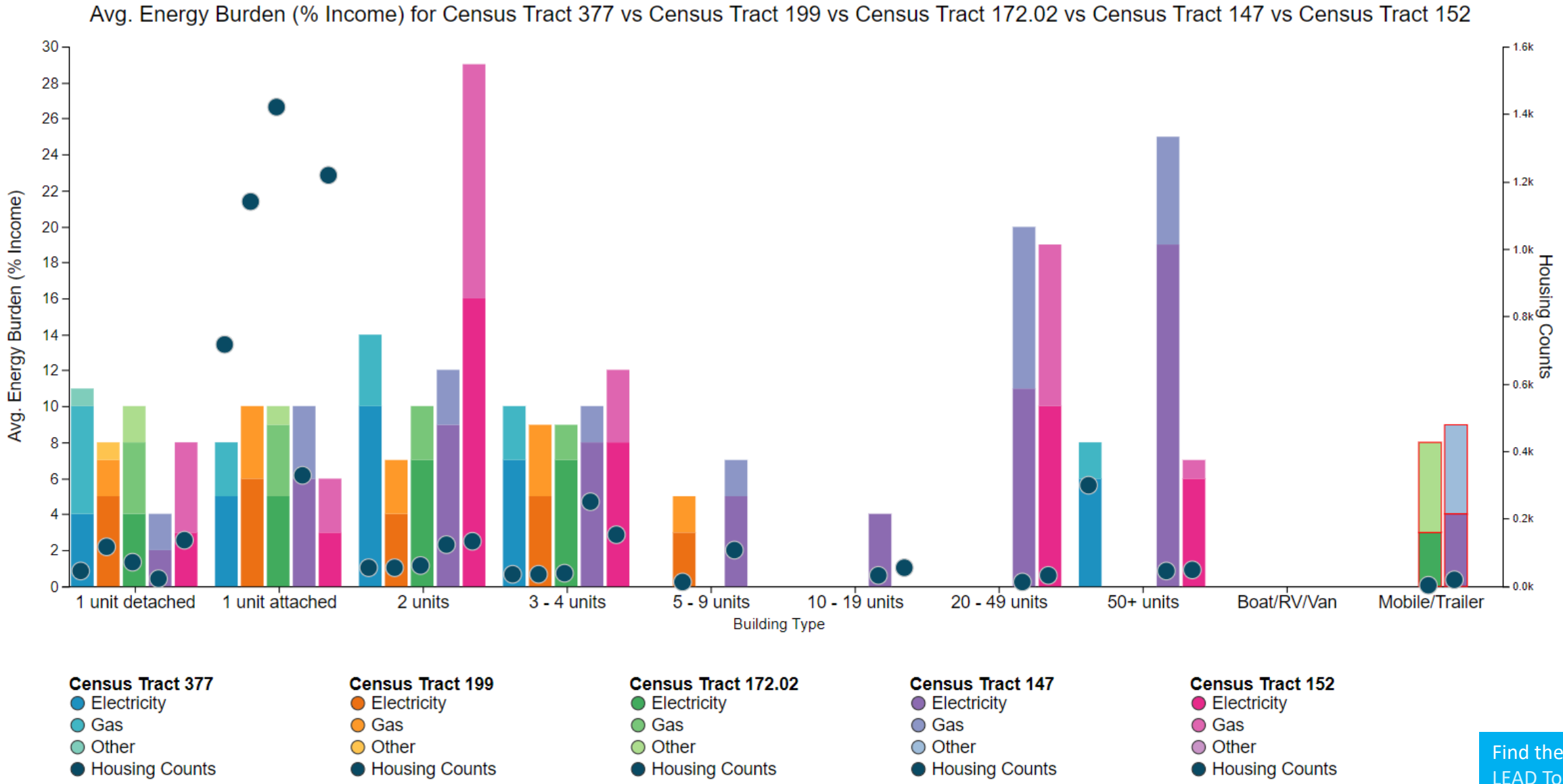
How does energy burden vary by heating fuel types?



Find the data: LEAD Tool

Over 4,500 households in these census tracts use utility gas, with an average energy burden of 8-10%. There are 190 households that use fuel oil for heating, and they have the highest average energy burden by fuel type—up to 15% in census tract 199.

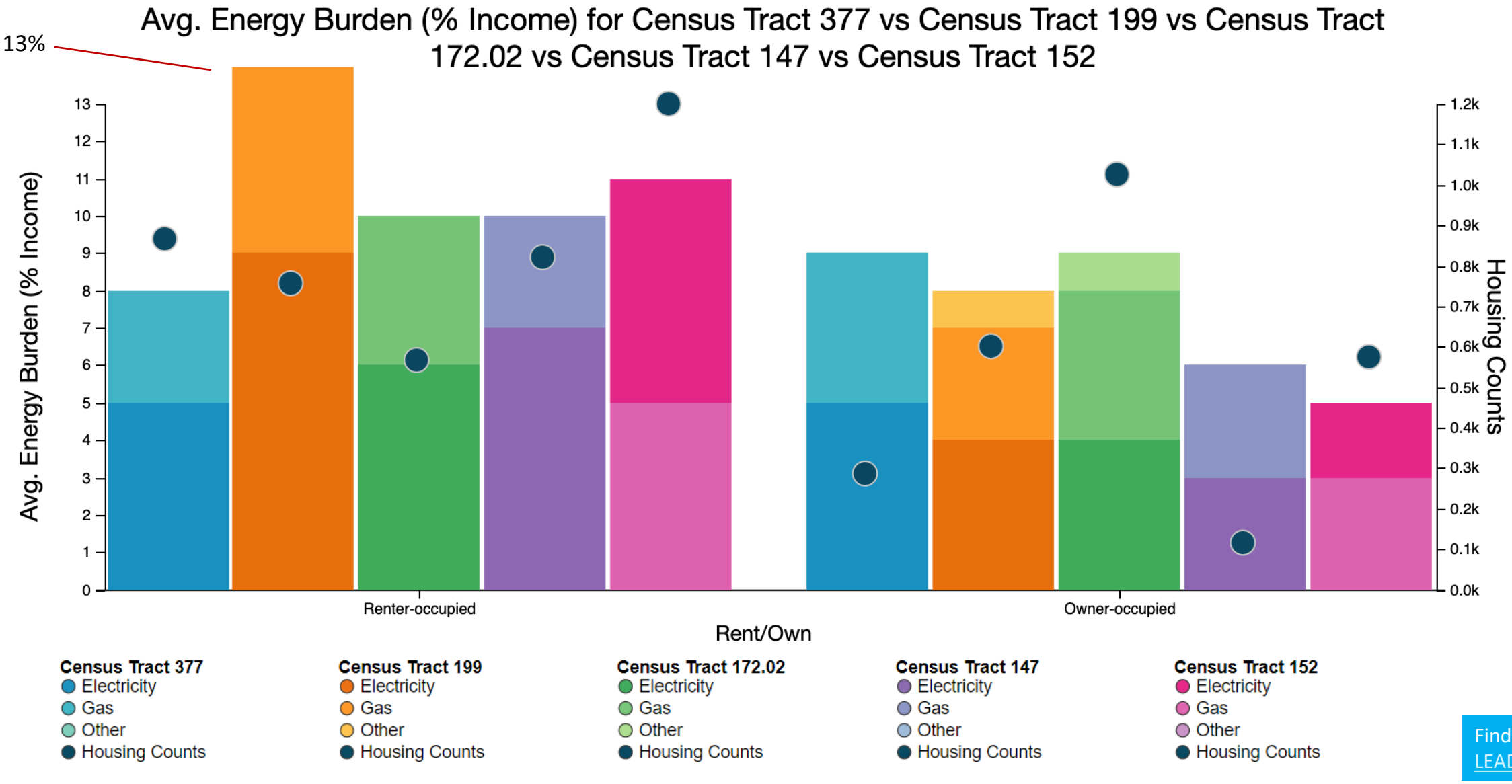
How does energy burden vary by building type?



Find the data: LEAD Tool

Small multi-family buildings with 2 units in tract 152 have exceptionally high energy burden—an average of 29%. Other structures that have high energy burden are large multi-family buildings with greater than 20 units.

How does energy burden vary by occupancy?



Find the data: LEAD Tool

Renter-occupied households tend to have higher energy burden than owner-occupied households, even in most of these burdened tracts. Policies that incentivize landlords to make efficiency upgrades while maintaining rent control might help alleviate these burdens.

JISEA Joint Institute for Strategic Energy Analysis

Addressing data interpretation and application challenges

Sustainable Communities Catalyzer

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

Authors:

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

NREL Transforming ENERGY · Colorado School of Mines Earth • Energy • Environment · Colorado State University · Massachusetts Institute of Technology · Stanford University · University of Colorado Boulder

Equitable Energy Investment Prioritization Research

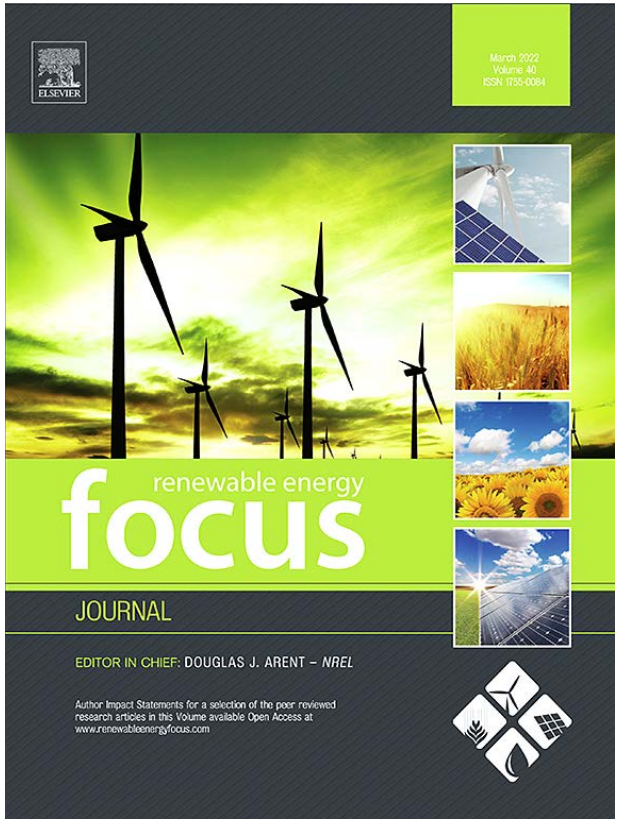
Goal: Intersect **disadvantaged community (DAC) metrics** with **renewable energy (RE) deployment potential metrics** to identify local clean energy opportunities and inform community-, state-, and national-level clean energy investment prioritization

Data set to aid in analysis

- "Equitable Energy Investment Prioritization" data set
  - https://data.nrel.gov/submissions/175

Paper with initial analyses

- "Intersections of Disadvantaged Communities and Renewable Energy Potential: Data Set and Analysis to Inform Equitable Investment Prioritization in the United States"
  - https://doi.org/10.1016/j.ref.2022.02.002



Equitable Energy Investment Prioritization Research

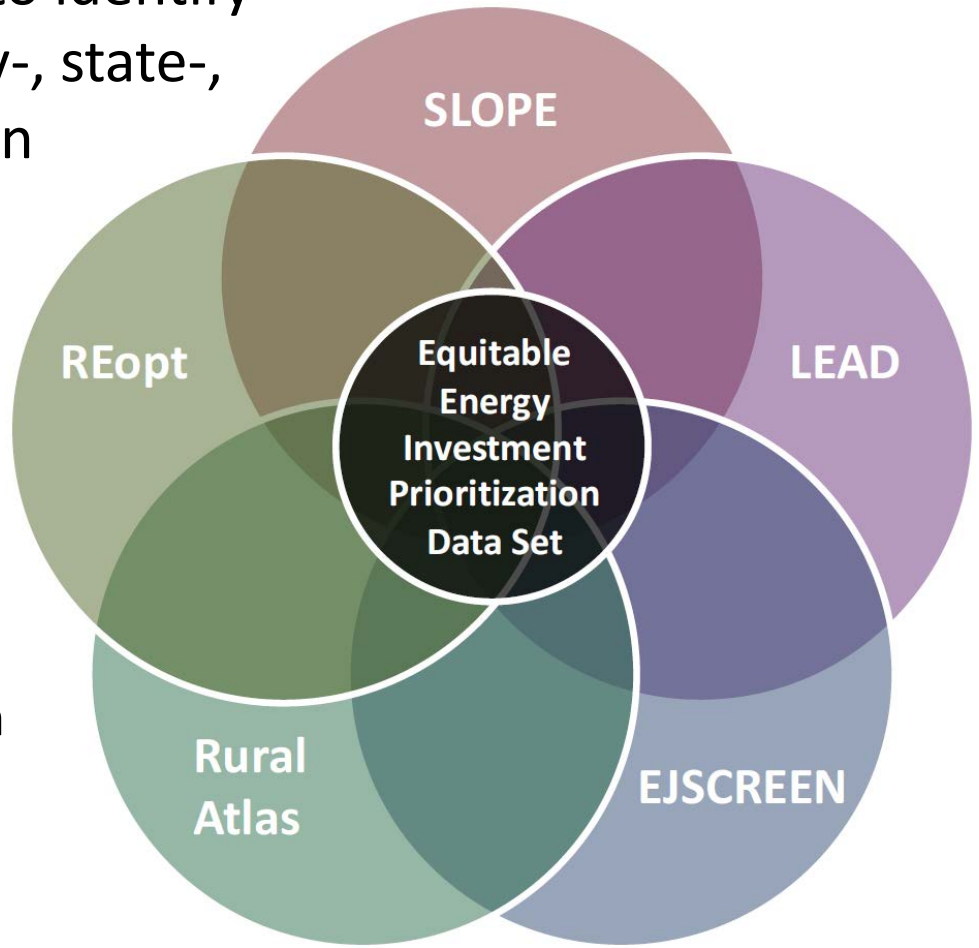
Goal: Intersect **disadvantaged community (DAC) metrics** with **renewable energy (RE) deployment potential metrics** to identify local clean energy opportunities and inform community-, state-, and national-level clean energy investment prioritization

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



Metrics Considered

Metric	Source
Cancer risk	EJSCREEN
Diesel PM	EJSCREEN
Lead paint	EJSCREEN
NPL* proximity	EJSCREEN
Ozone	EJSCREEN
$PM_{2.5}$	EJSCREEN
Respiratory hazard	EJSCREEN
RMP* proximity	EJSCREEN
TSDF* proximity	EJSCREEN
Traffic proximity	EJSCREEN
Wastewater discharge	EJSCREEN

Metric	Source
Energy burden	LEAD
% mining, quarrying, and oil & gas jobs	Rural Atlas
% unemployment	Rural Atlas
Rural-urban code	Rural Atlas
% less than HS education	EJSCREEN
% low income	EJSCREEN
% minority	EJSCREEN

Metric	Source
Commercial PV	SLOPE
Residential PV	SLOPE
Utility PV	SLOPE
Land-based wind	SLOPE
Geothermal	SLOPE
Hydropower	SLOPE
Solar-plus-storage	REopt

*NPL (national priorities list) sites; RMP (risk management plan) sites; TSDF (treatment, storage, and disposal facilities)

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: 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

