Removing Building Electrification Barriers

Costs, Grid Impacts, and Funding Strategies

Charging Ahead Webinar

April 23, 2024

ENERGEIA

Speaker – Ezra Beeman, Energeia

Ezra Beeman

Managing Director

Energeia Pty Ltd, Energeia USA, Empower Energy

Formerly, Pricing Strategy Manager for EnergyAustralia (now Ausgrid), the largest utility in Australia with 1.8 million customers serving Sydney

Empower Energy develops solar-batteries for virtual power plants, utilizing Ezra's patented battery optimization algorithm

Master of Applied Finance, Macquarie University, Australia

Bachelor of Arts in Economics, Claremont McKenna College, United States

Bachelor of Arts in Philosophy, Claremont McKenna College, United States

energeia-usa.com

LinkedIn.com/company/energeia-au

LinkedIn.com/in/ezra-beeman

ENERGEIA

Agenda

- CO2 Pathways
- Building Emissions
- Electrification Barriers
- Case Study
- Program Funding
- Q&A

Housekeeping

This webinar is being recorded and distributed to all registrants along with this presentation

Add your questions in the chat. My colleague, Sara, is monitoring the queue of questions for the Q&A session

ENERGEIA

CO2 Pathways

Paris Agreement

Reference Case by Sector

Reference Case by Sub-Sector

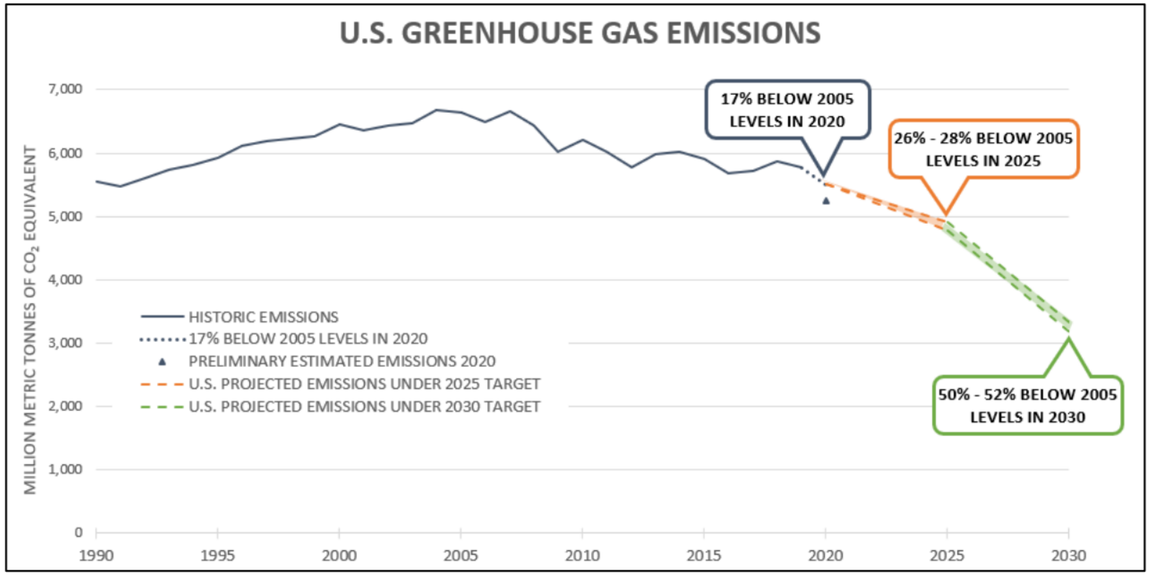
Impacts by Measure Type

Benefits by End Use and Sub-Sector

ENERGEIA

Paris Agreement and the US

US Historic and Projected Emissions Under 2030 Target



- The Paris Agreement targets limiting global warming below 2°C, with an additional goal to keep global temperatures below 1.5°C, from pre-industrial levels
- The US rejoined the Paris Agreement in 2021, signaling a commitment to global climate action
- US targets include a 50-52% reduction in 2005-level (baseline) emissions by 2030, and a net-zero goal for 2050
    - Energeia notes that the UNFCCC has modeled US targets to be insufficient to achieve those temperature goals
- Every 5 years, each country must submit a climate action plan, known as a Nationally Determined Contribution (NDC)
- The United States NDC highlights key roles for renewable energy, efficiency improvements, transport electrification, carbon capture, and aiming to curb methane emissions
- Some US States, which are detailed later, have committed to more ambitious emissions reduction targets

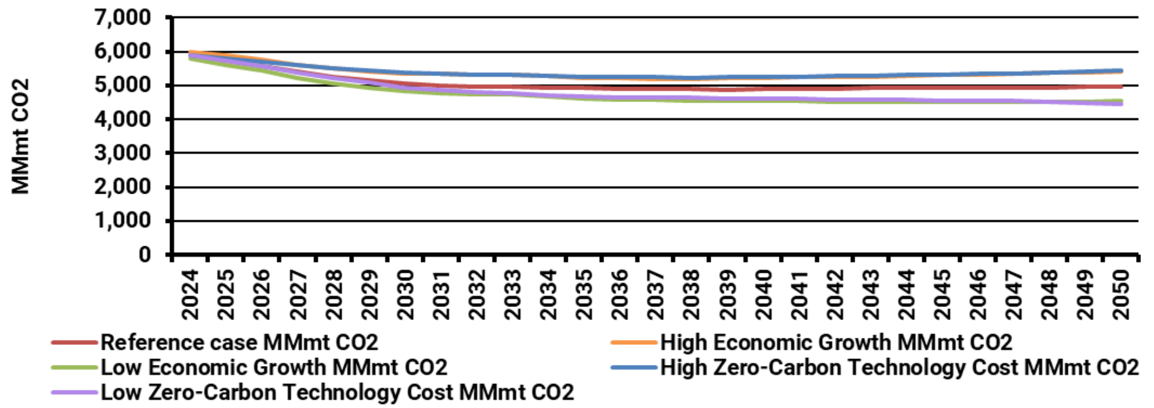
Source: United Nations Framework Convention on Climate Change (2022)

Source: The Paris Agreement, United Nations (2015)

ENERGEIA

United States Emissions Projections

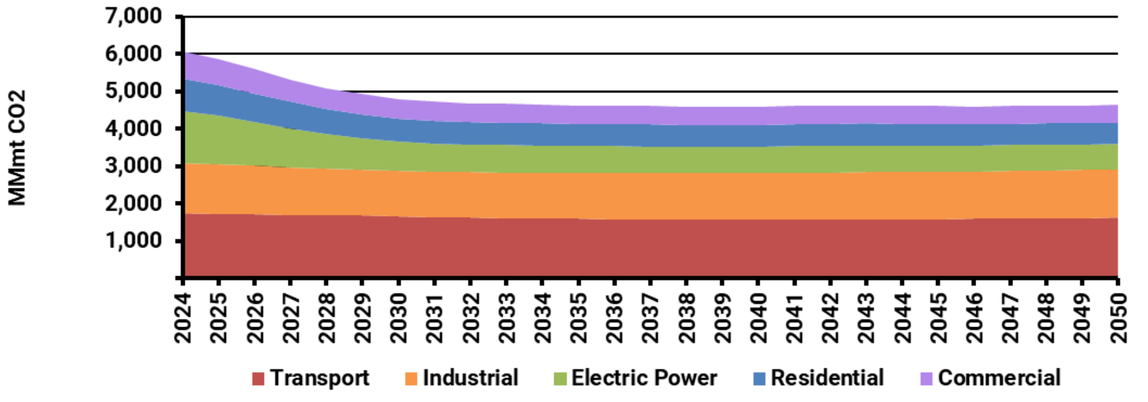
US Baseline Emissions Projections by Scenario



Source: Energeia Research, US EIA (2022)

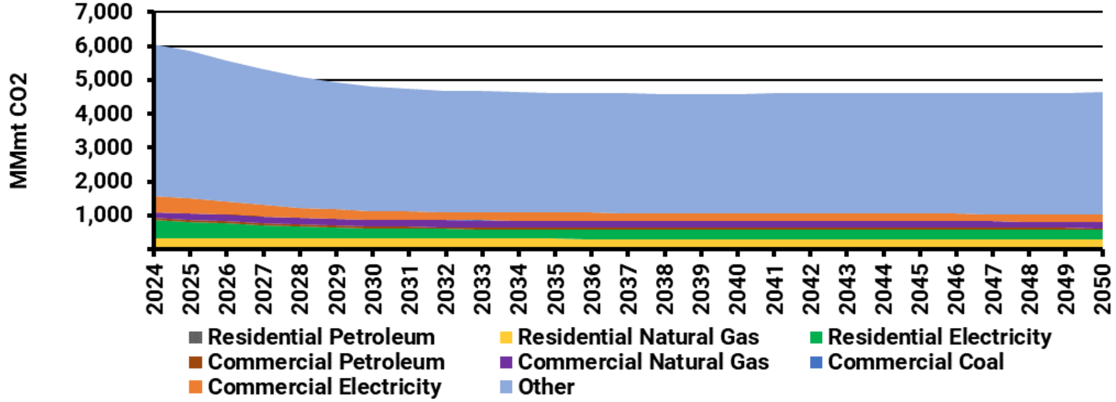
- Baseline US emissions projections show a steady increase or minimal change, even with high development and adoption of new technology
- Majority of US emissions from transport, coal, and residential and commercial end uses
- Transport emissions remain relatively constant throughout the forecast period

Reference Case Emissions Projections by Sector



Source: Energeia Research, US EIA (2022)

