OFFICE OF SUSTAINABILITY
COUNTY OF SAN MATEO

Decarbonizing Single Family Homes

January 26, 2023 | Josie Gaillard & Tom Kabat

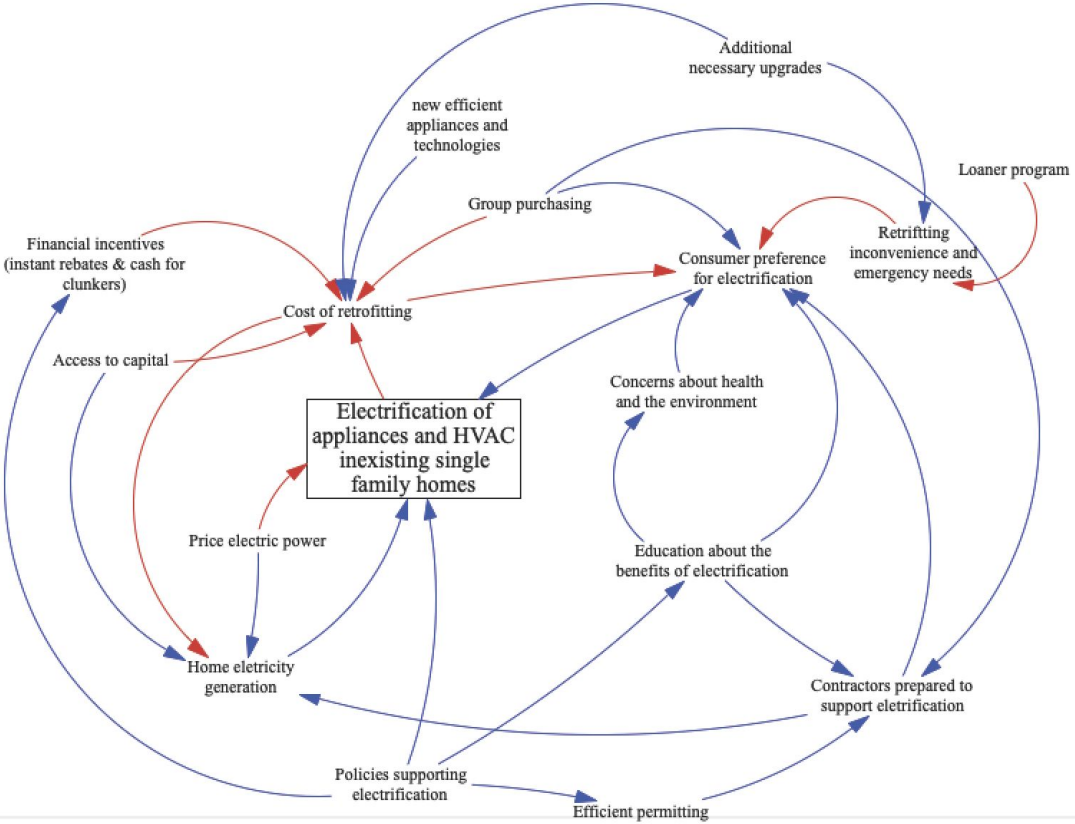
BAYREN
Local Governments Empowering Our Communities

Zoom Functions

Please use the Q&A feature to share thoughts, concerns and your questions with the Panelist.

Clarifying questions will be answered after each section. Discussion questions will be answered during the Q&A at the end of the presentation.

Systems Mapping Paved the Way for a Cost Study



Introducing the Presenters

Josie Gaillard

Josie's decarbonization journey started in the solar industry. She served on Menlo Park's Environmental Quality Commission and has a special interest in rapid electrification.

Tom Kabat

Since retiring from 30 years as an energy engineer for the City of Palo Alto, Tom has been applying his analytical skills as a board member and consultant for multiple environmental organizations.

Agenda

- Study goals
- Value of electrification plans
- Working with home contractors
- Homeowner economics
- Policies to support rapid electrification
- Feedback/discussion

STUDY GOALS

Our Goals

- Learn about costs and strategies for decarbonizing existing homes in San Mateo County
  - What does is cost to decarbonize a home?
  - Does a plan help homeowners?
  - What can we learn from assisting homeowners in electrifying?

Our Process

1. On-line survey(s) - 78 homeowners applied, 10 selected
2. Intro calls w/ homeowners - 45 mins each
3. Site visits - 2 hours each
4. Created drawings and detailed plans (w/ equipment types, sizing, locations, controls)
    a. Heat loss calcs per Manual J
    b. Panel load calculations per NEC 220.83 (B)
5. Developed contractor quote request packets – 3 iterations
6. Recruited and screened contractors – from 5 trades, 50+ screened in total, 11 selected
7. Solicited bids from contractors
8. Reviewed bids, requested changes, ran financial projections
9. Presented plans w/ costs and available incentives to homeowners
10. Summarize findings

Home Selection Criteria

Aimed for variety in:

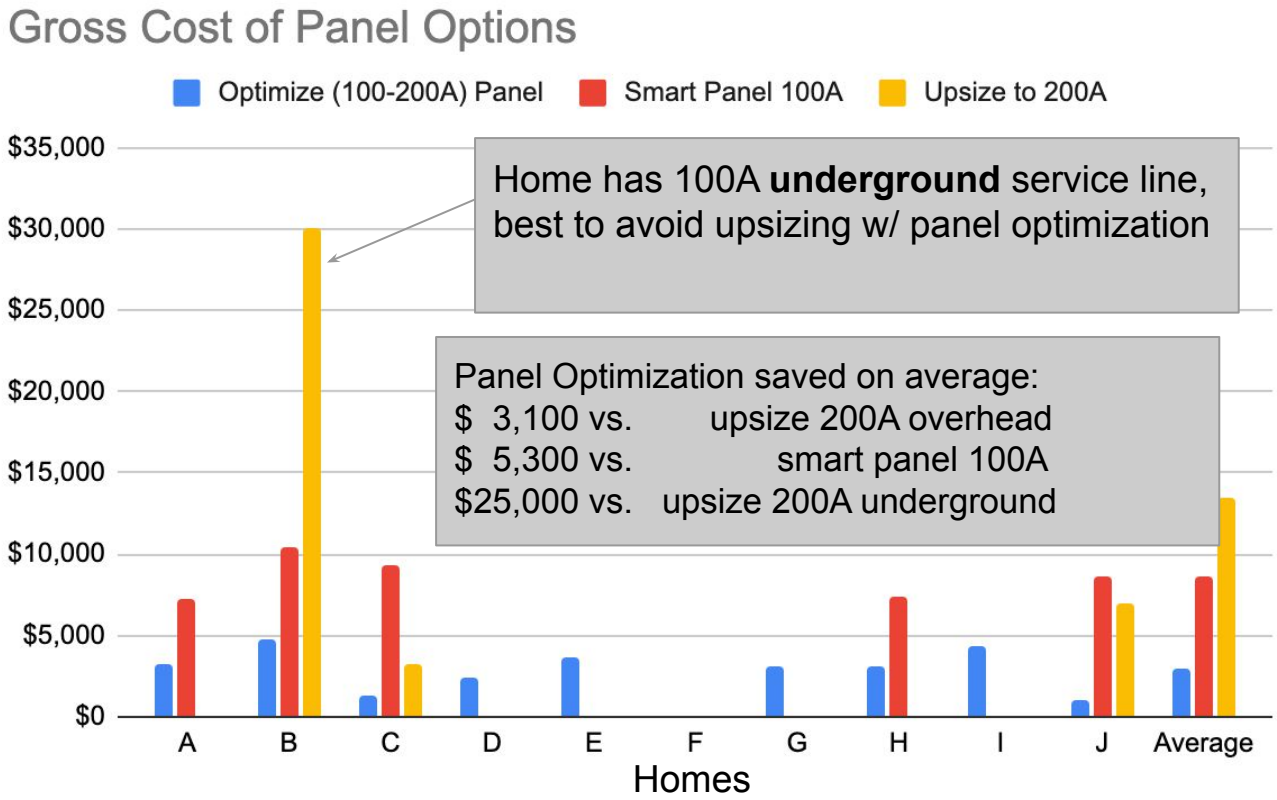
- Location
- Home vintage
- Home size
- Electrical panel size
- Income level

Locations

- Belmont
- Brisbane
- East Palo Alto
- Half Moon Bay
- Pescadero
- Redwood City (2)
- San Bruno
- San Carlos
- San Mateo

ELECTRIFICATION PLANS

Why Plan? It Saves Money



Electrification Plan Example

San Bruno Home Home
Quote Request

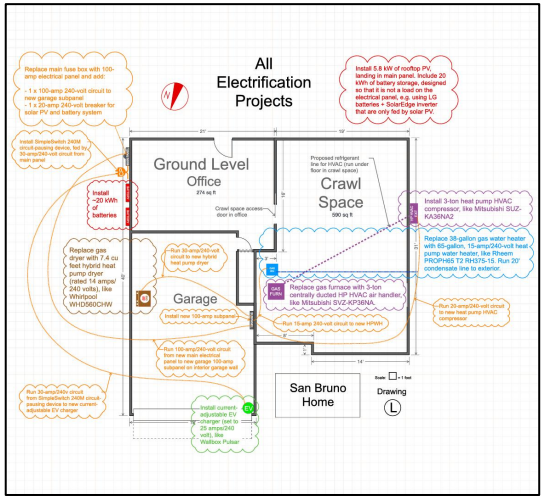
Home Info

- 1700 sq ft
- Single-family detached
- 2-story on hill
- 4 BR 2 BA
- Built 1958
- San Bruno, CA

Please provide notional quotes (± 10% of expected cost) for the relevant projects below, **breaking out equipment cost, labor and permits**. Show discounts for combining projects.

Project #	Contractor Type	Description	Drawing Color
1	Electrician	Replace 100-amp main fuse box with 100-amp main breaker box. No electrical service increase required. If existing service wires allow, right-size main panel to take advantage of larger existing service wire. Install new 100-amp subpanel in garage. Run 5 new 240-volt circuits from new garage subpanel to locations for: circuit pausing device and EV charger, induction cooktop, heat pump water heater, heat pump HVAC compressor and heat pump dryer. Install new induction cooktop, circuit pausing device and EV charger. Equipment: - Circuit pauser, like SimpleSwitch 240M, serving EV charger circuit - Current adjustable EV charger, like Wallbox pulse EV charger with adjustable current (set to 25 amps/240 volts) - To be purchased by homeowner: 30" induction cooktop like Frigidaire 30-inch Induction Cooktop, Model #FFIC3026TB (rated 30 amps/240 volts), hybrid heat pump dryer like Whirlpool 7.4 cu ft Hybrid Heat Pump Dryer, Model	Orange for Electrical Green for EV Brown for Dryer

1



San Bruno Home

San Bruno, CA 94066
Main panel size: 100 amps
Square footage: 1700

Electrical Panel Information

Existing Circuits

Main Panel, rated amps: 100

Circuit Number	Voltage	Breaker Amps	Type	Splittable ?	Notes
1	120	25	Lights and Plugs	no	
2	120	20	Lights and Plugs	no	"Track lights Hollis' Office"
3	120	30	Lights and Plugs	no	
4	120	25	Lights and Plugs	no	
5	120	20	Lights and Plugs	no	"Bedroom track lights"
6	120	20	Lights and Plugs	no	
7	120	20	Lights and Plugs	no	
8	120	6	Furnace	no	Fuse with spring, we think for furnace
9	240	25	Unknown	no	"Lights and Appliances"
10	240	50	Oven	no	Labeled "Range" but it's the oven only

