Achieving Building Decarbonization Through Large-Scale Data Analytics



CalBEM 2025

The 10th CA Building Energy Modeling Symposium

Keynote Presentation

Dr. Eric D. Fournier, CCSC at UCLA





High Level Objectives for this Talk

Introduce myself and the work of the California Center for Sustainable Communities (CCSC) at UCLA.

Discuss the various roles that building energy models play in California's ongoing energy transition.

Comment on some experiences derived from our Center's recent research projects.





High Level Objectives for this Talk

Introduce myself and the work of the California Center for Sustainable Communities (CCSC) at UCLA.

Discuss the various roles that building energy models play in California's ongoing energy transition.

Comment on some experiences derived from our Center's recent research projects.





Funder	Project	Themes
CALIFORNIA ENERGY COMMISSION	Bassett Avocado Heights Advanced Energy Community (BAAEC)	Developing a scalable DER + electrification program tailored to disadvantaged communities
	Gas distribution system decommissioning screening tool	Planning for a managed transition away from underperforming gas distribution infrastructure
CALIFORNIA AIR RESOURCES BOARD	Equitable electrification of existing buildings	Understanding barriers and opportunities to electrification of existing gas end-use appliances
GALIFOR CALIFORNIA	Data access working group	Identifying barriers to data access and opportunities for improvement while maintaining customer privacy







About me

Associate Researcher at the Institute of the Environment & Sustainability at UCLA

Research Director at the California Center for Sustainable Communities (CCSC)

Geographic Information Science

Building Energy Modeling

Assessment

ME

Multi-Criteria Decision Assessment

> Energy Systems Analysis

Life Cycle

Water Systems Ánalysis







Yale



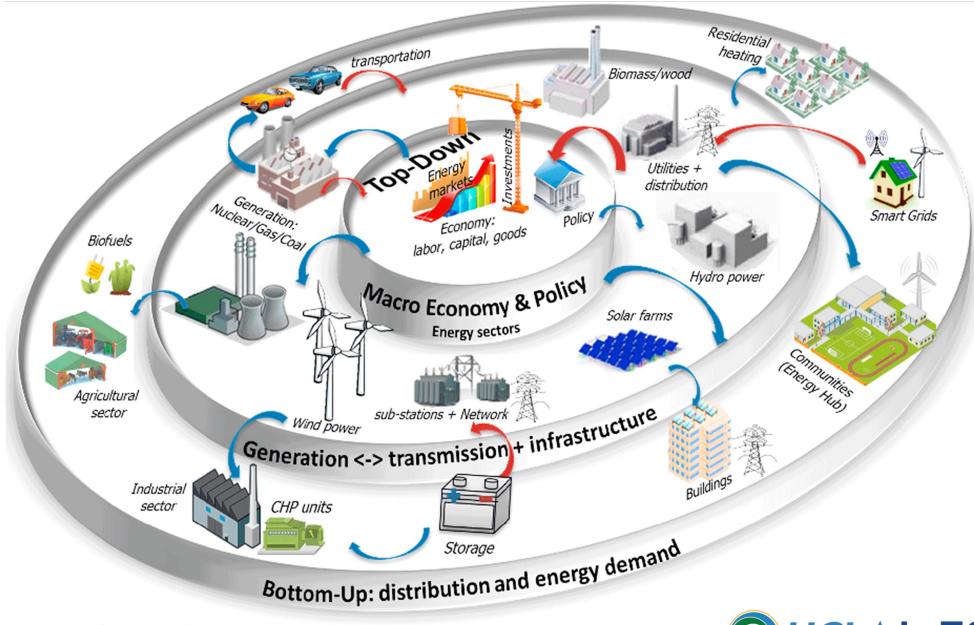




About CCSC

A soft money academic research center that uses big data to conduct energy and water systems analyses.

Our mission is to do science in the public interest.







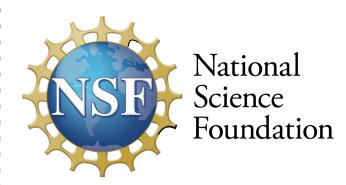


















Regional State National







Energy Atlas

Confidential Back-end Database

- Account level consumption data for IOUs from 2015-2023
- Housed in a secure computing environment hosted on a dedicated subnet in UCLA's campus data center
- Extensive physical and software / networking security protocols in place
- Subject to 3rd party cybersecurity audits
- Access limited to key researchers
- IRB Certified

Public Websites & Data

- Implements all CPUC mandated customer privacy protection aggregation and anonymization guidelines
- Publishes data aggregated to County, City Zip, Census Tract levels with masking
- NO account-level data whatsoever
- Aggregated / masked data are independently hosted via UCLA's Enterprise Tableau Server





Confidential Back-end Database

- All PII Data stored in a secure computing environment hosted on a dedicated subnet in UCLA's campus data center
- Extensive physical and software / networking security protocols in place
- Environment administered by UCLA professional IT security staff
- Subject to 3rd party cybersecurity audits
- Access limited to key researchers
- IRB Certified

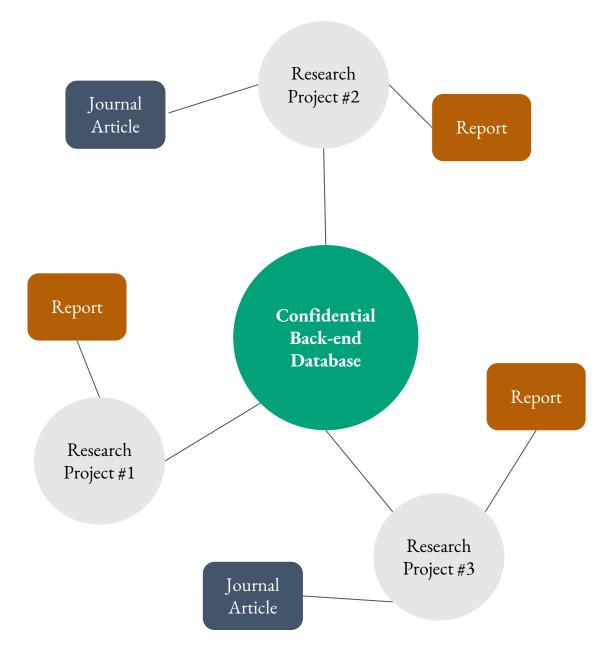
Energy Atlas

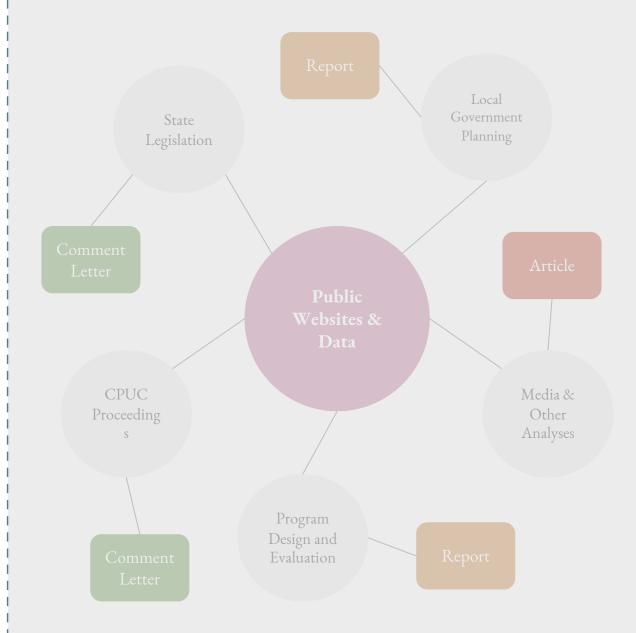
Public Websites & Data

- Implements all CPUC mandated customer privacy protection aggregation and anonymization guidelines
- Publishes data aggregated to County, City,
 Zip, Census Tract levels with masking
- NO account-level data whatsoever
- Aggregated / masked data are independently hosted via UCLA's Enterprise Tableau Server