Reference Case Emissions Projections by Sector and Fuel

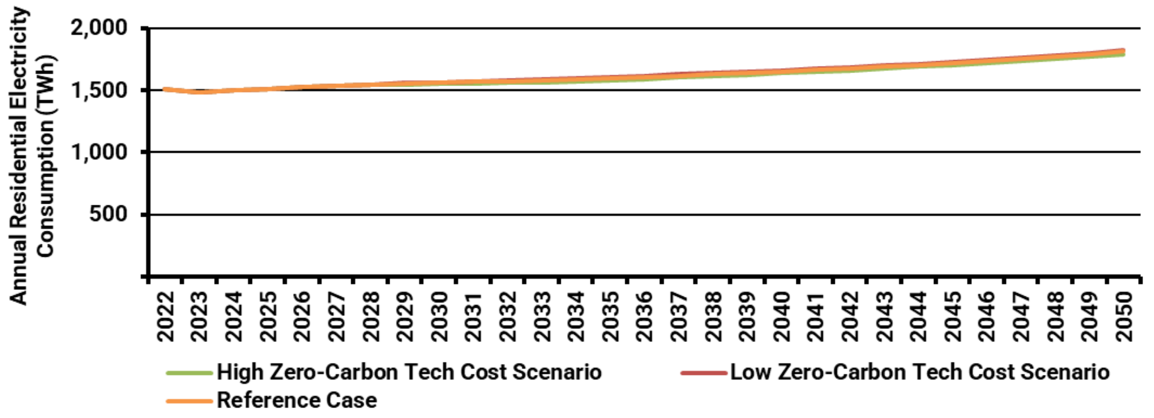


Source: Energeia Research, US EIA (2022)

ENERGEIA

U.S. Building Electrification Forecasts – By Scenario

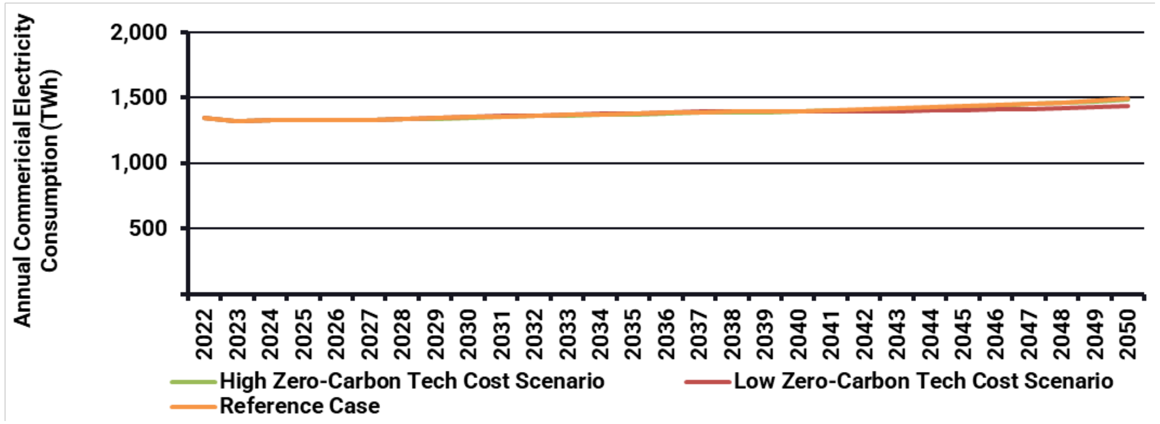
Residential - EIA Building Electrification Scenarios



Source: EIA (2023), Annual Energy Outlook 2023 - Table 2. Energy Consumption by Sector and Source

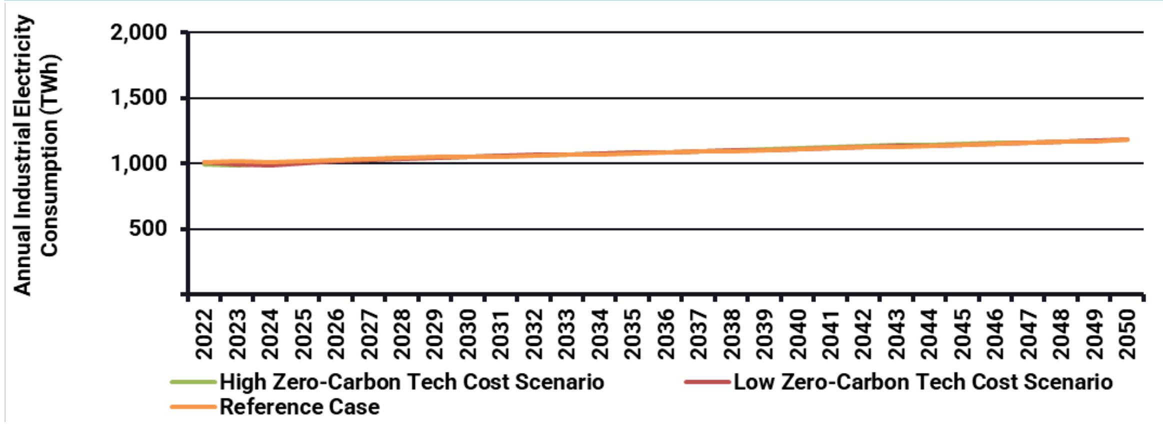
- The EIA's latest electrification scenarios for residential and commercial buildings are shown to the left
- The reference case includes consideration for federal legislation and benchmarks, including the Inflation Reduction Act (IRA)
- Residential buildings see the most significant changes, commercial and industrial sectors are about 50% lower

Commercial - EIA Building Electrification Scenarios



Source: EIA (2023), Annual Energy Outlook 2023 - Table 2. Energy Consumption by Sector and Source

Industrial - EIA Building Electrification Scenarios

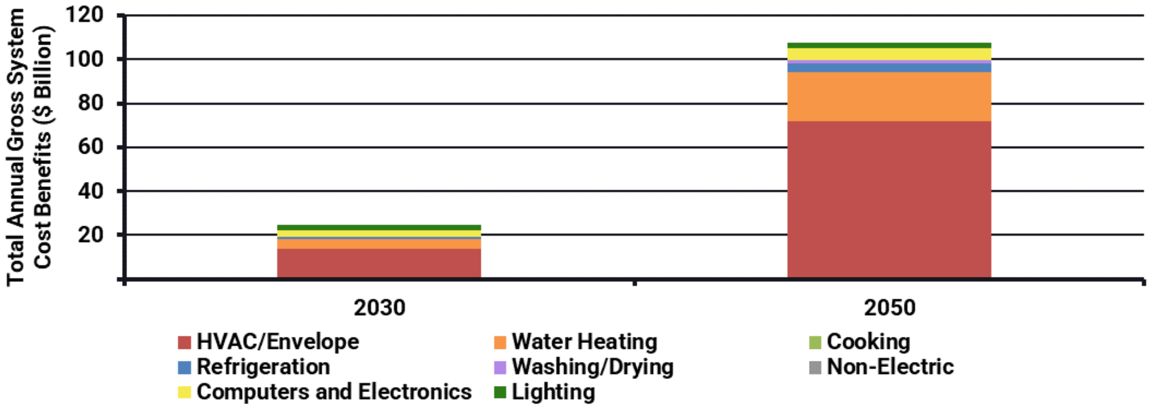


Source: EIA (2023), Annual Energy Outlook 2023 - Table 2. Energy Consumption by Sector and Source

ENERGEIA

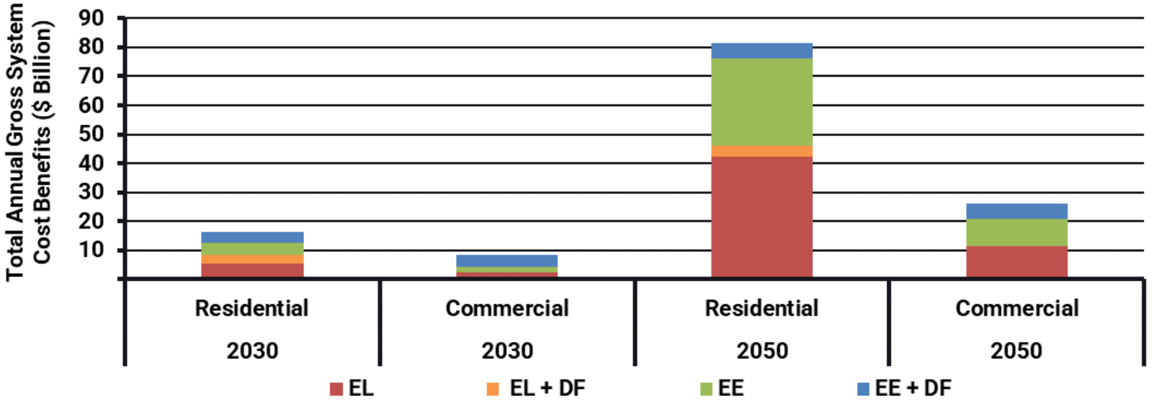
Annual Benefits by End Use, Customer Segment and Program

Benefits by End-Use, Scenario 3: Aggressive Benchmark



Source: Source: LBNL (08/13/23), Demand-side solutions in the US building sector

Benefits by Sector, Scenario 3: Aggressive Benchmark



Note: EE = Energy Efficiency, EL = Electrification, DF = Demand Flexibility
Source: LBNL (08/13/23), Demand-side solutions in the US building sector, https://doi.org/10.1016/j.oneear.2023.07.008

- Aggressive deployment of EE, BE and flexibility measures generates $107 billion in annual power system cost savings by 2050
- Most benefits, almost 90%, from HVAC and water heating
- Most benefits in residential, and most are in the 2030-2050 period