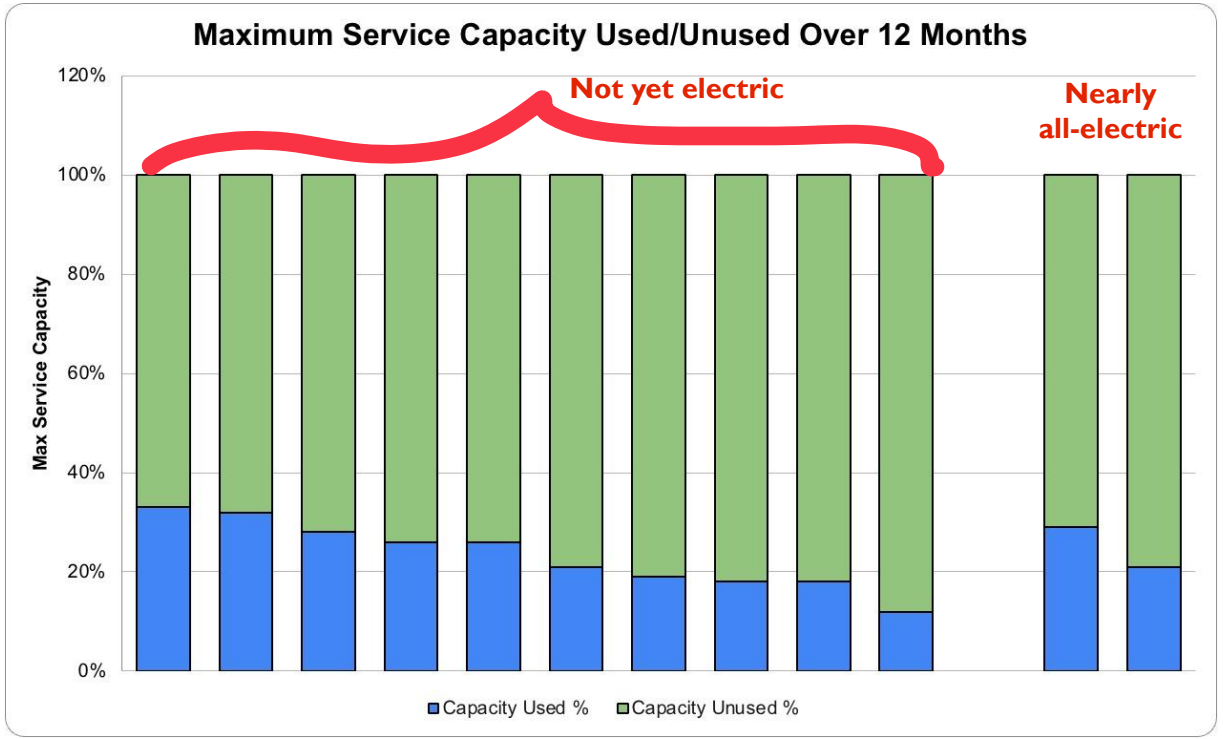
Electrical Load Calculations (Fully Electrified)

Name	Voltage	Nameplate Amps	Panel Number	Circuit Number	Notes
Lights and Plugs	120	6.07	0	1	
Lights and Plugs	120	6.07	0	2	"Track lights Hollis' Office"
Lights and Plugs	120	6.07	0	3	
Lights and Plugs	120	6.07	0	4	
Lights and Plugs	120	6.07	0	5	"Bedroom track lights"
Lights and Plugs	120	6.07	0	6	
Lights and Plugs	120	6.07	0	7	
Furnace	120	0	0	8	Fuse with spring, we think for furnace
Unknown	240	0	0	9	"Lights and Appliances"
Oven	240	14	0	10	Labeled "Range" but it's a single wall oven only

SAN BRUNO HOME

Location: San Bruno, CA
Square footage: 1,700
Occupants: 2
Main panel size: 100 amps
Vintage: 1958

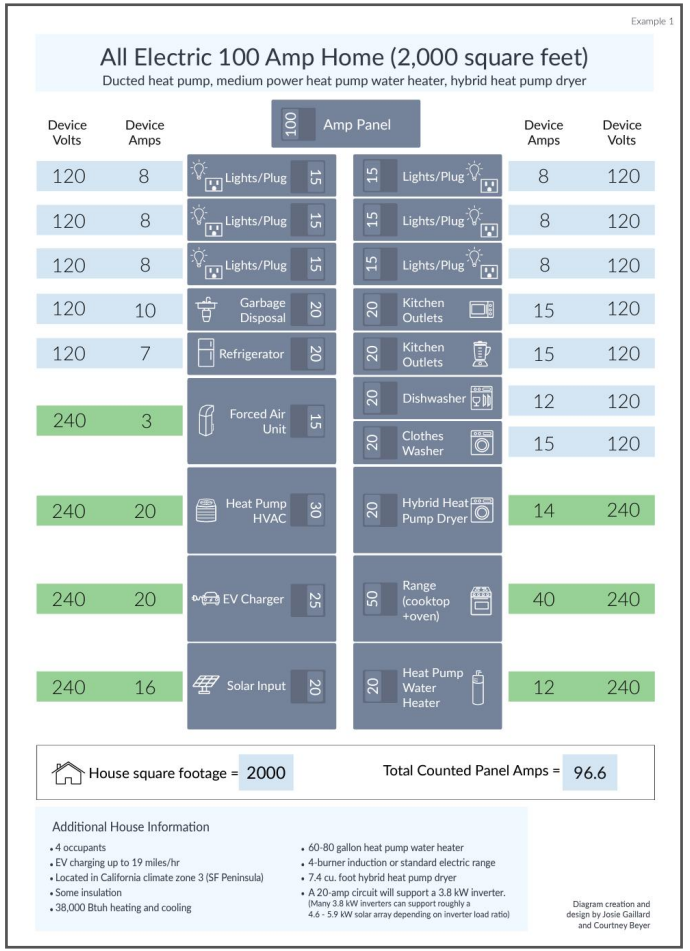
Ample Space to Electrify



10 Homes plus Josie's and Tom's

“PANEL OPTIMIZATION” for 2,000 sq ft home

- For homes with 100 amp electrical panels
- Helps avoid ~$5,000 electric panel upgrade
- Favors efficient devices w/ low rated amps
- Provides roadmap for building owner
- Helps guide tradespeople



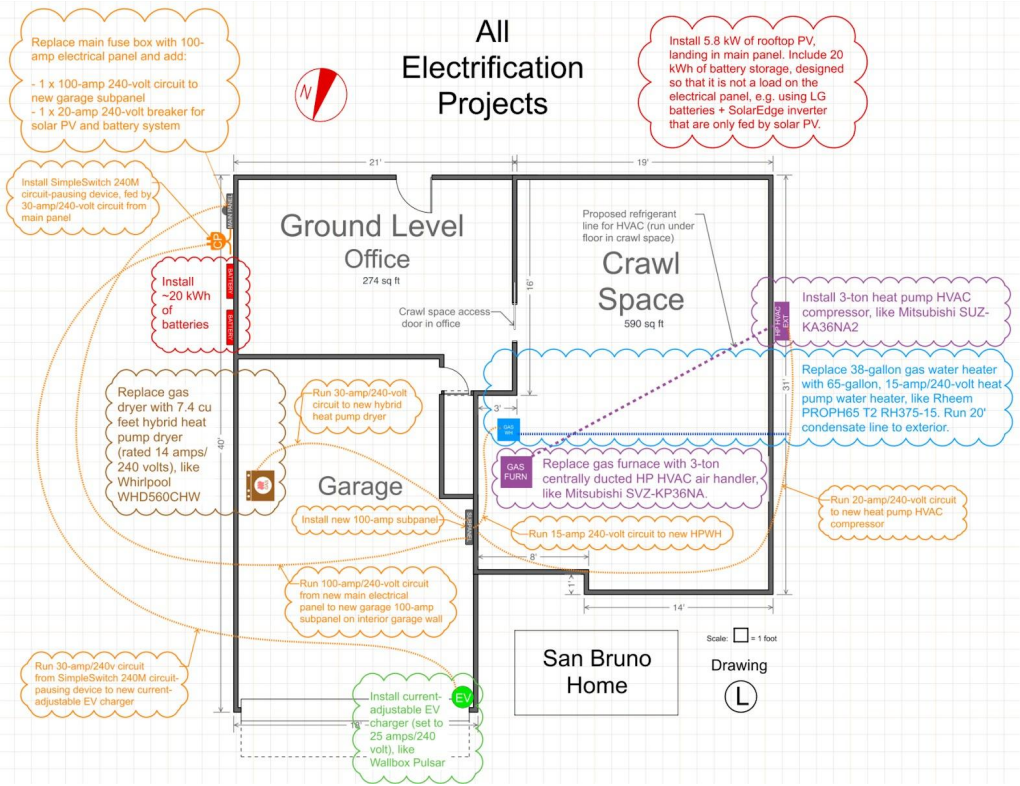
Main Electrical Panel

Today: 100-amp fuse box

Recommended: 100-amp breaker panel

New Garage Subpanel

Today: No garage subpanel



Recommended: 100-amp garage subpanel

Water Heater

Uses 1/3 the energy of a gas water heater

Today: 40-gallon gas tank WH in basement

Recommended: 65-gallon, 15-amp heat pump tank WH in garage

Space Heating and Cooling

Today: Centrally ducted gas furnace

Uses 1/3 the energy of a gas furnace

Recommended: Mitsubishi 3-ton inverter-driven heat pump HVAC system w/ ducted air handler

Cooking

Today: 30” gas cooktop

Recommended: 30” induction cooktop

Clothes Drying

Today: 7.5 cu ft gas dryer

Recommended: Whirlpool 7.4 cu ft hybrid heat pump dryer 14 amps / 240 volts

EV Charging

Recommended: Wallbox Pulsar with adjustable current from 6 to 32 amps (rated 13 amps/240 volts)

Budget Option: NEMA 6-15 outlet with 12-amp/240-volt circuit for outside of garage

Circuit Sharing and Pausing

SimpleSwitch
Allows 2 appliances to share one circuit

DCC9
Sheds load for one circuit

Span.io
Sheds load for 0-32 circuits in the panel

Solar + Battery

Recommended: 5.8 kW rooftop solar system + 10 kWh battery system

Building Shell Improvements

Today: Attic, some insulation
Recommend: R-38

Today: Crawlspace, no insulation, limited duct insulation
Optional: R-19 or R-30 for floors, insulate ducts

Quote Request Packet

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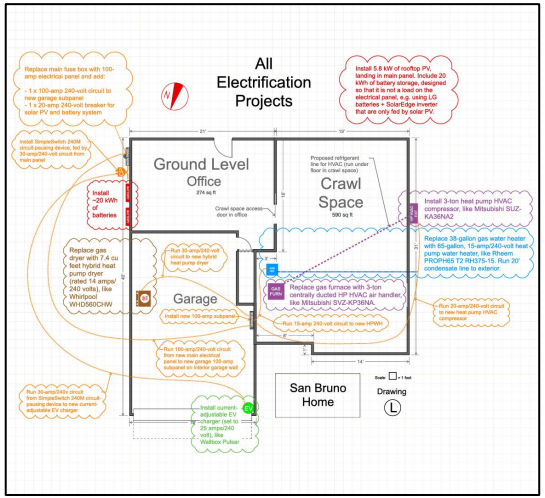

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Value of Electrification Plans

- Saves homeowner $$
- Gives homeowner confidence to get started
- Provides roadmap for multi-year conversion process
- Provides contractors w/ critical technical information, e.g. load calcs
- Optimizes existing electrical panel by taking all systems into account
- Could make permitting easier (city govt opportunity)
- Helps homeowners avoid unnecessary work and expense
- Our plans evolved with experience. We share:
  - What worked
  - What didn’t
  - What we recommend going forward

Equipment Silver Bullets

- 15-amp heat pump water heaters like some Rheem and Stiebel models
- 17-amp inverter-driven heat pump HVAC systems that are not just power-efficient and energy-efficient, but also extremely quiet
- Centrally ducted heat pumps w/ air handlers on same circuit
- Upsizing water heater and/or adding a mixing valve to be sure to deliver lots of hot water
- Split heat pump water heaters to fit smaller tanks in tight spaces
- Heat pump dryers
- EV chargers that have adjustable current dip-switch settings (6 to 32 amps)
- Circuit-sharing devices like Neocharge and SimpleSwitch
- Circuit-pausers like DCC9 and EV Duty or Emporia Smart Charger
- Smart electric panels like Span.io

What Worked/Didn't?