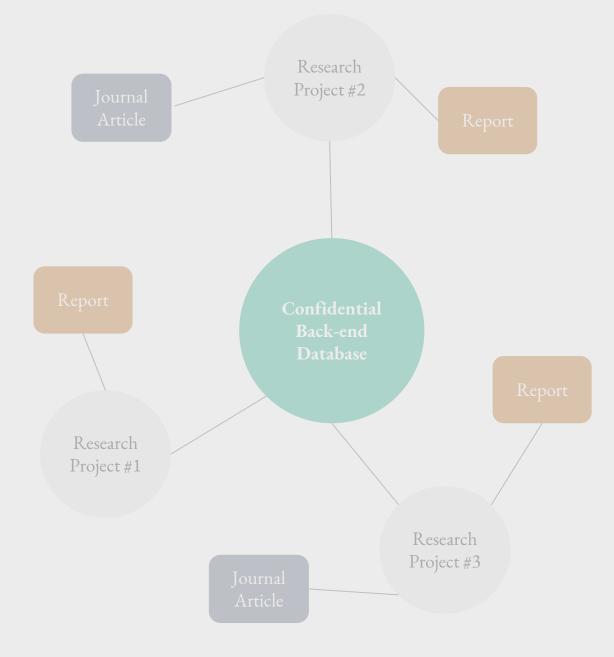


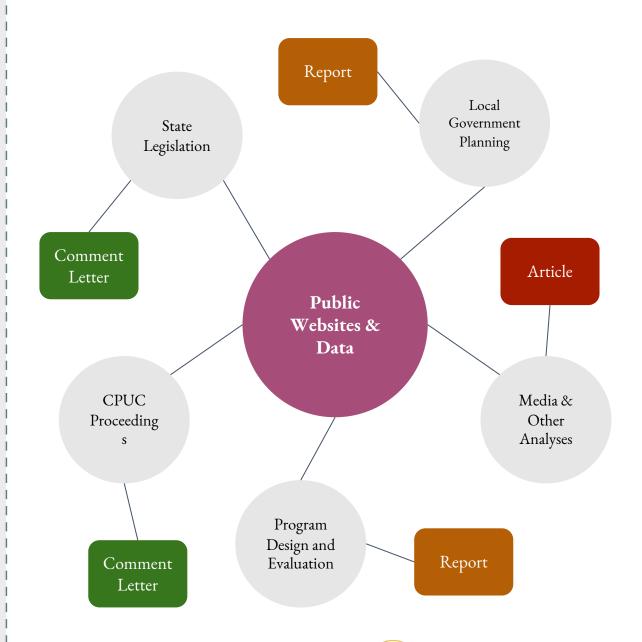








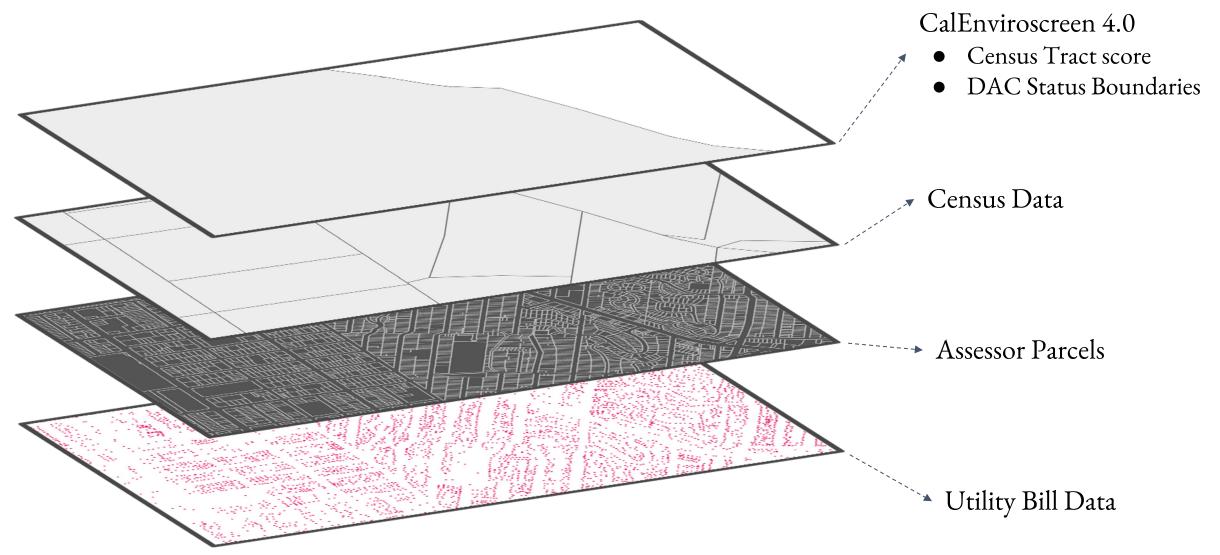






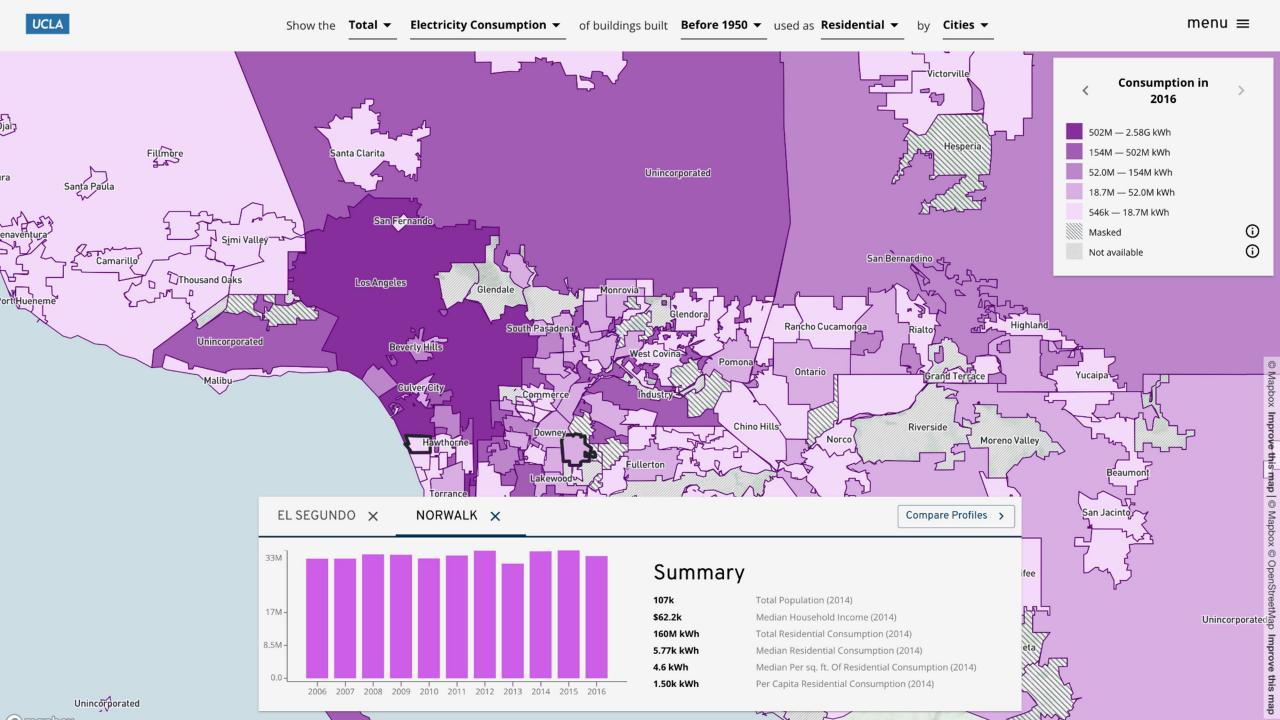


Contextual Enhancement









Let's talk briefly about California's decarbonization strategy







California's decarbonization strategy has three core pillars:

