A Progress Pride Flag of Induction: Elmira, Big Chill, AGA, Ilve, Thor, AGA, Bertazonnis, Magic Chef, Viking and Ilve

Invisacook's countertop induction; David Kaneda's countertop wok; Ninja's family size air fryer.

A Pocket Guide to Home Electrification in the Bay Area

Hosanna's battery heated vest in SF; Prince funded Oakland solar incubator Powerhouse; Berkeley wins the 1st gas ban.

Karen Harrington's Hydronic Harvest; Wei-Tai Kwok's DIY heat pump; Sean Armstrong's Combo W/D; Safe induction.

Contents

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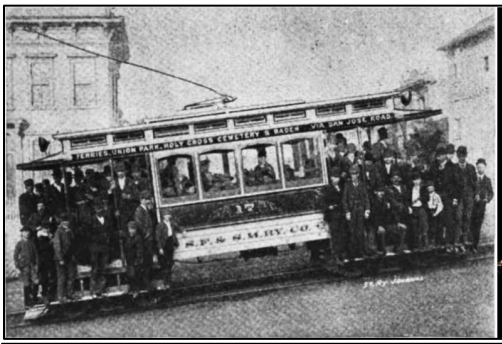
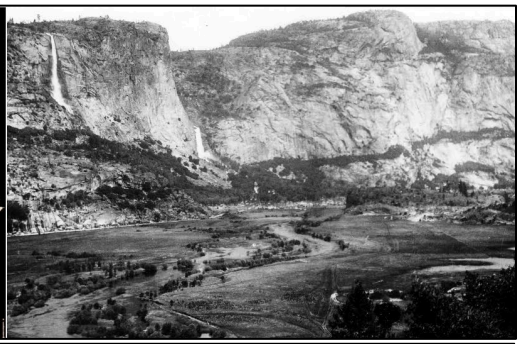
Chapter 1: Introduction



Following the deadly wildfires in nearby Santa Rosa and Paradise, in 2019 the East Bay Electrification Exposition audience considers a proposal to ban gas plumbing in new construction to address climate change. Berkeley's gas ban in August of 2019 was followed by another California city every 2 weeks for almost 2 years and was joined by other states, changing policies at California utilities, state agencies and the federal government. (Paradise fire photo credit: Josh Edelson AFP/Getty. Berkeley City Council photo credit: Emilie Raguso)

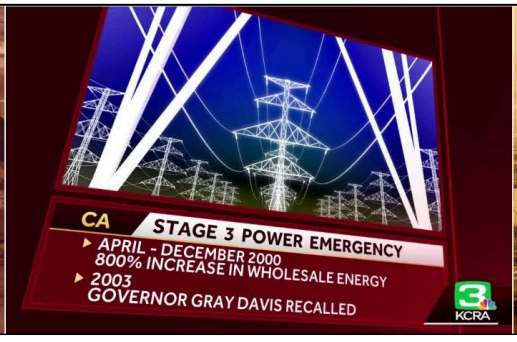
Did you know that San Francisco had the world's first power plant? It was built in 1879 to power 22 street lamps, and just 15 years later San Francisco was showing off the spectacular 266 foot San Francisco Electric Tower, modeled after France's just-completed Eiffel Tower in what has become Golden Gate Park. The Electric Tower produced a beam so bright it was said a person could read a newspaper at night 10 miles distant. Electricity came first to San Francisco street lights in 1879, then street trolleys in 1892, and finally houses in 1902.