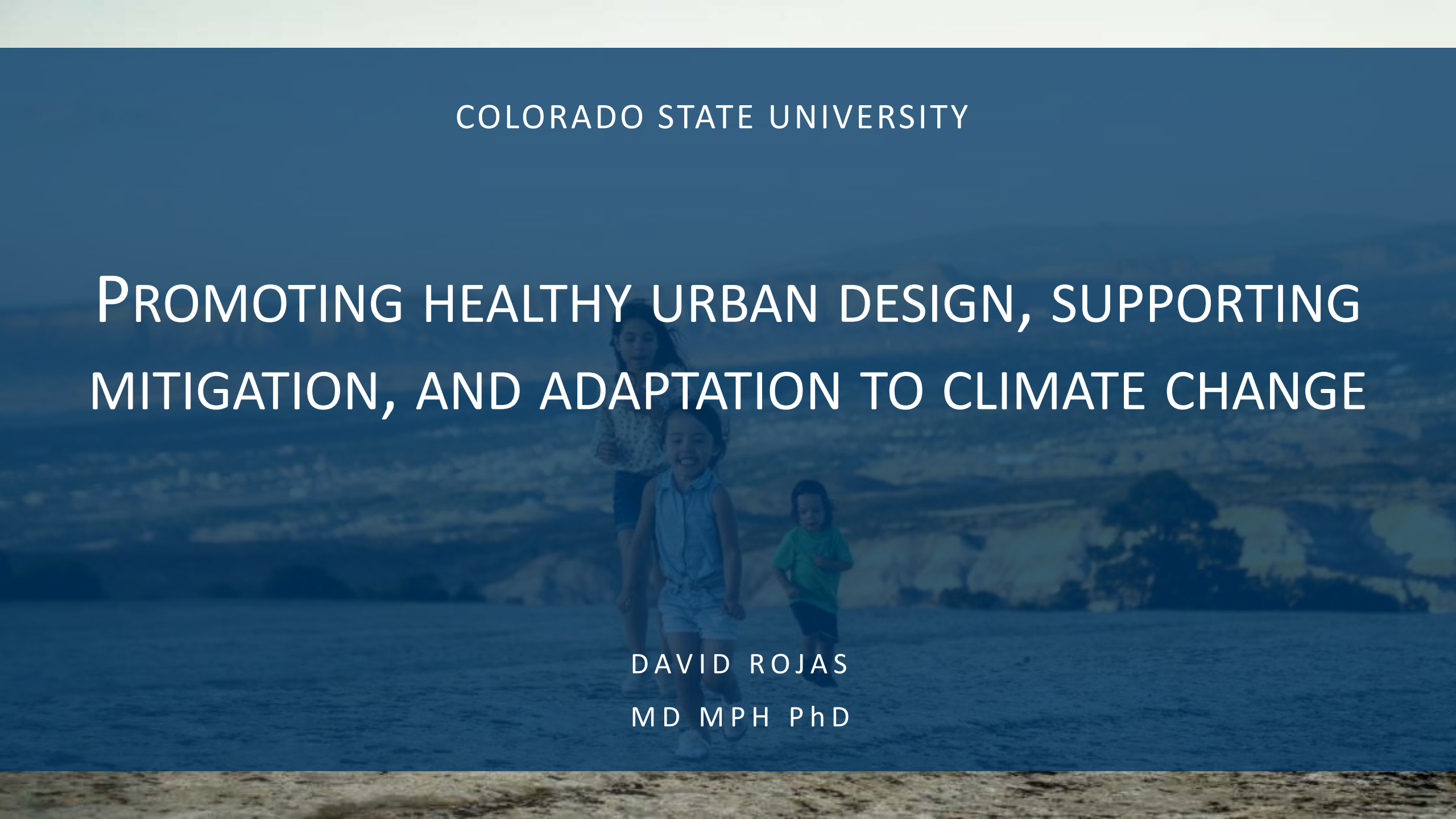
www.jisea.org

NREL Publication #NREL/PR-6A50-81527
https://www.nrel.gov/docx/gen/fy22/81527.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



COLORADO STATE UNIVERSITY

PROMOTING HEALTHY URBAN DESIGN, SUPPORTING MITIGATION, AND ADAPTATION TO CLIMATE CHANGE

DAVID ROJAS

MD MPH PhD

NEW TRANSPORT TECHNOLOGIES

684 electric scooter operators

Selected Systems

Atlanta, Georgia

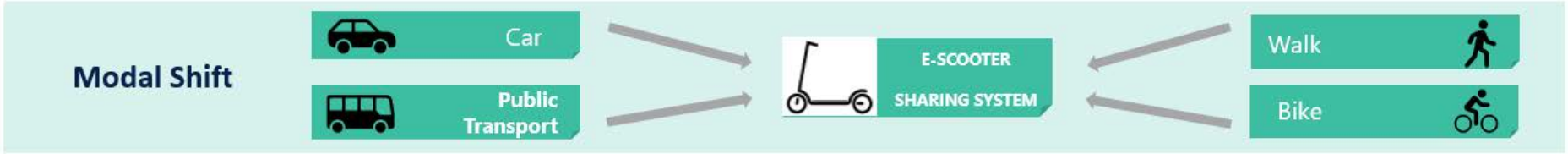
- 9 companies.
- 12,700 scooters.
- 15,792 daily rides.
- Population of 5,950,828

Portland, Oregon

- 3 companies.
- 2,043 scooters.
- 4,885 daily rides
- Population of 2,478,996

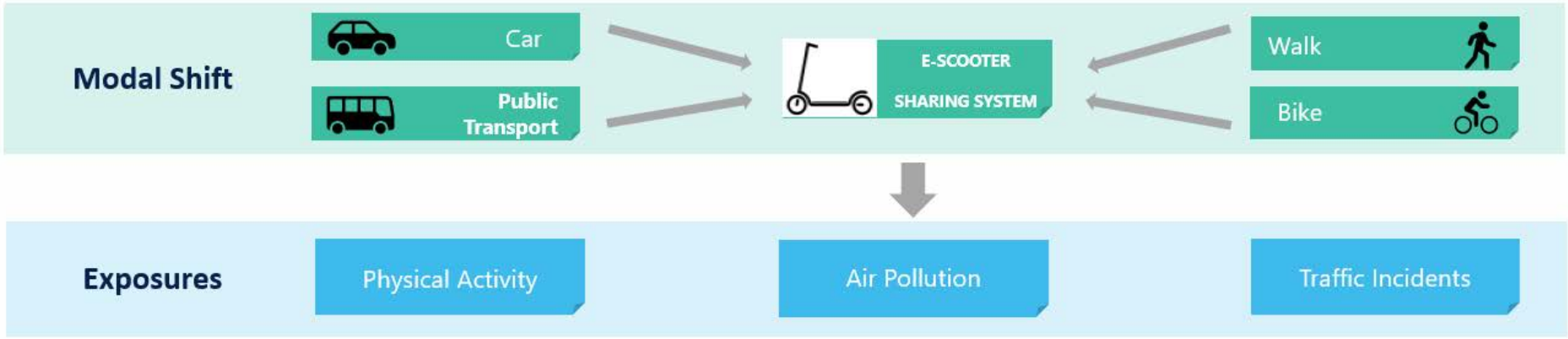
Rojas
PUBLIC HEALTH LAB

Quantitative Health Impact Assessment



Rojas
PUBLIC HEALTH LAB

Quantitative Health Impact Assessment



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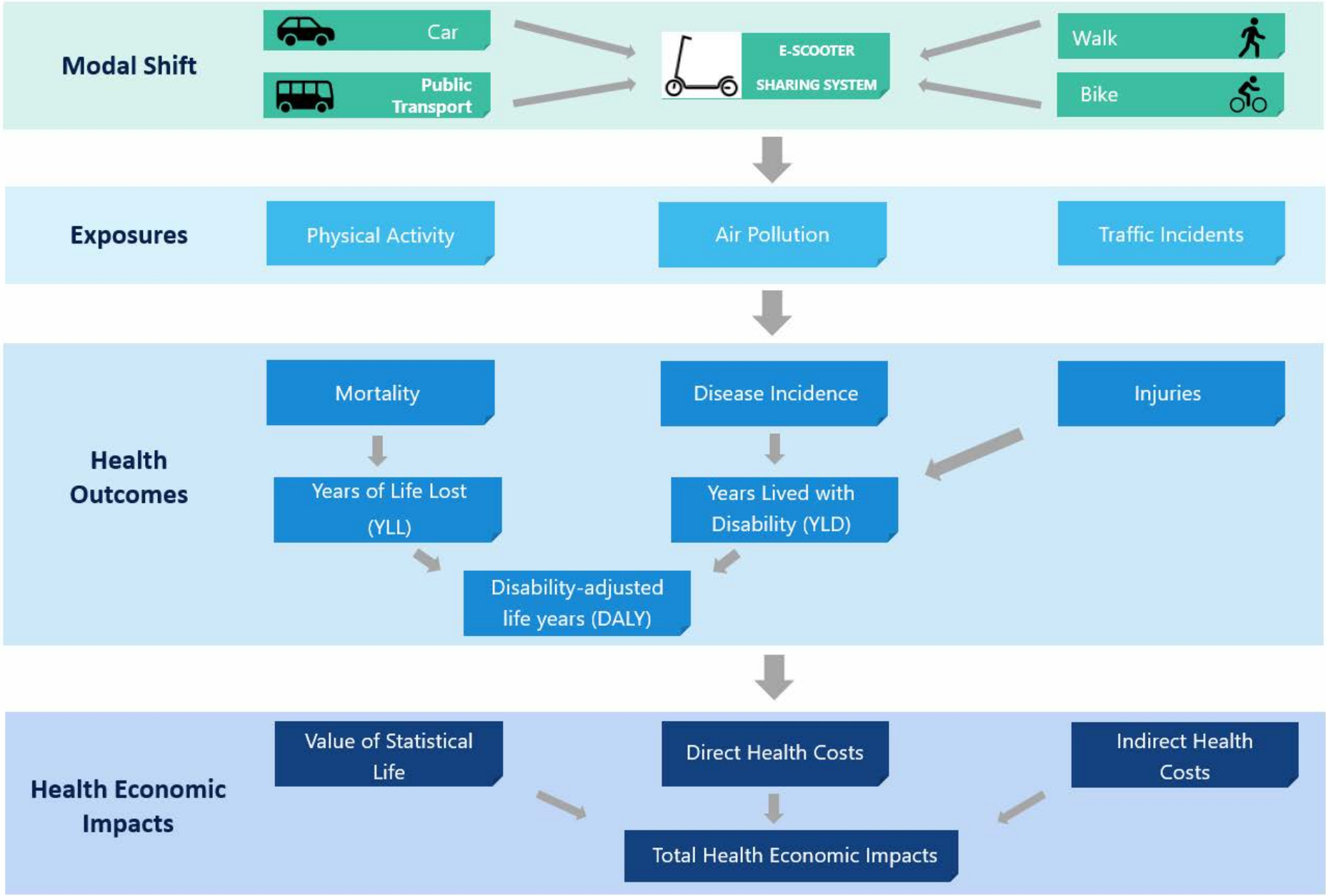
PUBLIC HEALTH LAB