- Initial contractor recruitment - fell short
- Initial phone interviews w/ homeowners - helpful
- 2-hour site visit - too long
- Detailed window measurements - not necessary
- Fine to size heat pump w/ gas bill (peak day) data vs. Manual J calcs
- Smart meter electric data - very useful
- Digital drawings - too much effort (even though contractors valued them)
- Wordy quote requests - not good, briefer verbiage better
- Doing electric load calcs per NEC - critical
- Challenging to make design choices, keeping all constraints in mind at one time
- Hard to keep all the data organized and easily accessible

Problems We Encountered

Problem	Solution
Couldn't access one home due to COVID concerns	Homeowner provided photos and measurements
Info for each home spread across information systems, difficult to organize	Built web tools to consolidate: photos, measurements, utility data, load calcs, equipment options, key constraints, homeowner prefs
Standard-power appliances sometimes did not fit on existing 100A panels per NEC	Identified "silver bullet" (power efficient) equipment and innovative load management approaches
Building official told contractor a home needed bigger panel and service line, when it didn't	Met with building department to resolve
Struggled to find appropriate contractors	Cast a wider net
Struggled to get contractors to send quotes	Chased them down
Contractors made errors in quotes	Followed up to request corrections
Contractors lumped together costs in quotes that we needed to disaggregate for analysis	Got help from contractors and made educated guesses

Recommendations Going Forward

- Simplify processes to speed things up
- Keep home visits to < 1 hour: take photos, choose equipment sites, minimize measurements, but measure constrained passages & space for equipment
- Develop tools for making fast plans (e.g. www.zerocarbon-home.com)
- Eliminate detailed architectural drawings, use google satellite images to estimate circuit lengths and other basic dimensions
- Eliminate Manual J calcs, use gas bill data for HVAC sizing
- Identify contractors willing to submit quotes via standard form
- Require contractors to submit quotes via form to eliminate cost bundling
- Make sure form fields map to best output for decision making
- Identify better incentive to recruit contractor participation
- Educate building officials in jurisdictions where you will be working about “panel optimization” approach and relevant NEC sections

Questions?

WORKING WITH HOME CONTRACTORS

Working with Contractors

- Barriers
- Opportunities
- Recommendations

Hugo Conchas, Owner Ideal Electric

Participating Contractors

Building Efficiency
Bay Area Climate Control
Bay Area Insulation Services
DG Heating and Air Conditioning
Fuse Electric
Fuse HVAC
Ideal Electric
JR Power
Nabu Energy
Phil Barnett Plumbing
SDI Insulation
SunWork

Barriers

- Contractors prefer to see homes in person and meet clients
- Contractors didn’t necessarily read plans carefully
- Difficult for them to bid various permutations
- Some were able to make use of plans and load calcs…even appreciated them, but this was not the norm
- Some pushed back on: load calcs, heat pump sizing

Opportunities

- Contractors love photos, use them to communicate
- Although not all contractors used plan details and load calcs, some appreciated them, therefore you could...
- Screen contractors based on whether they value plans
- Some seemed to understand that a good plan could help them streamline their work

Recommendations

- Revamp electrification plan format w/ input from team of contractors
- Identify high-potential contractors and train them:
  - Eager to learn
  - Comfortable with new technology
  - Good with customers
  - Ready to grow
- Create networks of contractors that are trained in home electrification
- Identify the best:
  - Offer public recognition or prizes for excellence
- Make it easy for homeowners to find them!

Recommendations

- Train contractors in:
  - NEC electrical load calculations, so they know what will ACTUALLY fit on a panel
  - Whole-home electrification plans, so they know how all the pieces fit together
  - Technical differences between gas equipment and electric equipment
  - Siting requirements of electrification equipment

Questions?

HOMEOWNER ECONOMICS

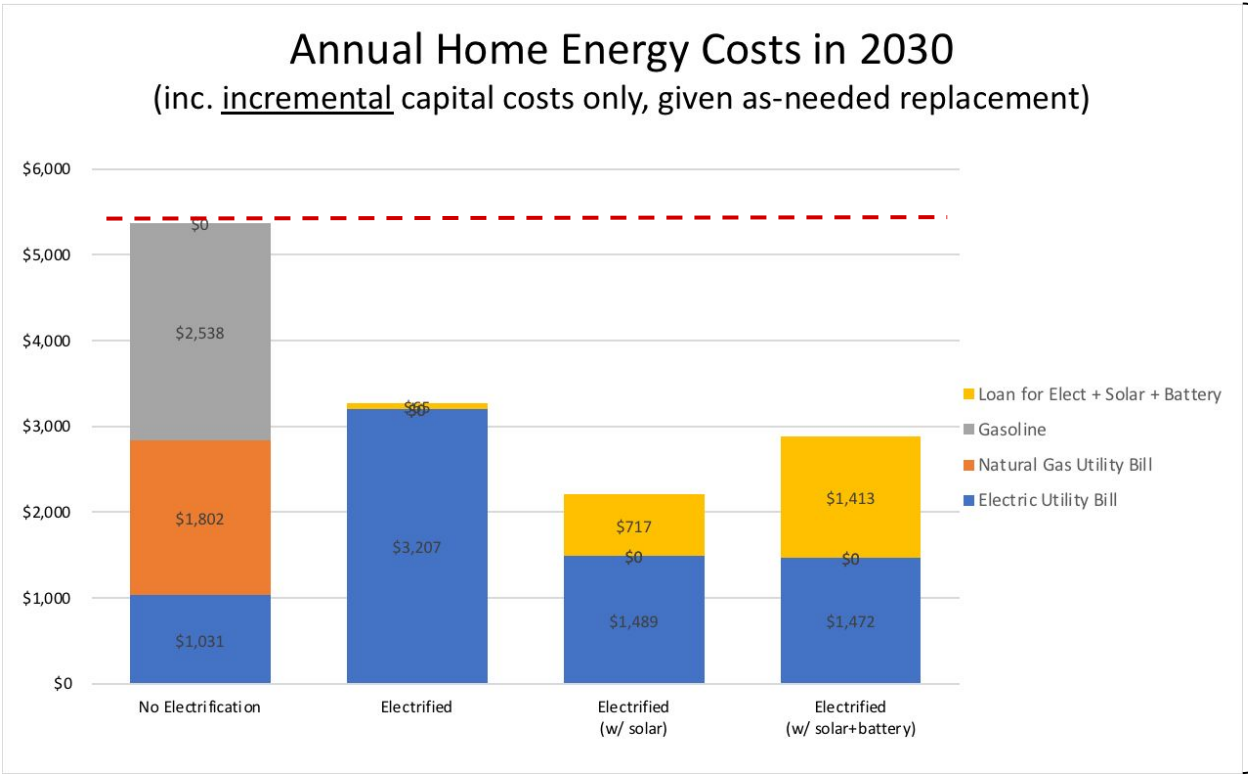
Homeowner Economics

- Installation costs by appliance
- Rebates
- Net installation costs (after rebates)
- Cash flow analysis

We **did not look at** home value increase from getting the upgrades such as:

Getting Solar
Getting Battery
Getting Cooling
Safer Cooking
Removing future electric conversion cost liability.

What Does it Cost to Electrify?



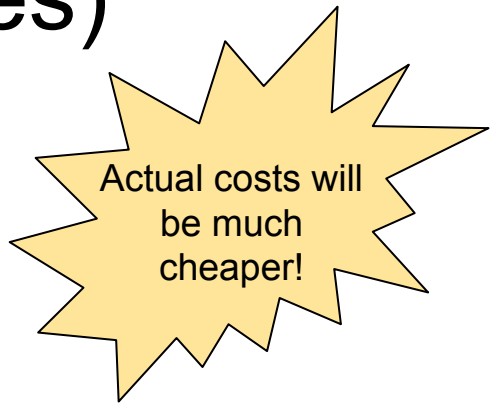
Includes both capital costs and operating costs

Contractors were bidding the same specific equipment models and sizes we asked for.

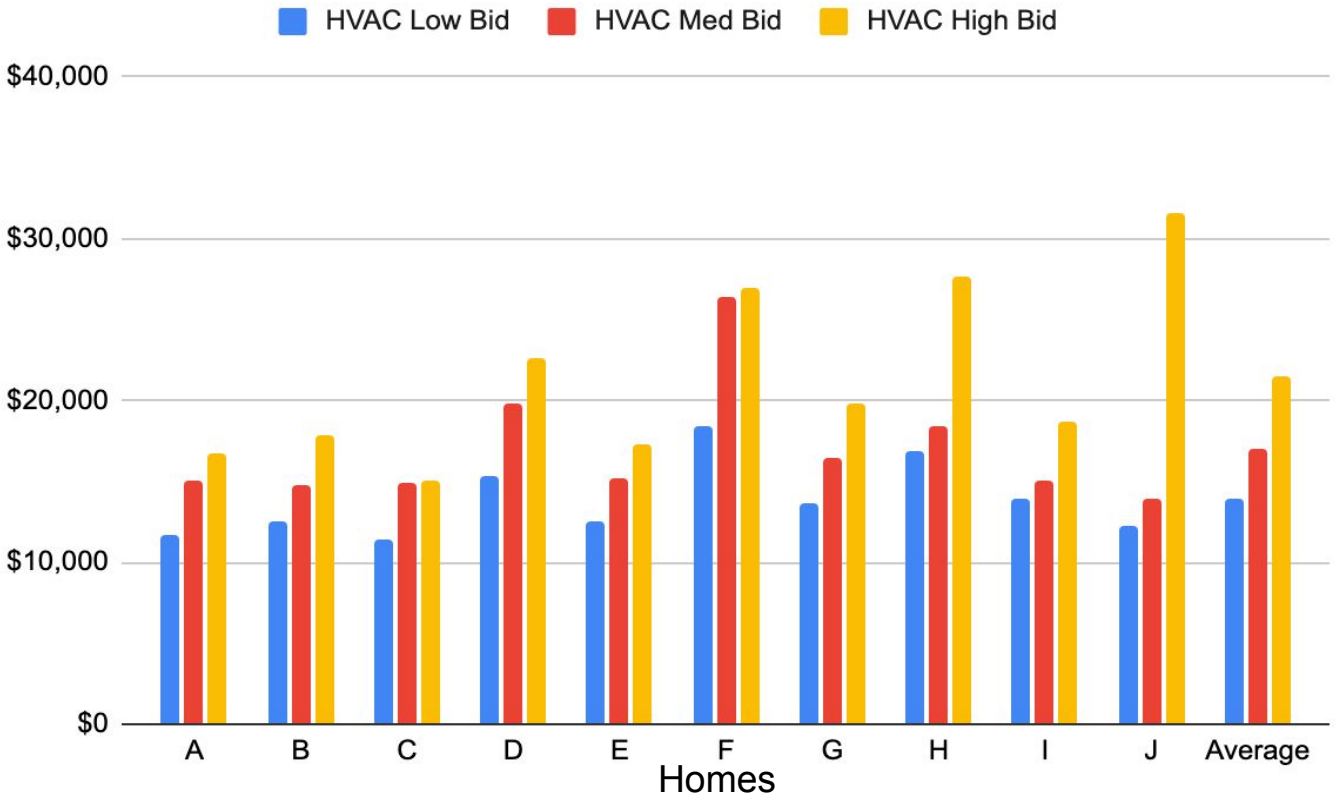
Bids included all costs including:
Permits, Clean-up, ancillary parts and thermostats, etc.