1. Increase the amount of renewable energy supplied to the power system

2. Improve the energy efficiency of buildings and installed end-use equipment

3. Substitute remaining fossil fueled end-uses, primarily via electrification







California's decarbonization strategy has three core pillars:

1. Increase the amount of renewable energy supplied to the power system

State Legislature → SB-100 Renewables Portfolio Standard (RPS)

2. Improve the energy efficiency of buildings and installed end-use equipment

CEC → **Title-24 Building Energy Codes**

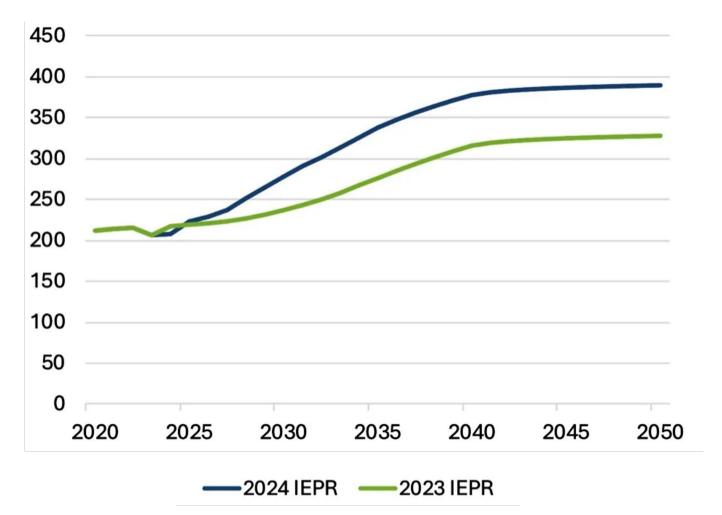
3. Substitute remaining fossil fueled end-uses, primarily via electrification

CARB → Zero Emissions Technology Regulations (in development)

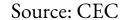




CEC's Most Recent IEPR Load Forecasts



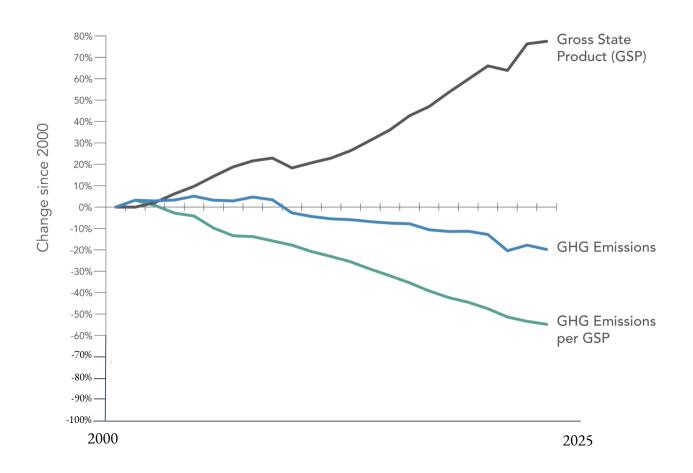
There is tremendous uncertainty about the pace of future electrical load growth (and corresponding gas demand reductions)







California's Overall GHG Emissions



Policy makers like to focus on GHG emissions per unit economic output as a metric of progress

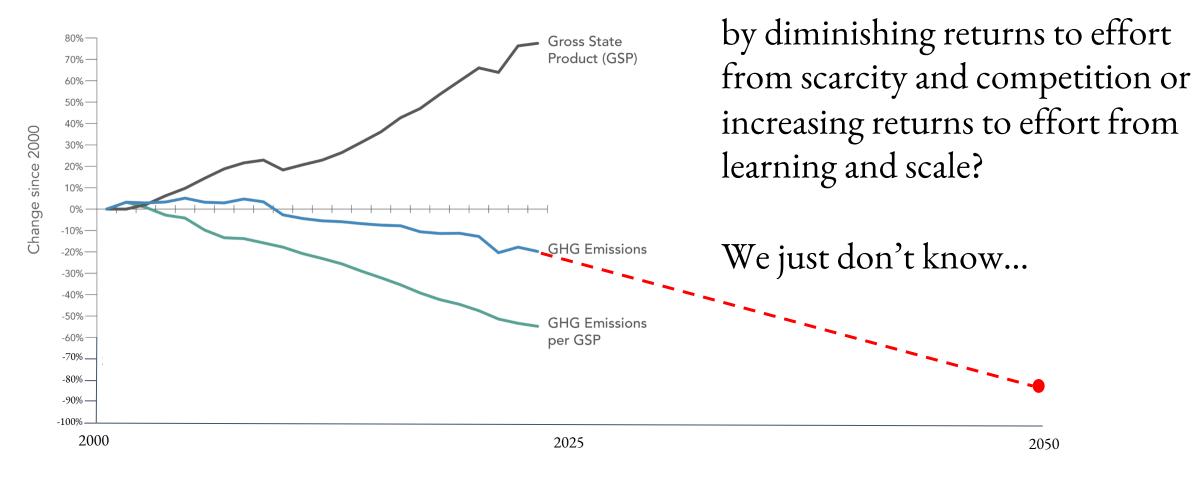
But the reality is that the climate system only cares about the emissions part

Source: CARB (with extrapolation)





California's Overall GHG Emissions



Source: CARB (with extrapolation)





Will the future be characterized



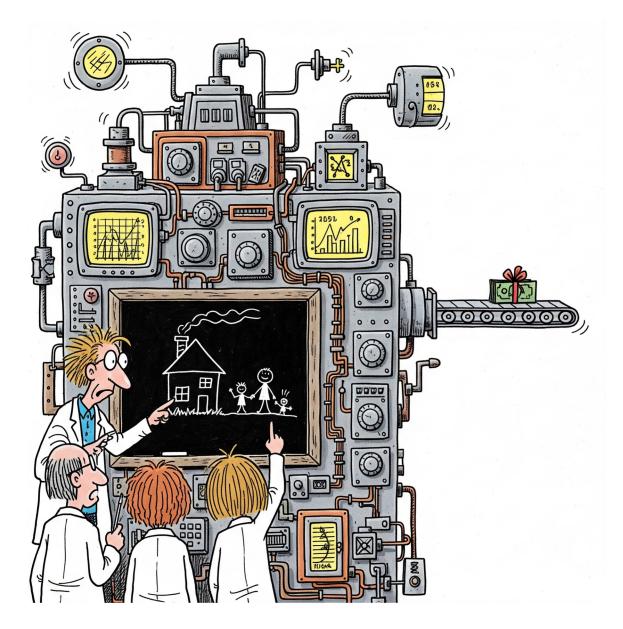
It is safe to say the energy system is embarking upon a period of rapid and accelerating change





What roles do building energy models play in this transition?