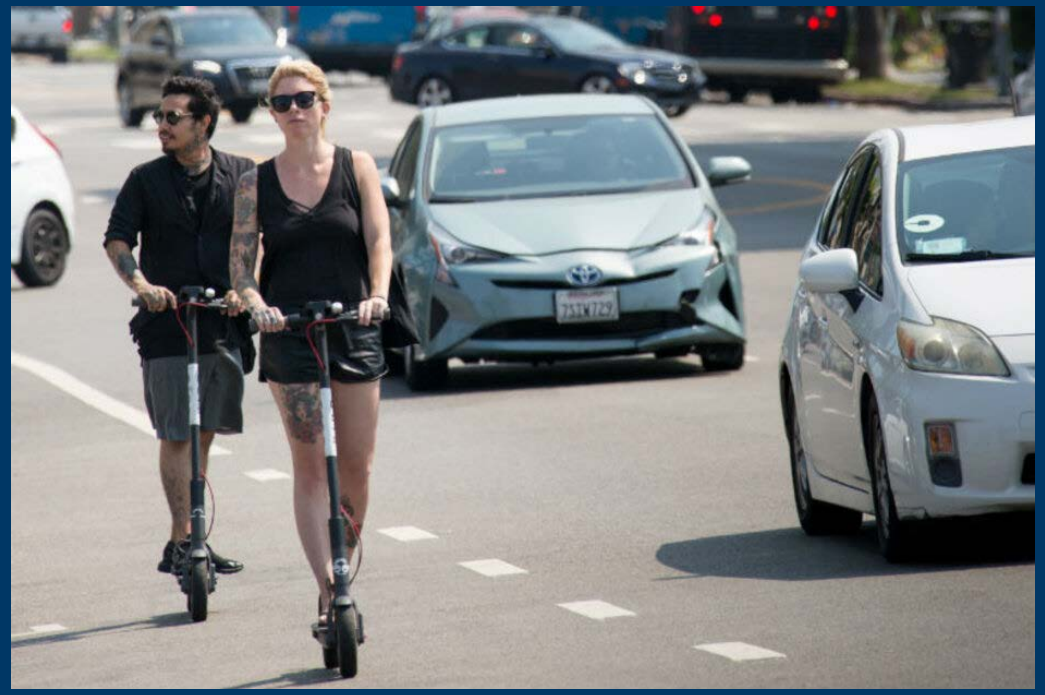
Quantitative Health Impact Assessment



Rojas
PUBLIC HEALTH LAB

Atlanta
E-scooter

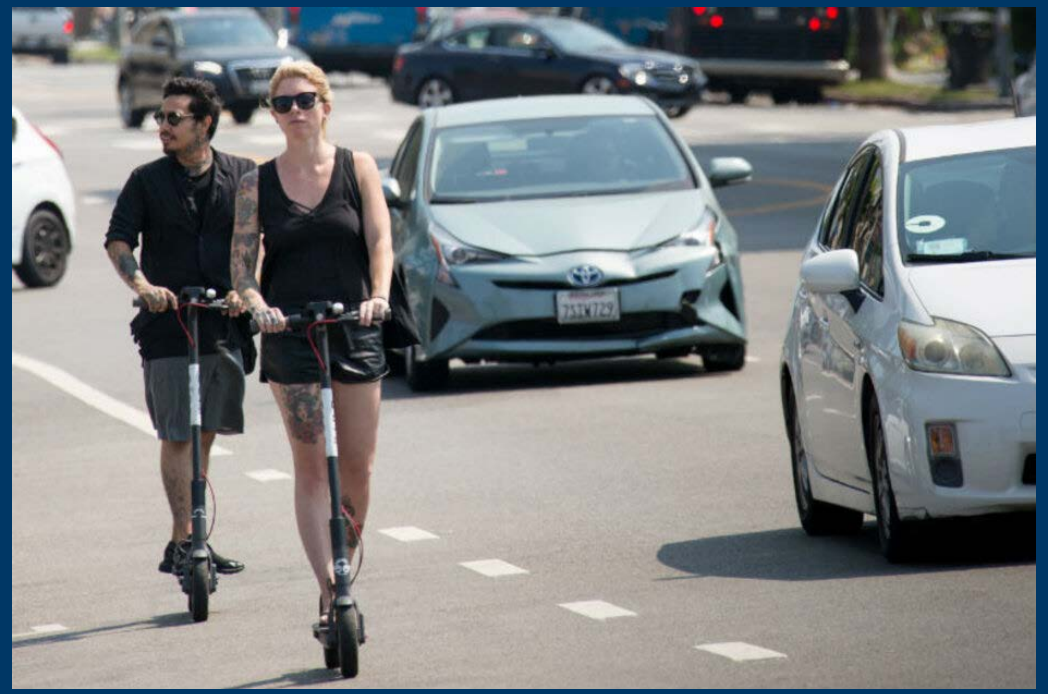
15,792 trips/day

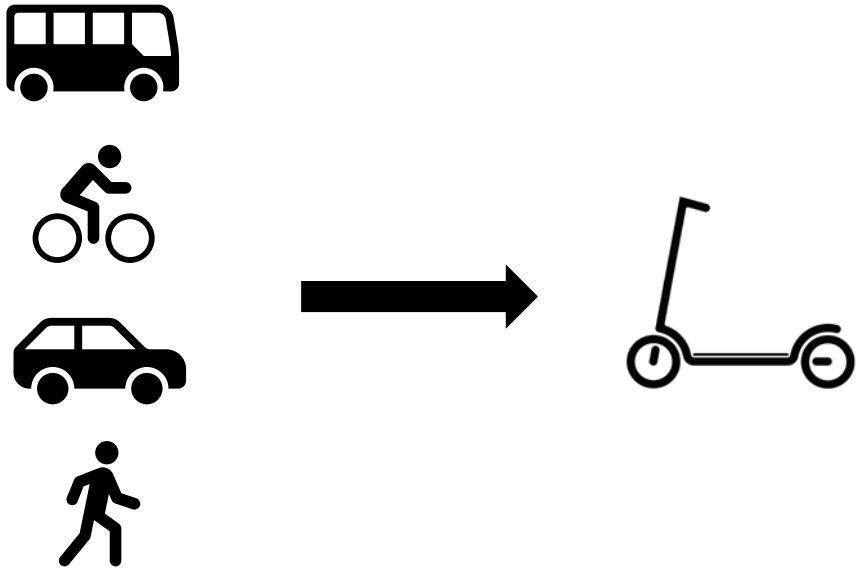


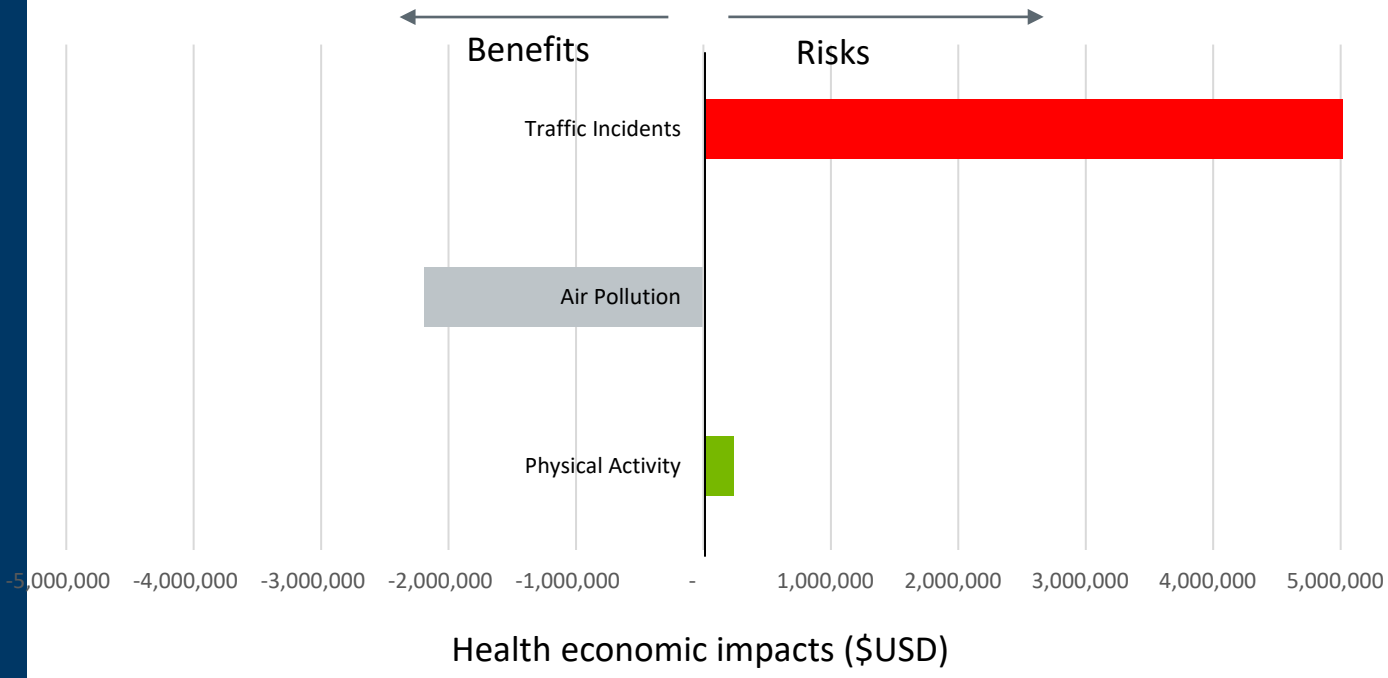
Rojas
PUBLIC HEALTH LAB

Atlanta
E-scooter

15,792 trips/day

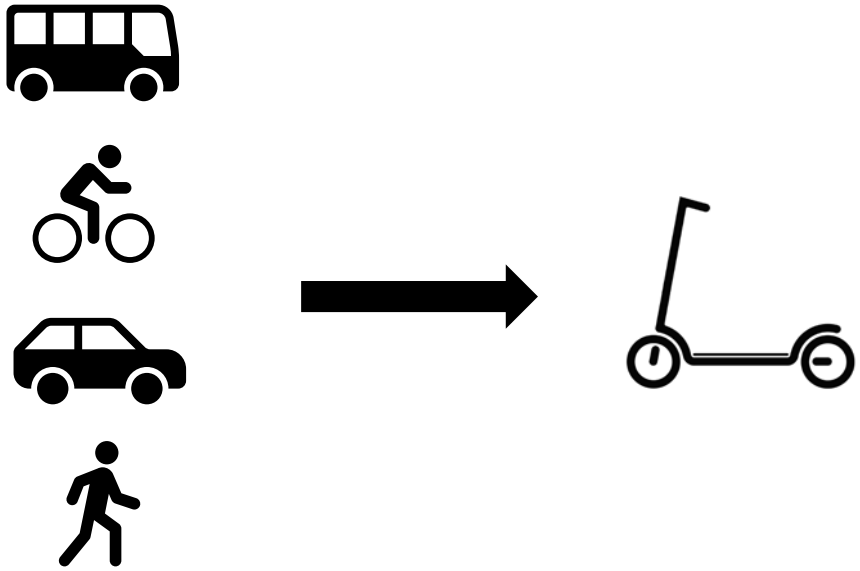






Portland
E-scooter

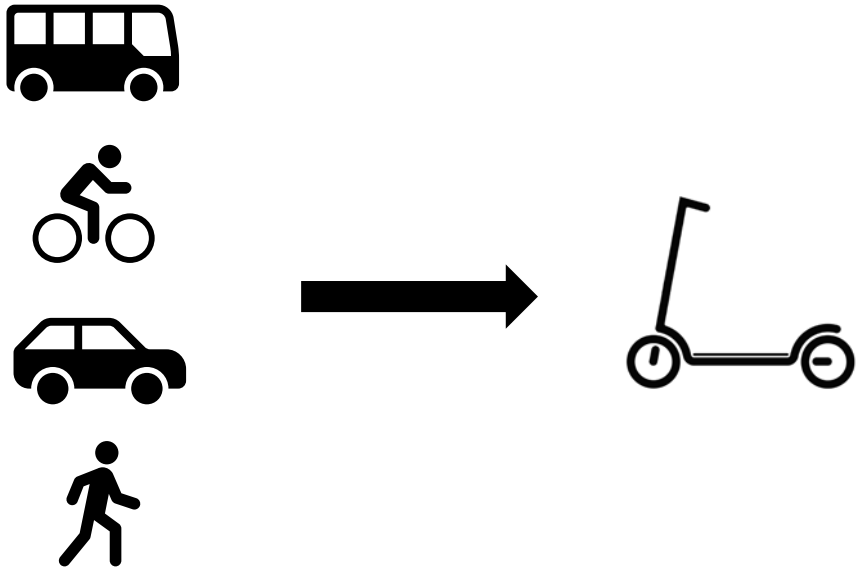
4,885 trips/day

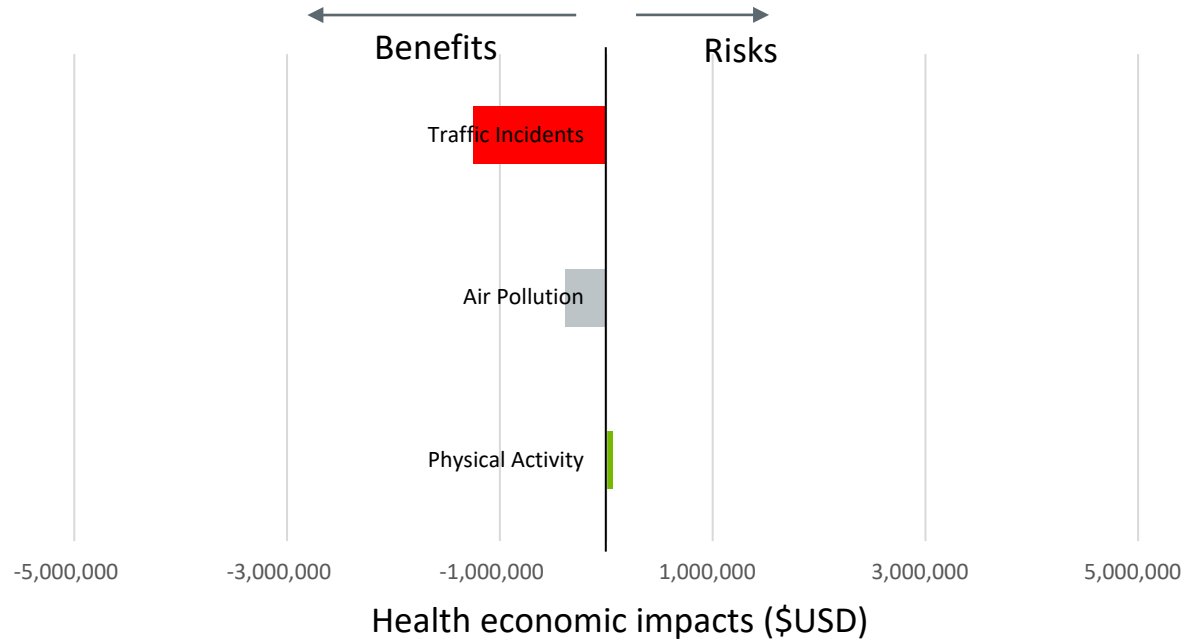


Rojas
PUBLIC HEALTH LAB

Portland
E-scooter

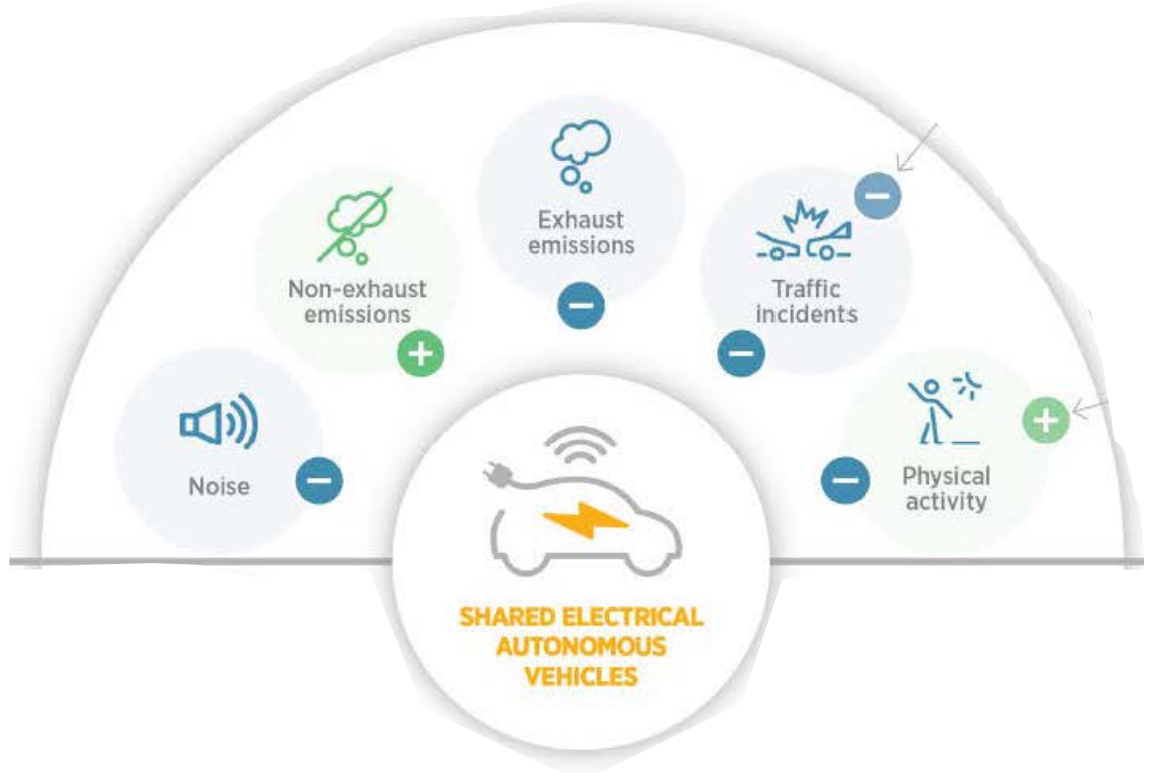
4,885 trips/day





Autonomous Vehicles


WAYMO



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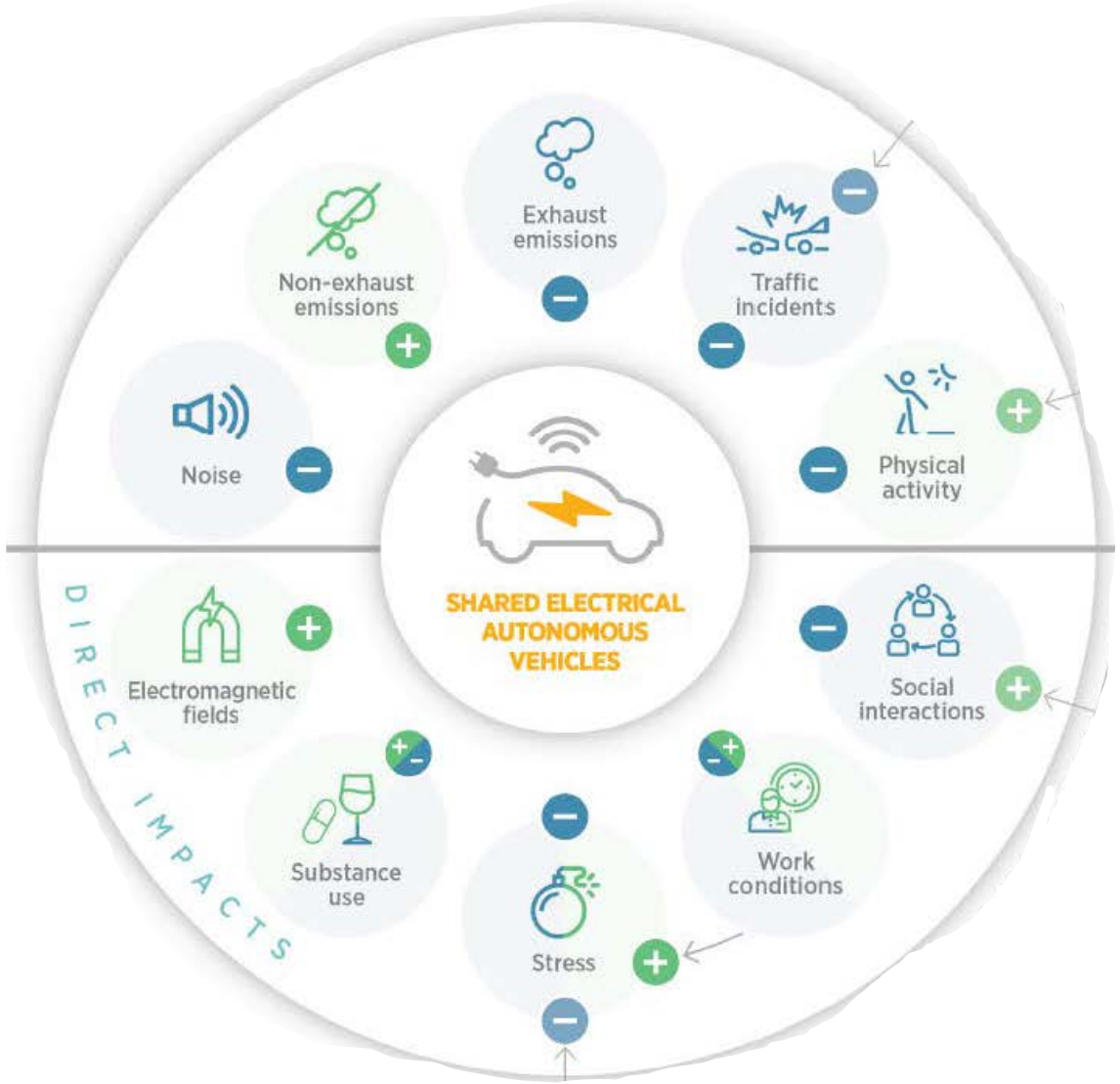