Raw Costs for Installation (before incentives)

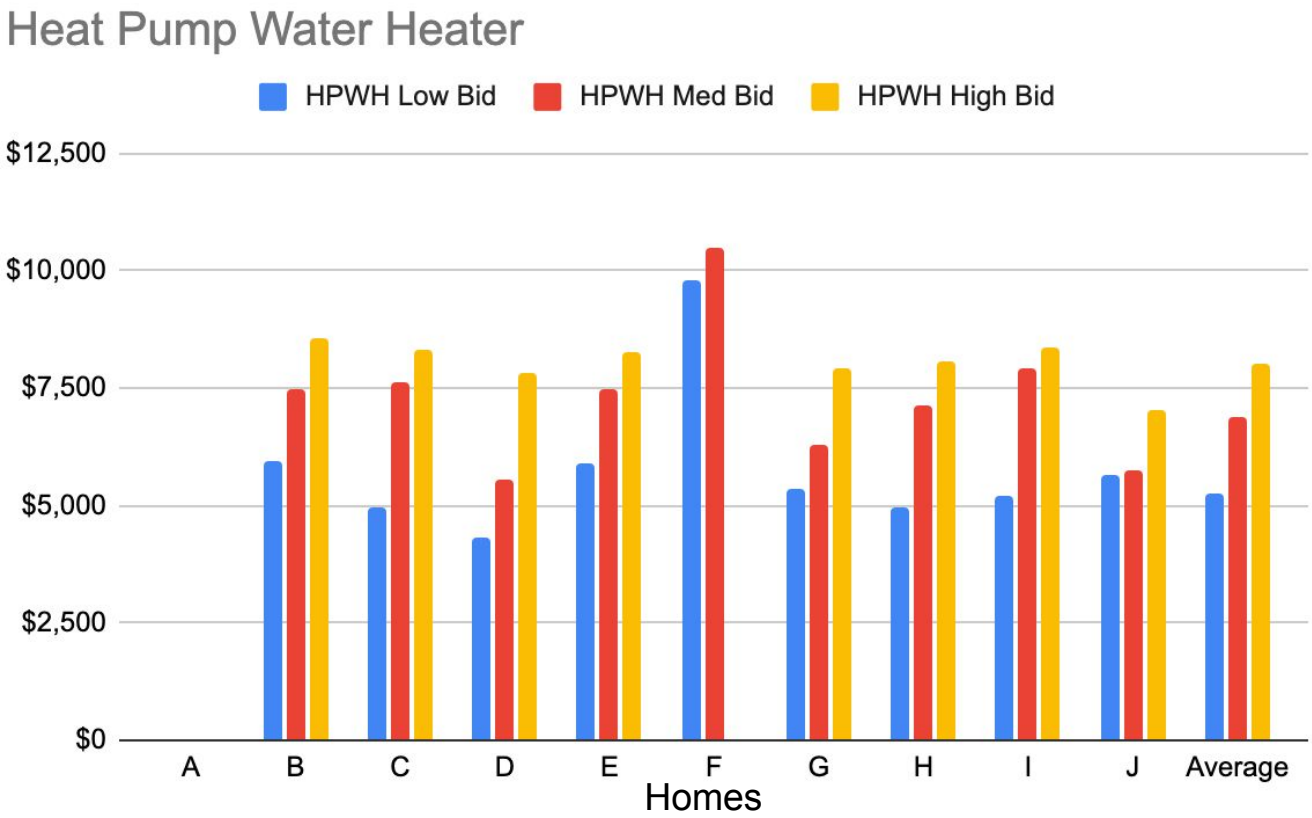
Some contractors said they needed to bid higher since the project was… Sight-Unseen