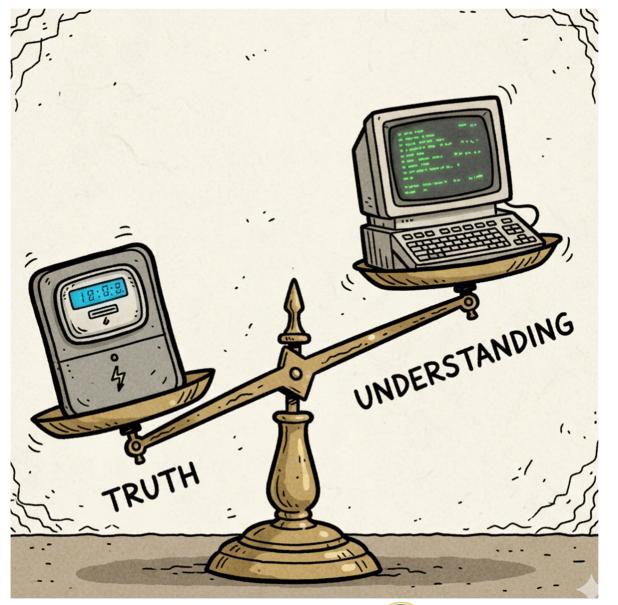


Fundamentally, building energy models are used to support decision making under uncertainty





They should not be used as a source of truth, but they can be valuable as a source of understanding









They can be valuable for comparing the relative merits of structurally different solutions to a problem - such as weighing investments in electrification versus conservation and efficiency, for instance





Using Metered Consumption Data for Building Energy Model Calibration to Support Program Design

Example: CEC - Bassett Avocado Heights Advanced Energy Community (BAAEC) Project







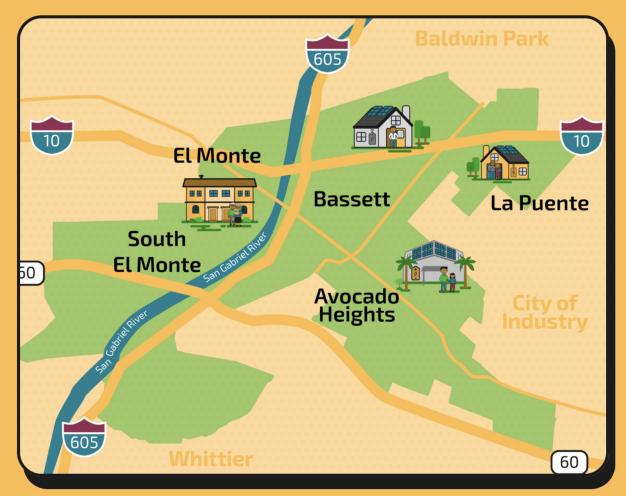




Let's do this, Bassett & Avocado Heights!

Hi! We are the Bassett Avocado Heights Advanced Energy Community (or BAAEC, pronounced "bay-sea", for short). We're a team of local nonprofits, community organizations, and energy technology leaders here to bring together the community to produce renewable energy locally. That means saving you money on your energy bills, reducing local pollution, and showing the rest of California (and the world for that matter!) how we can transition to a just and clean energy future. Join us!





This project calls the Los Angeles County unincorporated neighborhoods of Bassett and Avocado Heights home.

CEC Funded Technical Demonstration Project

Eligible to low-income households located within a designated set of 33 disadvantaged community census tracts (CalEnviroScreen-4.0)

Multiple overlapping scopes, implemented by numerous project partners.

High Level Objective:

Develop a scalable plan for the deployment of advanced distributed energy resource technologies in a hard-to-reach, historically disadvantaged community.





Implementation Team

We've assembled a team of experts to take the dream of an advanced energy community in Basset and Avocado Heights and make it real. Learn more about our clean energy crew below!



The Energy Coalition

The Energy Coalition (TEC) is a California-based 501(c)3 nonprofit with over 45 years of experience designing and implementing programs and strategies that transform energy use and empower communities to take action.



Aclima

Aclima delivers hyperlocal air quality data and insights to improve human and planetary health.



Active SGV

ActiveSGV works to create a more sustainable, equitable, and livable San Gabriel Valley.



Sustainable Communities, UCLA Institute of the

California Center for

Environment and
Sustainability
The California Center for

The California Center for Sustainable Communities at UCLA conducts research on energy, water, and urban ecosystems.



Community Electricity

Community Electricity is an advanced electricity community developer that assesses, designs, aggregates, finances and manages prosumer electricity networks block by block.



Haven

Hercules Roofing is an expert roofing service company that specializes in efficient roof repair and roof replacement services.



Pivot Energy

Pivot Energy is a leader in community solar & clean energy projects. They serve the commercial solar ecosystem: retail customers, system operators, utilities & financiers.



Day One

Day One has 30 years of experience in building healthy, vibrant cities by advancing public health, empowering youth, and igniting change in the San Gabriel Valley.



Hercules Roofing

Hercules Roofing is an expert roofing service company that specializes in efficient roof repair and roof replacement services.



GRID Alternatives

GRID Alternatives is a national leader in making clean, affordable solar power and solar jobs accessible to low-income communities and communities of color.



(5) peristreet

Perl Street

Perl Street is a platform for developing, financing, and managing distributed energy and infrastructure assets. It enables project developers to aggregate their assets into a bankable structure, raise capital and become scalable asset managers.



Quality Conservation Services (OSC)

Quality Conservation provides moderate- and lower-income households with totally free energy efficiency improvements and appliances, funded by local electric and gas utilities.



Sensor Comm Tech

SensorComm seeks to build a better, more sustainable world with smart internet of things solutions for transportation and healthcare.





Advanced Homes



Transform your house into an Advanced Home

Affordable sustainable home upgrade program

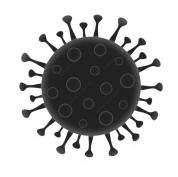
- Zero up-front cost to participate
- Eligible site remediation measures
- Program measures included: rooftop solar + (optional):
 - o battery energy storage system
 - o heat-pump water heater
 - o induction stove