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Exhaust emissions
Non-exhaust emissions
Traffic incidents
Noise
Physical activity
SHARED ELECTRICAL AUTONOMOUS VEHICLES
Traffic congestion
Electromagnetic fields
Social interactions
Substance use
Work conditions
Stress
Energy consumption
Climate change
DIRECT IMPACTS
INDIRECT IMPACTS

Rojas
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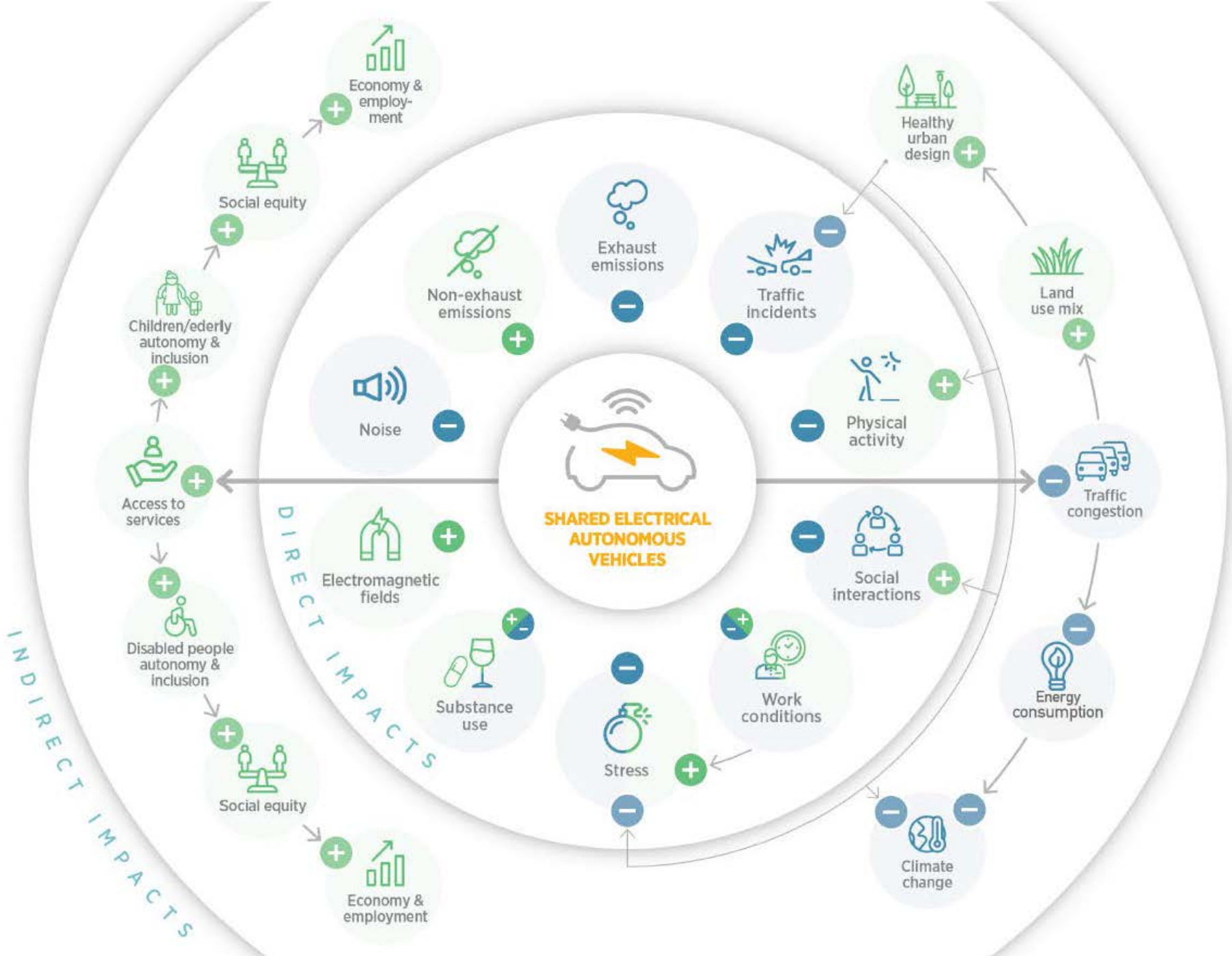

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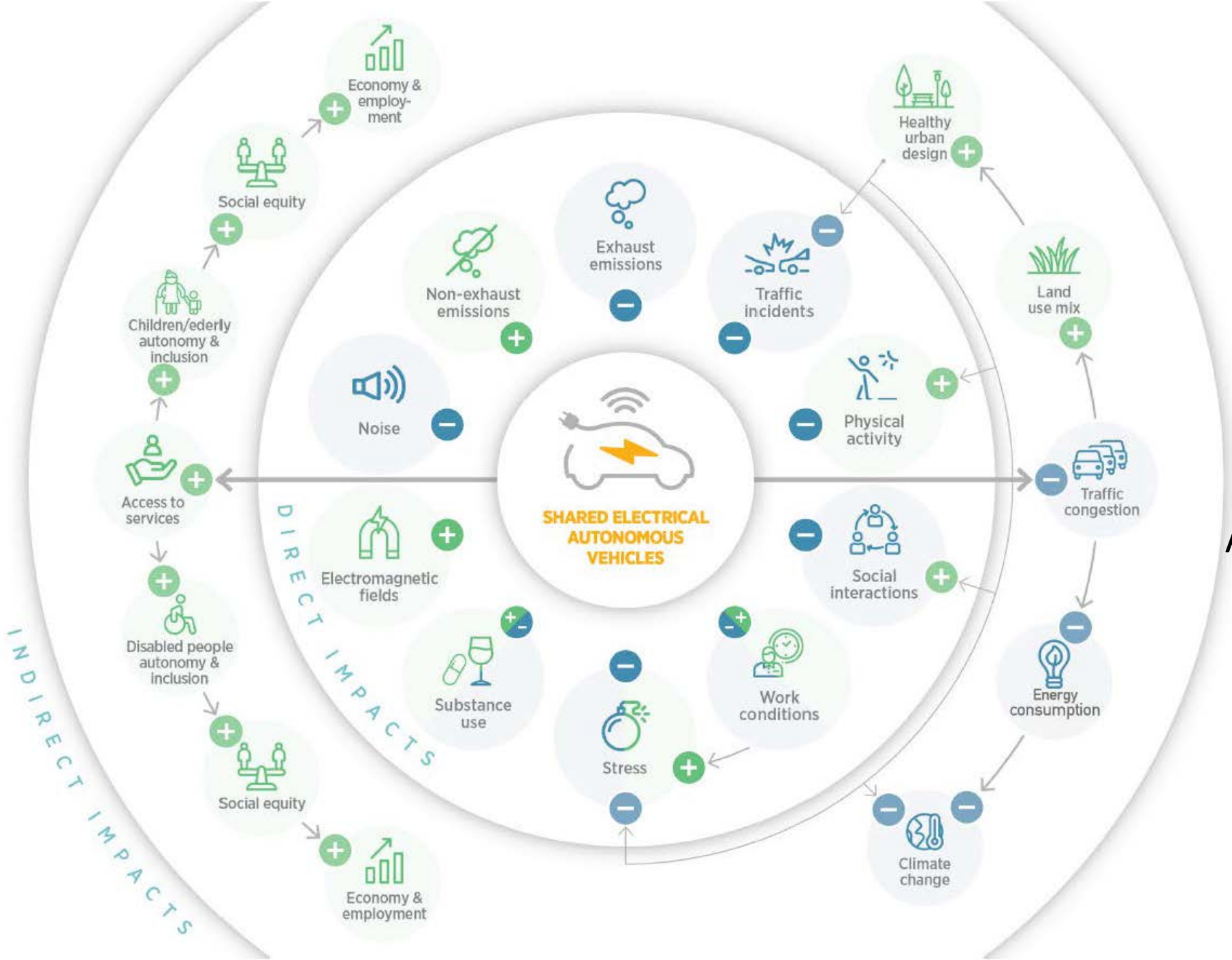
PUBLIC HEALTH LAB



Health Impacts of Autonomous Vehicles

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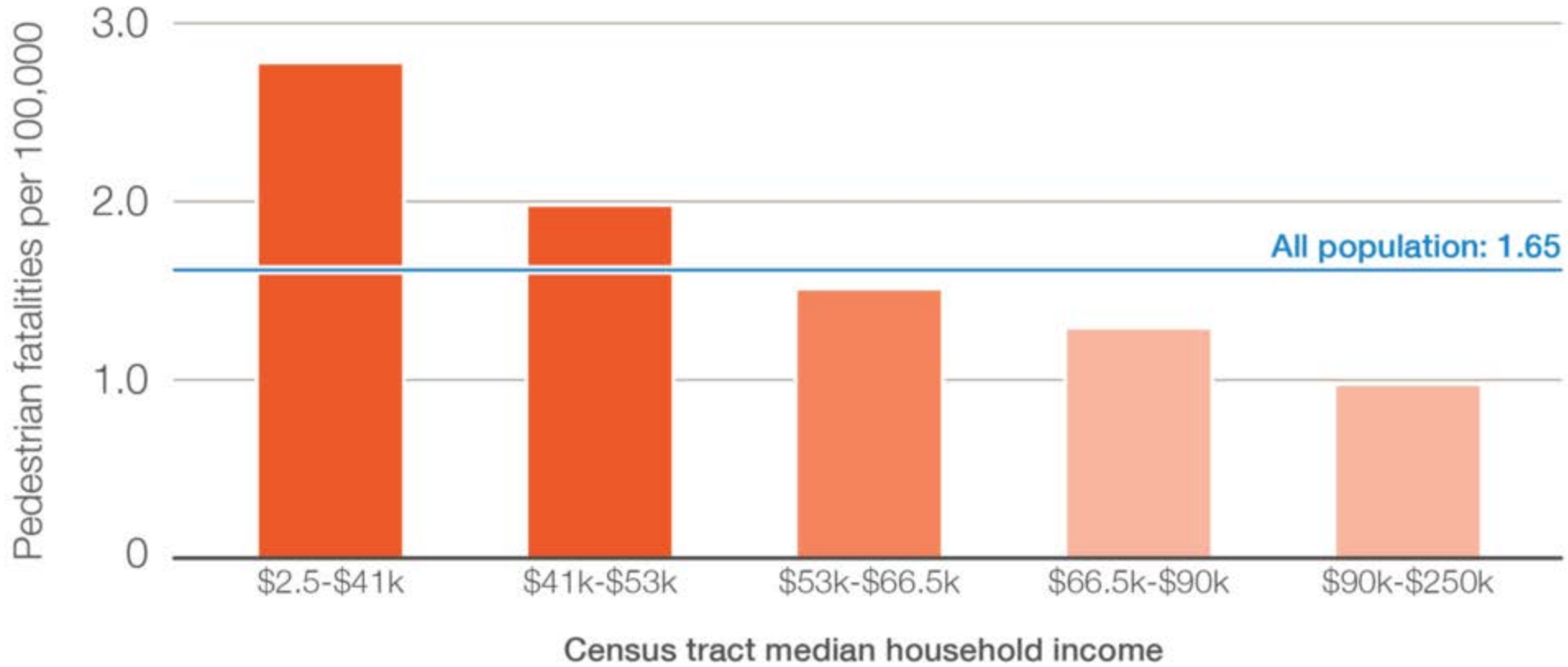
People walking in lower-income areas are struck and killed at much higher rates. People walking in wealthier neighborhoods are killed at far lower rates



Rojas
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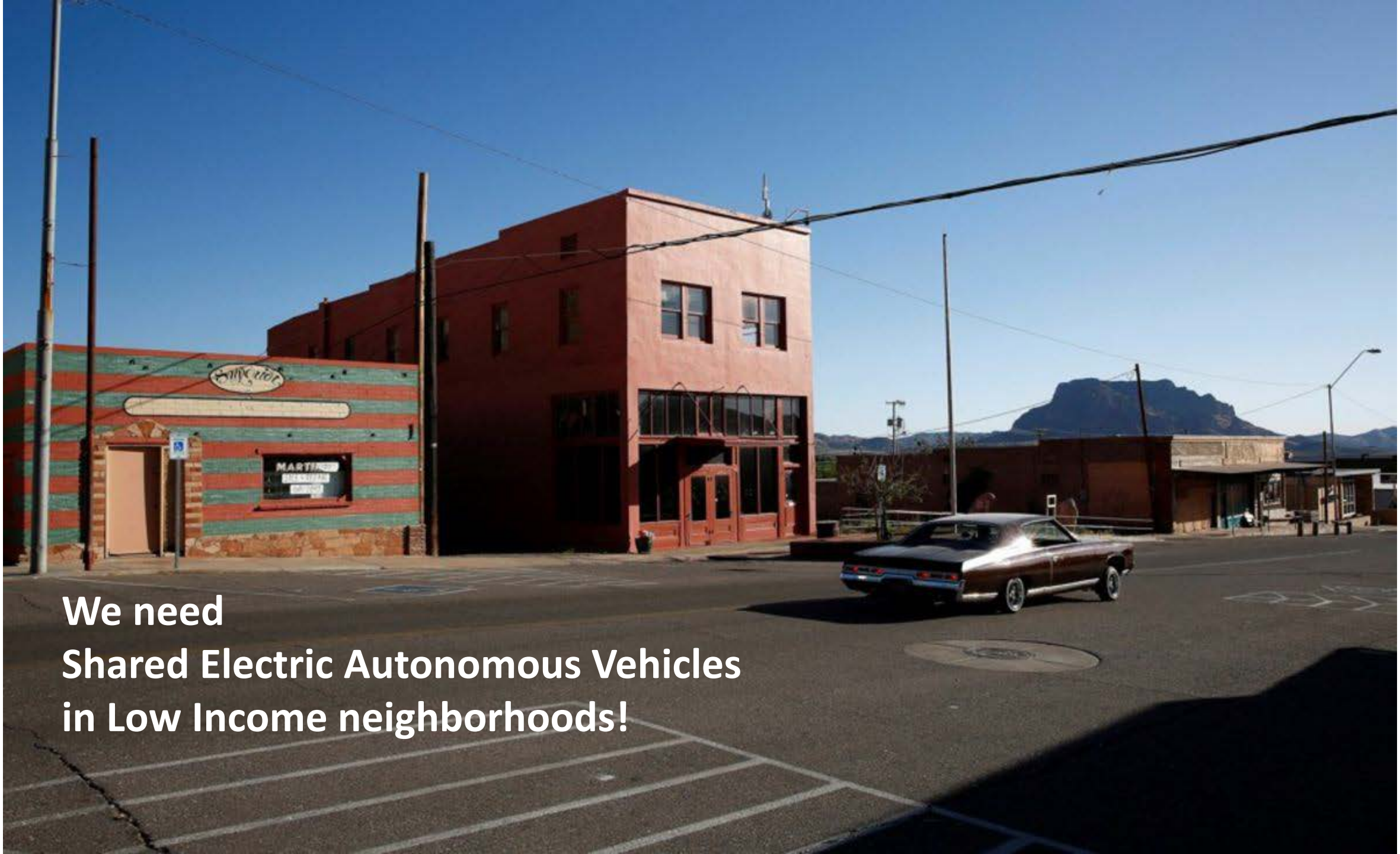
MARTIN

Rojas
PUBLIC HEALTH LAB


We need
Shared Electric Autonomous Vehicles
in Low Income neighborhoods!

