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 it 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

Gross Cost of Panel Options

- Optimize (100-200A) Panel
- Smart Panel 100A
- Upsize to 200A

Home has 100A underground service line, best to avoid upsizing w/ panel optimization

Panel Optimization saved on average:
- $3,100 vs. upsize 200A overhead
- $5,300 vs. smart panel 100A
- $25,000 vs. upsize 200A underground

Homes

- A
- B
- C
- D
- E
- F
- G
- H
- I
- J
- Average
Electrification Plan Example

San Bruno Home

Quote Request

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

Please provide finalized 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 wires. | Orange for Electrical, Green for EV, Brown for Dryer

San Bruno Home

Electrical Panel Information
Existing Circuits

<table>
<thead>
<tr>
<th>Circuit Number</th>
<th>Voltage</th>
<th>Breaker</th>
<th>Amps</th>
<th>Type</th>
<th>Splitphase</th>
<th>Notes</th>
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<tbody>
<tr>
<td>1</td>
<td>120</td>
<td>20</td>
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<td>no</td>
<td>&quot;Track lights Holiday Office&quot;</td>
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<tr>
<td>2</td>
<td>120</td>
<td>20</td>
<td>20</td>
<td>Lights and Fuses</td>
<td>no</td>
<td>&quot;Bedroom track lights&quot;</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
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<td>20</td>
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<td>4</td>
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<td>20</td>
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<tr>
<td>5</td>
<td>120</td>
<td>20</td>
<td>20</td>
<td>Lights and Fuses</td>
<td>no</td>
<td>&quot;Bedroom track lights&quot;</td>
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<tr>
<td>6</td>
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<td>Lights and Fuses</td>
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<td></td>
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<tr>
<td>7</td>
<td>120</td>
<td>20</td>
<td>20</td>
<td>Lights and Fuses</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>120</td>
<td>6</td>
<td>25</td>
<td>Fuses</td>
<td>no</td>
<td>Fuse with spring, we think for furnace</td>
</tr>
<tr>
<td>9</td>
<td>240</td>
<td>25</td>
<td>Unknown</td>
<td>&quot;Lights and Appliances&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>240</td>
<td>50</td>
<td>Owen</td>
<td>no</td>
<td>&quot;Labelled &quot;Range&quot; but it's the oven only&quot;</td>
<td></td>
</tr>
</tbody>
</table>

Electrical Load Calculations (Fully Electrified)

<table>
<thead>
<tr>
<th>Name</th>
<th>Voltage</th>
<th>Panel Number</th>
<th>Circuit Number</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lights and Fuses</td>
<td>120</td>
<td>0.07</td>
<td>0</td>
<td>&quot;Track lights Holiday Office&quot;</td>
</tr>
<tr>
<td>Lights and Fuses</td>
<td>120</td>
<td>0.07</td>
<td>0</td>
<td>&quot;Bedroom track lights&quot;</td>
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<td>0.07</td>
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<td>Fuses</td>
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<td>240</td>
<td>0</td>
<td>0</td>
<td>&quot;Lights and Appliances&quot;</td>
</tr>
<tr>
<td>Owen</td>
<td>240</td>
<td>0</td>
<td>0</td>
<td>&quot;Labelled &quot;Range&quot; but it's the oven only&quot;</td>
</tr>
</tbody>
</table>
SAN BRUNO HOME

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

Maximum Service Capacity Used/Unused Over 12 Months

- Not yet electric
- Nearly all-electric

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

All Electric 100 Amp Home (2,000 square feet)
Ducted heat pump, medium power heat pump water heater, hybrid heat pump dryer

<table>
<thead>
<tr>
<th>Device Volts</th>
<th>Device Amps</th>
<th>Amp Panel</th>
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</thead>
<tbody>
<tr>
<td>120</td>
<td>8</td>
<td>Lights/Plug</td>
</tr>
<tr>
<td>120</td>
<td>8</td>
<td>Lights/Plug</td>
</tr>
<tr>
<td>120</td>
<td>8</td>
<td>Lights/Plug</td>
</tr>
<tr>
<td>120</td>
<td>10</td>
<td>Refrigerator</td>
</tr>
<tr>
<td>240</td>
<td>3</td>
<td>Forced Air Unit</td>
</tr>
<tr>
<td>240</td>
<td>20</td>
<td>Heat Pump HVAC</td>
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<tr>
<td>240</td>
<td>20</td>
<td>FV Charger</td>
</tr>
<tr>
<td>240</td>
<td>16</td>
<td>Solar Invert</td>
</tr>
<tr>
<td>240</td>
<td>12</td>
<td>Heat Pump Water Heater</td>
</tr>
</tbody>
</table>