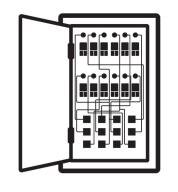




Enrollment Challenges







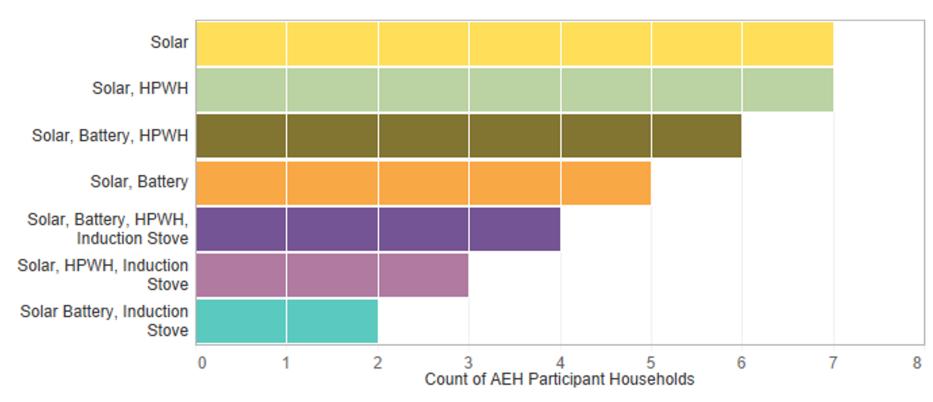


COVID-19 Pandemic

NEM-2.0 -> 3.0

Panel Upgrades

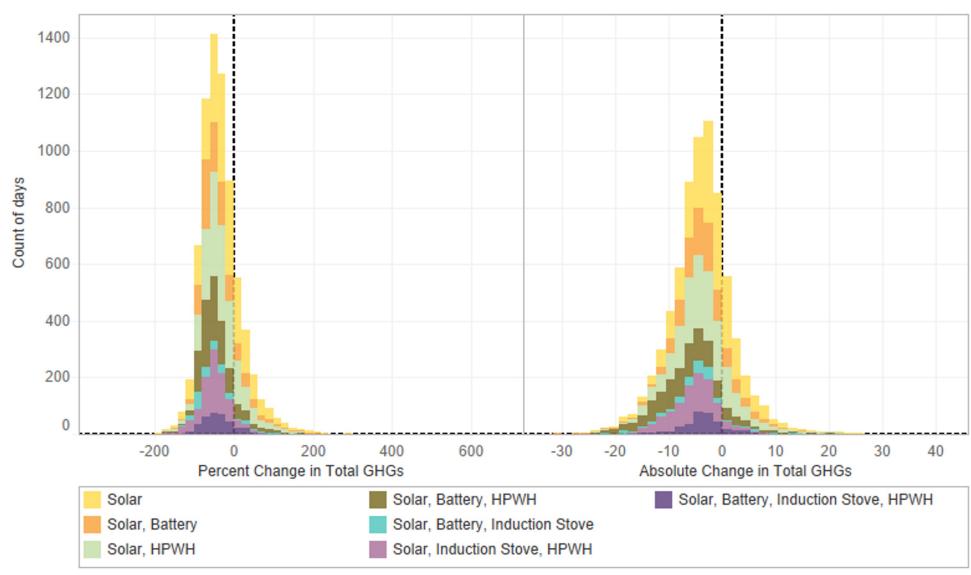
Roof Replacements







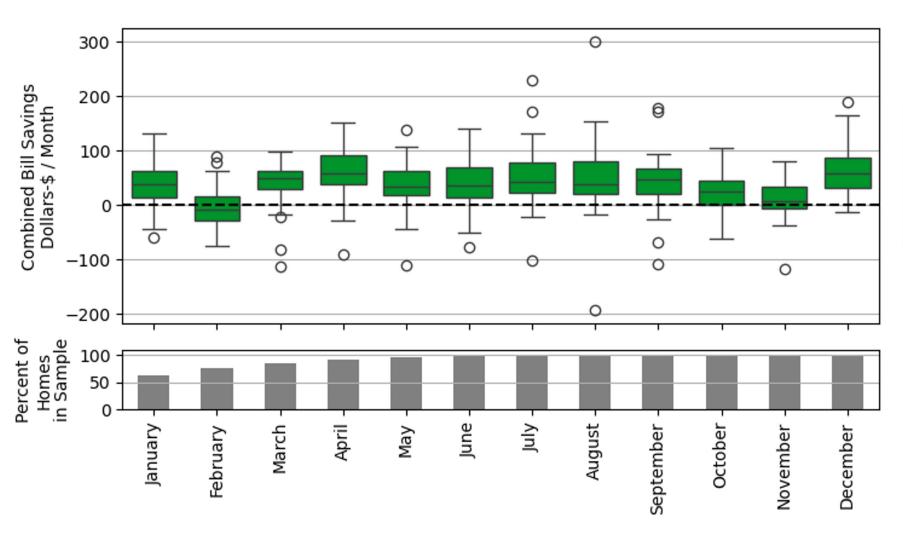
Overall GHG Emissions Reductions (Gas + Electricity)







Overall Energy Bill Reductions (Gas + Electricity)



Average Monthly Combined Bill (Pre) = \$110.77

Average Monthly Combined Bill Savings (Post) = \$38.45

(35% Reduction on Average)

* Negative Values Indicate Bill Increases





Community Solar



Save money with a local solar electricity rate!

Power your home with clean electricity from your neighborhood

- Clean Power Alliance (CPA) pilot
 Disadvantaged Community Solar Green
 (DAC-GT) tariff project
- 2 generation sites, 670 kW combined capacity
- First ever CAISO interconnected distributed generation resource aggregation
- Customer auto-enrollment delivering automatic 20% on-bill savings

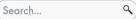






Market and operations ~

Legal and regulatory ~





03/10/2025



A first of its kind infront of the meter generation resource aggregation

A small distributed energy resources project that could have a big impact

ISO Staff

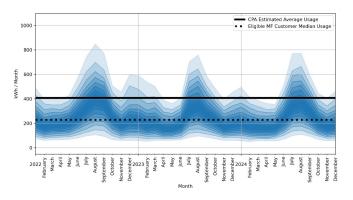
Aggregating small distributed energy resources such as residential batteries, home or community solar installations and electric vehicles has long been seen as a promising way to achieve enhanced flexibility and decarbonization for the grid by utilizing renewable generation to balance energy needs at the local, distribution and transmission levels.

The protocols needed to make that happen, however, are still new and have challenges more traditional transmissionconnected projects don't face.

Now, with help from a demonstration project grant from the California Energy Commission (CEC) and the hard work of ISO staff and various energy practitioners from around the state, the first such aggregation project has reached commercial operation. It will soon be providing low-cost, clean power to an estimated 340 households in Los Angeles County while earning wholesale market revenue.

Known as the Bassett-Avocado Advanced Energy Community (BAAEC) serving the area of Los Angeles County where it is located, the project is relatively small, at .67 megawatts of dispatchable capacity. Nevertheless, it required careful planning and coordination by a number of different entities to come to fruition.

Key Takeaways



CCSC provided insights about eligible customer energy usage patterns as well as local grid infrastructure capacity constraints (Sub-LAPs & circuit interconnection capacities) to support the project's implementers.

These data were used to calibrate different types of building energy and financial models that were essential for the project's success in terms of achieving significant net energy and GHG emissions reductions and customer electricity and gas bill savings.





Assessing Potential Constraints to the Electrification of Existing Gas End-Uses

Example: CARB - Zero Emissions Space & Water Heating Regulations





CARB is developing zero-emissions space and water heating standards for the residential and small commercial sectors



Source: CARB



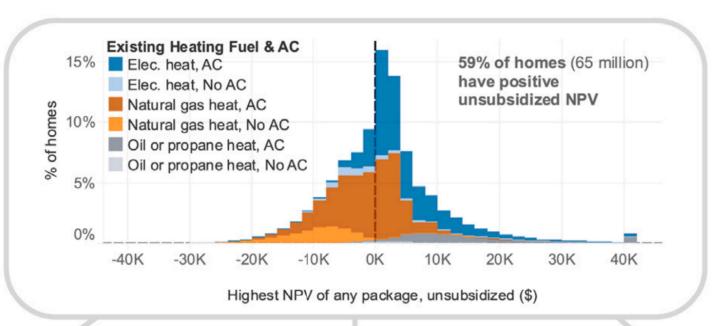


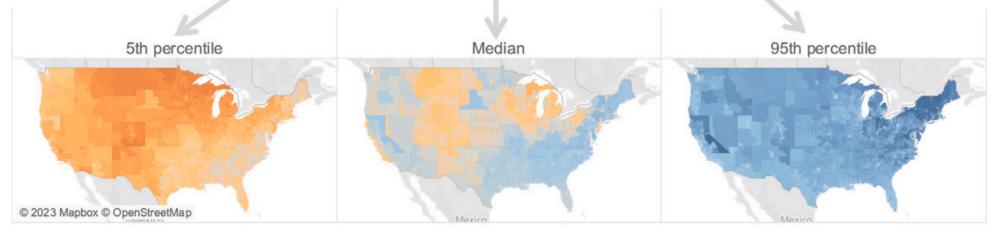
Electric technologies
can have a range of
different NPVs
depending on individual
usage levels and
locations

-50,000

Source: Wilson et al. "Heat pumps for all? Distributions of the costs and benefits

of residential air-source heat pumps in the United States." Joule. 2024.