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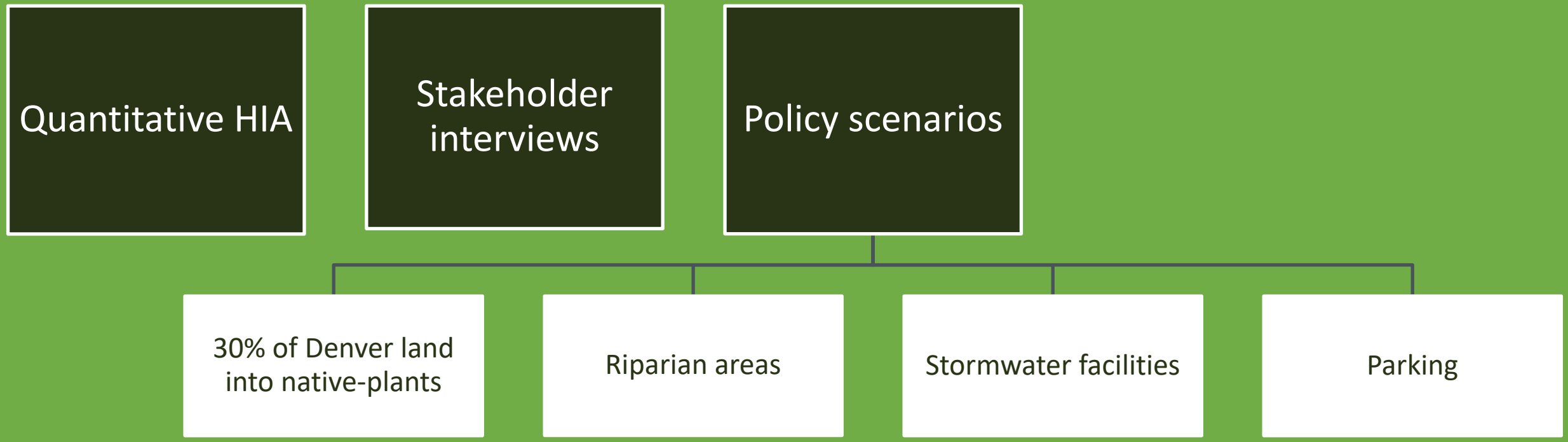
Pollinator Habitat
This area has been planted with pollinator-friendly flowers and is protected from pesticides to provide valuable habitat for bees and other pollinators.
To learn how you can help to bring back the pollinators, please visit www.xerces.org.
Bring Back the Pollinators

HUMAN HEALTH ANALYSES



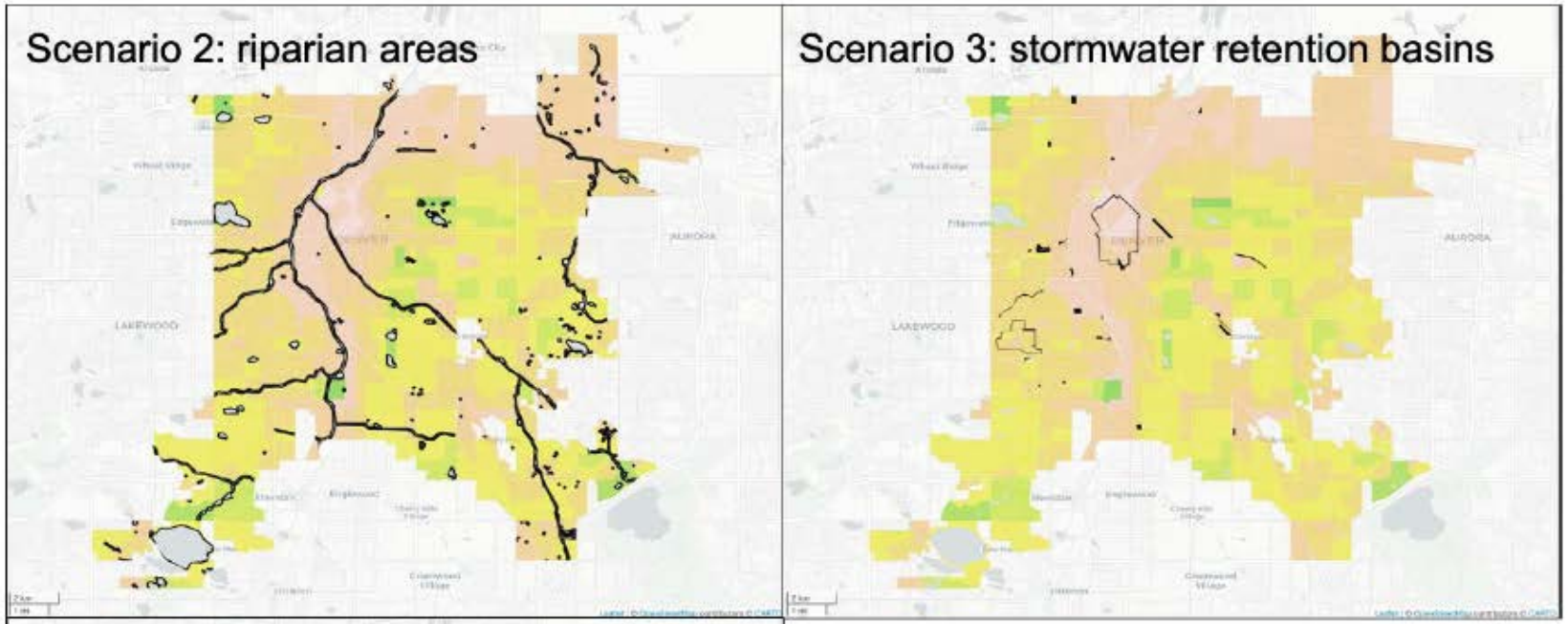


Figure 3. The intervention areas in the three location-based scenarios (scenarios 2-4) layered on the normalized difference vegetation index (NDVI) of the block groups. Individual maps for each scenario appear in **eAppendix 4**.

RESULTS

Scenario	Impacted area (mi^2)	Population	Deaths prevented (per year)	Economic value in millions (VSL/per year)
1 – Block-group level	68	281K	33	$247
2 – Riparian areas	35	130K	3	$24.7
3 – Retention basins	14	67K	1	$7.5
4 – Parking	68	285K	8	$60

Value of statistical life (VSL) = $7.5m, FEMA 2020

COLORADO STATE UNIVERSITY

Colorado EnviroScreen

DAVID ROJAS

MD MPH PhD

COLORADO
EnviroScreen
Environmental Justice Mapping Tool

¿Que es Colorado EnviroScreen?

Es un mapa en línea, que presenta información demográfica, ambiental y de salud en Colorado.

What is Colorado EnviroScreen?

An interactive online mapping tool of Colorado that displays demographic, environmental, and health information.

Actualizar mapa

Escala geográfica

Condado

Indicador

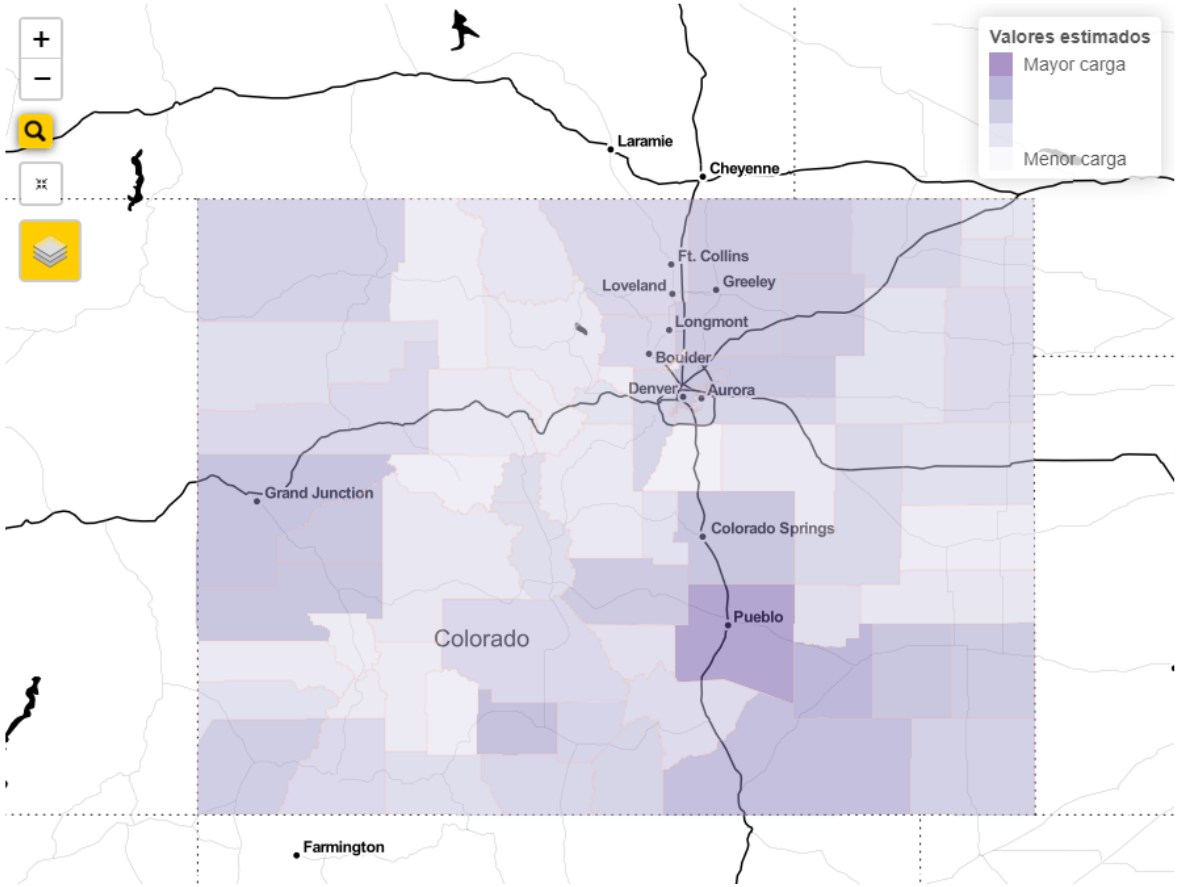
Puntaje de Colorado EnviroScreen

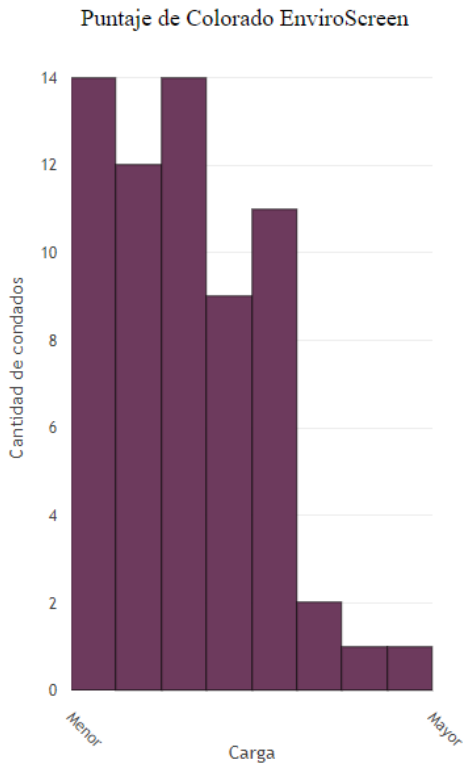
Medida o %

Rango percentil

Eliminar resaltado

Puntaje de Colorado EnviroScreen : El puntaje de EnviroScreen combina las características de la población con las cargas ambientales. Este puntaje varía de 0 a 100. Cuanto más alto es el puntaje, mayor es la carga. El puntaje de EnviroScreen se expresa como percentil, que es un rango o categoría. El número representa la cantidad de condados, áreas censales o grupos de manzanas censales del estado que reciben un puntaje más bajo que la zona en cuestión. Haga de cuenta que el puntaje de EnviroScreen de un condado es 70. Esto significa que el puntaje de EnviroScreen de este condado es más alto que el puntaje del 70 % de todos los condados de Colorado. En otras palabras, es menos probable que el 70 % de los condados de Colorado se vean afectados por injusticias de salud ambiental que el condado en cuestión. Haga de cuenta que el puntaje de EnviroScreen de un área censal es 20. Esto significa que el puntaje de EnviroScreen de esta área es más alto que el puntaje del 20 % de todas las áreas censales de Colorado. En otras palabras, es menos probable que el 20 % de los condados de Colorado se vean afectados por injusticias de salud ambiental que el área censal en cuestión, o es más probable que el 80 % de las áreas censales de Colorado se vean afectadas por injusticias de salud ambiental que el área censal en cuestión.





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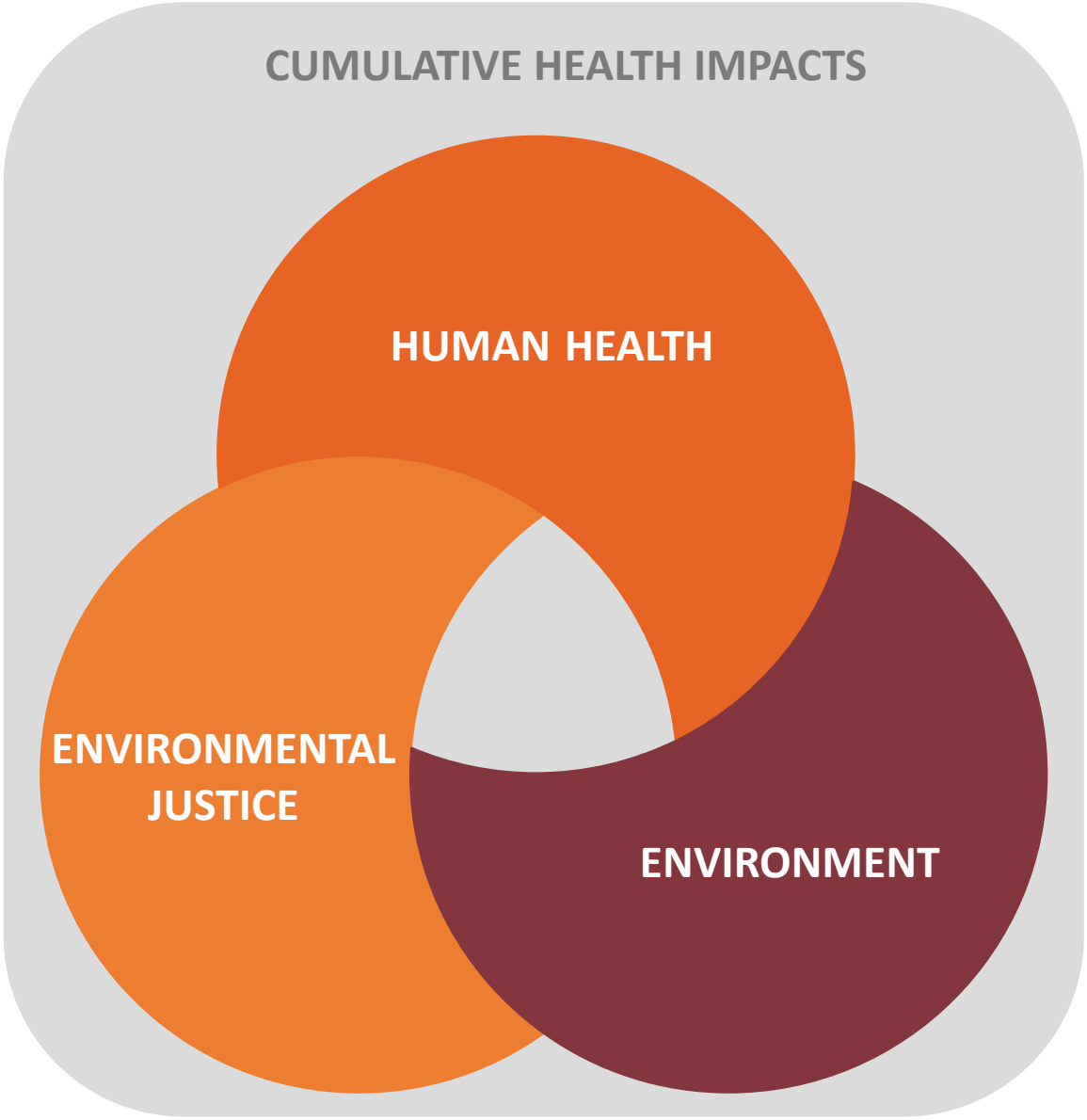
Framework / Abordaje



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Propósito de la herramienta

Ser un recurso que ayuda a disminuir las inequidades de salud ambiental.

Purpose of the Tool

Provide a resource to help reduce environmental health disparities.