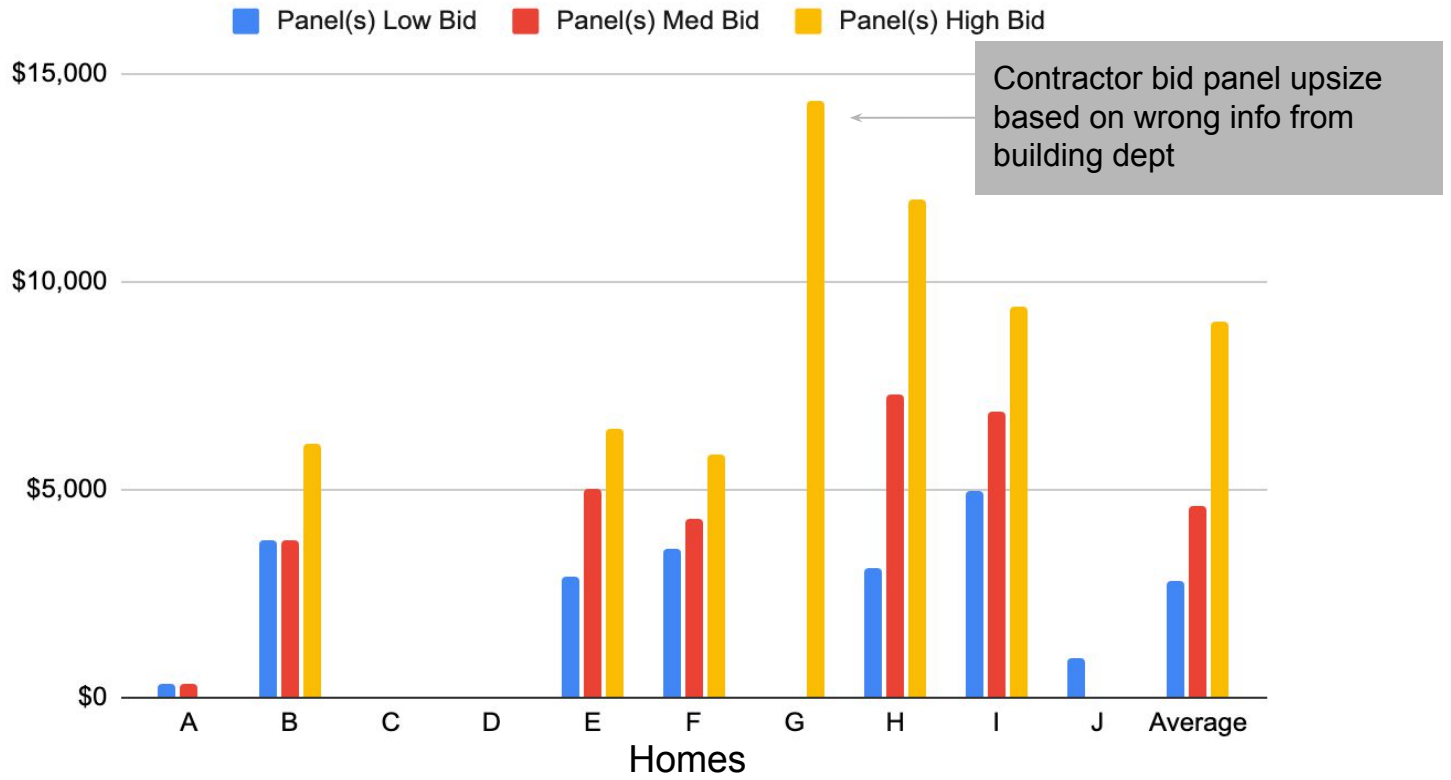
HVAC Bids for 10 homes



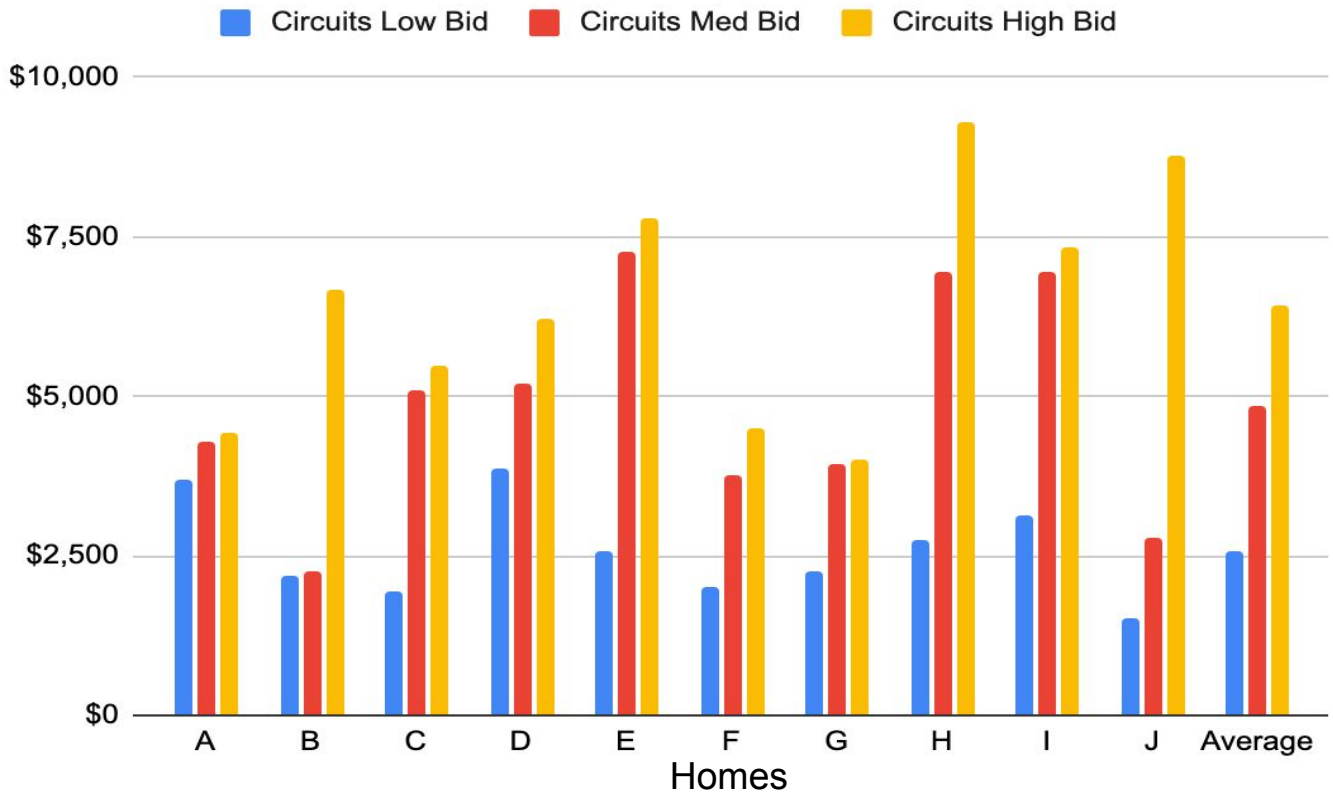
HPWH Bids for 10 Homes



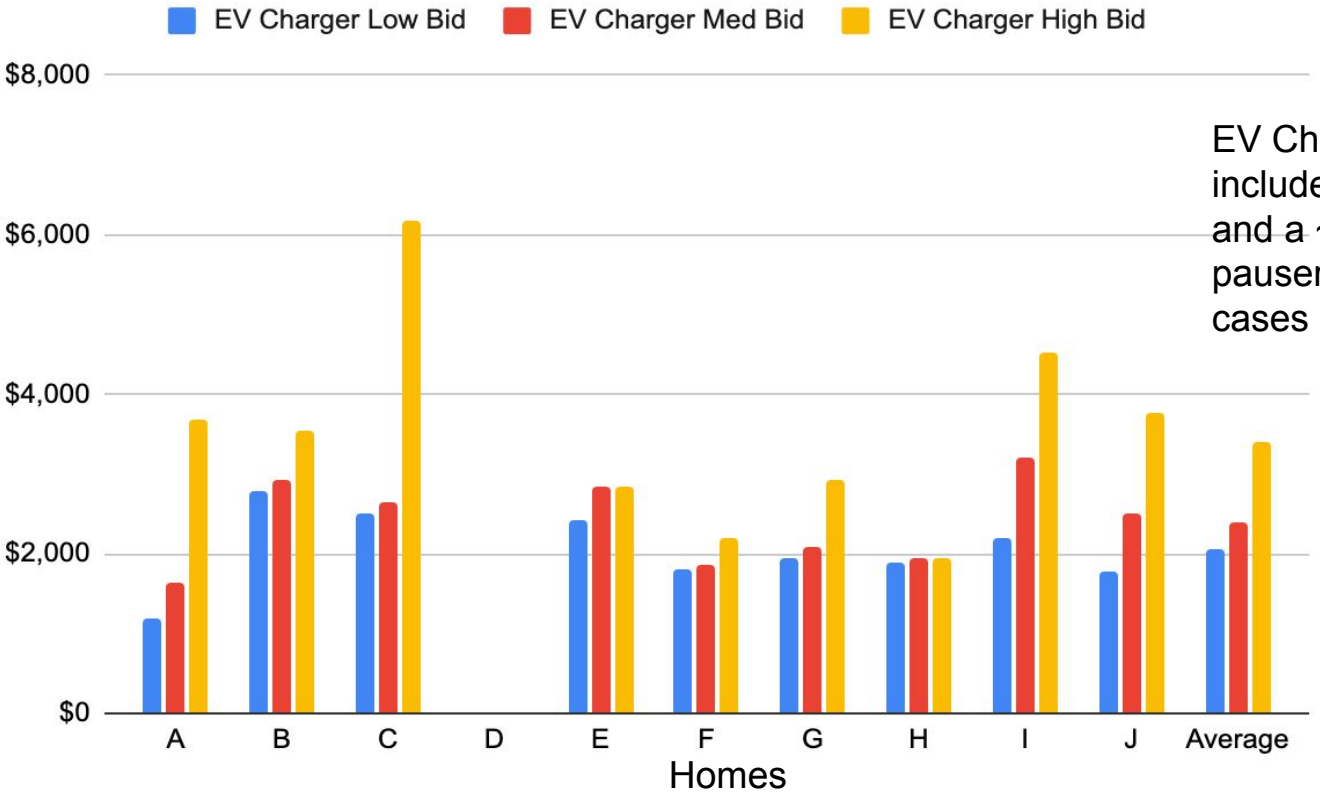
Electrical Panel Bids for 10 Homes



Circuit Bids for 10 Homes

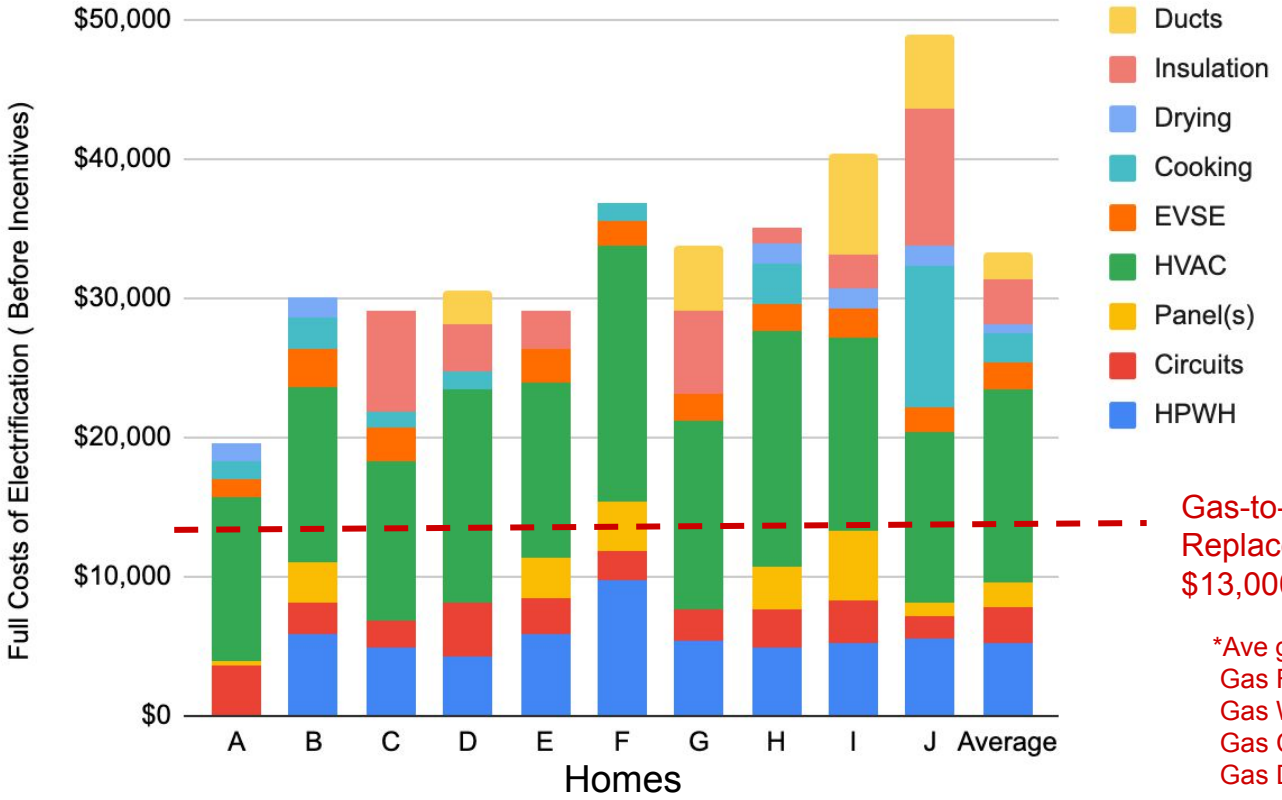


EV Charger Bids for 10 Homes



EV Charger bids included the circuit and a ~$1,000 pauser in most cases

Gross Cost to Decarbonize Home (no solar, no battery)



*Ave gas replacement costs

Gas Furnace /AC	$7,931
Gas Water Heater	$2,779
Gas Cook	$1,500
Gas Dryer	$ 790

Incentives for Electrification

Incentives Available

Incentive Type	Effective Date	Income Restrictions	Caps
Rebate (PCE)	now	none	$3,000 on heat pump water heater $3,500 on heat pump $1,500 on electrical panels
Rebate (BayREN)	now	none	$2,000 for insulation, $800 Ducts $1,250 for heat pump HVAC $750 for induction cooking
Rebate (IRA)*	TBD (could be retroactive to Jan 1, 2023)	50% for family of 2 making < $166k 100% for family of 2 making < $89k 50% for family of 4 making < $208k 100% for family of 4 making < $111k	$14,000 per household (heat pump HVAC $8000, heat pump water heater $1750, circuits $2500, induction cooking $840, weatherization $1600)
Tax Credit (IRA)* (30% of cost, after rebates)	now	Must have taxable income	$2,000 on heat pump/yr $2,000 on water heater/yr $1,200 on insulation/yr $600 on electric panels no cap on solar or batteries

Example: Space Heating and Cooling Cost

Recommended: Mitsubishi 3-ton inverter-driven heat pump HVAC system w/ ducted air handler

Cost to Homeowner:

Fuse HVAC Quote	$13,885
Rebate (PCE)	-$ 3,500
Rebate (BayREN)	-$ 1,250
Rebate (IRA) [2024]	-$ 8,000
Tax Credit (IRA)	-$ 341
Total	$ 794

Gas Furnace Cost: $4,808
With AC: Add $4,800 more = $9,600

Example: Water Heating Cost 2023

Recommended: 65-gallon heat pump WH

Lowest bid:

SunWork.org	$5,182
Rebate (PCE)	-$3,000
Rebate (BayREN)	-$1,000
Rebate (IRA)	
Tax Credit (IRA)	-$ 354
Total	$ 828

Compares to $2,500 for a gas water heater

Example: Water Heating Cost 2024

Recommended: 65-gallon heat pump WH

Lowest bid:

SunWork.org	$5,182
Rebate (PCE)	-$3,000
Rebate (BayREN)	-$1,000
Rebate (IRA)	-$1,182
Tax Credit (IRA)	-$ 0
Total	$ 0

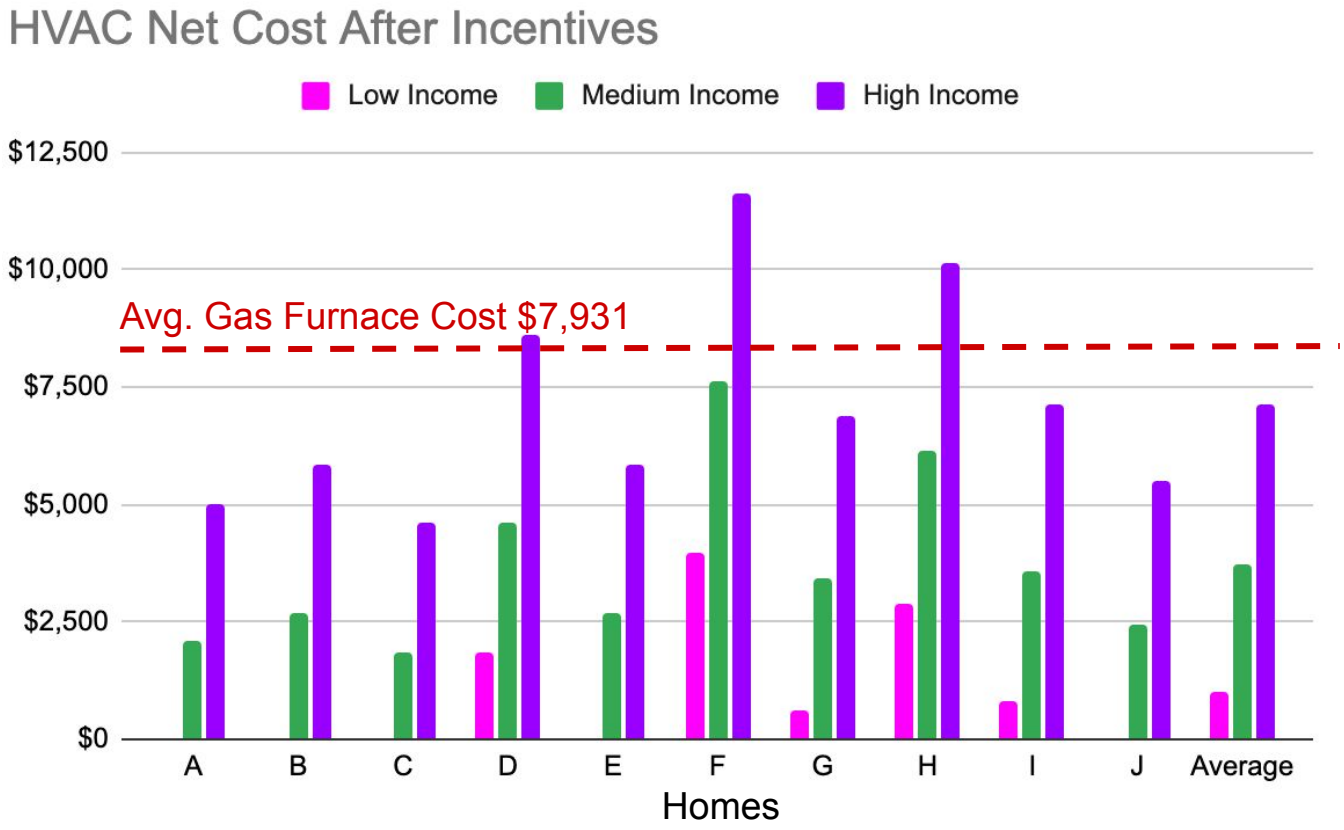
Compares to $2,500 for a gas water heater

Net Cost (w/ Incentives)