Net present value (unsubsidized), capped at +/- \$50k (Winter 21-22 prices), max across six scenarios

50,000





Part of the reason why there is such a wide range of NPVs for these technologies are challenges related to building integration

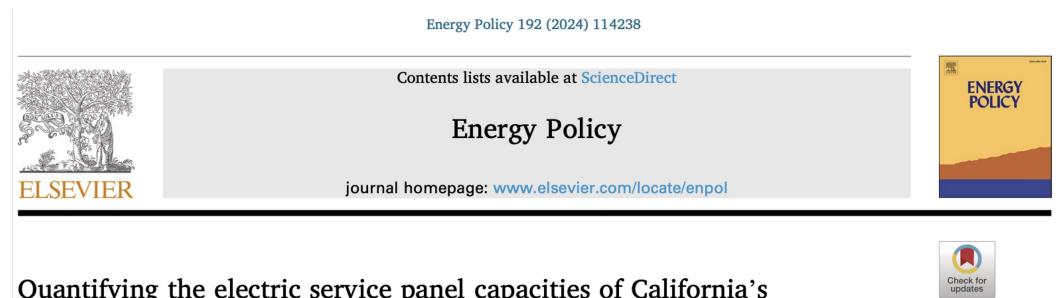
Building	Retrofit Element	Cost range (2023\$) (\$ per unit)	References	
Electrical Panel Optimization, Upsizing, and Wiring				
· · · · · · · · · · · · · · · · · · ·	mart splitters, circuit breakers, smart -sharing device, smart sub-panel, and	\$49 - \$4,500	NV5 Inc., 2022, Simple Switch, 2023, Stop Waste, 2021, Tofel, 2023, Opinion Dynamics, 2024, SMUD, 2023, CPUC, 2024	
Increasing amperage up to on building type and size	150-amp to 600-amp panel, depending	\$1,300 - \$45,000	NV5 Inc., 2022 Opinion Dynamics, 2024 CPUC, 2024	
Upgrade to dedicated 240	-Volt branch circuit, connect to panel	\$250 - \$7,300	NV5 Inc., 2022, CPUC, 2024	
Service Entrance Upgrades				
Service connection, equipr	ment service upgrade fees, permitting	\$4,425 - \$55,500	Stop Waste, 2021 NV5 Inc., 2022	
Space Configuration				
Reconfigure walls to accommodate physical footprint		\$1.95 per square foot	Craftsman, 2023	
Relocate to different space to accommodate physical footprint		\$200 - \$10,000	Carthan, 2023	
Upgrades to pipe sizing/pl condensate pan	umbing modifications and added	\$775 - \$1,002	Opinion Dynamics, 2022, Kenney, et al., 2022	
· · · · · · · · · · · · · · · · · · ·		\$200 - \$505	Opinion Dynamics, 2022	

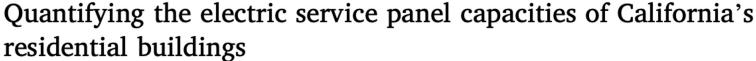


Source: CARB



We recently published the first study that quantifies the extent to which residential electric service panel capacities may be a barrier to electrification





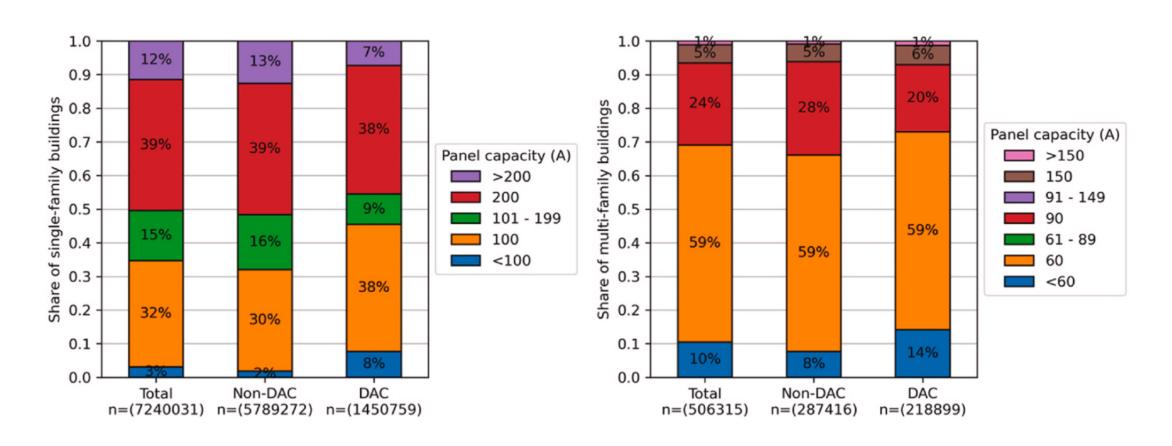
Eric Daniel Fournier*, Robert Cudd, Samantha Smithies, Stephanie Pincetl

The California Center for Sustainable Communities (CCSC) at the Institute of the Environment and Sustainability (IoES), University of California Los Angeles (UCLA), USA



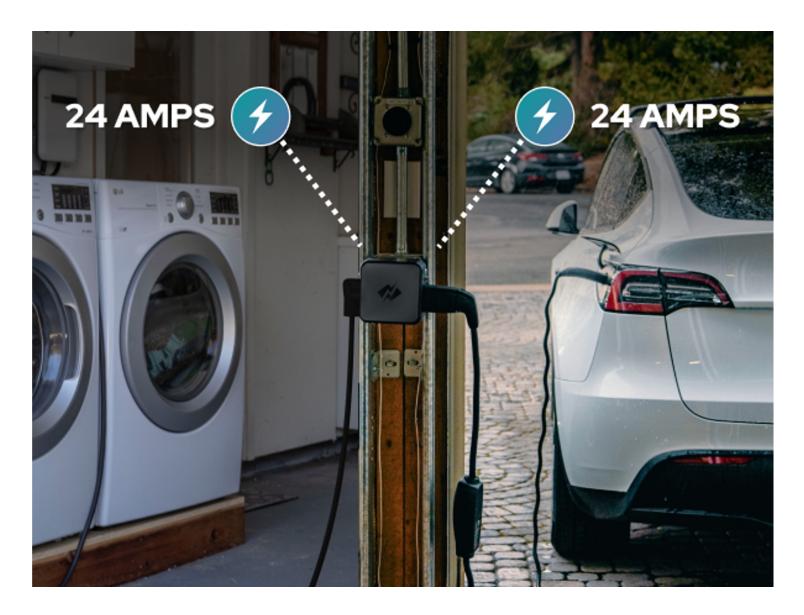


Relative to existing residential electrical service panel capacities there is some good news and some bad news









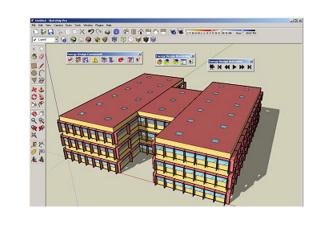
There are lots of emerging new technologies to help address power capacity constraints that may be encountered in the process of electrifying end-uses.