Intended Users

- Community advocates
- Members of disproportionately impacted communities
- CDPHE staff, boards, and commissions
- Legislators
- General public
- State agencies
- Health advocates
- Non-profits
- Businesses & regulated industry
- Academics / researchers

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Medio Ambiente

Incluye:

El ambiente físico como la naturaleza, el entorno construido o la contaminación

---

Environment

Includes:

The physical environment such as nature, built environment, or pollution

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Medio Ambiente

Incluye:

El ambiente físico como la naturaleza, el entorno construido o la contaminación

***No** incluye:*

El ambiente social, exposiciones ocupacionales, microorganismos, saneamiento e higiene, factores de riesgo conductuales o desastres no naturales

Environment

Includes:

The physical environment such as nature, built environment, or pollution

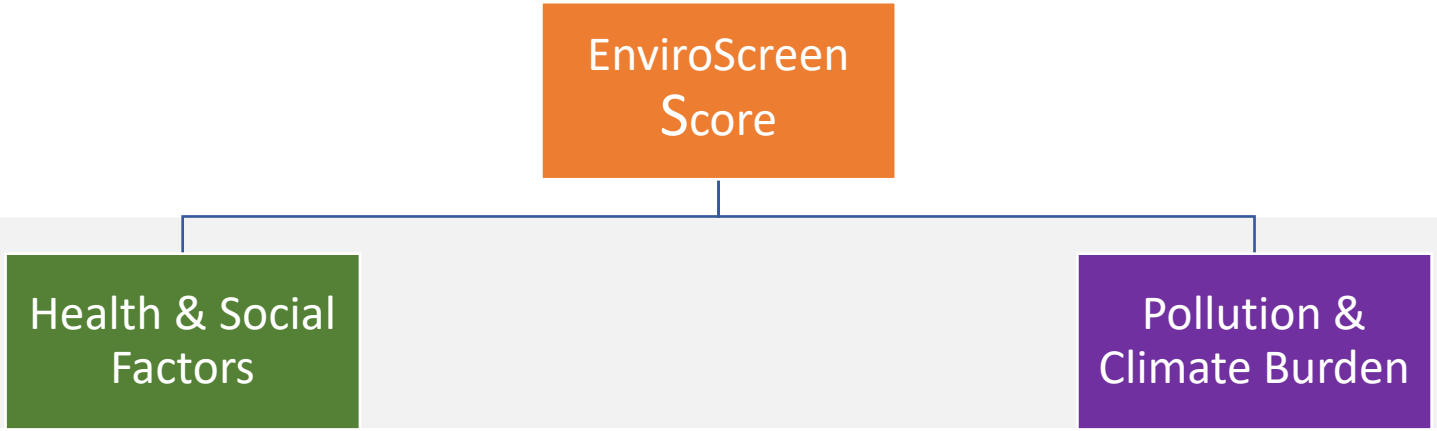
*Does **not** include:*

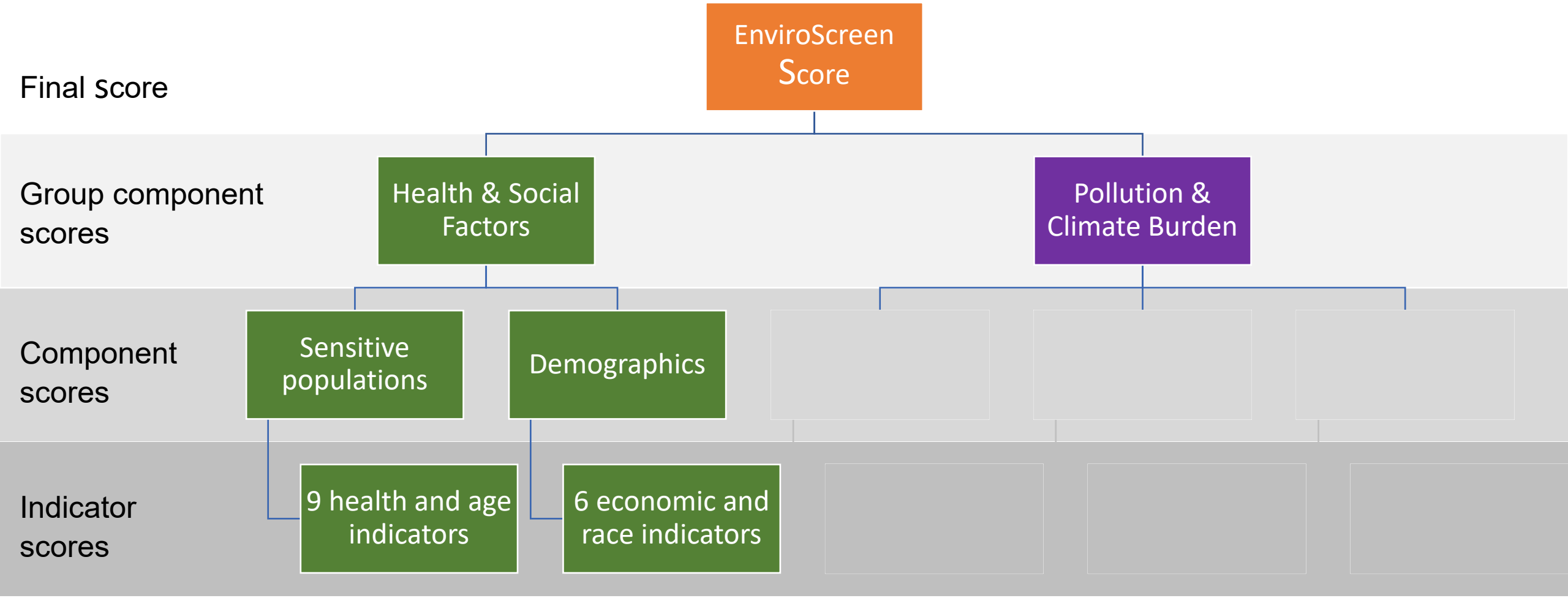
Social environment, occupational exposures, microorganisms, sanitation and hygiene, behavioral risk factors, or unnatural disasters

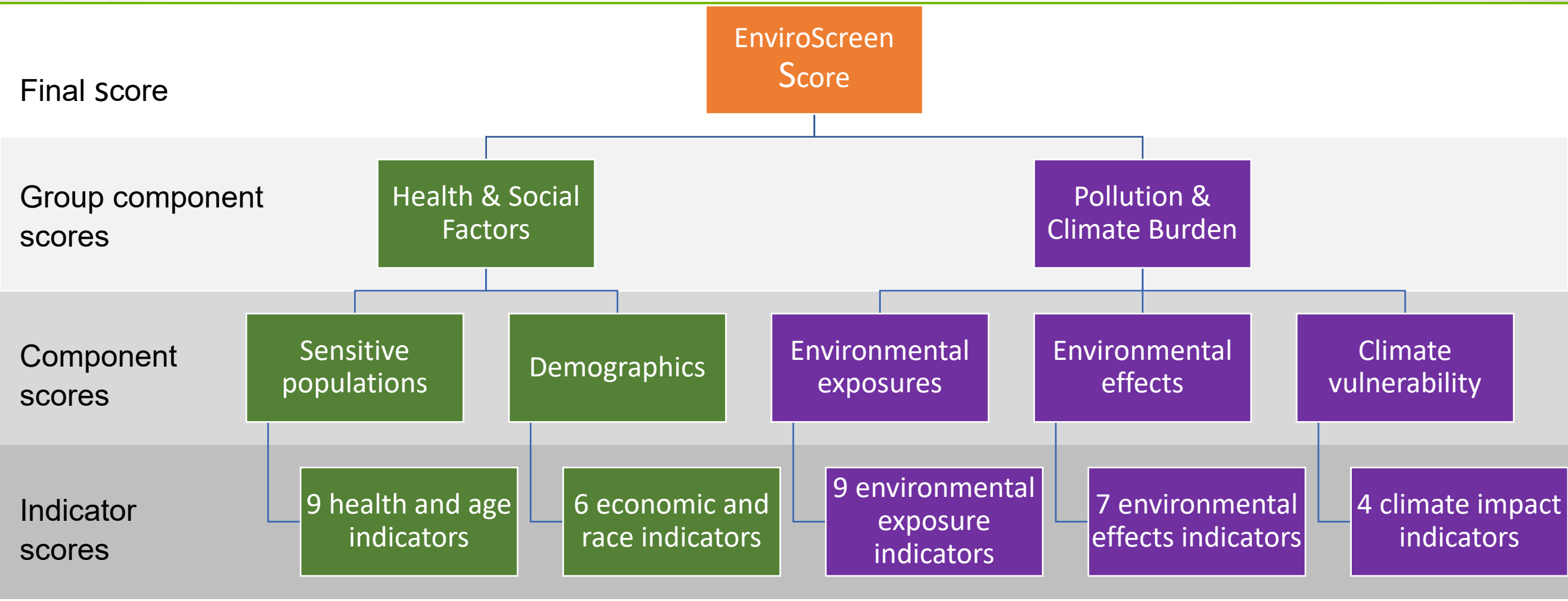
Final score

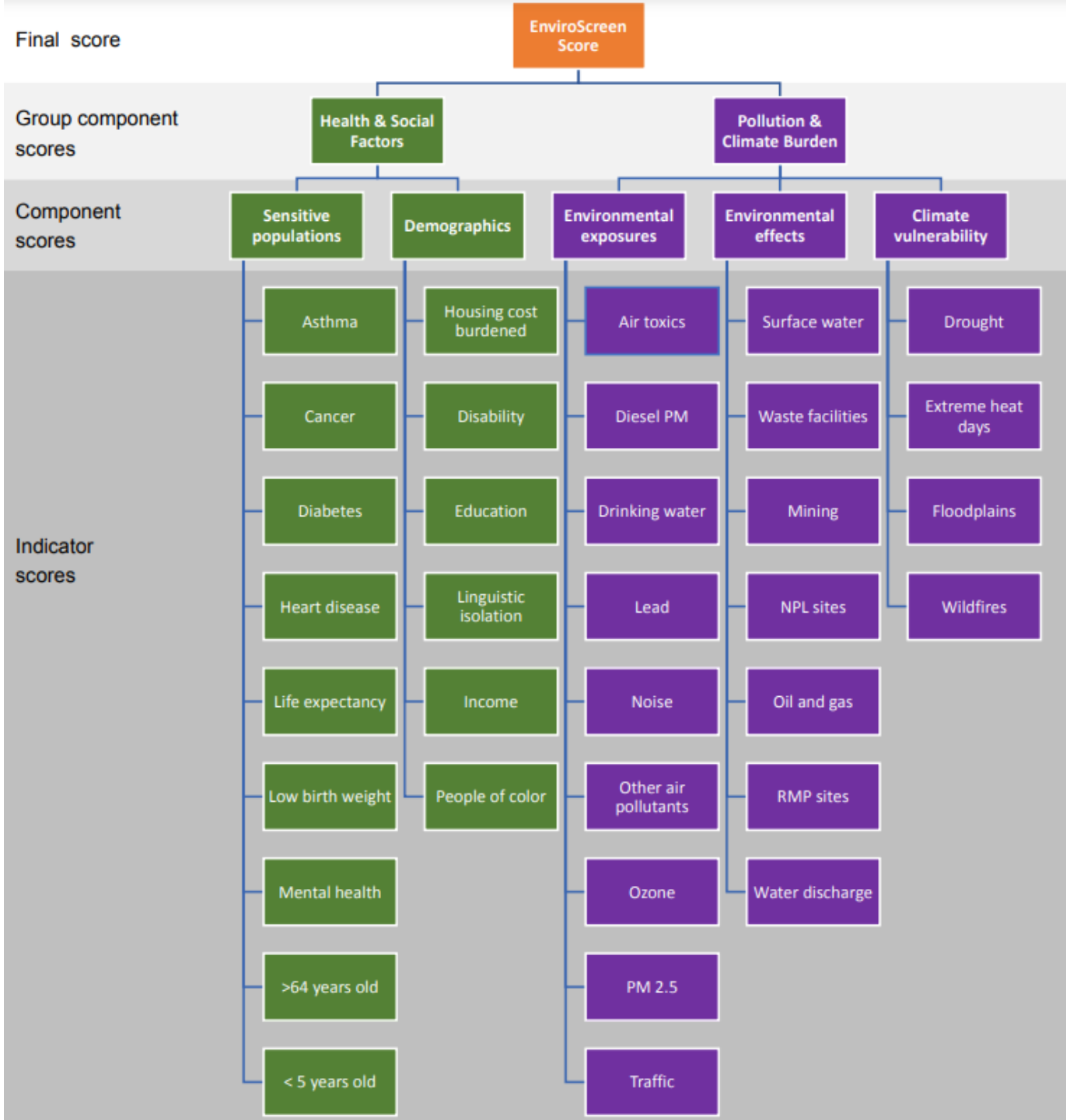
Final score

Group component scores




Final score
EnviroScreen Score
Group component scores
Health & Social Factors
Pollution & Climate Burden
Component scores
Sensitive populations
Demographics
Indicator scores
9 health and age indicators
6 economic and race indicators


Final score
EnviroScreen Score
Group component scores
Health & Social Factors
Pollution & Climate Burden
Component scores
Sensitive populations
Demographics
Environmental exposures
Environmental effects
Climate vulnerability
Indicator scores
9 health and age indicators
6 economic and race indicators
9 environmental exposure indicators
7 environmental effects indicators
4 climate impact indicators

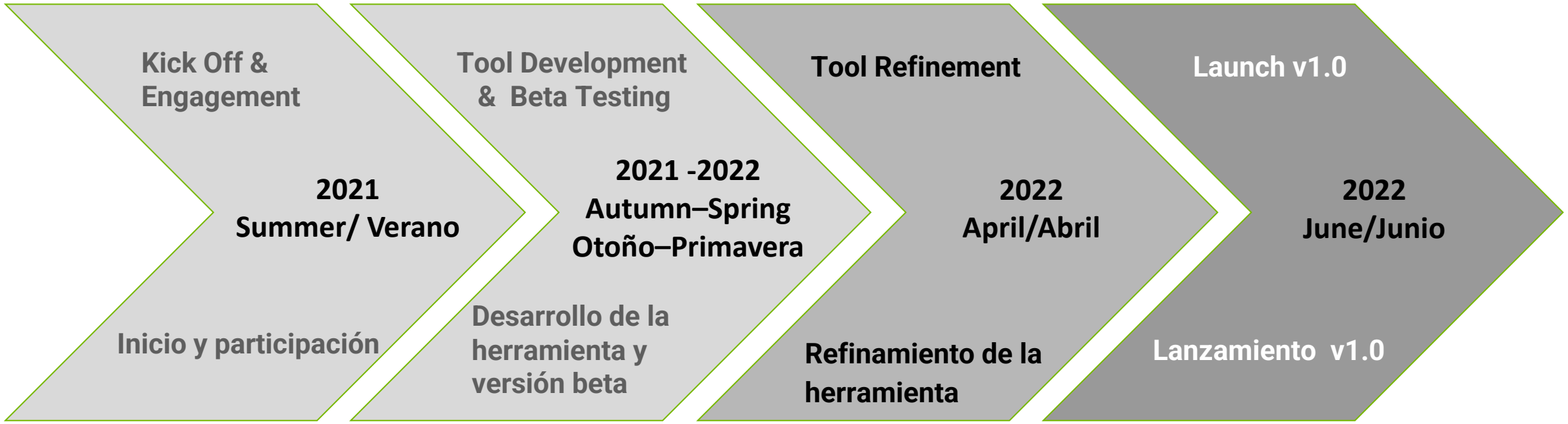


35 indicators

Census block group

PM2.5: Particulate matter less than 2.5 micrometers of diameter
NPL: National Priority List sites
RMP: Risk Management Plan sites