Building Emissions

Modeling Methodology

Building Segments and Sizing

Market Potential Sizing

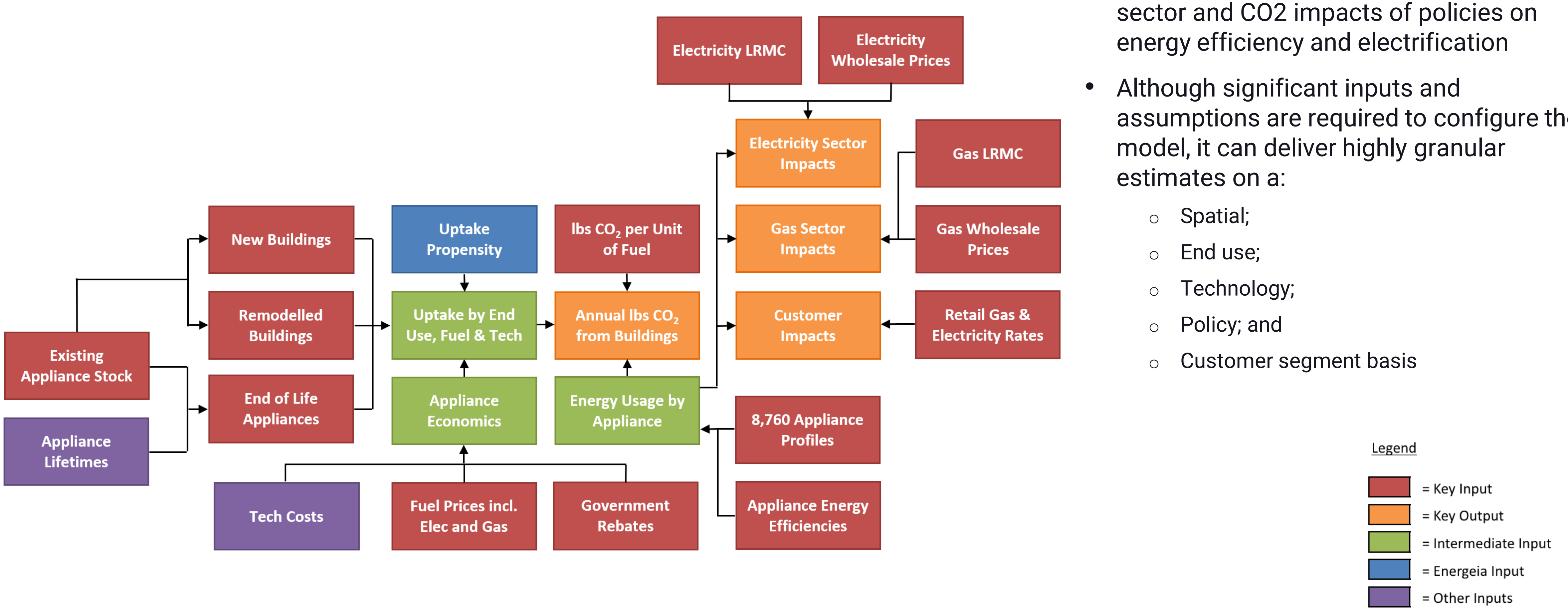
Standards and Regulations

Voluntary Technology Adoption Drivers

ENERGEIA

Sub-load Modeling Tool Overview

Sub-load Model Diagram

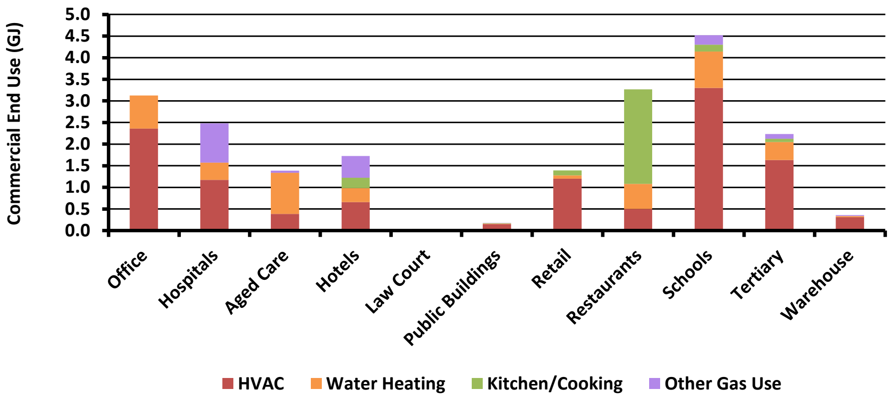


Source: Energeia

- Energeia's sub-load modeling tool estimates customer bill, power and gas sector and CO2 impacts of policies on energy efficiency and electrification
- Although significant inputs and assumptions are required to configure the model, it can deliver highly granular estimates on a:
  - Spatial;
  - End use;
  - Technology;
  - Policy; and
  - Customer segment basis

Quantifying Commercial Gas Consumption by Segment and End Use

Gas Consumption by Sector and End Use



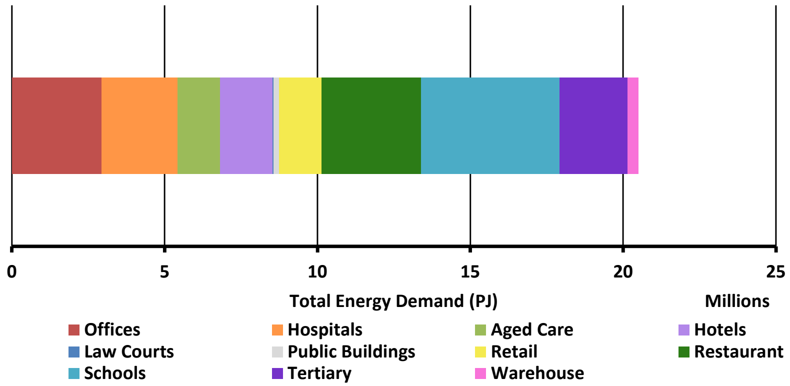
Source: Energeia Analysis, Commercial Baseline Study (2012), DOE/EIA (2012)

- Accurately planning and optimizing building electricity usage requires a detailed knowledge of end uses and technologies
- Different premise, end use and technology types will require different least cost solutions
- This information is available for selected existing buildings in the NREL Res and Com Stock models

Total Annual Gas Consumption (PJ) by End Use

Source: Energeia Analysis, Commercial Baseline Study (2012), DOE/EIA (2012)

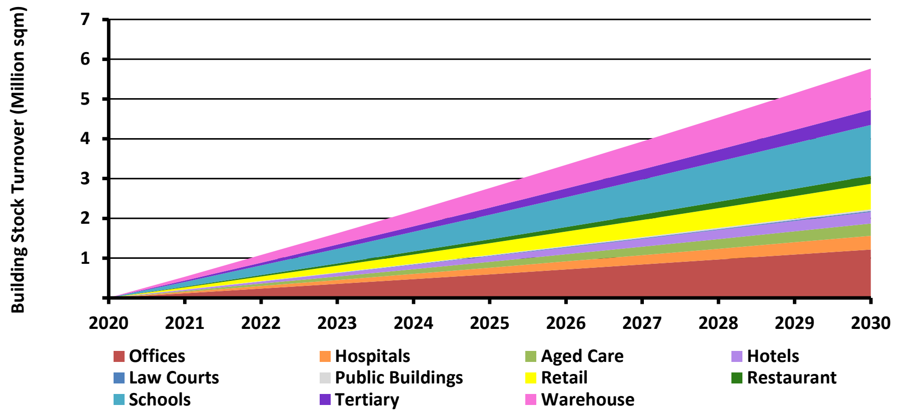
Total Annual Gas Consumption (PJ) by Commercial Type



Source: Energeia Analysis, Commercial Baseline Study (2012), DOE/EIA (2012). Note: "Schools" estimates use public and private school data from Commercial Baseline Study and DOE datasets

Estimating Technical Electrification Potential

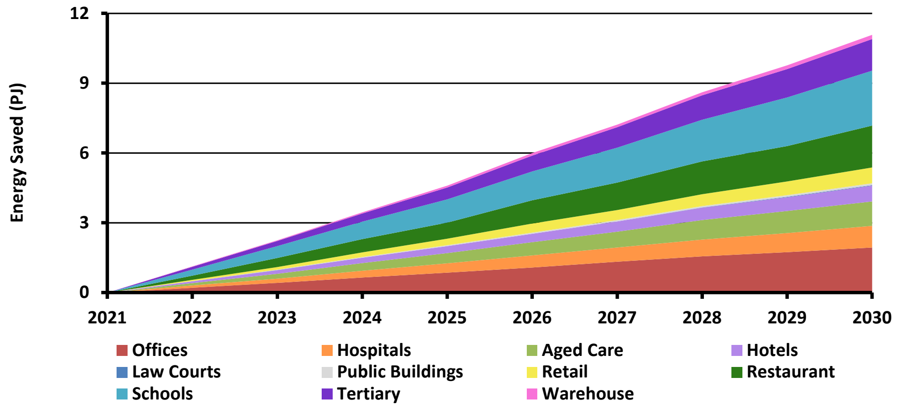
Existing Commercial Premise Replacement Rate



Source: Energeia Analysis, P&S

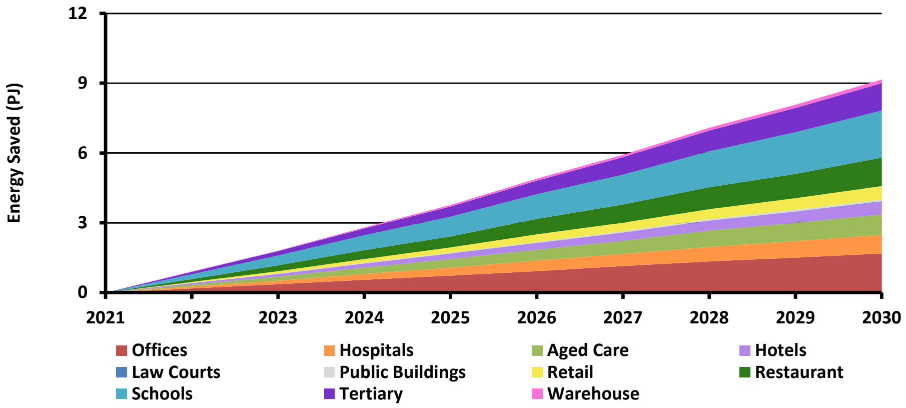
- These graphics show typical outputs of the end use modeling tool, including example remodeling activity, gas savings and energy savings (assuming 100% replacement here)
- Whether or not this actual converts is a function of model configuration, e.g.:
  - Timing and nature of bans on new connections and appliances
  - Electrification incentives and differentials in energy costs
  - Customer uptake propensity