Key Takeaways

Most existing building energy modeling frameworks are not designed to solve for constraints.



But this is exactly the type of problem that most property owners and contractors face when planning to electrify the gas end-use equipment within existing buildings.







Key Takeaways

Wouldn't it be great if models could tell us how to electrify without:

- Increasing operational energy expenses across all fuel types
- Exceeding available electrical panel and utility service capacities
- Requiring major structural modifications to a building or the programming of its spaces
- Compromising on occupants' thermal comfort and control
- Enduring significant downtime for implementation
- Exacerbating challenges for serving utilities in managing connected gas and electricity distribution infrastructure





Planning for What Happens to the Gas System if We are Successful Accelerating Electrification

Example: CEC - Gas Distribution System Decommissioning Screening Tool





Maryland Law Review

Volume 80 | Issue 3

Article 4

The Natural Gas Paradox: Shutting Down a System Designed to Operate Forever

Heather Payne





Looking at the ten largest investor-owned natural gas distribution companies, the current value of their natural gas distribution systems—what they already have in the ground—is more than \$67 billion dollars.

Utility	Value
Pacific Gas and Electric Company	\$11,112,794,189 ⁷²
Southern California Gas Company	\$10,096,491,751 ⁷³
Atmos Energy Corporation	\$8,141,733,000 ⁷⁴
Public Service Electric and Gas Company	\$7,854,000,000 ⁷⁵
Consolidated Edison Company of New York,	\$7,223,220,281 ⁷⁶
Inc.	
Brooklyn Union Gas Company	\$4,876,812,892 ⁷⁷
Northern Illinois Gas Company	\$4,742,864,837 ⁷⁸
Consumers Energy Company	\$4,668,819,474 ⁷⁹
Washington Gas Light Company	\$4,246,823,38580
Peoples Gas Light and Coke Company	\$4,178,157,77381

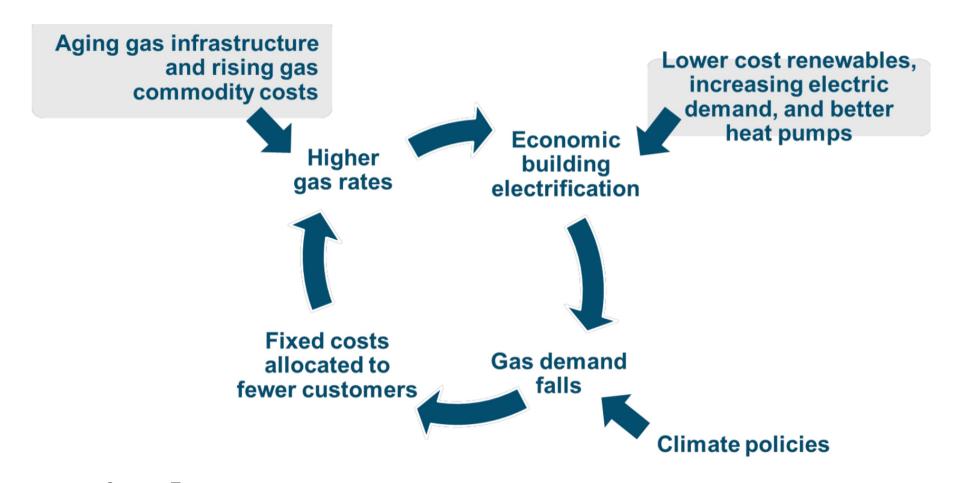
The top twenty combined have a current value of more than \$99.8 billion. 82 Assuming the next 184 investor-owned natural gas distribution companies have a valuation equal to at least the top ten systems, the combined asset value in investor-owned natural gas distribution systems is more than \$160 billion.

There is an enormous amount of gas distribution infrastructure in this country and it is hugely expensive to maintain





The challenge of the retail gas market in California's low-carbon future

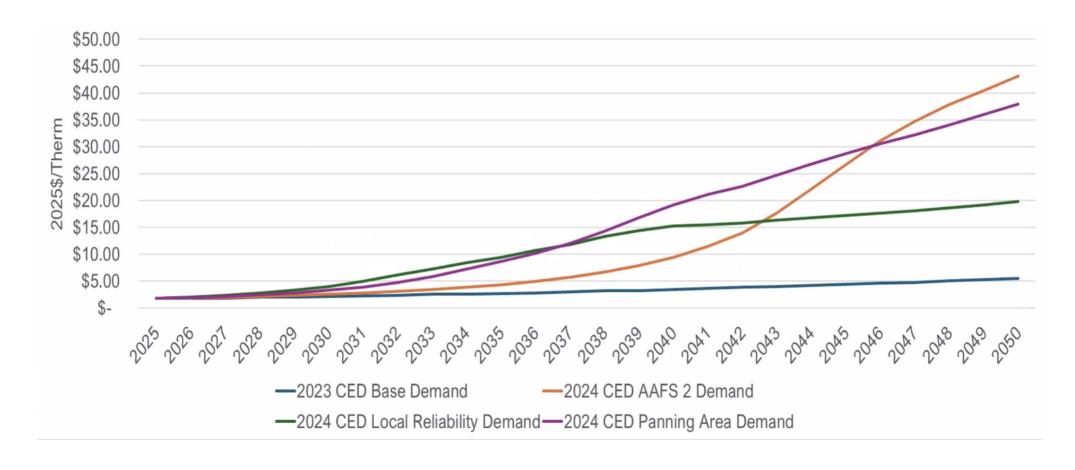


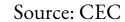
Source: E3





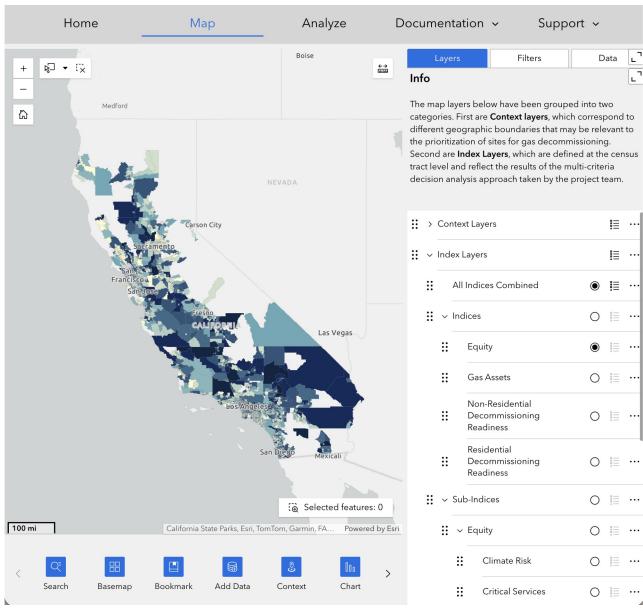
Without a managed transition away from gas distribution infrastructure, and a reduction in the system's fixed costs, retail gas rates could spiral