Tool development / Desarrollo de la herramienta



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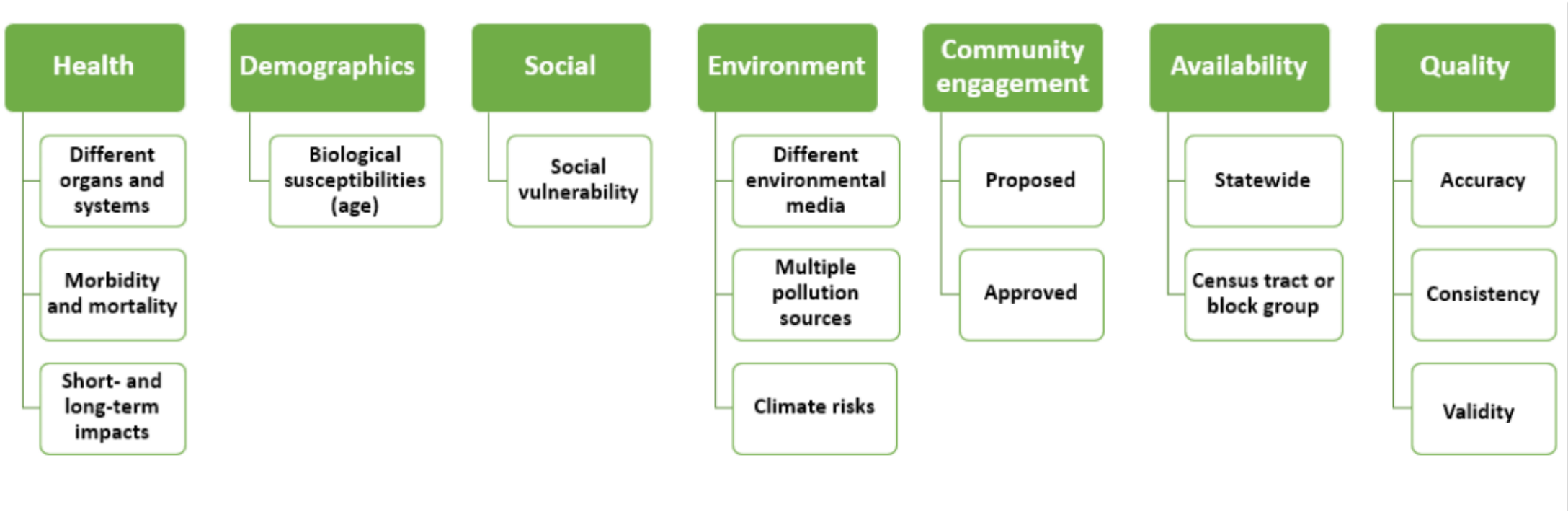
Inclusion criteria



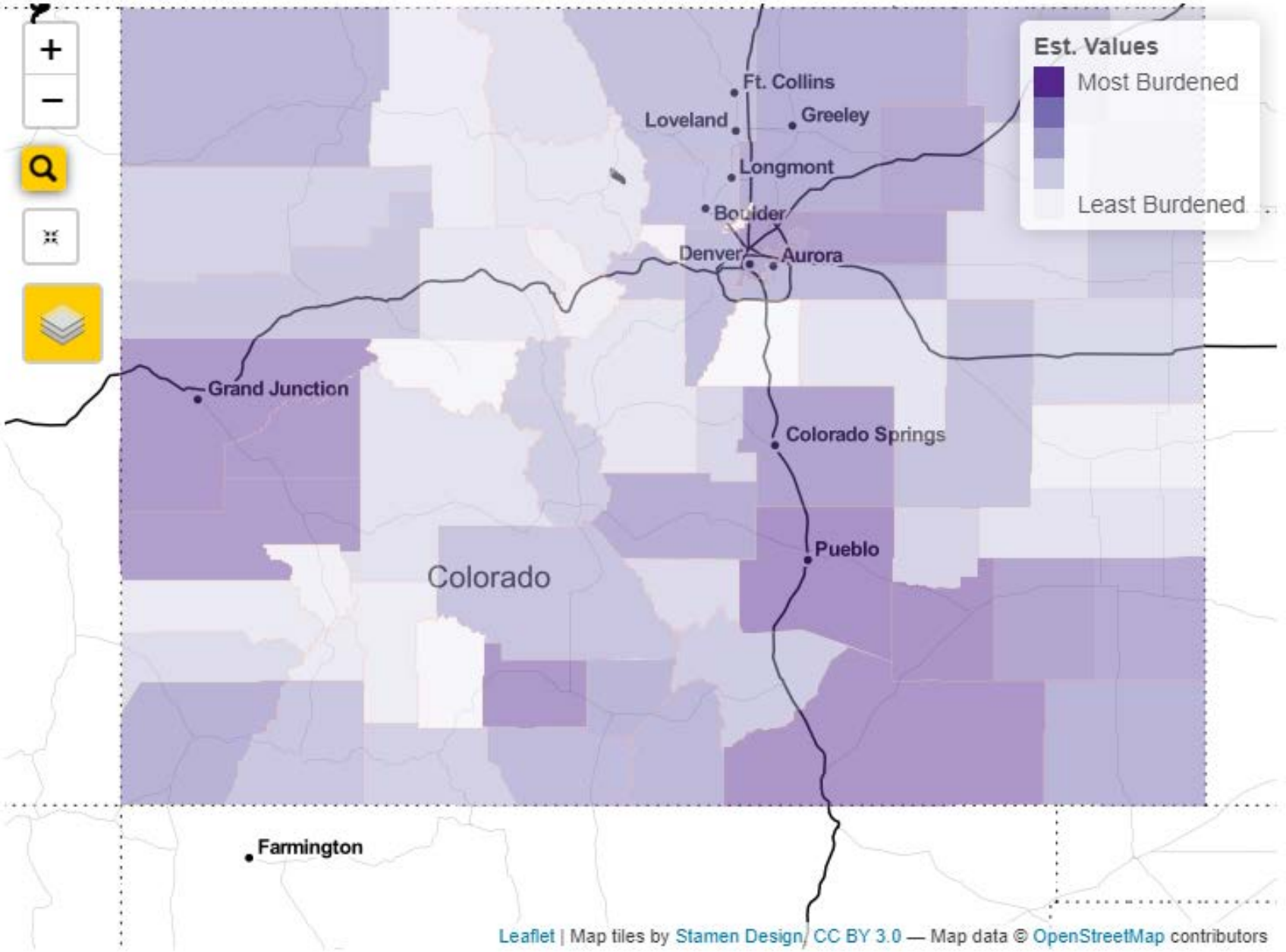
HERRAMIENTA

TOOL

COLORADO

EnviroScreen
Environmental Justice Mapping Tool

County level results / Resultados a nivel de condado



primary legal divisions of most states

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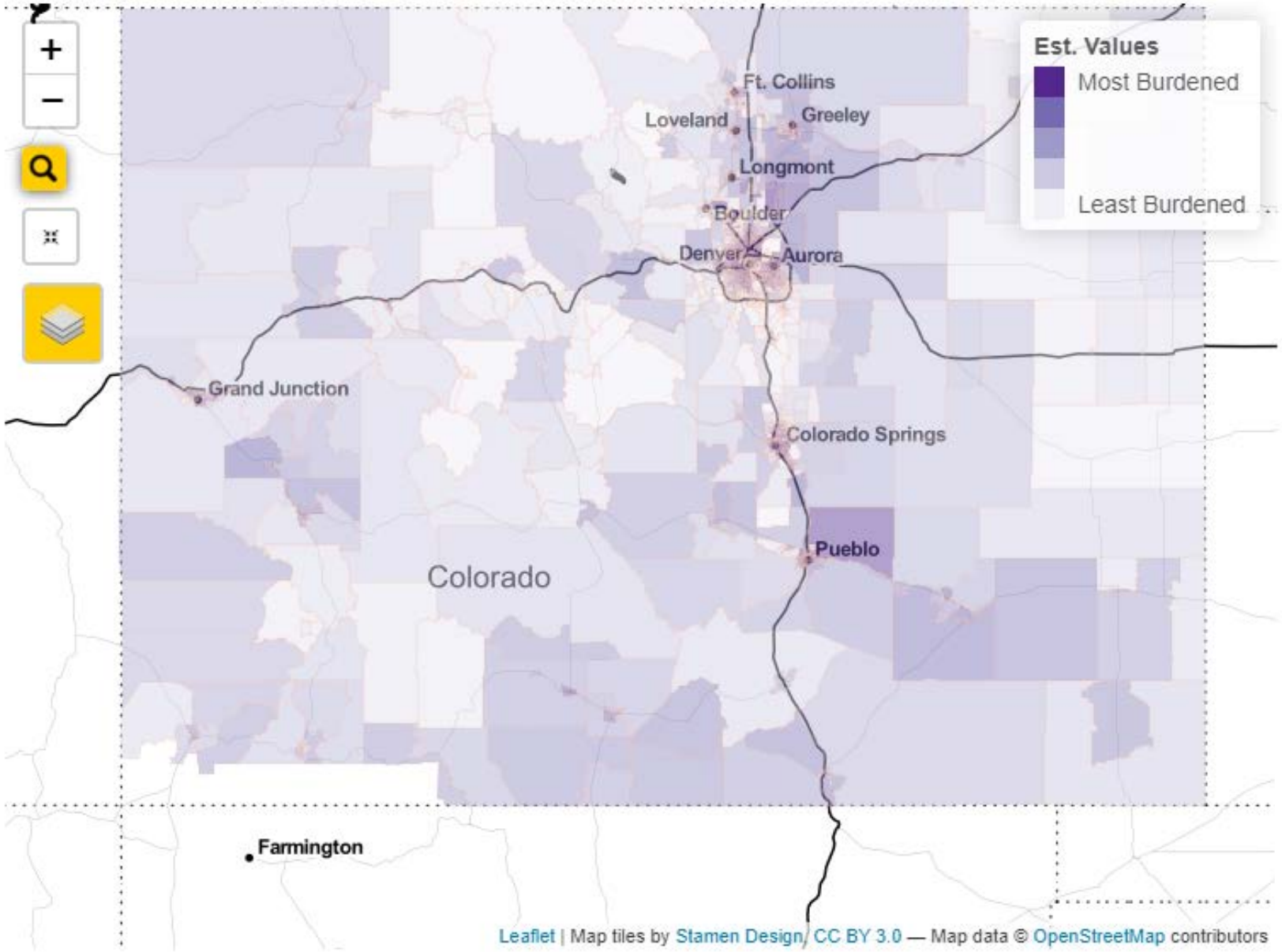
Census tract level results / Resultados a nivel de area censal



1,200 and 8,000 people

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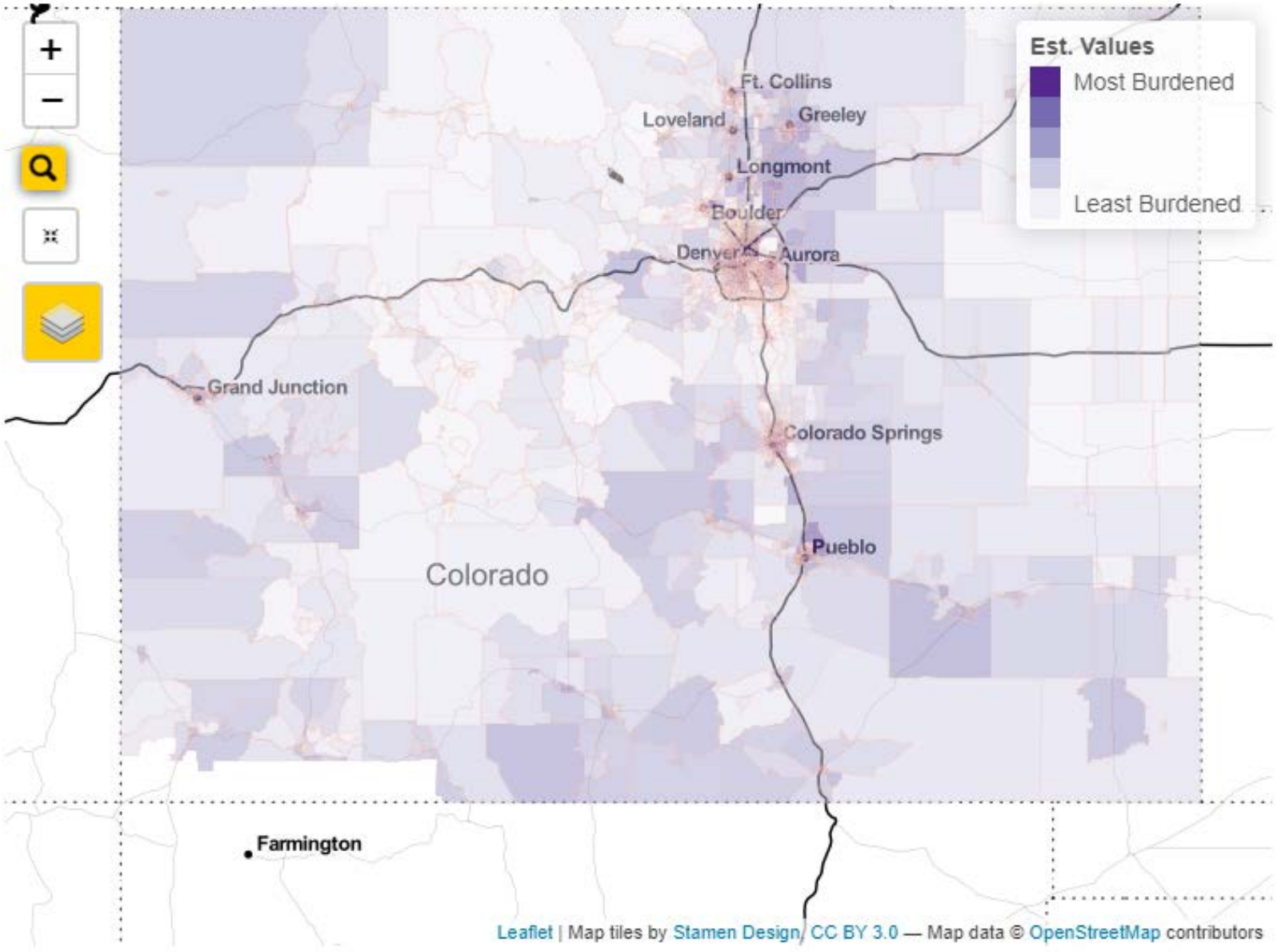
Block group level results / Resultados a nivel de grupo de manzanas



600 and 3,000 people

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Select geographic scale displayed on map