Gas Savings by Sector



Source: Energeia Analysis, P&S

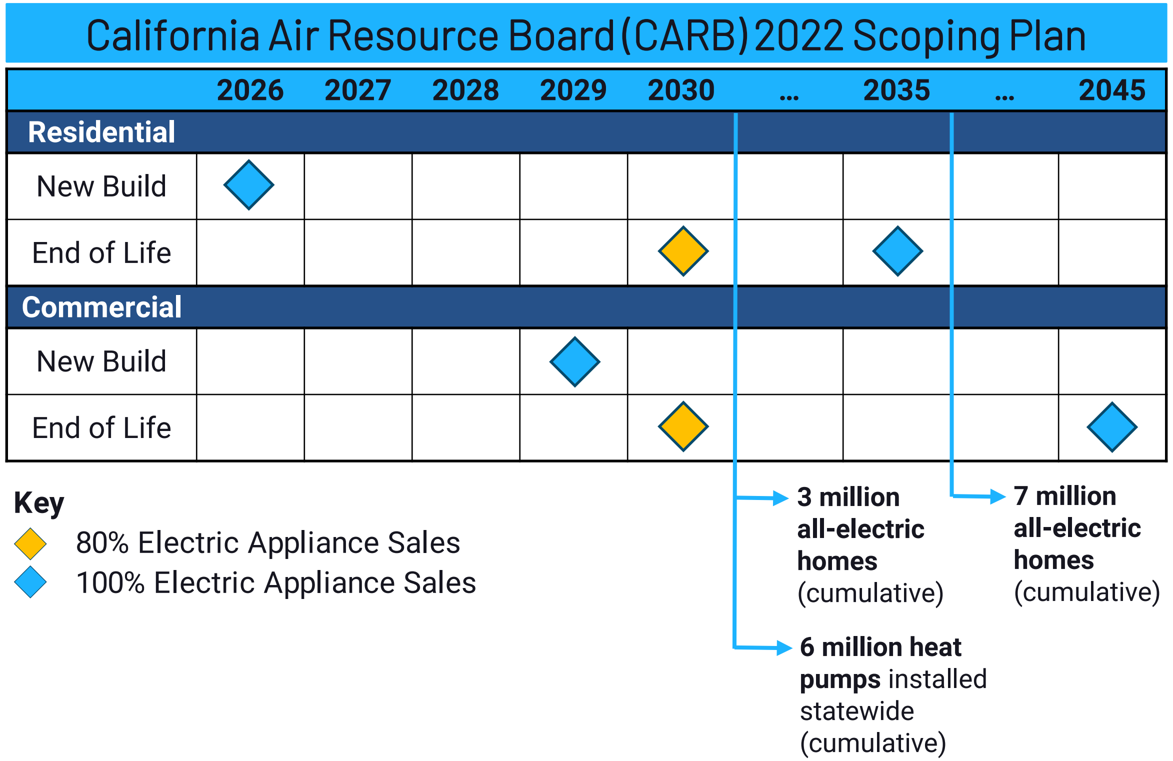
Energy Savings by Sector



Source: Energeia Analysis, P&S

ENERGEIA

Capturing Standards and Regulations

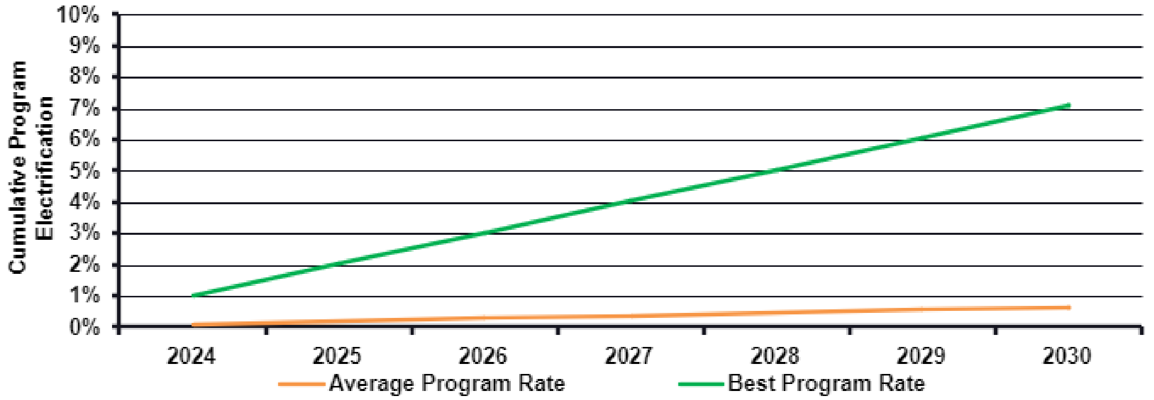


- Standards and regulations need to be mapped to identify when they impact on end of life replacements and/or new construction in the stock and turnover model
- The remaining activity is then subject to customer behavior

Source: CARB (12/22), 2022 Scoping Plan for Achieving Carbon Neutrality

Customer Appliance Uptake Modeling Approach

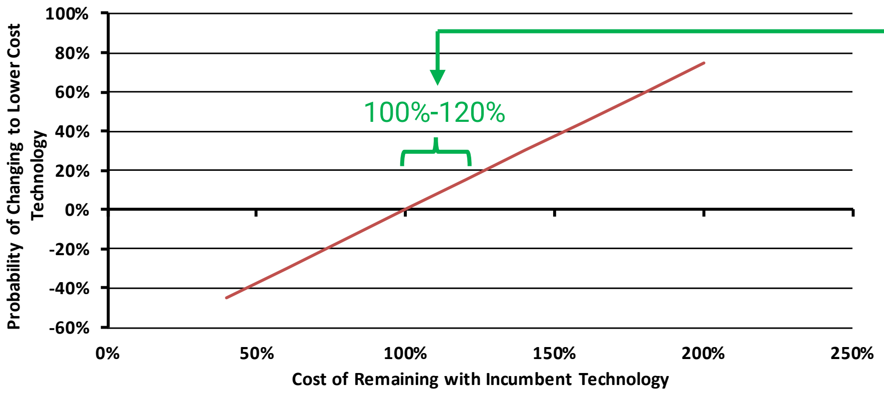
Average and Best Practice Uptake Rates (California)



Source: Energeia Research and Analysis, BE Program Administrator Interviews (2024

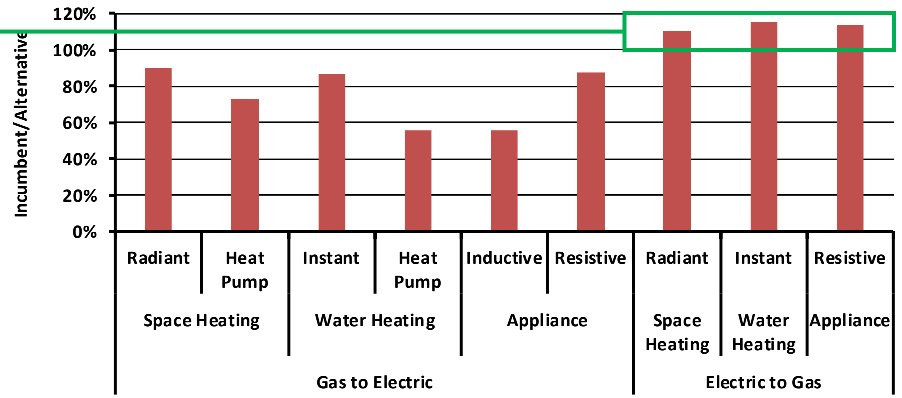
- Research has identified best practice vs. average practice in CA
  - Differences based on customer barriers, which vary by customer segment
- Based on our experience modeling customer behavior, Energeia developed an appliance 'switching' model, featuring:
  - **Negative Intercept** – Recognizes higher hurdle for switching away from incumbent
  - **20% Residual** – Research shows 20% of customers unlikely to switch regardless
- Key modeling applications:
  - The level of incentives needed to drive efficient appliance adoption
  - The pros and cons of mandating appliance efficiency compared to using pricing signals

Energeia's Assumed Fuel Switching Curve at Replacement



Source: Energeia Analysis

Incumbent vs. Alternative Technology Cost (4 Year Horizon)

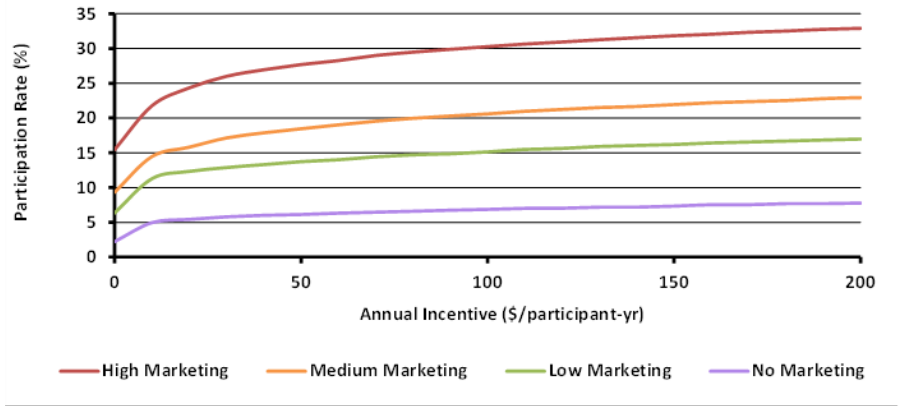


Source: Energeia Analysis

ENERGEIA

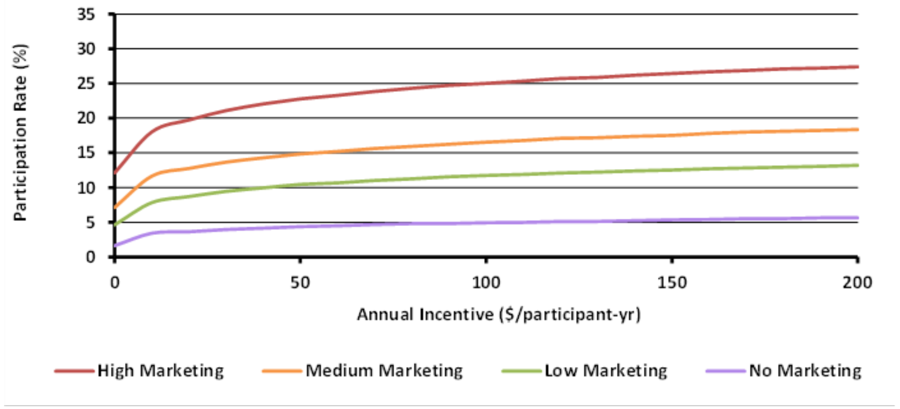
NREL's Estimate of Impact of Rebates vs. Marketing Expenditure