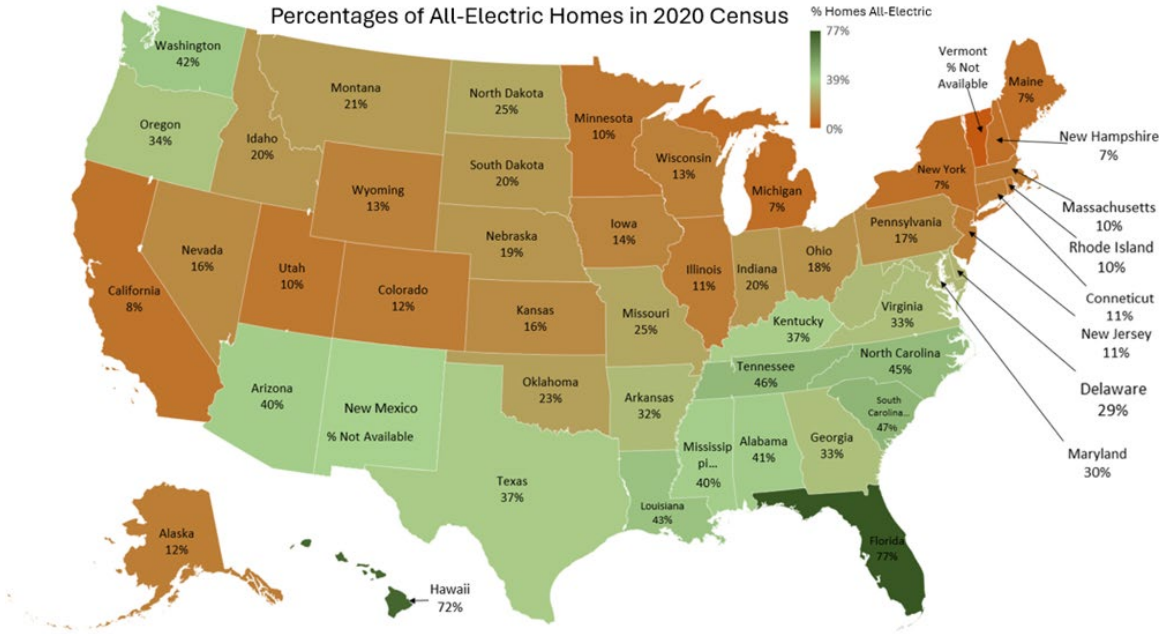
(L) The first electric trolley in San Francisco, triple overloaded for its inaugural ride in 1892. (Center) The spectacular "San Francisco Electric Tower" built in 1894 to celebrate San Francisco's electricity at California's Midwinter International Exposition. (R) After 30 years of debate, the Hetch Hetchy Valley in Yosemite Park was dammed and began providing power to San Francisco in 1925, with fresh water following in 1934. The dam still provides 20% of San Francisco's electricity.

California led the gas ban movement while joining a natural national electrification trend (Figure 0)—90% laundry dryers purchased each year are electric, more than 50% homes built since 1970 have both electric space and water heaters[1], and 60% of Americans cook on an electric stove.[2] But until 2020 California's Energy Commission and Public Utilities Commission had strong anti-electrification policies for two historical reasons--the 1973 Oil Embargo and the 2000 California Energy Crisis, both of which raised electricity prices to crisis levels, and led regulators to discourage all-electric construction. But the 2022 Climate Emergency Declaration has set the state on a regulated path to 90% all-electric buildings by 2035.



(L) OAPEC's 1973-74 oil embargo raised electricity costs 400%. (Center) Deregulation of California electricity markets led to an energy cost scam in 2000 with 800% more expensive electricity. (R) After 6 years of catastrophic fires, in 2022 Gov. Newsom declares a Climate Emergency, directs his state agencies to accomplish 90% electrification of all gas uses by 2035.

Figure 0: California is the #1 consumer of "natural" gas in the nation, and currently has only 8% all-electric construction, compared to leading states like Florida (77%). It is changing though: 80% of new construction state-wide was all-electric in California in 2023 (CPUC).