House square footage = 2000
Total Counted Panel Amps = 96.6

Additional House Information
- 40 Amps charger up to 30 miles/hr
- Located in California Climate zone 3 of Peninsual
- Some Insulation
- 180,000 Btu heating and cooling
- 69-Gallon heat pump water heater
- 6-Number induction or standard electric range
- 7.4 cu. ft. hybrid heat pump dryer
- A 20-amp circuit will support a 3.9 KW inverter.
- Home (1,000 square feet) can expect 46amps
- 1-5.7kW solar array depending on rooftop east side
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
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

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

Uses 1/3 the energy of a gas furnace
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
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
San Bruno Home Home
Quote Request

Home Info
- 1700 sq ft
- Single-family detached
- 2-story on hill
- 4 BR 2.5 BA
- Built 1956
- San Bruno, CA

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

<table>
<thead>
<tr>
<th>Project #</th>
<th>Contractor Type</th>
<th>Description</th>
<th>Drawing Color</th>
</tr>
</thead>
</table>
| 1         | Electrician     | Replace 100-amp main fuse box with 100-amp main breaker box. All electrical service removed; if existing service allow, right-size main panel to take advantage of larger existing service wires. Install new 100-amp subpanel in garage. Run new 240-volt circuits from new garage subpanel to locations for circuit panel device and EV charger. Induction cooktop, heat pump water heater, heat pump HVAC compressor and heat pump dryer. Install new induction cooktop, circuit panel device and EV charger. Equipment:
- Circuit Breaker: 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: CFI3026TB (rated 30 amps/240 volts), hybrid heat pump dryer like Whirlpool 7.4 cu ft Hybrid Heat Pump Dryer. | Orange for Electrical Green for EV Brown for Dryer |

Electrical Panel Information
Existing Circuits
Main Panel, rated amps: 100

<table>
<thead>
<tr>
<th>Circuit Number</th>
<th>Voltage</th>
<th>Breaker Amps</th>
<th>Type</th>
<th>Splice Box</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>120</td>
<td>25</td>
<td>Lights and Plugs</td>
<td>no</td>
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<td>8</td>
<td>120</td>
<td>6</td>
<td>Furnace</td>
<td>no</td>
<td>&quot;To have, we think for furnace&quot;</td>
</tr>
<tr>
<td>9</td>
<td>240</td>
<td>25</td>
<td>Unknown</td>
<td>no</td>
<td>&quot;Lights and appliances&quot;</td>
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<tr>
<td>10</td>
<td>240</td>
<td>50</td>
<td>Oven</td>
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<tr>
<td>Lights and Plays</td>
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<td>8.07</td>
<td>0</td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
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<td>240</td>
<td>0</td>
<td>0</td>
<td>9</td>
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<td>Oven</td>
<td>240</td>
<td>14</td>
<td>0</td>
<td>10</td>
<td>&quot;Labelled &quot;Range&quot; but it's the oven only&quot;</td>
</tr>
</tbody>
</table>
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

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

Annual Home Energy Costs in 2030
(incl. incremental capital costs only, given as-needed replacement)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Gasoline</th>
<th>Natural Gas Utility Bill</th>
<th>Electric Utility Bill</th>
<th>Loan for Elect + Solar + Battery</th>
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</thead>
<tbody>
<tr>
<td>No Electrification</td>
<td>$1,031</td>
<td>$1,802</td>
<td>$3,207</td>
<td>$2,538</td>
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<tr>
<td>Electrified</td>
<td>$1,489</td>
<td>$717</td>
<td>$3,176</td>
<td>$6</td>
</tr>
<tr>
<td>Electrified (w/ solar)</td>
<td>$1,472</td>
<td>$717</td>
<td>$3,176</td>
<td>$6</td>
</tr>
<tr>
<td>Electrified (w/ solar+battery)</td>
<td>$1,413</td>
<td>$717</td>
<td>$3,176</td>
<td>$6</td>
</tr>
</tbody>
</table>

Includes both capital costs and operating costs.
Actual costs will be much cheaper!

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

$40,000

$30,000

$20,000

$10,000

$0

A B C D E F G H I J Average

HVAC Low Bid  HVAC Med Bid  HVAC High Bid

Homes
HPWH Bids for 10 Homes

Heat Pump Water Heater

- HPWH Low Bid
- HPWH Med Bid
- HPWH High Bid

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<th>J</th>
<th>Average</th>
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<td>$2,500</td>
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<td></td>
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<tr>
<td>$5,000</td>
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<tr>
<td>$7,500</td>
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<tr>
<td>$10,000</td>
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<tr>
<td>$12,500</td>
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<td></td>
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</tr>
</tbody>
</table>
Electrical Panel Bids for 10 Homes

Contractor bid panel upsize based on wrong info from building dept.
Circuit Bids for 10 Homes