Residential – No Installation Required



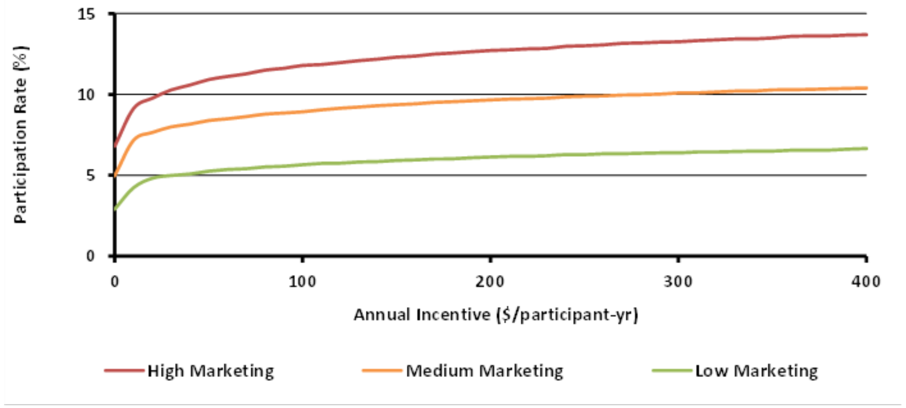
Source: NREL (2021)

Residential – Installation Required



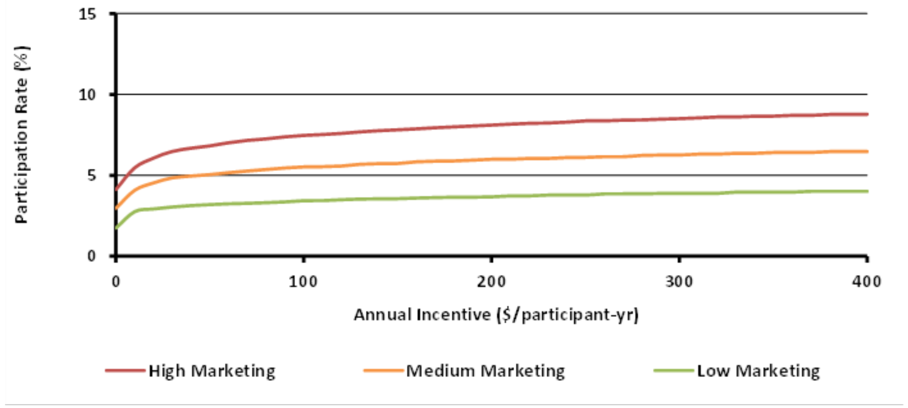
Source: NREL (2021)

SMB – No Installation Required



Note: SMB = Small and Medium-sized Businesses
Source: NREL (2021)

SMB – Installation Required



Note: SMB = Small and Medium-sized Businesses
Source: NREL (2021)

ENERGEIA

Electrification Barriers

Consumer Barriers

Grid Barriers

Natural Gas Barriers

Workforce Barriers

Whole-of-System Case Study

ENERGEIA

Key Consumer Barriers

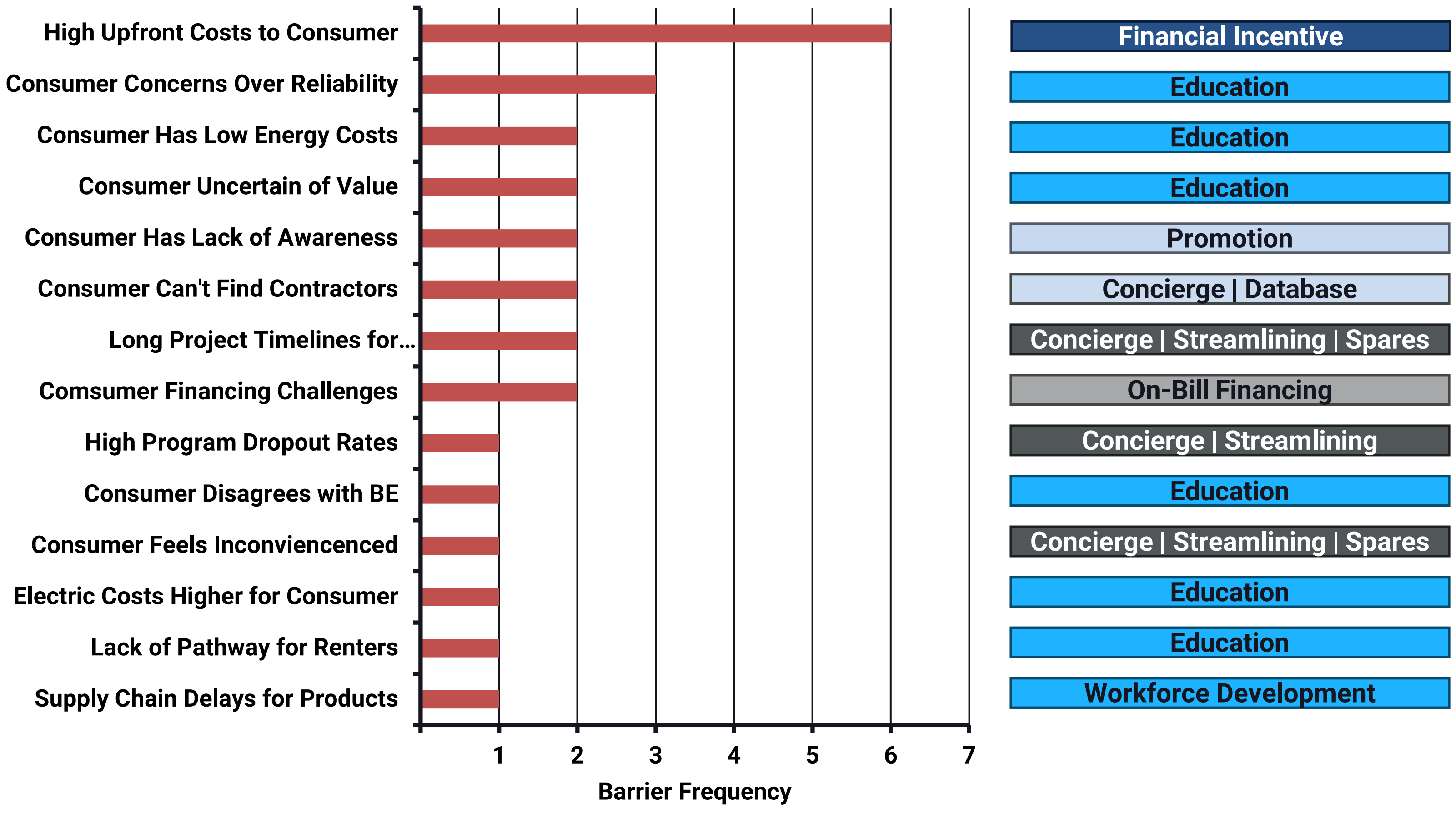
Survey Results

Upfront Cost Analysis

ENERGEIA

Key Consumer Barriers and Mitigation Strategies

Consumer Barriers Identified in Desktop Research and Interviews

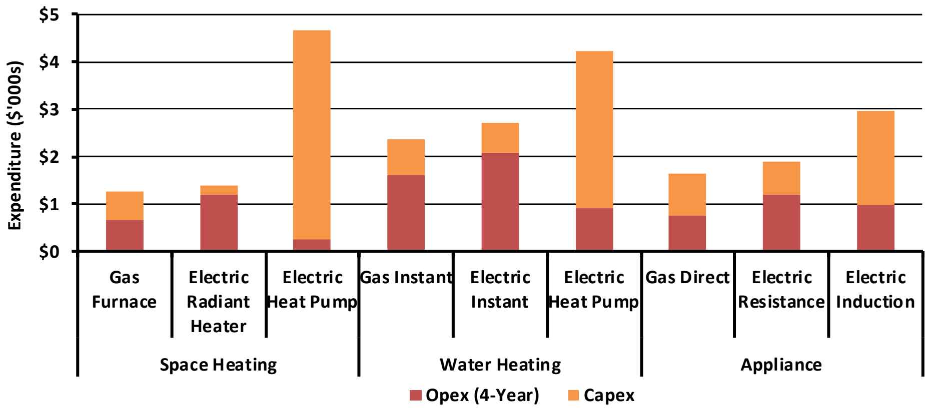


- From our research and interviews, we found that customers are primarily concerned with high upfront costs
- Our interviews also identified:
  - Customers are concerned with quality over health benefits
  - 100 AMP panel upgrades are sometimes necessary
  - Installation cost and time are difficult barriers for LI people
  - Financing can be an issue for LI segment
- Based on the above, strategies have been identified for addressing the barriers
  - Focus on upfront costs most important
  - Streamlining, turnkey service and spares addresses inconvenience barrier
  - An integrated, best practice approach to panel upgrades probably a good idea
  - Education also key as addresses multitude