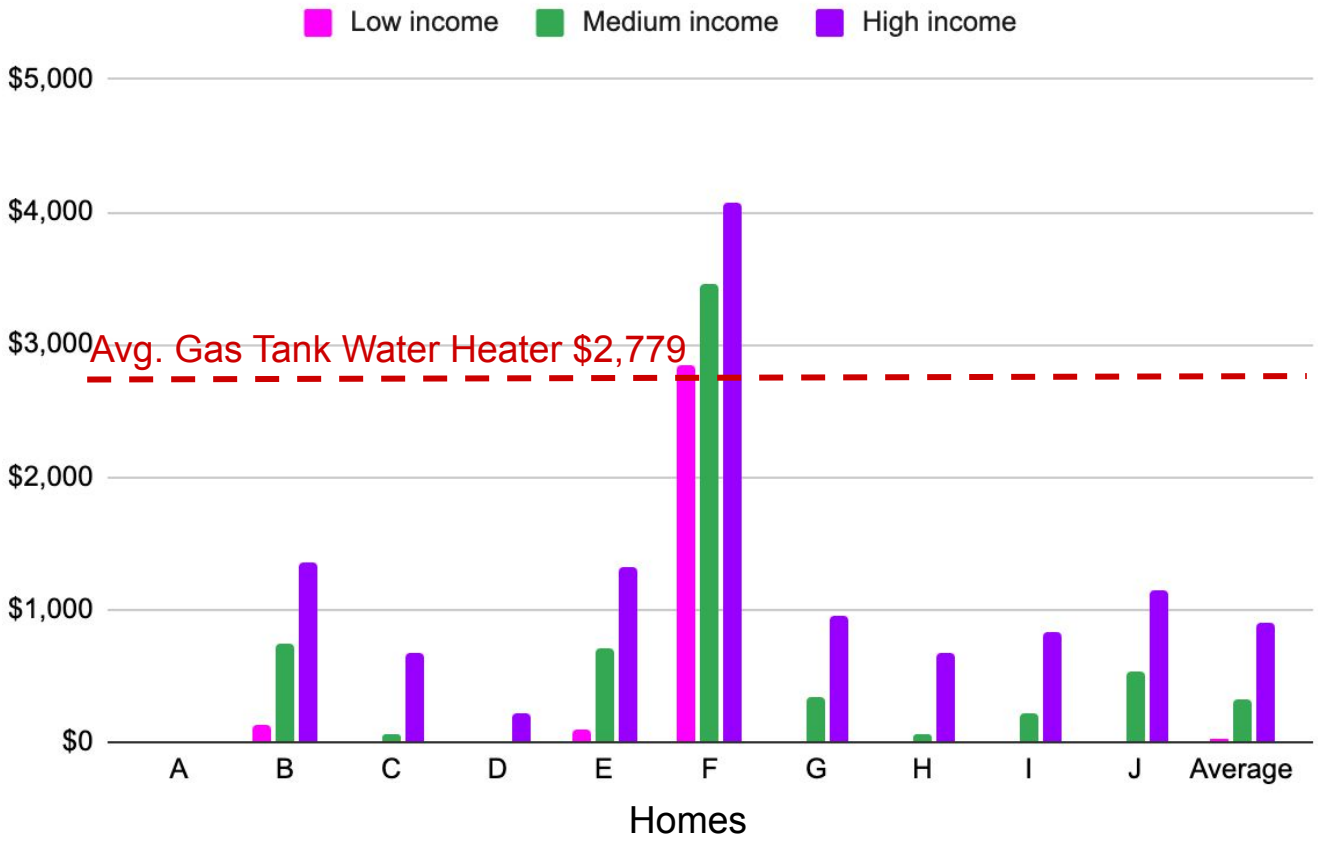
Existing Condition	Proposed Electrification	Trade	Applicable Project	Replace Existing (Gas)	DIY Electric	Low Bid Electric	Mid Bid Electric	High Bid Electric
100-amp main fuse box	100-amp main electrical panel + new subpanel in garage	Electrician	Panel(s)		$2,859	$2,859	$4,767	$7,322
No 240-volt circuits to: water heater, HVAC, range, dryer	4 new 240-volt circuits to: water heater, HVAC compressor, cooktop, dryer	Electrician	Circuits		$625	$625	$4,467	$4,825
40-gallon gas water heater	65-gallon heat pump water heater	Plumber	HP Water Heater	$2,849	$0	$0	$2,727	$3,183
80% efficient centrally ducted gas furnace	36,000 BTU centrally ducted heat pump HVAC system w/ MERV 13 filter	HVAC	HVAC	$7,690	$0	$795	$1,962	$5,609
4-burner 30" gas cooktop	4-burner 30" induction cooktop	Electrician	Range/Cooktop/ Oven	$598	$0	$0	$0	$0
7.5 cu ft gas dryer	7.4 cu ft hybrid heat pump dryer	None	Dryer	$1,079	$254	$254	$254	$254
Insulation: attic - some	Insulation: attic - R38	Insulation	Attic		$178	$0	$104	$722
Insulation: walls - none	Insulation: walls - none	Insulation	Walls		$0	$0	$0	$0
Insulation: floor - none	Insulation: floor - none	Insulation	Floor		$0	$0	$0	$0
Ductwork: fair condition	Ductwork: sealed and insulated	HVAC	Ducts	$5,750	$6,550	$5,750	$5,750	$6,625
No at-home fueling for: 2 gas cars: [15,000 miles/yr]/	At-home fueling for: 2 EVs [15,000 miles/yr]	Electrician	EV Charger		$1,200	$1,200	$2,217	$3,516
SUBTOTAL				**$17,966**	**$11,666**	**$11,483**	**$22,248**	**$32,056**
Rooftop solar PV: none	Rooftop solar PV: 5.8 kW	Solar/Battery	Solar		$8,120	$8,120	$9,683	$12,950
Home battery: none	Home battery: 10 kWh	Solar/Battery	Battery		$8,680	$8,680	$10,272	$12,950
SUBTOTAL					**$16,800**	**$16,800**	**$19,956**	**$25,900**

Net Installation Costs (after incentives)