Benefits of Home Electrification

You likely want an all-electric home because:

- Studies show **gas stoves are responsible for 12% of childhood asthma** in the US[3] and produce the same wheeze and heart stress in home cooks as second-hand cigarette smoke[4].
- You can watch a pot boil on an electric induction stove, because **induction is *3 times faster*** than a gas stove, because it's 3 times as efficient!
- **You can sleep better** because heat pumps use a quiet, consistent blower fan, while gas furnaces turn on-and-off 3 to 8 times an hour to avoid overheating, and blow harder to compensate for less run time.
- **You can get your laundry clean with one machine**, a combination electric washer/dryer.
- You can immediately **reduce your contribution to Climate Change**, and every year the grid is getting cleaner with new power plants that world-wide are 93% solar, battery and wind power!
- You can **lower your utility bills** with the most efficient electric appliances.

Figure 1: Gas stove smoke, seen at right in orange and pink polluting the purple air, is as bad for you as cigarette smoke and makes smog-like air pollution throughout your home.

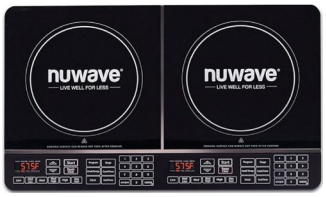
			
Stovetop Cover Cutting Board	IKEA Induction	Nuwave Induction 94 Temp Settings	Nuwave 12-in-1 Countertop XL Smart Oven
$70	**$50**	**$220**	**$150**

Figure 2: For rapid electrification, cover your gas stove with a stovetop cutting board and use appliances that plug into any standard outlet.

- **Avoiding Electrical Upgrades**: There are ways to avoid the added costs and hassle from electrical upgrades, as discussed in Chapter 2. There are simple strategies and technologies choices worth months of your time and thousands of your dollars to avoid a "electrical service wire" upgrade from the utility pole to your breaker panel. EV chargers and solar arrays are often blamed for triggering an electrical service upgrade, and this book helps you avoid that hassle.
- **Budget**: Using Bay Area data, in Chapter 3 this guide shows you can replace your gas appliances for a range of prices. You can get DIY window heat pumps for $600, or high-end hydronic heat pumps for luxury warm floors that install for $30,000. This cost swing is less true of water heaters ($4500-$8000), stoves ($1100-$4000) and dryers ($800-$2000)—their installations are simple using factory-finished appliances.

Chapter 2: Minimizing Electric Panel Upgrade Needs

When electrifying your home, it is important to consider your existing electrical equipment and how this impacts the cost and scope of your project. Electrification may cause the need for new circuits, a new electrical panel, or a utility "service" upgrade that add costs and extends the timeline of your project. However, there are strategies to avoid these costly upgrades presented in this section.

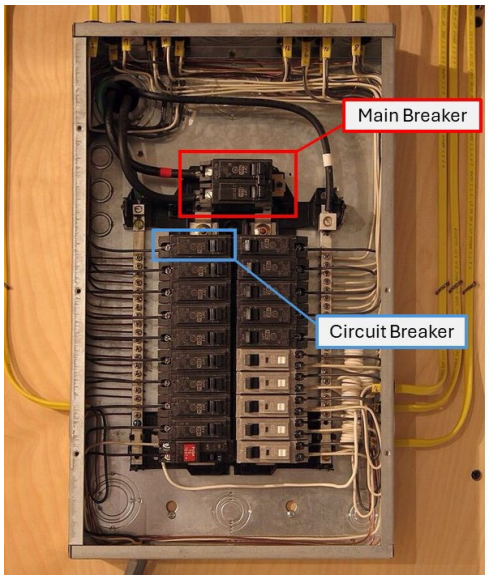


Figure 3: An example electrical panel, showing the main breaker and circuit breakers.