Select data indicator to display

Choose measure or percentile values

Update Map

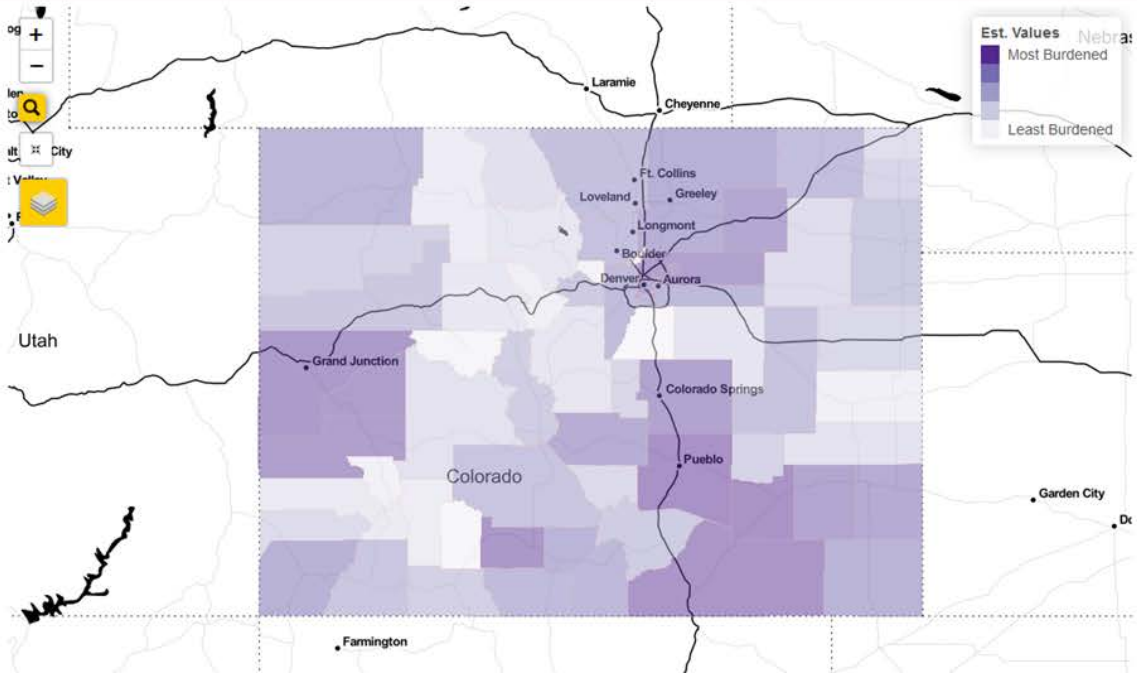
Geo Scale: County

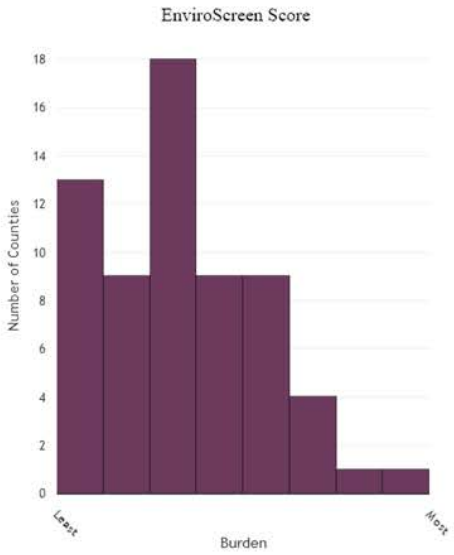
Indicator: EnviroScreen Score

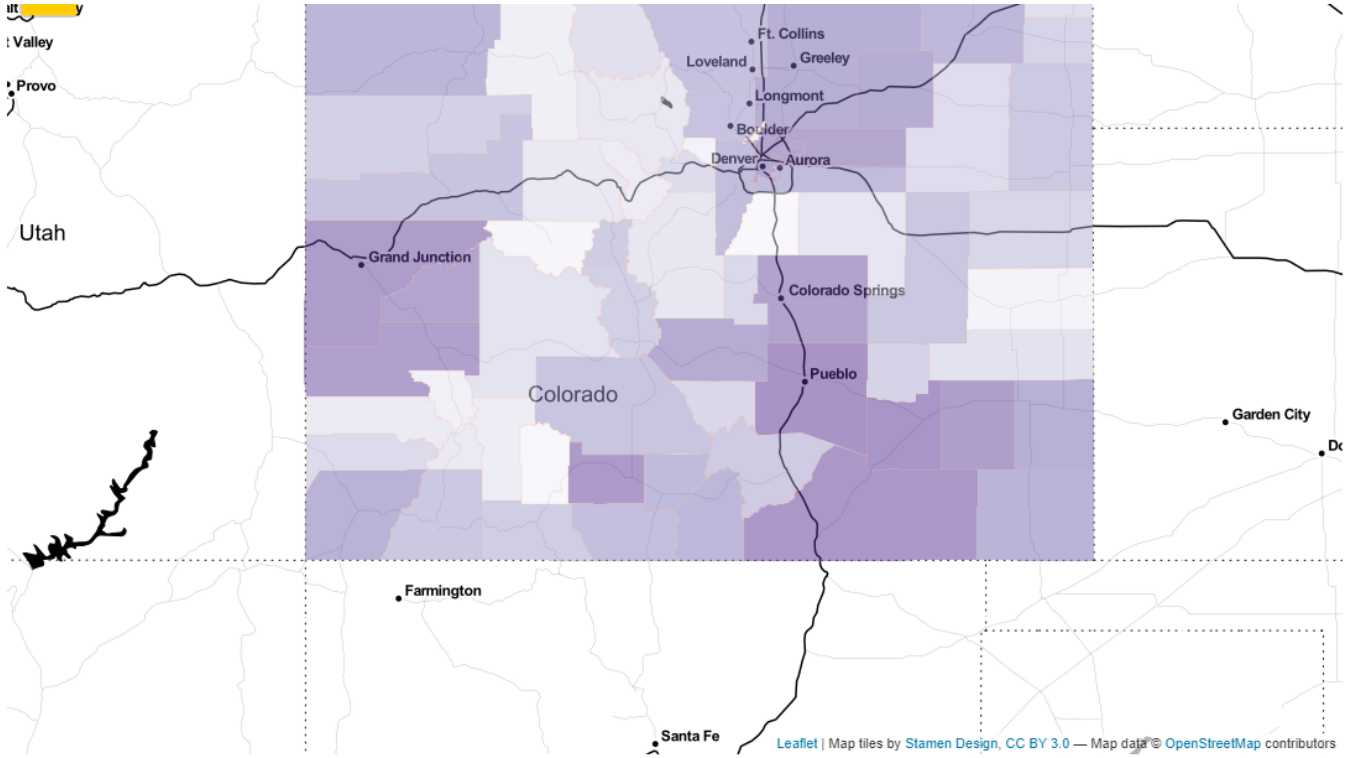
Measure or %: Percentile Rank

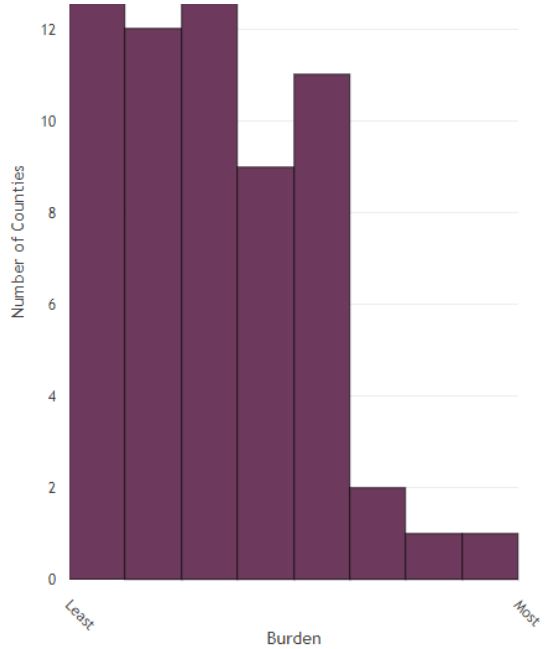
Remove Highlighted Areas

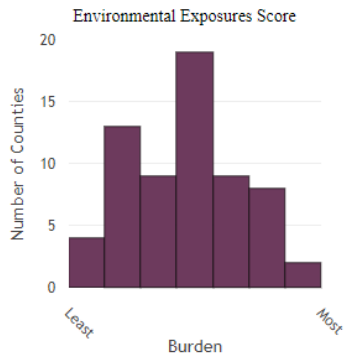
EnviroScreen Score : The EnviroScreen Score combines population characteristics and environmental burdens. The score goes from 0 to 100, with the highest score representing the highest burden. The EnviroScreen score is a percentile, which is like a ranking. The number represents how many of the state's counties, census tracts, or census block groups have a lower score than the area in question. Suppose a county has an EnviroScreen score of 70. This means its EnviroScreen score is higher than 70% of all counties in Colorado. In other words, 70% of counties in Colorado are less likely to be affected by environmental health injustices than the selected county. Suppose a census tract has an EnviroScreen score of 20. This means its EnviroScreen score is higher than 20% of all census tracts in Colorado. In other words, 20% of counties in Colorado are less likely to be affected by environmental health injustices than the selected census tract, or 80% of census tracts in Colorado are more likely to be affected by environmental health injustices than the selected census tracts.

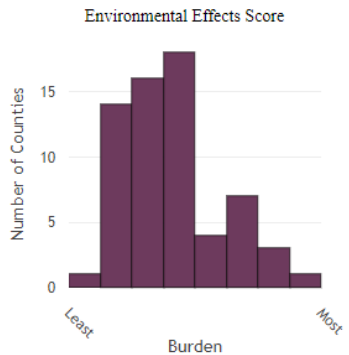


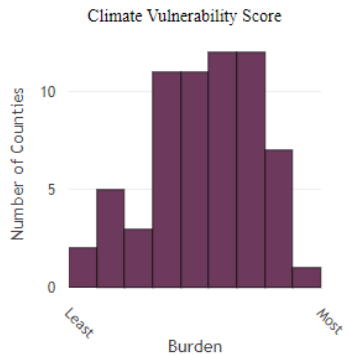


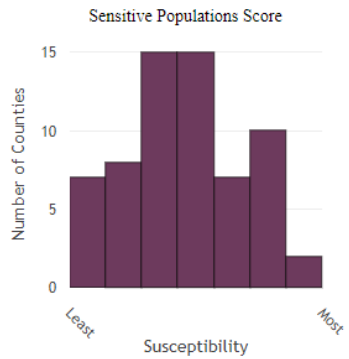

Valley
Provo
Utah
Ft. Collins
Loveland
Greeley
Longmont
Boulder
Denver
Aurora
Grand Junction
Colorado Springs
Pueblo
Colorado
Garden City
Farmington
Santa Fe
Leaflet | Map tiles by Stamen Design, CC BY 3.0 — Map data © OpenStreetMap contributors

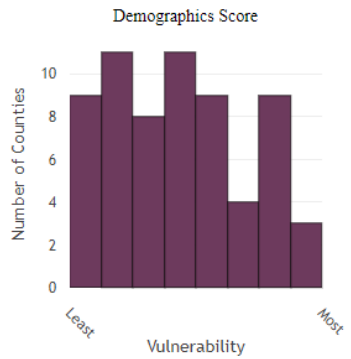

Number of Counties
Least
Most
Burden


Environmental Exposures Score
Number of Counties
Least
Most
Burden


Environmental Effects Score
Number of Counties
Least
Most
Burden


Climate Vulnerability Score
Number of Counties
Least
Most
Burden


Sensitive Populations Score
Number of Counties
Least
Most
Susceptibility


Demographics Score
Number of Counties
Least
Most
Vulnerability

Group Component Scores | Component Score | Environmental Exposures | Environmental Effects | Climate Vulnerability | Sensitive Population | Demographics | Community Classifications | Indicator Descriptions

Search:

Show 10 entries

	GEOID	County Name	EnviroScreen Score Percentile	EnviroScreen Score	Pollution and Climate Burden Percentile	Pollution and Climate Burden Score	Health and Social Factors Percentile	Health and Social Factors Score
1	08099	Prowers County	81.25	53.36	39.06	40.19	93.75	69.39
2	08101	Pueblo County	100	85.57	93.75	62.53	96.88	71.53
3	08103	Rio Blanco County	43.75	31.96	50	42.67	42.19	39.15
4	08105	Rio Grande County	95.31	62.86	64.06	46.53	95.31	70.61
5	08107	Routt County	15.62	17.6	68.75	47.05	4.69	19.55
6	08109	Saguache County	57.81	38.43	7.81	31.29	89.06	64.21
7	08111	San Juan County	17.19	18.98	6.25	31.11	31.25	31.9
8	08113	San Miguel County	18.75	19.08	57.81	44.58	12.5	22.38
9	08115	Sedgwick County	31.25	25.38	1.56	24.15	75	54.93
10	08117	Summit County	12.5	16.59	34.38	37.49	15.62	23.14

Showing 1 to 10 of 64 entries

Highlight Selection on Map

Download Data for Current Geography

Download Indicator Descriptions

UTILITY

LIMITATIONS

COLORADO

EnviroScreen
Environmental Justice Mapping Tool

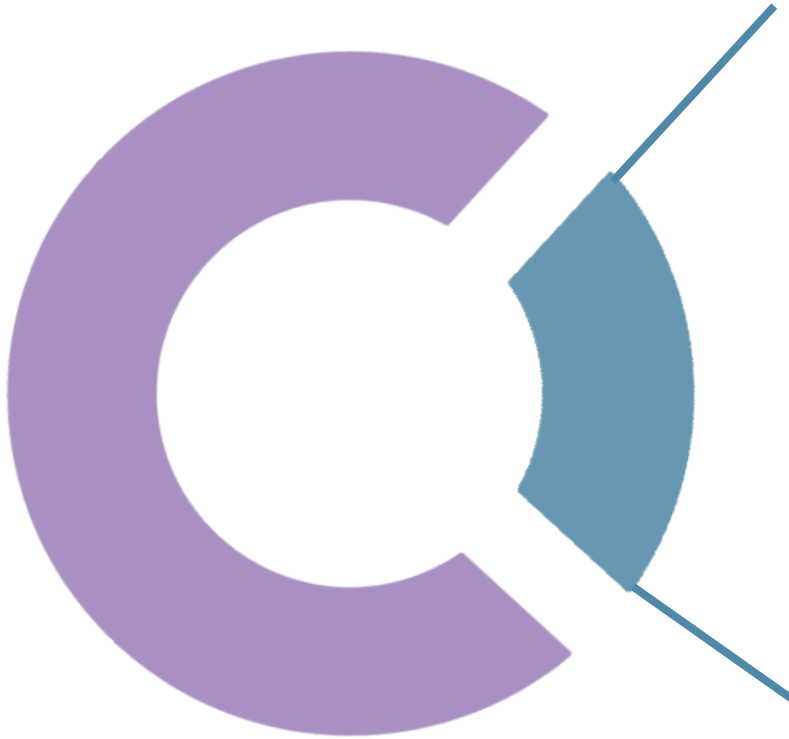
UTILITY

- One-stop shop to visualize EJ in Colorado
  - English & Spanish
  - Cumulative score/ Climate/ Exposure/Indicator
  - CDPHE is providing training to community members
- CDPHE – EJAB, Colorado Departments/Agencies
- CDPHE - EJ grants

COLORADO STATE UNIVERSITY

Social determinants of health and focus in this study

Housing
Employment
Education
Social networks
Health services
Environment
Food
Agriculture
Water and sanitation



Air Pollution
Noise
Heat
Soil
Water

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PUBLIC HEALTH LAB

Environment and health

The environment can affect any organ and system in the human body

Disease and mortality: **skin**, bones, muscles and the nervous, **endocrine**, cardiovascular, **lymphatic**, **respiratory**, **digestive**, urinary, and **reproductive** systems

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PUBLIC HEALTH LAB

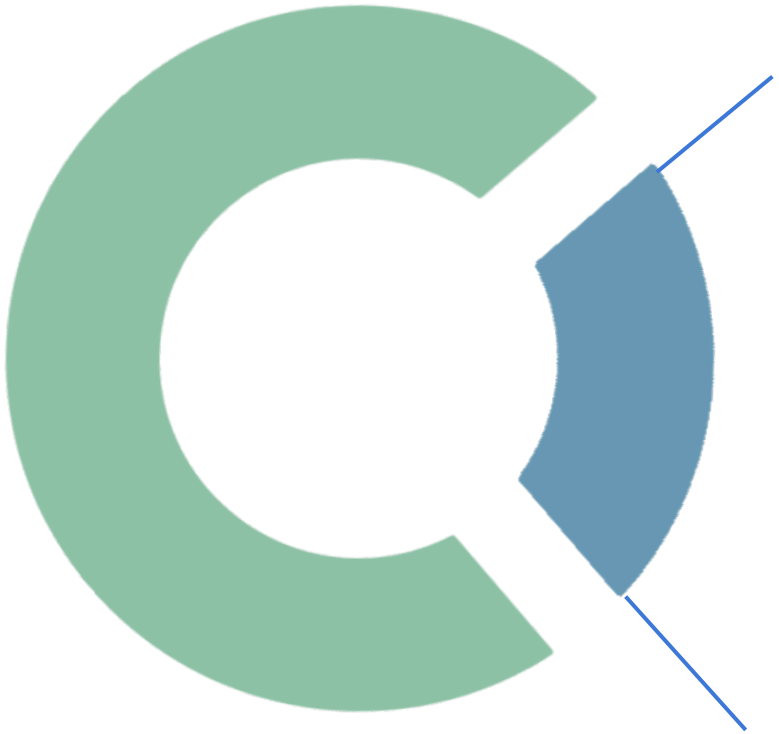
Environment and health

The environment can affect any organ and system in the human body

Health outcomes that can be quantified

...but only few diseases can be quantified based on the available robust epidemiological evidence

Disease and mortality: **skin**, bones, muscles and the nervous, **endocrine**, cardiovascular, **lymphatic**, **respiratory**, **digestive**, urinary, and **reproductive** systems



Mortality
Ischemic heart disease
Stroke
Breast cancer
Colon Cancer
Lung Cancer
Type 2 diabetes
Dementia
Depression
Anxiety
Traffic injuries

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Thank you!
¡Gracias!

DR. DAVID ROJAS

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