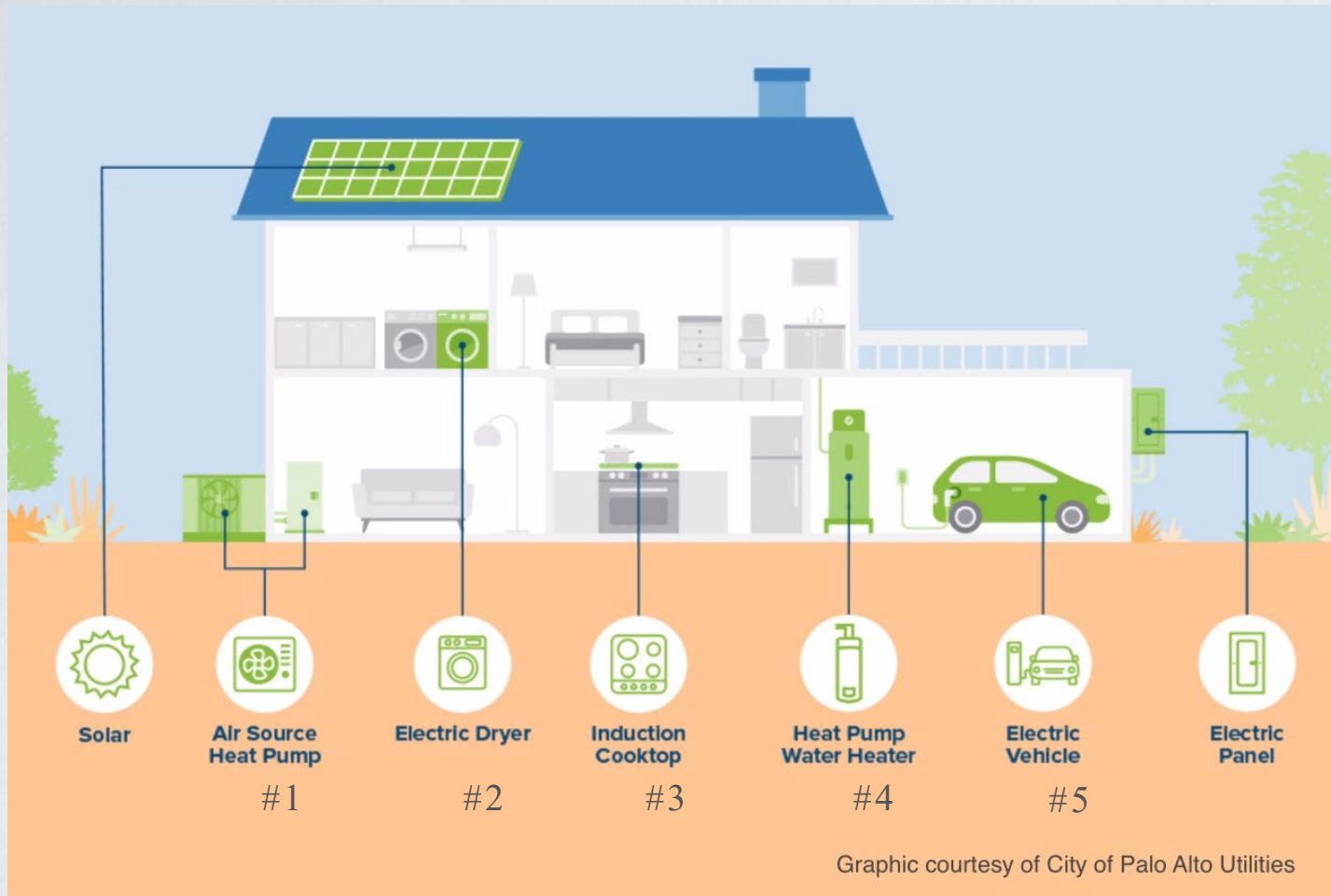


Building Electrification Case Studies: Notes from the Field

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WHAT IS BUILDING ELECTRIFICATION?



Replacing all fossil fuel appliances in the building:

- #1 gas furnace
- #2 gas dryer
- #3 gas range
- #4 gas water heater
- #5 gasoline for car

...with high efficiency electric alternatives

- Rooftop solar (at \$0.05–0.10 per kWh) makes all-electric home conversions affordable
- Battery backup systems make all-electric homes reliable during grid outages

STUDY 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?