Source: Energeia

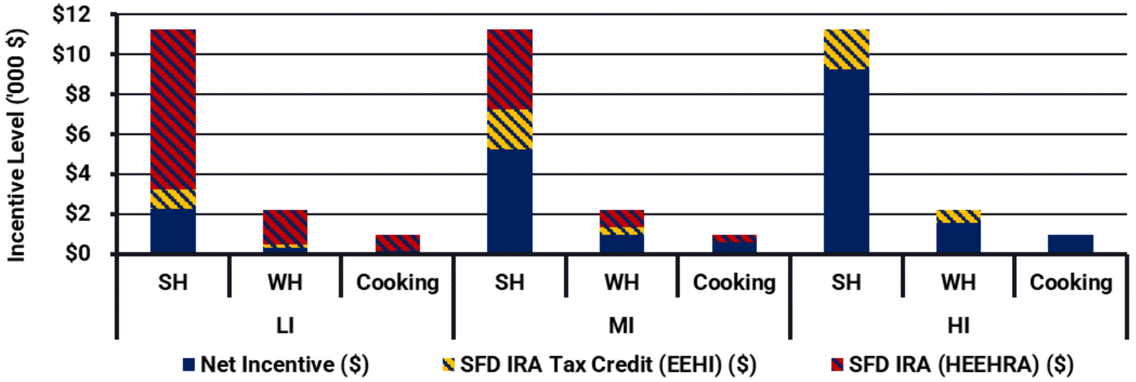
Costs and Tenure Key Consumer Barriers to Electrification

4-Year Capex and Opex Costs by End Use



Source: Energeia Research

Upfront Cost Differentials Net of Incentives (50th Percentile)



Note: SH = Space Heating, WH = Water Heating, LI = Low Income, MI = Middle Income
Source: Energeia Analysis (2024), TECH Clean CA (2024), BEI (2022)

- Heat pumps are typically higher cost than gas, with a lower operating cost
  - Energeia research found that there is almost no difference in installation costs when switching to ducted electric heating
  - Previous conventional wisdom was that switching installation costs was much more expensive
- Payback periods can vary, but none are less than 5 years
- This creates split incentives, where the benefit from an investment is split from the cost
  - People typically their own home for around 12-13 years
  - Renters typically move every 4.4 years
- Best practice here is to offer upfront incentives to address higher upfront costs and landlord split incentives
  - Funding is drawn from electricity consumption, clawing back price reductions to help fund them
  - Not entirely fair, as everyone benefits, regardless of their private knowledge of their likely tenure

ENERGEIA

Key Grid Barriers

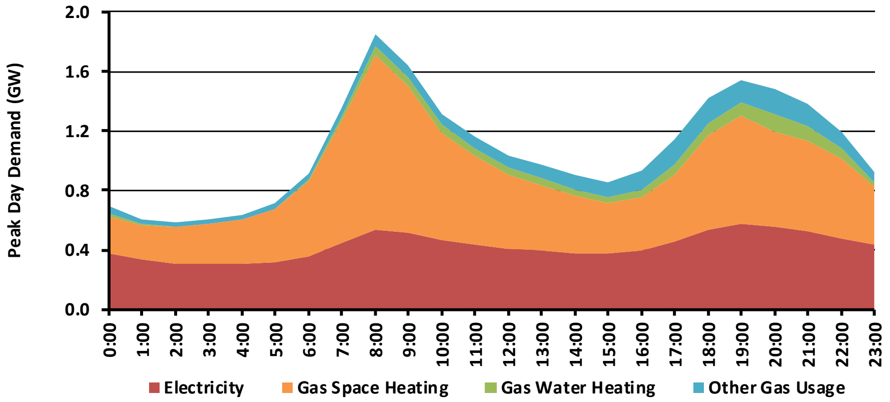
Grid Augmentation Costs

Key Cost Mitigation Strategies

ENERGEIA

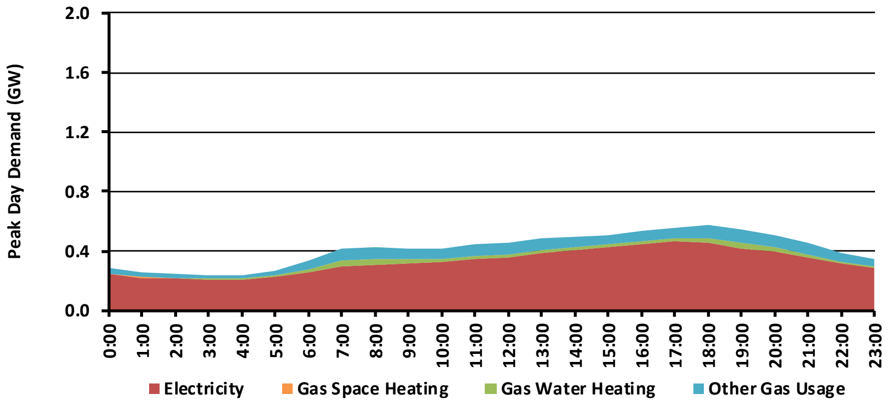
Gas Peak Demand Impacts by Sub-load on Peak Electricity Day

Winter Electricity Peak Day Load Profile



Source: Energeia Modeling; Note: Gas to electricity conversion assumes 100% energy conversion; Peak day is the average of the top 2.5% of peak days in Summer

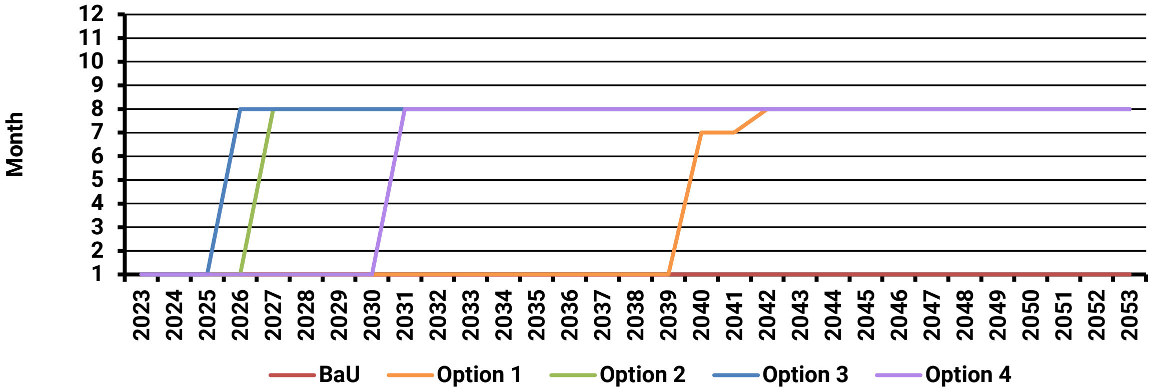
Summer Electricity Peak Day Load Profile



Source: Energeia Modeling; Note: Gas to electricity conversion assumes 100% energy conversion; Peak day is the average of the top 2.5% of peak days in Winter

- Gas demand varies significantly by state and by season
  - Winter demand driven mainly by space heating
  - Summer demand driven mainly by water heating and other
- Example peak day load impact estimates based on wholesale gas consumption data at the total level for the given jurisdiction
- Bottom right example shows different timing of a change in the peak month depending on the policy settings assumed

Changes in the Timing of Peak Demand (Example)



Source: Energeia Analysis

ENERGEIA

Key Options for Reducing Electricity Grid Costs

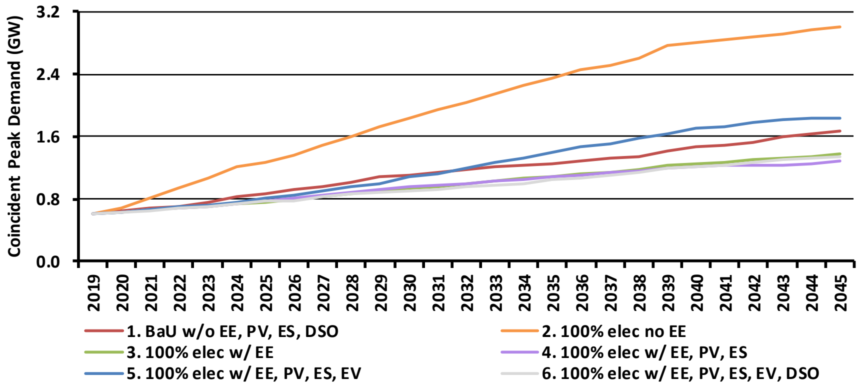
Key Options for Reducing Customer Costs

Low Temp Heat Pump · *Water Heating Heat Pump* · *Schneider Wallbox Electric Vehicle Charger* · *Tesla PowerWall 2 Battery* · *LG Solar Panels*

Source: Energeia Analysis

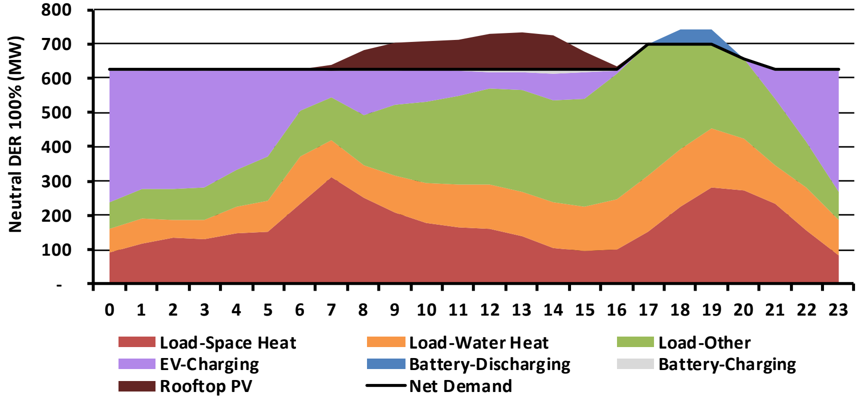
- Example technologies for minimizing the impact of building electrification on peak grid demand shown top left
- Heat pumps reduce demand compared to resistive instant loads, but are higher in upfront cost terms
- Heat pumps and EV chargers that can be remotely controlled provide another tool
- Orchestrating the resources can significantly alter load on the grid, moving it away from the peak and into the valley