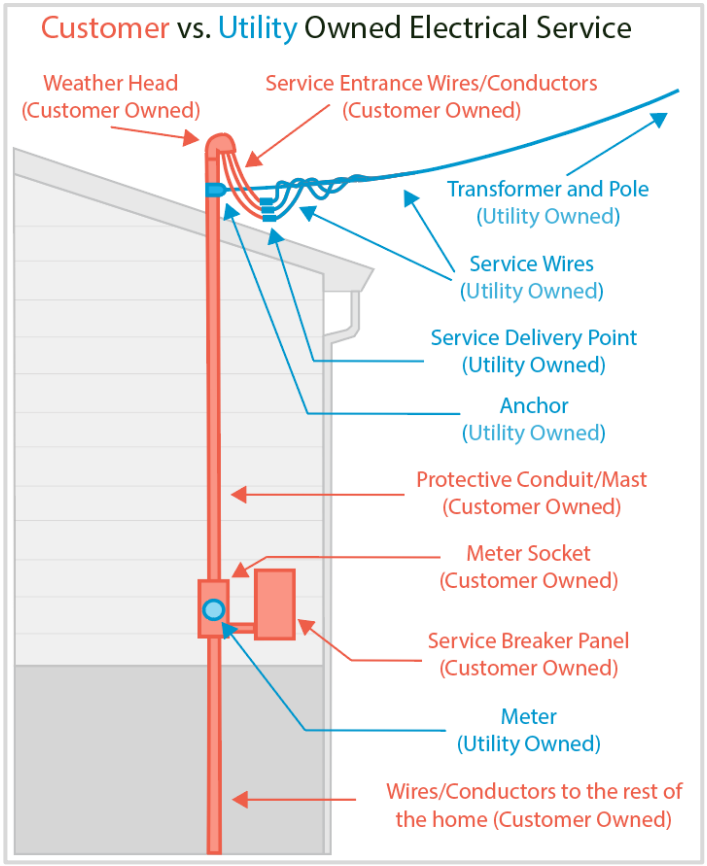


Figure 4: The customer versus the utility owned portions of a typical overhead utility electrical service.

As you electrify, the total electrical demand on the panel will inevitably increase. In some cases, total demand increases enough to where an electrician may recommend a panel or service upgrade. This could involve replacing your panel with a higher capacity option, but sometimes it extends beyond that and requires utility companies to upgrade the poles, wires, and other components that power your home, and can sometimes trigger other requirements that also increase costs (for example having to relocate the main electric panel away from the gas meter). It can be expensive ($3000 to $30,000)[5] and time-consuming (2 months to 18 months) to increase the electrical power "service" delivered to your house, and the bill for some of the changes like conduit and service boxes (red) are the responsibility of the homeowner (Figure 4).