TEN HOMES SELECTED FOR STUDY

Key selection criteria:

- 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



STEPS IN COUNTY STUDY

- On-line survey(s) - 78 homeowners applied
- Intro call - 45 mins
- Site visit - 2 hours
- Develop contractor bid packet
- Solicit bids from contractors
- Review bids and run financial projections
- Present plan w/ costs to homeowner
- Write up case study

WOLF HOME

Location: Redwood City,
CA

Square footage: 1,900

Occupants: 4

Main panel size: 100 amps

Vintage: 1960's



“AMP DIET” for 2,000 sq ft home

- For homes with 100 amp electrical panels
- Helps avoid ~\$3,000 electric panel upgrade
- Favors efficient devices w/ low rated amps
- Provides roadmap for building owner
- Helps guide tradespeople

Example 1

All Electric 100 Amp Home (2,000 square feet)

Ducted heat pump, medium power heat pump water heater, hybrid heat pump dryer

Device Volts	Device Amps	100 Amp Panel		Device Amps	Device Volts
120	8	Lights/Plug 15	Lights/Plug 15	8	120
120	8	Lights/Plug 15	Lights/Plug 15	8	120
120	8	Lights/Plug 15	Lights/Plug 15	8	120
120	10	Garbage Disposal 20	Kitchen Outlets 20	15	120
120	7	Refrigerator 20	Kitchen Outlets 20	15	120
240	3	Forced Air Unit 15	Dishwasher 20	12	120
			Clothes Washer 20	15	120
240	20	Heat Pump HVAC 30	Hybrid Heat Pump Dryer 20	14	240
240	20	EV Charger 25	Range (cooktop +oven) 50	40	240
240	16	Solar Input 20	Heat Pump Water Heater 20	12	240

House square footage = 2000

Total Counted Panel Amps = 96.6

Additional House Information

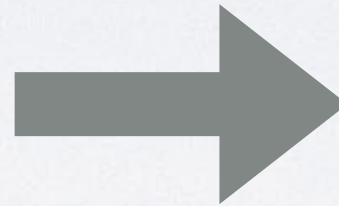
- 4 occupants
- EV charging up to 19 miles/hr
- Located in California climate zone 3 (SF Peninsula)
- Some insulation
- 38,000 Btuh heating and cooling
- 60-80 gallon heat pump water heater
- 4-burner induction or standard electric range
- 7.4 cu. foot hybrid heat pump dryer
- A 20-amp circuit will support a 3.8 kW inverter. (Many 3.8 kW inverters can support roughly a 4.6 - 5.9 kW solar array depending on inverter load ratio)

Diagram creation and design by Josie Gallard and Courtney Beyer

WATER HEATER



Today: 50-gallon gas tank WH in garage



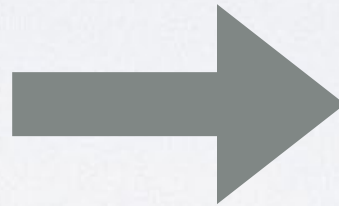
Unmatched Savings & So Much More

Get the Rheem Hybrid Electric Water Heater today and enjoy years of energy-saving and worry-free hot water.

- ✓ **Save Money & Energy**
Save up to \$480 per year in energy costs—that's almost \$5,000 over 10 years!
- ✓ Energy Saving Scheduling
- ✓ Set Vacation or Away Mode
- ✓ Demand Response Scheduling
- ✓ LeakGuard™ Auto Water Shut-off Valve
- ✓ Built-in EcoNet WiFi Technology
- ✓ Carbon Footprint Reduction
- ✓ Heat Pump Technology
- ✓ Energy Use Tracking
- ✓ Operation Modes and Scheduling
- ✓ Advanced Diagnostics