Illustration of Orchestrated CER



Source: Energeia Analysis

Example Impact of Different Policy Scenario Impacts



Source: Energeia Research

ENERGEIA

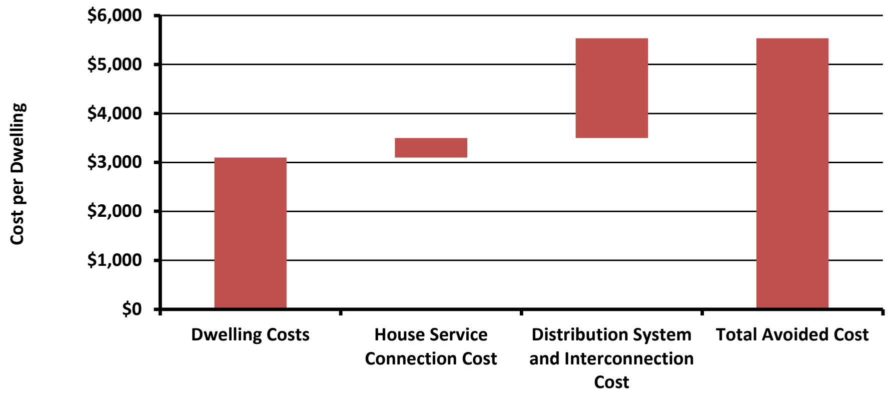
Key Natural Gas Sector Barriers

Avoidable Costs

ENERGEIA

Avoidable Builder and Network Costs

Gas Connection Cost (Detached Dwelling Example)



Source: Energeia Research

Available Avoided Gas Connection Costs by Type

	Greenfield		Renewal/Brownfield	
	Dwelling	Precinct	Dwelling	Precinct
Dwelling Costs	✓	✓	✓	✓
House Service Connection Cost	✓	✓	✗	✗
Distribution System and Interconnection Cost	✗	✗	✗	✗

Source: Energeia

- Avoided costs of new gas connections per dwelling are significant:
  - Cost to install gas into the dwelling itself
  - Costs to connect to gas services (pipe running from the main in the street to your gas meter)
  - Cost for the mains in the street, and their connection to the nearest gas system connection point
- Avoided augmentation costs are also significant
- Builder savings from avoided gas reticulation and gas service connection charges will ultimately feed through to lower prices
- What is less well understood are the following key issues:
  - Impact of lower volumes on gas prices
    - Reduces gas demand, and accelerates electrification
    - May be unfair to those unable to electrify due to barriers
  - Impact of decommissioning gas assets
    - Costs not widely available
    - Allocation of costs to consumers or tax payers not well understood
- A key remaining challenge for the gas industry and policymakers is how to best manage and allocate these costs
- Decommissioning costs are key cost assumption, which remains relatively obscure

ENERGEIA

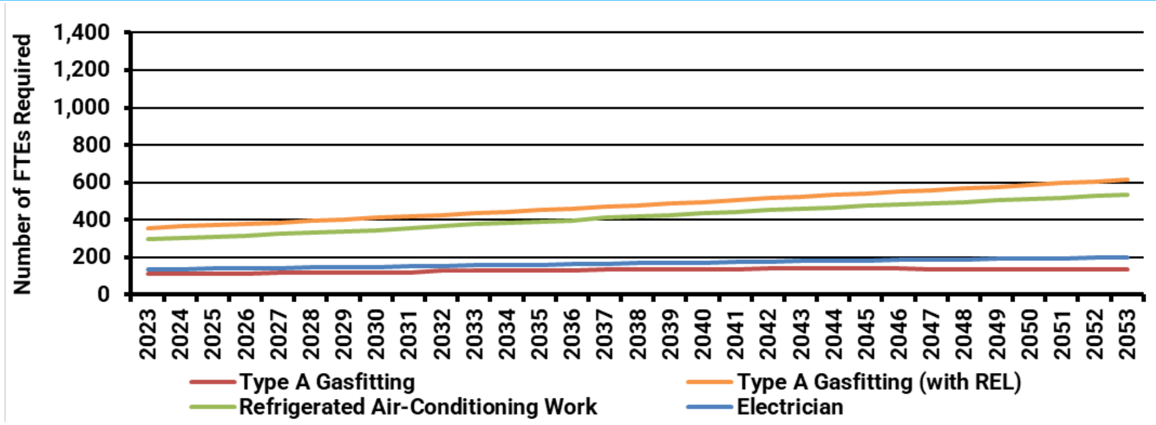
Industry Barriers

Workforce Capacity

ENERGEIA

Managing Industry Capacity Constraints

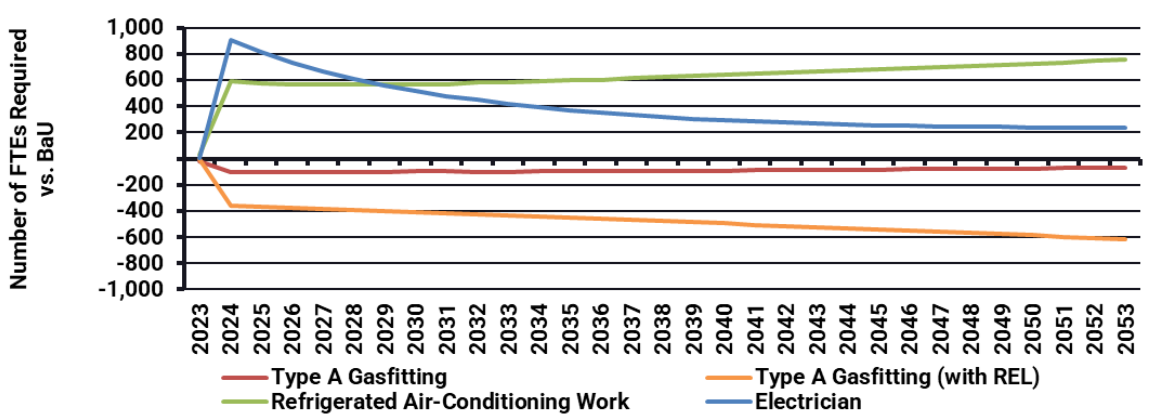
Licensed Practitioners Required (Example)



Note: Assumed 8 hours per working day and 249 working days per year
Source: Energeia Analysis

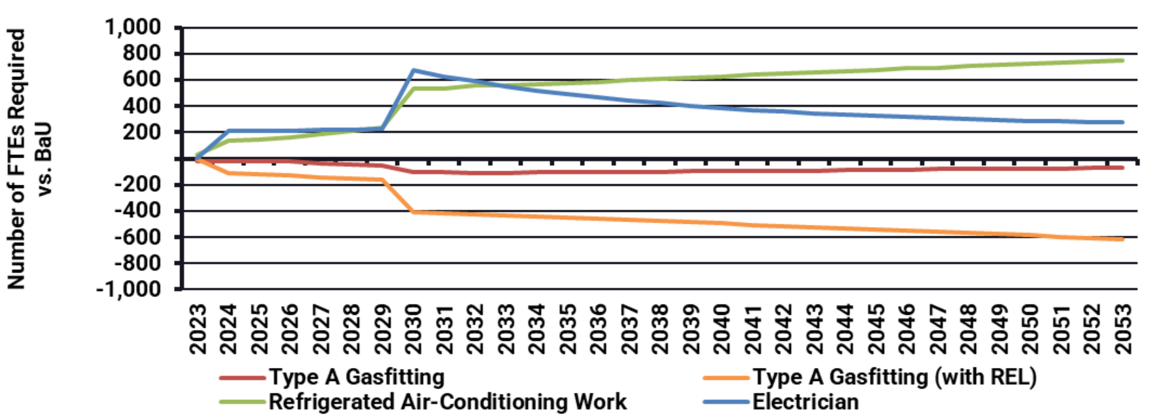
- Different policies will have different impacts on labor requirements
  - Gas bans on new and remodeled housing
  - Gas bans on gas appliances depends on which ones
  - Incentives a softer, voluntary impact
- Best practice is to model impact of different policies against total labor supply
  - Any bans should be set in the future with enough warning
  - Ideally, they should be staggered, and build up over time
  - This rules out full bans
- Investigation and development of the training institutions is also a best practice method for aligning training capacity to needs

Licensed Practitioners Required (Step Changes)



Note: Assumes new builds are all-electric, a gas appliance sales ban, and elec. appliance incentives
Source: Energeia Analysis

Licensed Practitioners Required (Optimized)



Note: Assumes new builds are all-electric, 2030 gas appliance sales ban, and elec. appliance incentives
Source: Energeia Analysis