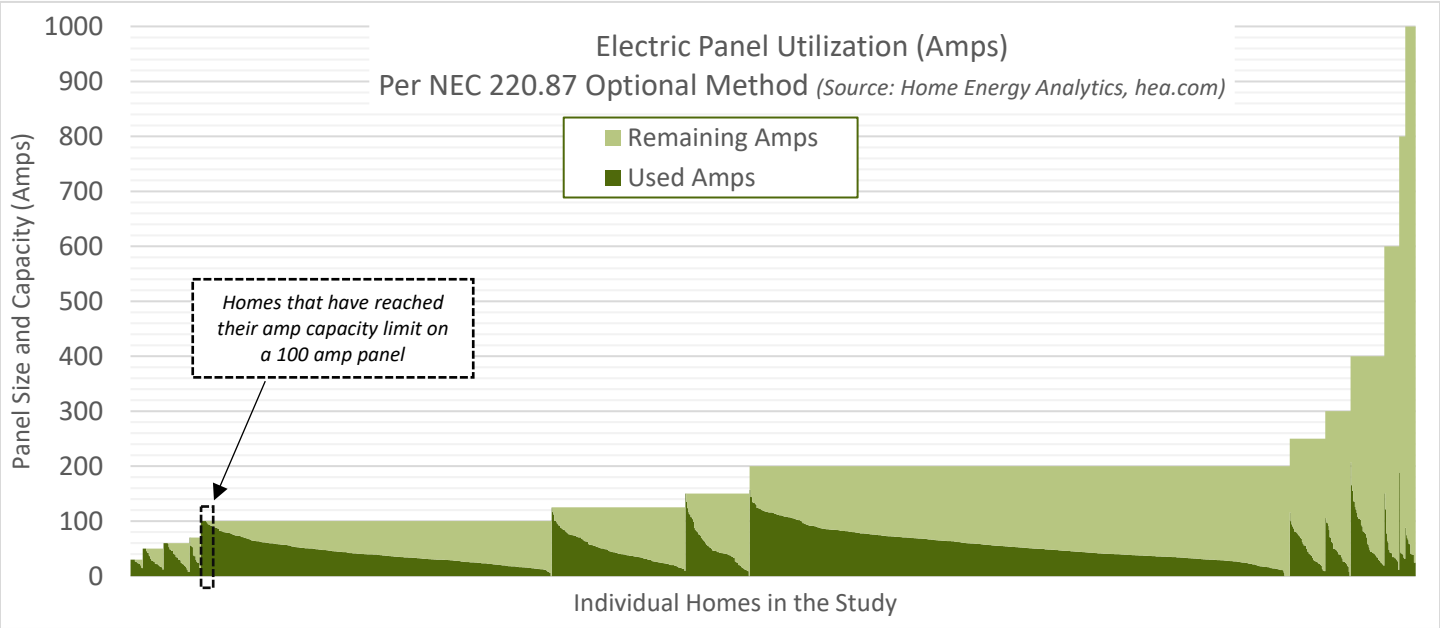


Figure 5: Data from thousands of PG&E customers showing home electrical panels have capacity to plug in new electric appliances without upsizing the utility service wire from the power pole (data from Home Energy Analytics).

The **"Watt Diet"** is a set of strategies for overcoming these technical challenges and increases in costs. In addition to this booklet, there are many online videos explaining this approach to utilize your existing circuits without upgrading them and to keep your house on its current panel and service with the Watt Diet:

- **Use power-efficient equipment and appliances** that reduce the need for larger circuits and also reduce your overall energy consumption.
    a. **Heat the home with "inverter driven" heat pumps** —Heat pumps are reversible air conditioners and use a third as much electricity as electric resistance or gas equivalents to heat the home. Tax credits and rebate programs often require the heat pump to have a computer, called an "inverter," to make it more efficient both during winter cold snaps and summer heat waves.
    b. **Use a heat pump-only water heater (HPWH)** —electric water heaters can be heat pump-only (900W), electric resistance (4500W), or a hybrid of both (2250W to 4500W). A shared circuit 120V HPWH (up to 900W) can be plugged into any standard wall outlet and let you avoid rewiring.
    c. **Use a combined washer/dryer**, which come in "condensing" and "heat pump" options and are the most popular type of laundry machine in Europe and Asia. The heat pump models from Samsung, LG and GE are especially fast at drying and come in large washer drum sizes up to 5 cubic feet.

- **Use devices that manage power between devices or for the whole home.** Circuit-sharing or circuit-pausing outlets (e.g. NeoCharge, SimpleSwitch) can safely share a single high-power circuit between two devices (like an EV charger and an electric dryer). EV charger pausers can be used to pause the EV charger if the whole building load ever exceeds 80% of the panel capacity. "Smart" panels (e.g. Span, EcoFlow) can replace your existing panel and manage the power across all circuits in a home. Each of these techniques may be able to eliminate the need for a utility service upgrade.

- **Use approaches that save breaker spaces.** The multi-function devices above and the circuit sharing approaches and lower voltage equipment all save breaker spaces. But sometimes you may also need to utilize tandem breakers or subpanels to add more circuits to your existing electrical panel and service. Your panel and service size are likely already big enough to incorporate the new electrical loads (Figure 5), however you may lack the actual physical space to install a new breaker and circuit. Utilizing tandem breakers can safely create two circuits in the same breaker space that originally only had one circuit. Subpanels that link to your main panel also provide more space for additional circuits and can have the capabilities to fit tandem breakers.