Recommended: 80-gallon, 15-amp heat pump tank WH in garage

SPACE HEATING/COOLING



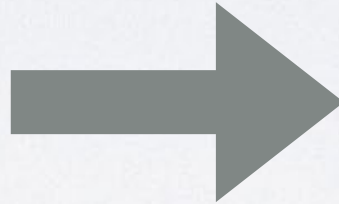
Today: A/C + Bryant gas furnace

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

COOKING



Today: 48" gas Jenn-Air range

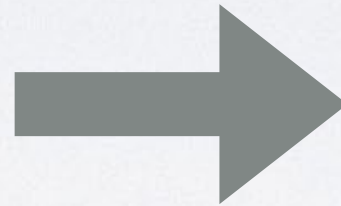


Recommended: 48" AGA induction range

CLOTHES DRYING



Today: Samsung 7.5 cu ft resistance electric dryer **22.5-amps** / 240 volts



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

EV CHARGING



Recommended: NEMA 14-30 outlet with 30-amp / 240-volt circuit for outside of garage

SOLAR + BATTERY



Recommended: 5.8 kW rooftop solar system + 20 kWh battery system

BUILDING SHELL IMPROVEMENTS



Today: Attic, R-19 insulation
Recommend: R-38

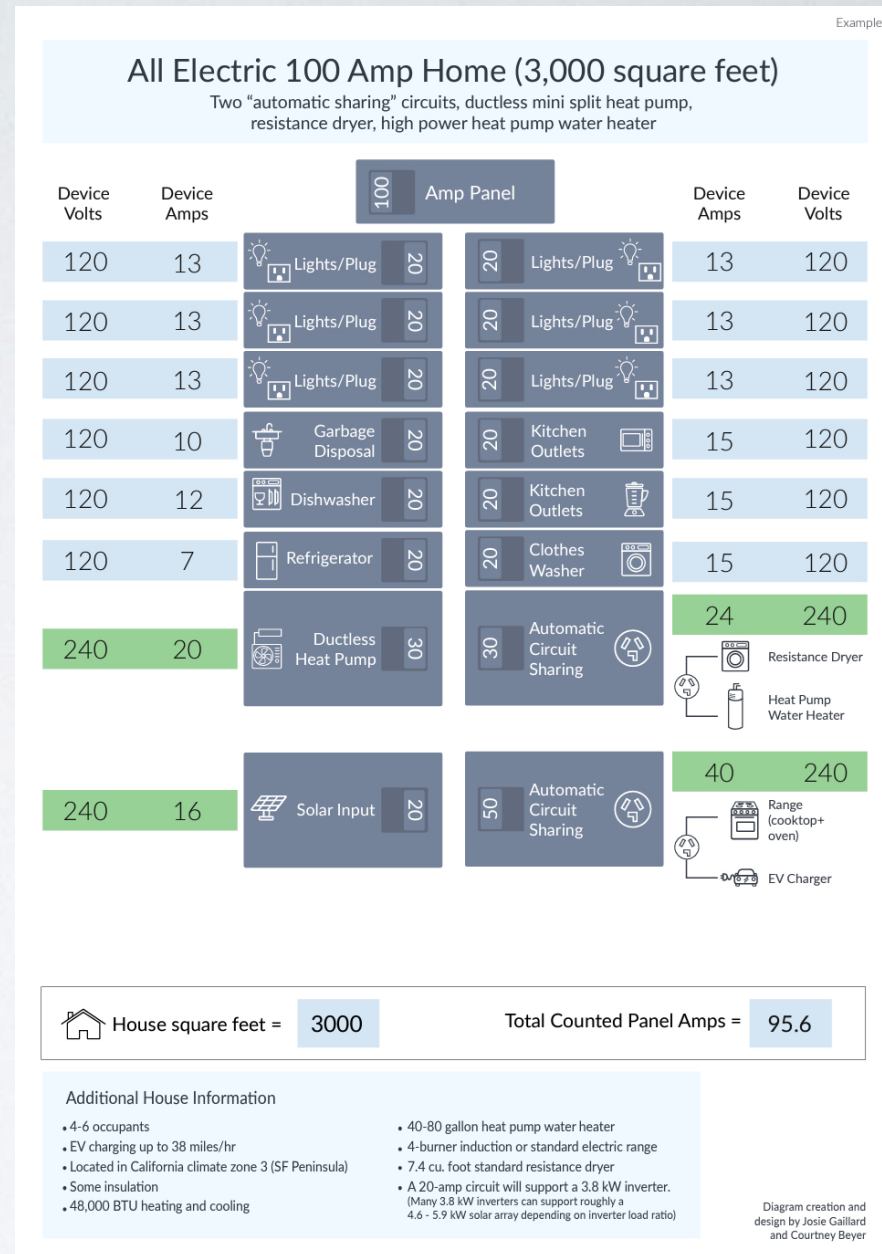


Today: Crawlspace, no insulation, poorly insulated ducts
Recommend: R-19 or R-30 for floors, repair ducts