ENERGEIA

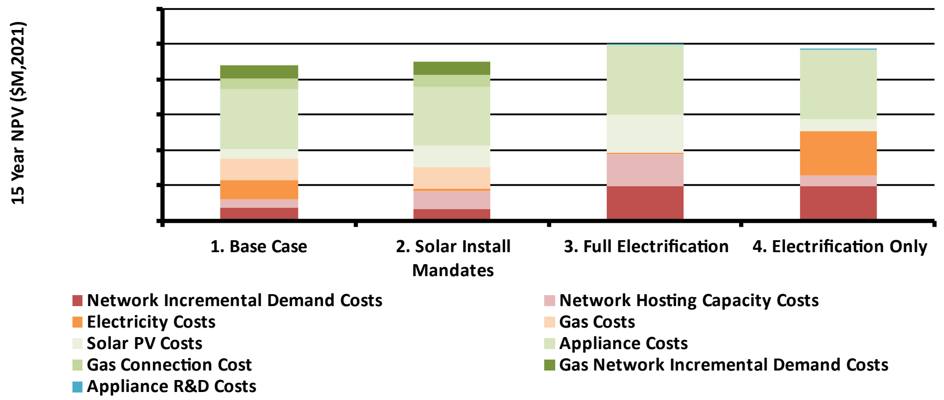
Whole-of-System Case Study

Unoptimized

Optimized

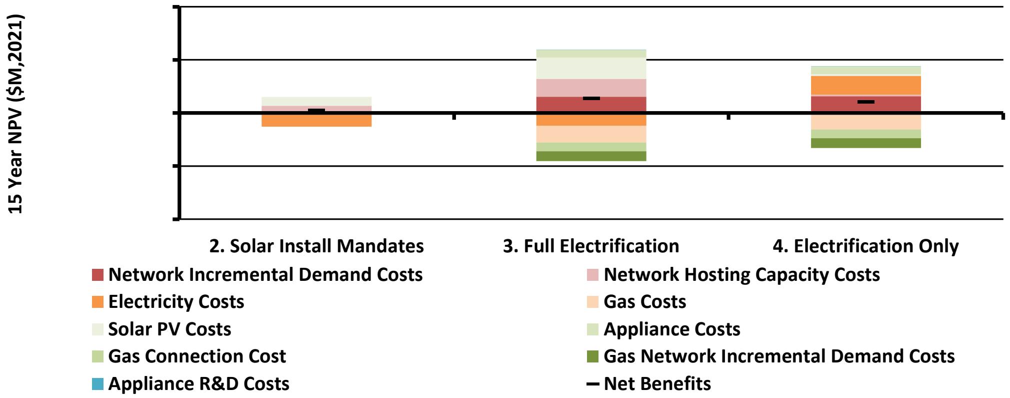
Unoptimized Policy Scenario Modeling Results – Case Study

15 Year NPV ($M, 2021) by Cost Category



Source: Energeia Modelling

15 Year NPV ($M, 2021) vs. Scenario 1



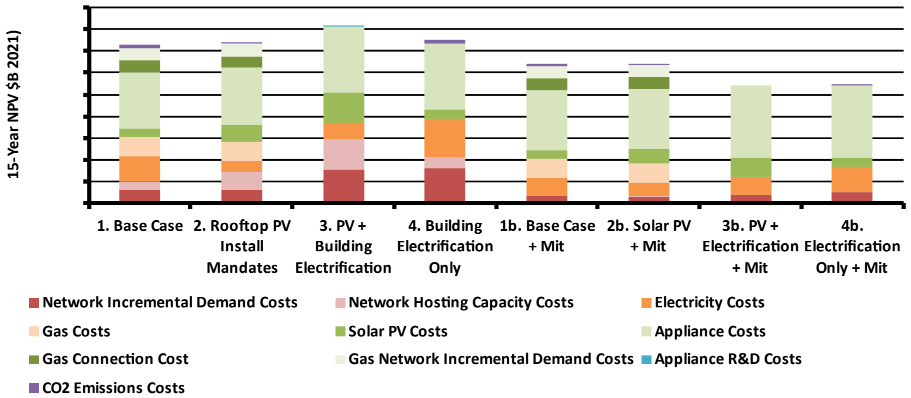
Source: Energeia Modelling

- Modeling of the unoptimized policy scenarios found that rooftop solar PV and/or electrification mandates would increase net costs overall
- The biggest drivers of higher costs were found to be
  - electric appliance costs;
  - solar PV costs;
  - electricity network peak demand costs; and
  - solar PV hosting costs
- The team then focused on identifying the optimal set of complementary measures to maximize net benefits

ENERGEIA

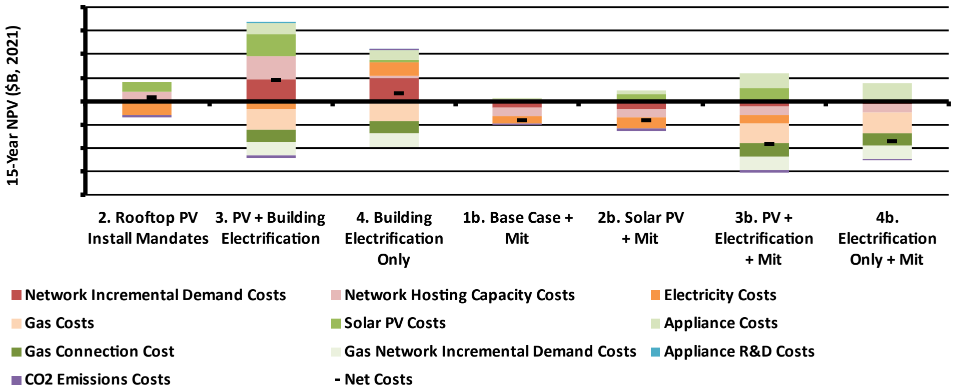
Optimized Costs and Benefits – Case Study

15 Year NPV ($M, 2021) by Cost Category



Source: Energeia Modelling

15 Year NPV ($M, 2021) vs. Scenario 1



Source: Energeia Modelling

Key mitigations include:

- Controllable heat pumps for water and space heating
  - Dynamic operating envelopes for networks and integration of flexible CER
  - Excludes any natural gas stranded costs, a topic for future webinars
  - Modeling of optimized policy and regulatory settings results in a multi-billion savings in discounted present (economic) value terms
- Savings is mainly due to the complementary measures

ENERGEIA

Program Funding Barriers

Consumers

Builders

Natural Gas Industry

Electricity Industry

Policymakers

ENERGEIA

Program Barriers and Solutions by Stakeholder

Summary by Stakeholder

Stakeholder	Impacts	Solution
Consumers (Res and Non-Res)		
Owner-Occupiers	Higher Electricity Equipment Costs	Gap Funding, Financing
	Higher Electricity Bills	Educate / Promote Lower Gas Bills
Landlords	Higher Appliance Upfront Cost	Gap Funding, Financing
Renters	Higher Rents	Gap Funding
	Higher Electricity Bills	Educate / Promote Lower Gas Bills
Builders / Remodelers		
All	Higher Appliance Costs	Gap Funding, Financing
	Higher Electricity Infrastructure Costs	BTM Resources
		Educate / Promote Lower Gas Costs
Electricity Industry		
Regulated Grids	Higher Peak Costs	Efficient Cost Recovery
	Higher Mitigation Costs	Efficient Cost Recovery
Suppliers, e.g. CCAs	Higher Wholesale Costs	Higher Revenues
Gas Industry		
Regulated Grids	Higher Stranded Assets	Efficient Cost Recovery
	Higher Decommissioning Costs	Efficient Cost Recovery
Technicians	Higher Retraining Costs	Mitigate Step Increases
		Retraining Funding

- Most cost or capital barriers are addressable, main issues for policymakers relate to consumers and industry retraining
  - Appliance premium the biggest barrier
  - Appliance financing can be helpful
  - Gas decommissioning impacts on appliance stranding
- Key question is which types of stakeholders will not benefit, and how to transfer gains to losses?
  - Transition to electric impacts different consumers differently (res and non-res)
  - How to compensate for gas decommissioning and stranded asset costs, from those benefiting the most?
    - Electrifying consumers greatest beneficiary in long-term
    - Near-term windfall gains possible for consumers and industry
- Analysis assumes effective gas and electricity mitigations put into place, e.g.
  - Smart storage water heating
  - Use of electric water heating for voltage management
  - Efficient gas network decommissioning

Source: Energeia

ENERGEIA

Key Takeaways and Recommendations

ENERGEIA

Key Takeaways and Recommendations

- Key Takeaways
  - Building electrification is an essential part of the US's decarbonization pathway
  - There are four main electrification triggers: new build, replacement, end-of-life, and retrofit
  - Building electrification impacts different consumers differently
  - Key barriers to electrification are higher upfront costs, higher grid costs, industry capacity constraints, and program funding
  - Electrification can impact on electricity sector costs, but these impacts can often be mitigated
  - Bans on appliances in new construction or at end of life can create step changes in workforce requirements
- Key Recommendations
  - Use bottom-up modeling of premises at the sub-load level to provide granularity needed to identify and size the key barriers and solutions
  - Overcome cost barriers via financing or rebates, recovering these costs from imposts on electricity usage aligned with expected benefits
  - Overcome electricity grid cost barriers by ensuring cost reflective pricing avoids cost shifting and cross-subsidies, and encouragement of load flexibility and management
  - A largely unknown key risk is the cost of gas network decommissioning, which Energeia believes could be at least in part funded by repurposing electrification benefits
  - Address potential industry labor constraints by giving industry plenty of notice, staggering any bands to minimize step changes in demand, and ensuring retraining capacity

ENERGEIA

Charging Ahead Webinar Series

Q & A

Next Charging Ahead Topic

ENERGEIA

Energeia's Charging Ahead Webinar Series

- Q&A
  - Add your questions in the chat
  - Unanswered questions will be answered via email
- Vote for your favorite Power Session webinar topic
  - Removing Barriers to Efficient Transport Electrification
  - Best Practice Virtual Power Plant Programs
  - Achieving Efficient Adoption of Behind the Meter Resources
  - Including Consumers and Distribution in System Planning
  - Best Practice in Grid Resiliency Planning using Microgrids

Reserve your place at the next **Charging Ahead** discussion

Achieving Efficient Adoption of Behind-the-Meter (BTM) Resources

June 18, 2024
9:30 AM – 10:00 (PDT)

- Where to find Energeia and Ezra Beeman
  - Website
    - Energeia.au
    - Energeia-USA.com
  - LinkedIn
    - Energeia
    - Energeia USA
  - Email
    - insights@energeia.com.au
    - ebeeman@energeia.com.au
- Watch for a follow-up email with links to the recording and presentation to share

ENERGEIA

Thank You!

Energeia USA
132 E Street, Suite 380
Davis, CA 95616

P +1 (530) 302-3861
energeia@energeia-usa.com

energeia-usa.com

ENERGEIA