- **Insulate and air seal the home.** Most houses do not need more than three tons (36,000 BTUs/hr) of heating and cooling capacity if they are reasonably insulated, regardless of the climate. Insulating the home can be done through adding (or fixing gaps) to the insulation in attic, crawl spaces, and walls to reduce the heating and cooling power needed from the heat pump. Usually, insulation in the attic to is often one of the easiest and most effective way to improve a home's energy efficiency; caulking or taping cracks to "air seal" the home can reduce the heating and cooling loads by one third. Keeping the heat pump capacity smaller allows the reuse of existing ducts, which aren't typically designed for more than three tons of air flow. Ductless designs save even more energy by not losing heat through ducting, nor requiring a powerful fan to push air through often convoluted and leaky ductwork.

- **Right size your heat pump.** It is important to request that your contractor also conduct a "heating load calculation" for your home so that your heat pump is right-sized for your specific home, often resulting in a smaller heat pump being installed. Smaller heat pumps use less power and energy, resulting in a smaller circuit being installed and more efficient operation. Heat pump sizing in our mild climate can be around 800 to 1500 square feet of home per ton of heat pump, but heat pump sizing calculations can show if your home is outside of that range.

In most cases, an existing panel has the capacity to provide energy to fully electrify a home. In a study conducted by Home Energy Analytics, data was collected over the course of a year for 1,480 homes of various panel sizes. Figure 5 shows the total capacity of the panel and what percentage of that is being used during the worst-case scenario peak hourly event. We can see that for panels sized above 200 amps, no house peaks anywhere near the upper limit. And for homes with 100 amp panels, we see very few houses consuming near the upper limit during their peak event.

With the potential for electrification available on most panels, the next step is the careful design of the panel and wiring to incorporate all new appliances and equipment. Typically, a design consultant or electrician will perform an "electrical load calculation" using the methods in the National Electrical Code.

Using the National Electric Code electrical load calculation methods and the Watt Diet concepts, below are two simplified panel diagrams showing some ways to fully electrify a home. In these diagrams, the blue boxes signify 120 Volt circuits, and the green boxes signify 240 Volt circuits.

Example 1 shows a 2,000 square foot home on a 100-amp panel, that includes a ducted heat pump, a heat pump water heater, a hybrid heat pump dryer, an electric range, an electric vehicle charger, and solar. The 120V circuit that was powering the furnace has been brought to zero amps, as the old furnace was replaced by a high efficiency heat pump seen directly below the furnace slot. In this scenario, the air handler for the heat pump and the heat pump itself share a circuit (an option some manufacturers provide to save on circuit space). Additionally, we can see the use of a heat pump water heater which only uses 12 amps, allows for other devices such as the EV charger to fit onto the panel without going over the 100 Amp limit.

Example 2 shows a 3,000 square foot home on a 100-amp panel, that includes a ductless heat pump, a heat pump water heater, a typical electric resistance dryer, an electric range, and electric vehicle charger, and solar. This example shows that power can be shared between devices – the resistance dryer and the electric vehicle charger share a 20 amp, 240 Volt circuit using a circuit sharing device. Similarly, the electric range and the heat pump water heater also share power on a circuit sharing device.

Your actual panel and circuit design will vary depending on the equipment present in your home and your retrofit goals. Electrification is feasible regardless of your home's layout or size, offering options to remain within your existing electrical panel and service, and there are a diverse range of energy-efficient and aesthetically pleasing appliance choices that are available to meet your specific needs.