“AMP DIET” for 3,000 sq ft home

- For homes with 100 amp electrical panels
- Uses “circuit sharing” devices like plug-in smart splitter *Neocharge* or hard-wired version *SimpleSwitch*
- Still easy to avoid ~\$3,000 electric panel upgrade

Example 2



CONTRACTOR BID PACKET

Quote Request

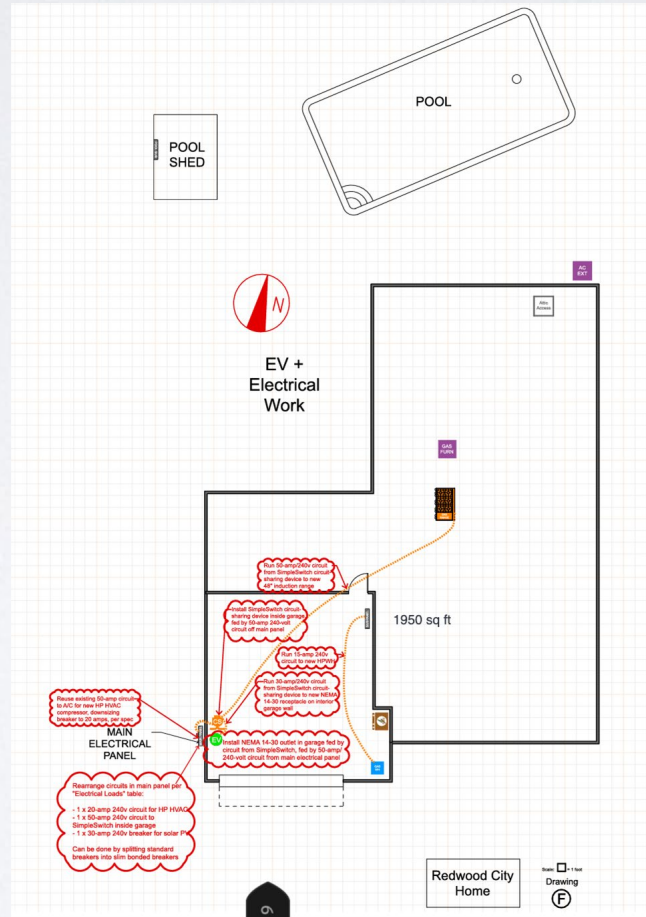
Please provide notional quotes ($\pm 10\%$ of expected cost) for the following work.

Home Background Info

Single-family, detached
1,900 sq ft
1-story
Built 1966
Redwood City Emerald Hills

Please provide separate estimates for each project and a discount estimate if the electrification projects were all combined together. Please separate the \$ quotes into separate cost categories of equipment, labor, permit labor

Work Type	Work Description	Price
1) HPWH	<p>Replace existing gas-fired 50-gallon tank water heater with new 15-amp electric HPWH in same location about 25 feet from sub panel in unconditioned garage workspace. (WH location is protected from car driving area.)</p> <p>Code minimum sizing for 4 BR 2 BA home is 62 gallons of first hour rating.</p> <p>To preserve Amps for future pool equipment, JT suggest 15-amp water heater similar to Rheem or Ruud 65-gallon or 80-gallon models or Stiebel Eltron tank models.</p> <p>Also please quote an alternative 80-gallon 120-volt retrofit ready HPWH if information can be found for it.</p> <p>Price an option for adding a mixing valve (for enhancing the ability to deliver more gallons of 120°F water from any storage tank operated at a higher temperature).</p> <p>Please price labor, permits and materials separately.</p> <p>Also please price a discount if electrification projects are combined.</p> <p>See Drawing B for details</p> <p>Contractor reply including prices:</p>	