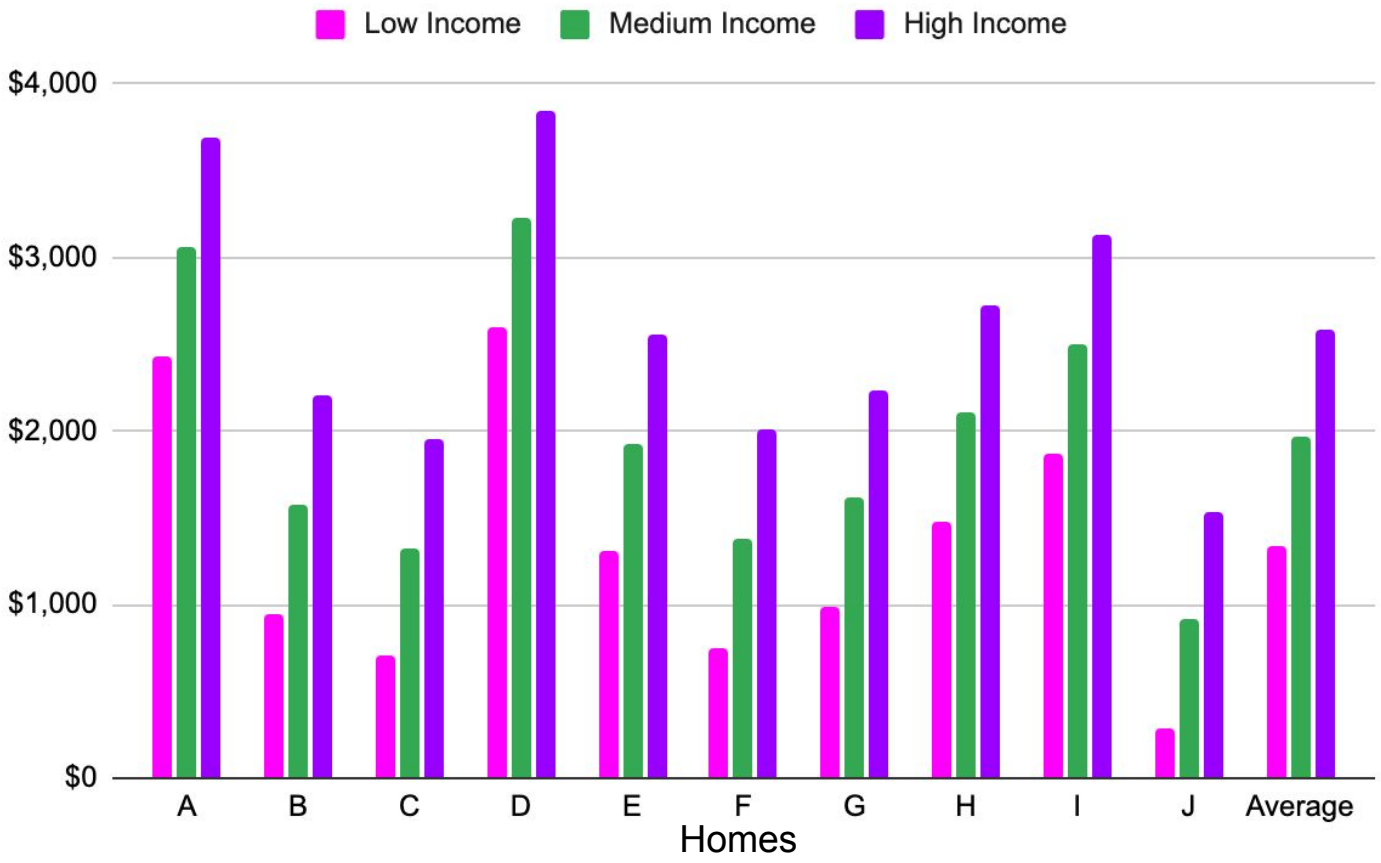
Net Cost for Heat Pump HVAC



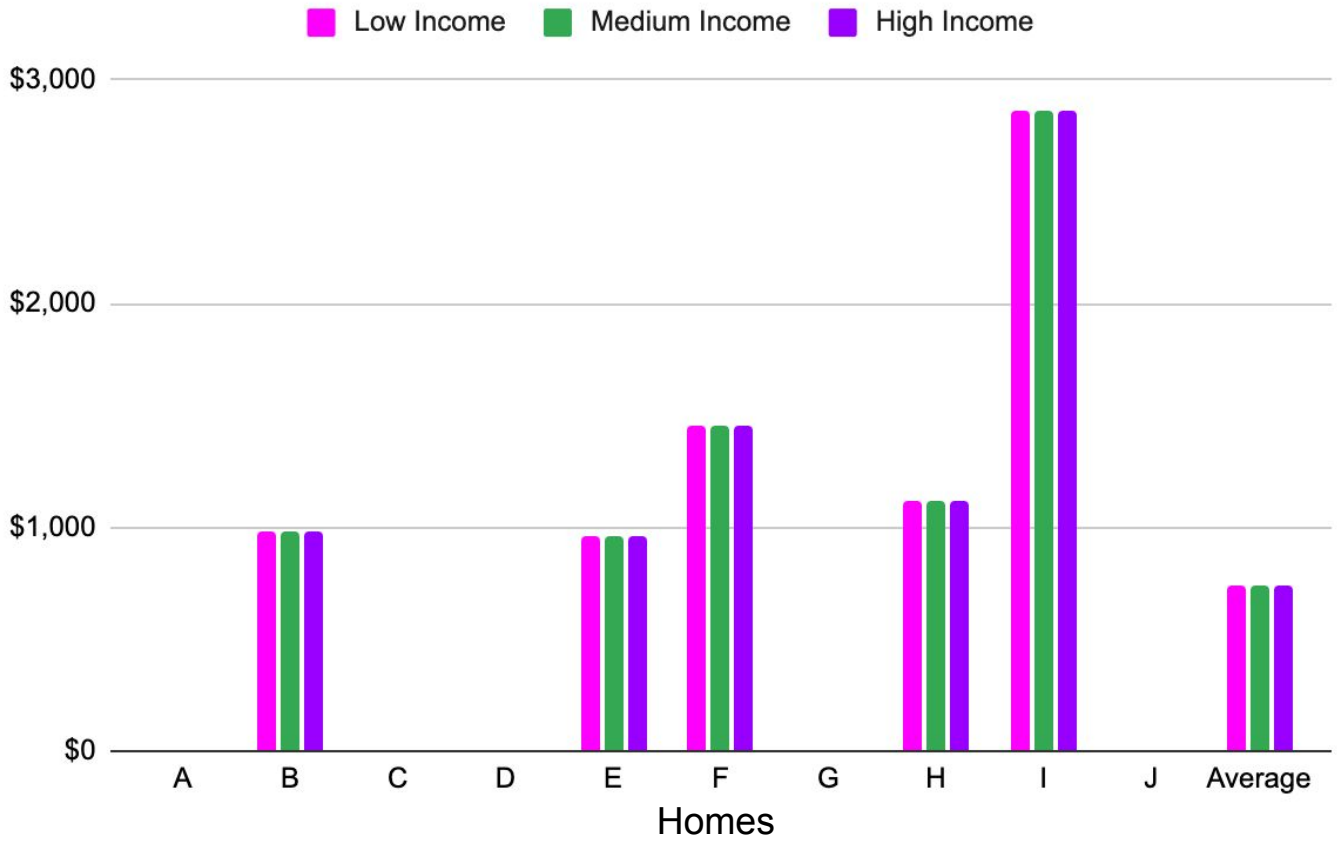
Net Cost for Water Heaters



Net Cost for Circuits



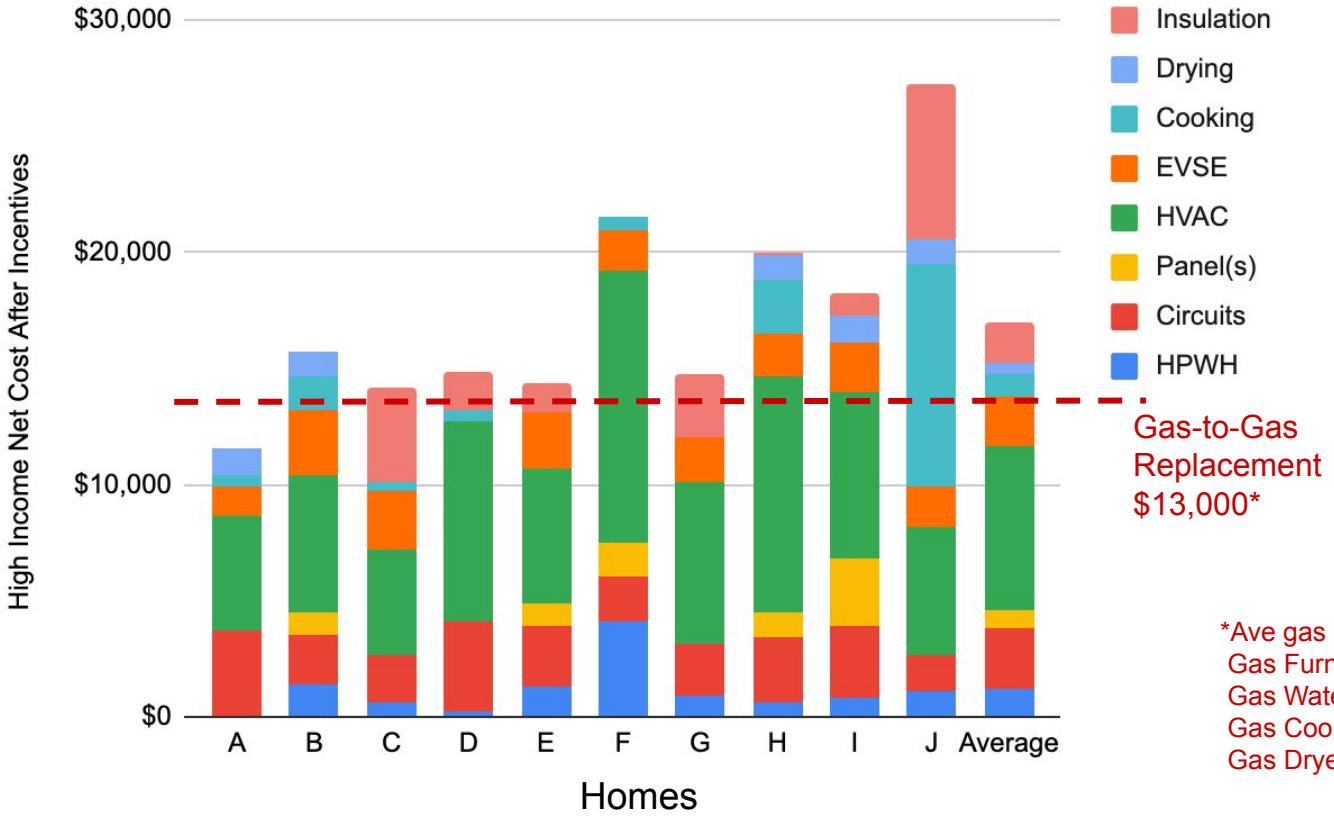
Net Cost for Panel Optimal Work



Net Home Decarbonization Costs (after incentives)

Net costs calculated here are for doing projects in different years.
There are minor tradeoffs of cost savings
vs.
hitting tax credit caps when you do some combined projects per year.

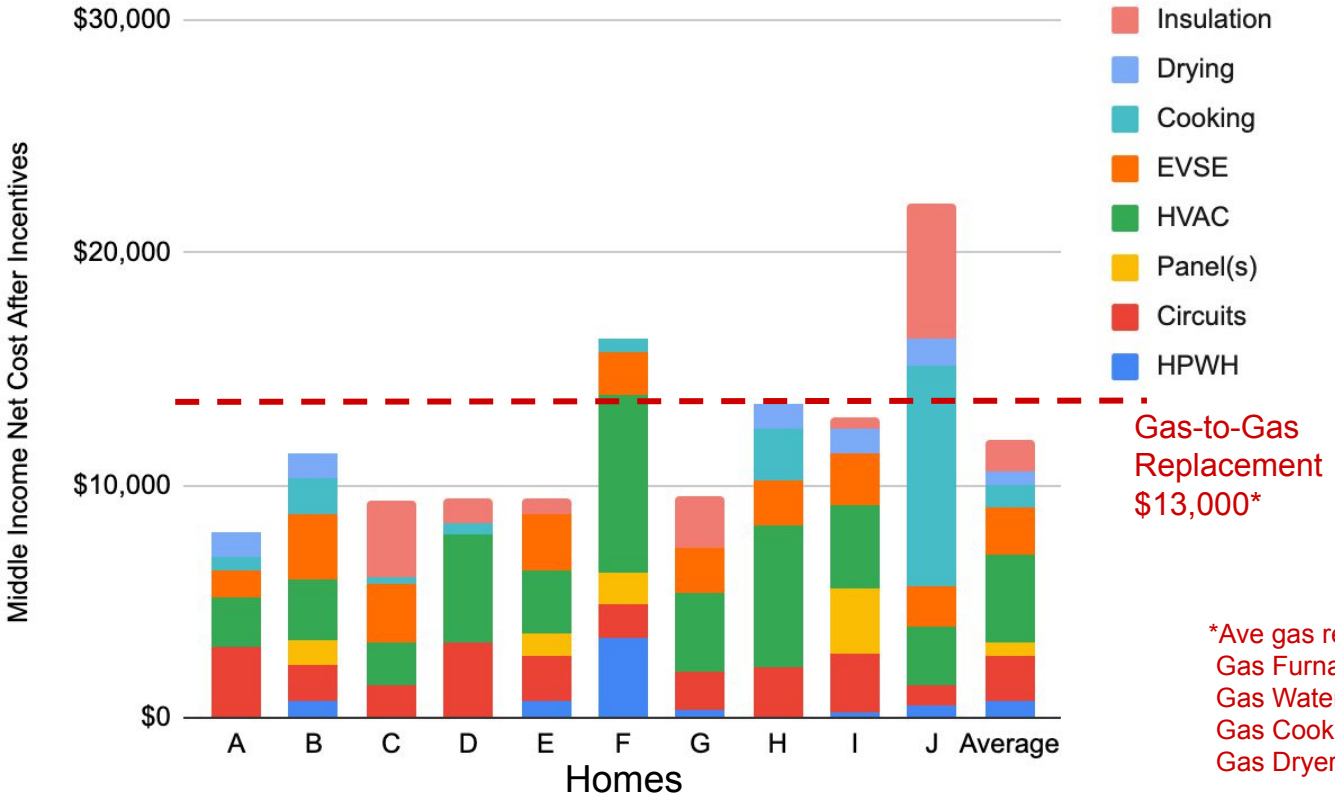
Net Cost to Decarbonize Home (high income, no solar, no battery)



*Ave gas replacement costs

Gas Furnace /AC	$7,931
Gas Water Heater	$2,779
Gas Cook	$1,500
Gas Dryer	$ 790

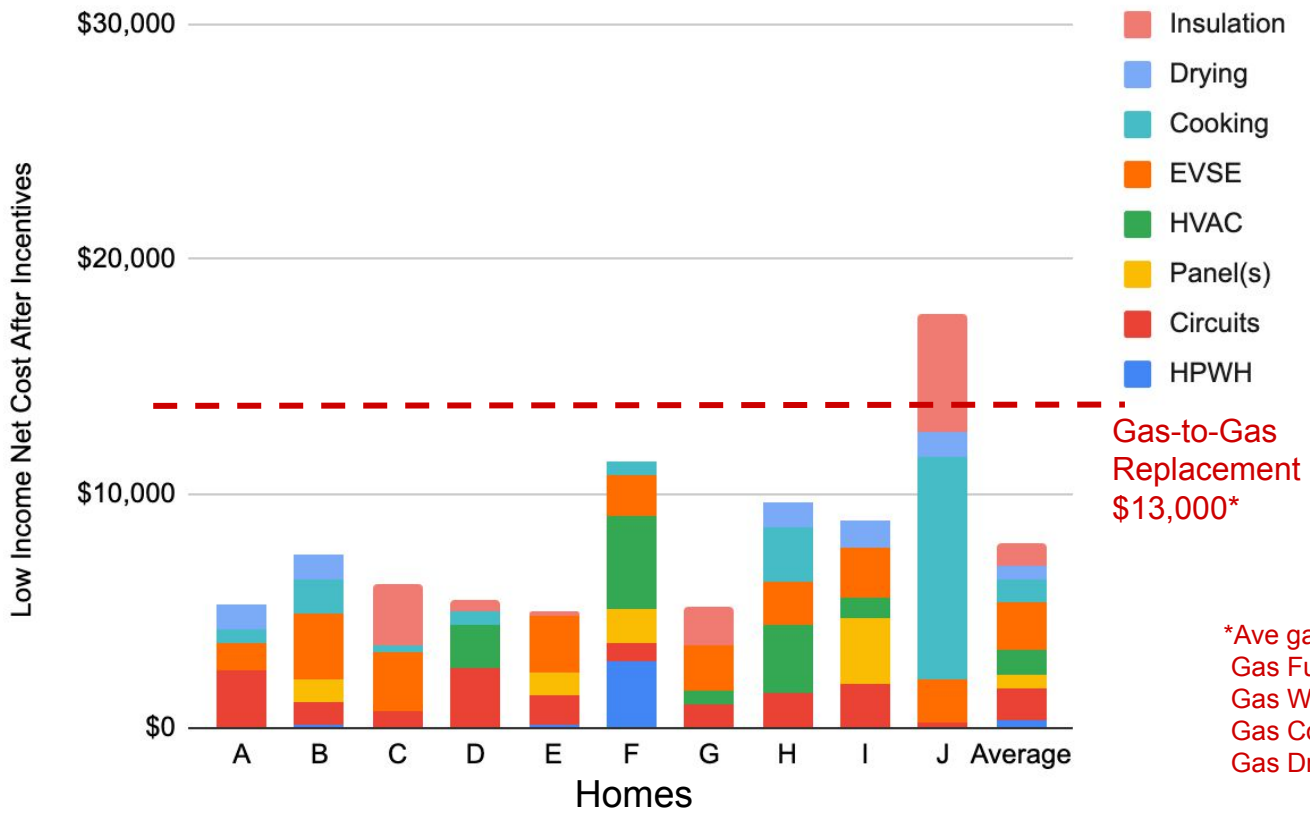
Net Cost to Decarbonize Home (medium income, no solar, no battery)



*Ave gas replacement costs

Gas Furnace /AC	$7,931
Gas Water Heater	$2,779
Gas Cook	$1,500
Gas Dryer	$ 790

Net Cost to Decarbonize Home (low income, no solar, no battery)