- **Circuits Low Bid**
- **Circuits Med Bid**
- **Circuits High Bid**

The graph shows the distribution of bids for 10 homes, with bids ranging from $0 to $10,000. Each home is represented by a bar, with colors indicating the bid category. The average bid for all homes is also shown.
EV Charger bids included the circuit and a ~$1,000 pauser in most cases.
**Gross Cost to Decarbonize Home**
(no solar, no battery)

*Average 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

<table>
<thead>
<tr>
<th>Incentive Type</th>
<th>Effective Date</th>
<th>Income Restrictions</th>
<th>Caps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rebate (PCE)</td>
<td>now</td>
<td>none</td>
<td>$3,000 on heat pump water heater $3,500 on heat pump $1,500 on electrical panels</td>
</tr>
<tr>
<td>Rebate (BayREN)</td>
<td>now</td>
<td>none</td>
<td>$2,000 for insulation, $800 Ducts $1,250 for heat pump HVAC $750 for induction cooking</td>
</tr>
<tr>
<td>Rebate (IRA)*</td>
<td>TBD (could be retroactive to Jan 1, 2023)</td>
<td>50% for family of 2 making &lt; $166k 100% for family of 2 making &lt; $89k 50% for family of 4 making &lt; $208k 100% for family of 4 making &lt; $111k</td>
<td>$14,000 per household (heat pump HVAC $8000, heat pump water heater $1750, circuits $2500, induction cooking $840, weatherization $1600)</td>
</tr>
<tr>
<td>Tax Credit (IRA)*</td>
<td>now</td>
<td>Must have taxable income</td>
<td>$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</td>
</tr>
</tbody>
</table>
Example: Space Heating and Cooling Cost

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

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

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

Compared 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)

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

Avg. Gas Furnace Cost $7,931

Homes
Net Cost for Water Heaters

Avg. Gas Tank Water Heater $2,779
Net Cost for Circuits

Homes

Low Income  Medium Income  High Income

$4,000

$3,000

$2,000

$1,000

$0

A  B  C  D  E  F  G  H  I  J  Average
Net Cost for Panel Optimal Work

- Low Income
- Medium Income
- High Income

Homes

- A
- B
- C
- D
- E
- F
- G
- H
- I
- J
- Average

Costs:
- $3,000
- $2,000
- $1,000
- $0
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)

$13,000*

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

*Average gas replacement costs

Ave gas replacement cost $13,000*
Net Cost to Decarbonize Home (medium income, no solar, no battery)

Gas-to-Gas Replacement $13,000*

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Furnace /AC</td>
<td>$7,931</td>
</tr>
<tr>
<td>Gas Water Heater</td>
<td>$2,779</td>
</tr>
<tr>
<td>Gas Cook</td>
<td>$1,500</td>
</tr>
<tr>
<td>Gas Dryer</td>
<td>$790</td>
</tr>
</tbody>
</table>

*Ave gas replacement costs

*Insulation
* Drying
* Cooking
* EVSE
* HVAC
* Panel(s)
* Circuits
* HPWH

Homes A, B, C, D, E, F, G, H, I, J, Average
Net Cost to Decarbonize Home (low income, no solar, no battery)

$13,000*

Gas-to-Gas Replacement

Insulation
Drying
Cooking
EVSE
HVAC
Panel(s)
Circuits
HPWH

* Ave gas replacement costs
Gas Furnace /AC $7,931
Gas Water Heater $2,779
Gas Cook $1,500
Gas Dryer $790

Homes
A  B  C  D  E  F  G  H  I  J  Average
Questions?
Cash Flow Analysis
What Does it Cost to Electrify?

Annual Home Energy Costs in 2030
(incl. incremental capital costs only, given as-needed replacement)

<table>
<thead>
<tr>
<th>Plan</th>
<th>Loan for Elect + Solar + Battery</th>
<th>Gasoline</th>
<th>Natural Gas Utility Bill</th>
<th>Electric Utility Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Electrification</td>
<td>$2,538</td>
<td>$0</td>
<td>$1,802</td>
<td>$1,031</td>
</tr>
<tr>
<td>Electrified</td>
<td>$3,207</td>
<td>$0</td>
<td>$1,489</td>
<td>$1,472</td>
</tr>
<tr>
<td>Electrified (w/ solar)</td>
<td>$1,717</td>
<td>$0</td>
<td>$1,489</td>
<td>$1,472</td>
</tr>
<tr>
<td>Electrified (w/ solar+battery)</td>
<td>$1,413</td>
<td>$0</td>
<td>$1,489</td>
<td>$1,472</td>
</tr>
</tbody>
</table>

Includes both capital costs and operating costs.
What Does it Cost to Electrify?

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

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 remolds, 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/BXU6uYuqW2jKyMza8

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:

Josie Gaillard
josie_gaillard@icloud.com

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

16 Combinations Data Points of: Home (Letter) and Electrician (Number)