Wolf Home

Redwood City Emerald Hills, 94062
Main panel size: 100 amps
Square footage: 1900

Electrical Panel Information

Circuits

Main Panel, rated amps: 100

Circuit Number	Voltage	Breaker Amps	Type	Splittable?	Notes
1 + 2	240	100	Subpanel	yes	Subpanel in garage serving most indoor loads
3 + 4	240	50	Air Conditioner	yes	Breaker can be reduced to 20 amps and circuit repurposed for heat pump
5	120	15	Unknown	yes	Assuming no load on this circuit, other than lights and plugs
6	120	20	Unknown	yes	Assuming no load on this circuit, other than lights and plugs
7 + 8	240	30	Subpanel	yes	Subpanel serving pool equipment

Subpanel 1, rated amps: 100

Circuit Number	Voltage	Breaker Amps	Type	Splittable?	Notes
1	120	20	Clothes Washer	no	Washer
3	120	20	Lights and Plugs	no	Lites + Plugs
5	120	20	Lights and Plugs	no	Lites + Plugs
7	120	20	Lights and Plugs	no	Lites + Plugs
9	120	20	Dishwasher	no	Disposal and Dishwasher
11	120	20	Lights and Plugs	no	Lites + Plugs
13	120	20	Lights and Plugs	no	Lites + Plugs
15	120	20	Lights and Plugs	no	Whole House Fan
17	120	20	Lights and Plugs	no	Dining Room Plugs
19	120	20	Kitchen Outlets	no	Kitchen Plugs
21	120	20	Microwave	no	Microwave Oven, microwave is built-in model, 1550 watts/120v
23	120	20	Unknown	no	
2 + 8	240	30	Clothes Dryer	no	Dryer
4 + 6	240	30	Oven	no	Oven 1, part of range
10 + 16	240	20	Oven	no	Oven 2, part of range
12 + 14	240	20	Griddle	no	BBQ but we think it now serves a griddle on the range
18	120	20	Lights and Plugs	no	Plug under pool, side yard light, house fan
20	120	20	Lights and Plugs	no	?
22	120	20	Garage Outlets	no	Garage refrigerator + freezer

WHAT WE LEFT OUT...FOR NOW



400,000-BTU gas pool heater



gas fireplace

TYPICAL SITE VISIT

- 2 hours long
- Replaces visits by 6+ different contractors
- 1 hour spent outside:
 - site sketch
 - building and window dimensions
 - electrical panel, potential HVAC sites
 - potential battery sites
 - rooftop solar potential
 - viewing crawlspace for insulation condition, key measurements duct condition and accessibility assessment
- 1 hour spent inside:
 - viewing key appliances to replace
 - recording energy ratings for other major electrical loads
 - viewing attic for insulation condition, key measurements, duct condition and accessibility assessment

KEY LEARNINGS...SO FAR

- Most any home can be fully electrified without upsizing the electrical panel
- A plan helps the homeowner "defend the electrical panel"
- A few key product choices make electrification really easy (and are gentle on the grid):
 - 15-amp heat pump water heaters
 - 17-amp inverter-driven heat pump HVAC systems that are super quiet
 - Centrally ducted heat pump air handlers
 - NEMA 6-15 or 6-20 outlets for EV charging...AVOID 50-amp EV chargers
 - Circuit-sharing devices like Neocharge and SimpleSwitch
 - Split water heaters are great solution for water heaters in tight spaces (e.g. interior closets)
 - Heat pump dryers

KEY LEARNINGS...SO FAR (CONT)

- You can electrify your pool heat or keep your 100-amp panel, but you can't do both
- Heating a pool for a home with a 100-amp panel will likely force a panel upside...but don't over do it, another 50 amps of panel capacity is plenty
- Upsize the water heater when going from gas to heat pump, for homeowner satisfaction
- Old resistance dryers are energy hogs (e.g. 26 amps), use more power than a 3-ton inverter-drive heat pump HVAC system (17 amps) which can easily heat an entire house
- Insulation is just one tool in the electrification/decarbonization tool kit
- Electrification is not rocket science, but you can be steered down bad paths by contractors
- We need more contractors who understand amp diets and want to sell heat pumps
- There is no shortage of ways to electrify a home on its existing electrical panel

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