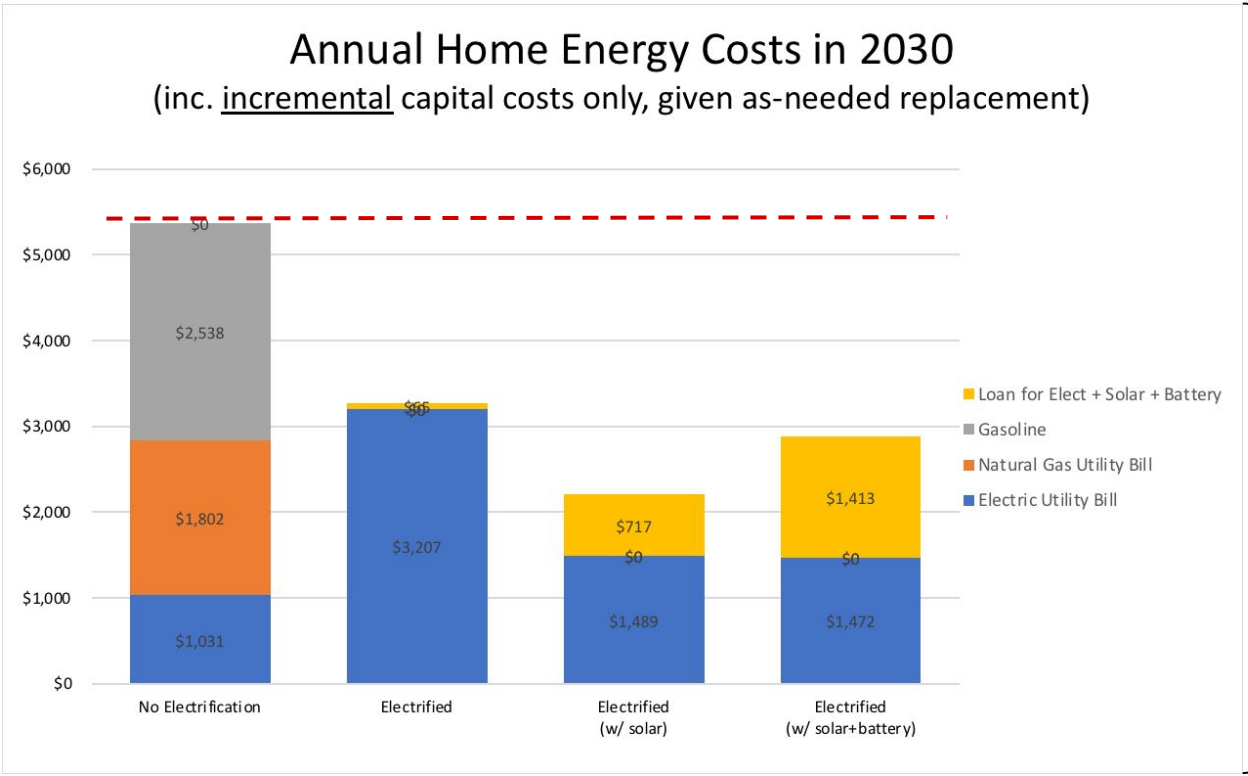
*Ave gas replacement costs

Gas Furnace /AC	$7,931
Gas Water Heater	$2,779
Gas Cook	$1,500
Gas Dryer	$ 790

Questions?

Cash Flow Analysis

What Does it Cost to Electrify?



Includes both capital costs and operating costs

What Does it Cost to Electrify?

Annual Home Energy Costs (Year 10)	No Electrification	Electrified	Electrified (w/ solar)	Electrified (w/ solar +battery)
Electric Utility Bill	$1,031	$3,207	$1,489	$1,472
Natural Gas Utility Bill	$1,802	$0	$0	$0
Gasoline	$2,538	$0	$0	$0
Loan for Elect + Solar + Battery	$0	$65	$717	$1,413
Total	**$5,371**	**$3,272**	**$2,206**	**$2,885**

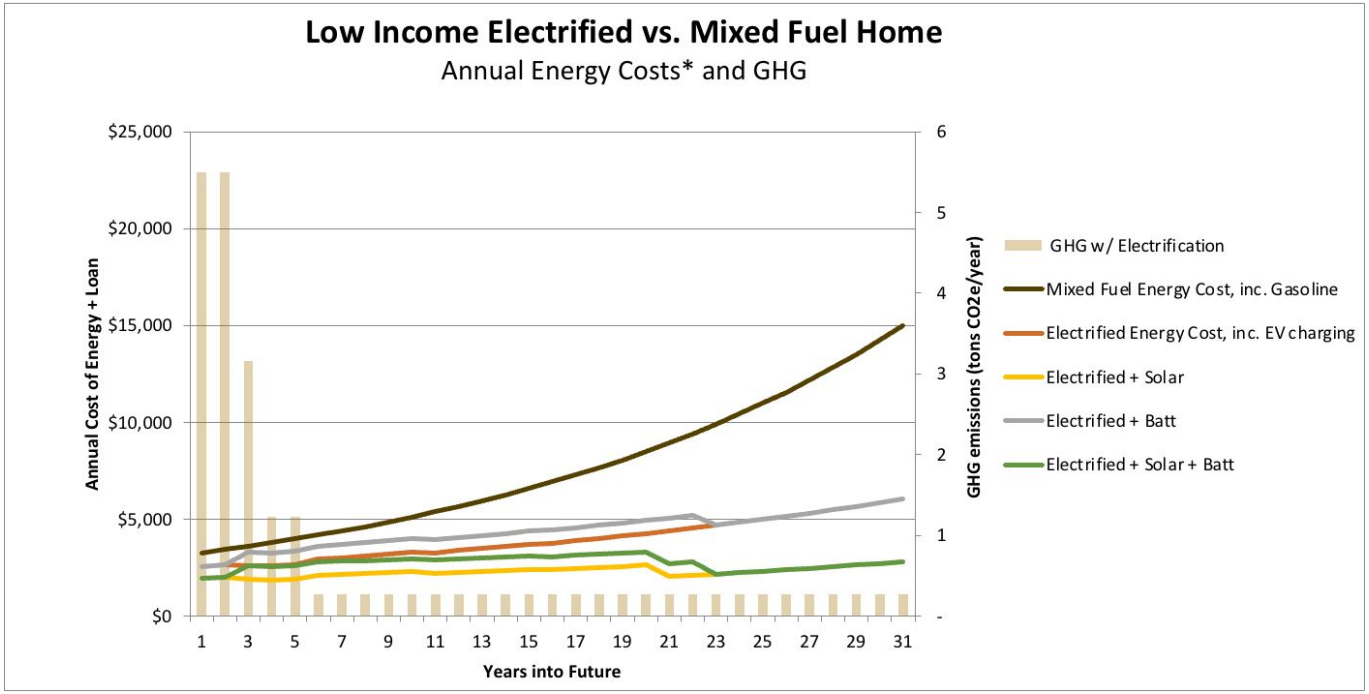
Key Assumptions

- Electrification loan term: 10 yrs
- Electrification loan interest rate: 0%
- Electrification loan max: $10,000
- Solar/battery loan term: 20 yrs
- Solar/battery loan interest rate: 5%
- Market rate loan term: 10 yrs
- Market rate loan interest rate: 6%
- Battery capacity reserved for outages = 30%
- Federal tax credit (for solar, batteries, heat pump water heaters, HVAC) = 30%
- Starting electric rate: PG&E TOU-D
- Ending electric rate: PG&E EV2-A

- 12,000 vehicle miles per year
- Energy cost annual escalation rates*:
  - Natural gas: 6.0%
  - Electricity: 3.2%
  - Gasoline: 5.4%
- Equipment conversion years:
  - EV - yr 0
  - HVAC - yr 3
  - Water heater - yr 2
  - Cooking - yr 5
  - Dryer - yr 5
  - Solar - yr 0
  - Battery - yr 2

*California Public Utilities Commission Report entitled "Utility Costs and Affordability of the Grid of the Future: an Evaluation of Electric Costs, Rates and Equity Issues, Pursuant to P.U. Code Section 913.1", February 2021, p. 73.

Staying on Gas Will be Costly



* Annual energy costs = utility payments + loan payment on incremental capital costs of new equipment

Questions?

POLICIES TO SUPPORT RAPID ELECTRIFICATION

Supportive Policies

- Streamline permit application for electrification
- Make incentives available at point-of-sale
- Mail every home a permit for 120V HPWH in garage, unsolicited
- Eliminate gas appliance rebates immediately
- Extend electrification incentives to panel/grid friendly devices (not upsizing)
  - Inverter driven HPs, CO2 refrigerant machines, panel keeping devices
- Limit Combustion Air Safety (CAS) tests to only when needed (gas lingers, P)
- No longer allow new strandings of gas appliances for existing buildings:
  - Require electric as gas appliances fail or are replaced
  - Require electric during remodels, renovations, additions
- Prohibit sale of one-way heat pumps, a.k.a. air conditioners
- Offer training and incentive programs for new:
  - Electricians
  - HVAC installers
  - Plumbers

System Level Solutions

- Find a way to make electrification plans widely available and easily accessible
- Streamline permitting for electrification and train building officials on relevant code
- Increase labor pool with community college grads trained in HVAC, plumbing, electrical, electrification design
- Encouraging formation of contractor businesses focused on electrification
- Organize bulk buy of equipment and/or services
- Acquire and store rotating stock of power efficient equipment to make available on short notice (e.g. for water heater burnouts)
- Launch a direct-install program with contractors bidding through RFP
- Electrification authority run as JPA

Why Plan? Why Design Programs to Optimize?

- Saves homes $3k-$25k vs. panel upsizing
- Frees up electricians from upsizing (no need for “make work” projects)
- Saves homes Six Months of wait time with PG&E
- Frees up PG&E staff for needed upsizing projects on 60A homes
- Frees up PG&E staff for needed projects on pole top transformers, on feeder line constraints, on substations, etc.
- Avoids T&D supply chain year long delay
- Provides workforce to do more electrification faster on existing infrastructure while we start upgrading central infrastructure
- Can’t meet science based climate goals w/o Plans and optimized loads
- Optimization helps reduce electric rates (by not needing to overbuild distribution) and that makes all-electric bills affordable.

Questions?

FEEDBACK/QUESTIONS

Please Help Us by Taking A Short Survey

Link to Survey: https://forms.gle/BXU6uYugW2jKyMza8

QR Code:

-Who else would this information be good for?

-What next steps would you suggest from here?

-Would you be interested in participating in a focused conversation about how we should move forward?

-What information would you like to hear about that wasn't covered today?

Presenters:

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Tom Kabat
tomgkabat@gmail.com

Thank you!

For More Information Please Visit:

https://www.smcsustainability.org/energy/decarbonizing-homes/

For additional questions please contact:

Alero Moju
amoju@smcgov.org

APPENDIX

Lessons learned on how to do these studies

Try to homogenize the contractor quote costs by making a form they fill out that helps you find additional info (like what is the cost savings from pre-wiring?). Could be online form or spreadsheet form to collect it electronically into database.

Plumber Questions

Ask plumber:

Cost of supplying and installing HPWH **and circuit** $_____ (with permit(s))

Cost of supplying and installing HPWH **without circuit** $_____ (with permit)

Cost of installing HPWH **and circuit** if homeowner supplies water heater $_____ (with permit(s))

Contractors like to grow the job size for economy of scale

General: How do you capture the “Mobilization cost” that is a constant e.g. $400 per job, plus $300 per travel day.

Mobilization cost is built into job estimates, so breaking a big job into more small jobs and more truck rolls adds costs since:

- The small job still has a transaction cost and permit time cost and
- The minimum mobilization time increment may be a whole day

Conversely: How might we help grow the job to cut the total costs.

Electrician Questions for Standard

Ask electrician:

Cost of total project done together $ ____ (with permit)
Cost of total project **without HVAC circuit** $ ____ (with permit)
Cost of **EV circuit and controller** $ ____ (with permit)
Cost of **HPWH circuit** done separately $ ____ (with permit)
Cost of **EV circuit+controller+HPWH circuit** $ ____ (with permit)

HVAC Questions

Ask HVAC:

Cost of total project done together **with a circuit** $ ____ (with permit)

Cost of total project using an **existing HVAC circuit** $ ____ (with permit)

Cost of total project **without special air filter** $ ____ (with permit)

Cost of total project done with **higher HSPF** machine $ ____ (with permit)

(higher HSPF machine's brand model size and model number ?)

_____

What did Josie and Tom gain?

- Developed a ton of expertise in:
  - calculations, codes, contractor methods
  - contractor concerns
- Found what works for electrifying
- Verified the theory of Panel Optimization to meet workforce needs
- Refined techniques of gathering and using information for quick accurate decision making
- Enhanced models and tools

Costs of 4 Ways to Fit on the Electric Panel