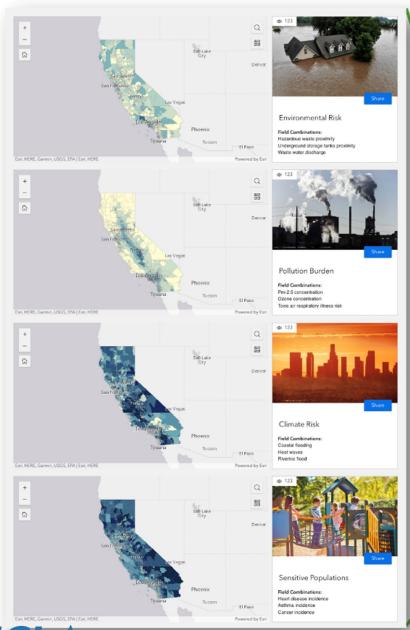


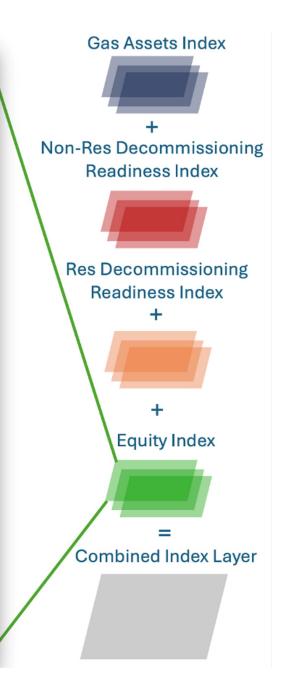


For the last three years we have been developing an interactive GIS tool for the CEC that can be used to identify promising sites for gas distribution system decommissioning projects









The dataset which powers this tool uses a GIS-MCDA framework to simultaneously quantify different issues of concern related to gas assets, equity, and customer readiness





Key Takeaways

There are places where electrification should be pursued more aggressively to enable the targeted decommissioning of underperforming gas distribution infrastructure while avoiding costly electrical distribution infrastructure capacity upgrades.

Partial electrification can lead to unwanted outcomes for gas retail customers down the road. Building energy modeling tools need to become aware of these infrastructure conditions so that they can help to promote the most appropriate solutions.





Facilitating Stakeholder Discussions Around Approaches to Improved Data Access

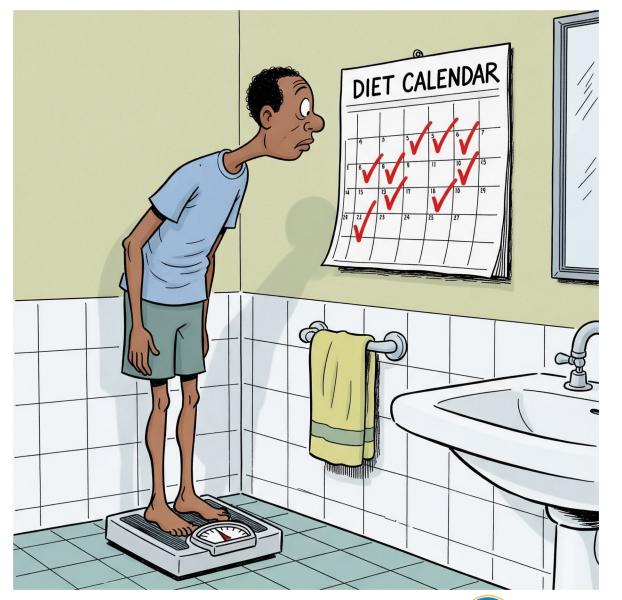
Example: CPUC - Data Access Working Group





The metering of utility customer consumption data was one of the first ever *Big Data* applications.

Yet, for a variety of reasons, these data remain difficult to access by those outside the utilities to support modeling and planning initiatives.







It is actually amazing the lengths that we must go to work around these barriers to data access

Model America: A model of every U.S. building

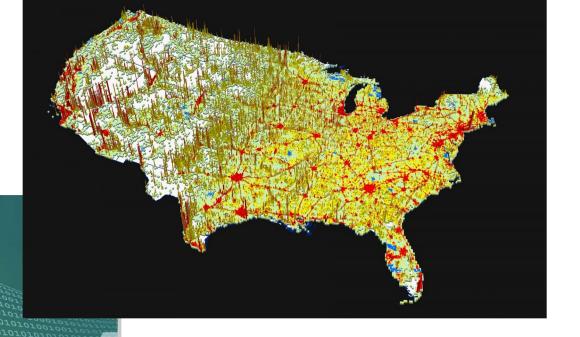
For: CalBEM 2021 – Power Talks

Presented by:

Joshua New, Ph.D., C.E.M., PMP, CMVP, CSM, IREE Senior R&D Staff, Oak Ridge National Laboratory

ORNL is managed by UT-Battelle, LLC for the US Department of Energy

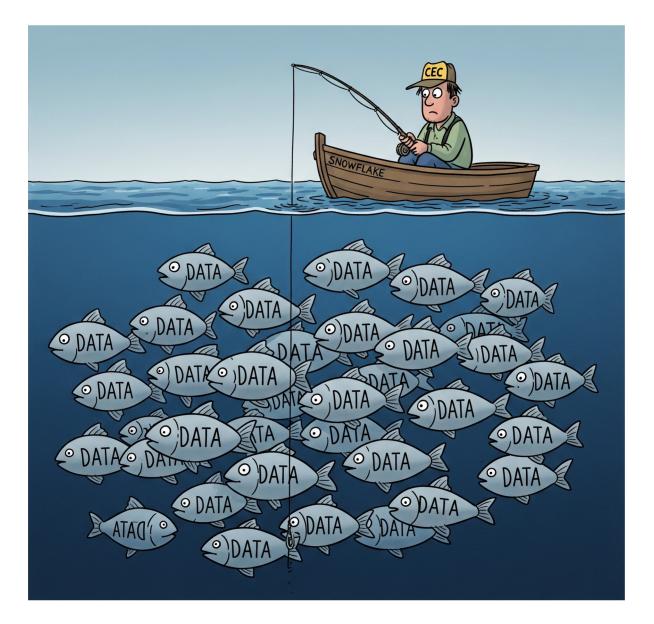








Significant changes may coming however, as the state has been developing its own repository of customer usage data and is currently considering new pathways for providing access to it







Enter keywords, e.g. Energy Code

Q

HOME

PROCEEDINGS Y

RULES AND REGULATIONS ~

PROGRAMS AND TOPICS ~

FUNDING ~

DATA AND REPORTS ~



The California Energy Commission's Energy Data Analysis Program (EDAP) enables governmental entities to access and analyze confidential energy data through CEC-vetted data analytics firms acting as agents. Final reports will be anonymized or include customer consent.

The Energy Data Analysis Program (EDAP) was developed by the California Energy Commission (CEC) to support governmental entities in meeting state-mandated energy planning and reporting requirements. An action plan will be required to describe why the data is needed, what particular data set is needed, and how the data will further their energy planning goals.

CONTACT

Energy Data Analytics Office edap@energy.ca.gov ⋈

RELATED LINKS

Agency Agreement Template 📑

Energy Data Analysis Program Flowchart 📑

This community needs to advocate for access to this data to support building energy modeling applications!





How can building energy models be improved going forward?





Model results are an Residential transportation important lubricant of Biomass/wood change at every level of TOP-DOWN the energy system. distribution Generation. Smart Grids Economy: labor, capital, goods Biofuels Hydro power Macro Economy & Policy Solar farms **Energy sectors** Agricultural Generation <-> transmission + infrastructure sector Buildings Industrial sector CHP units Bottom-Up: distribution and energy demand







• In order to further increase the utilization and impact of building energy models we need to continue to find ways to reduce the cognitive load that they place on users.



• One way of doing this is to more aggressively pull relevant contextual information about buildings and their energy consumption from a combination of public and private APIs (some of which may not exist yet...)



• Another way is to automatically convert this type of contextual data into design constraints that models can attempt to solve for.





• Wouldn't it be nice if our models were better equipped to present users with different feasible solutions to choose from?



• This is as opposed to the current status quo, which requires users to first propose solutions so that their feasibility can then be assessed.





Thank You!

efournier@ioes.ucla.edu