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			Device Amps	Device Volts
		100 Amp Panel			
120	8	Lights/Plugs 15	15 Lights/Plugs	8	120
120	8	Lights/Plugs 15	15 Lights/Plugs	8	120
120	8	Lights/Plugs 15	15 Lights/Plugs	8	120
120	5	Garbage Disposal 15	20 Kitchen Outlets	13	120
120	7	Refrigerator 20	20 Kitchen Outlets	13	120
120	5	Stove Hood 15	20 Dishwasher	12	120
120	0	Furnace (removed) 15	20 Clothes Washer	10	120
240	19	Heat Pump Centrally Ducted 25	20 Hybrid Heat Pump Dryer	14	240
240	15	Charger 20	50 Range (Cooktop + oven)	40	240
240	16	Solar Input 20	20 Heat Pump Water Heater	12	240

House square feet = 2000 Total Counted Panel Amps = 96

All Electric 100 Amp Home (3,000 square feet)

Two “automatic sharing” circuits, ductless mini split heat pump, resistance dryer, high power heat pump water heater

100 Amp Panel

Device Volts	Device Amps			Device Amps	Device Volts
120	13	Lights/Plugs 20	20 Lights/Plugs	13	120
120	13	Lights/Plugs 20	20 Lights/Plugs	13	120
120	13	Lights/Plugs 20	20 Lights/Plugs	13	120
120	5	Garbage Disposal 15	20 Kitchen Outlets	13	120
120	12	Dishwasher 20	20 Kitchen Outlets	13	120
120	7	Refrigerator 20	20 Clothes Washer	13	120
120	0	Spare 20	20 Stove Hood	5	120
240	17	Ductless Heat Pump 25	25 Automatic Circuit Sharing	20	240
240	16	Solar Input 20	50 Automatic Circuit Sharing	40	240

20 240: Resistance Dryer; EV Charger

40 240: Range (cooktop + oven); Heat Pump Water Heater

House square feet = 3000

Total Counted Panel Amps = 93

Chapter 3: Electrifying Appliances

Electrifying your home is a more achievable goal than ever before, no matter the layout or size of your residence. Advances in technology now allow you to seamlessly integrate electric solutions into your existing electrical panel and service, making the transition both practical and manageable. Today's market offers an extensive selection of energy-efficient and aesthetically pleasing appliances designed to meet a variety of needs while enhancing your home's comfort and efficiency. Below highlights just some example products for heating and cooling systems, water heaters, electric vehicle chargers, and modern cooking equipment, and other appliances for comprehensive home electrification. Important specifications, equipment costs, and installation costs are also listed.

Figure 1: The appliances and equipment in a home that can be electrified. From the top left: air source heat pump, heat pump dryer, solar panels, induction stove, heat pump water heater, electric vehicle charging, home battery backup.[6]

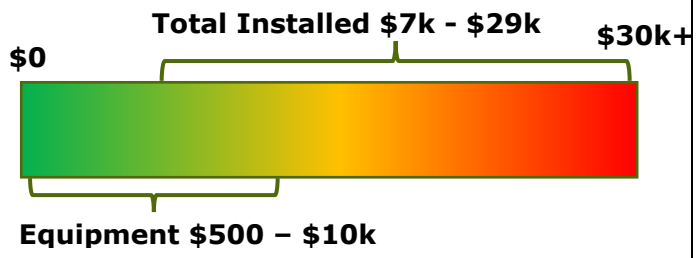
Split Systems (Mini, Multi, VRF)

Summary

Split systems describe any HVAC system that has two components, an outdoor unit (sometimes referred to the compressor), and an indoor unit. The indoor unit can be an air handler if the home has a ducted system or a series of wall-mounted "heads" or "fan coil units" for a ductless system. Unless a home already has appropriate ducting for a split system, it is almost always better to invest in a ductless system cost-wise. For larger capacity systems, more ductless "heads" can be paired with a singular compressor which will impact the cost. The cost to replace your ductwork on average is $7,000.[7]

Split systems come in a wide range of sizes, but in general a 1,500 square foot home requires about 2 tons (24,000 BTUh) of heating and cooling, 2,500 square foot home 3 tons (36,000 BTU), and 3,500 square foot home 4 tons (48,000 BTU). Split systems can be as small as a partial ton for tiny homes, or a "Variable Refrigerant Flow" (VRF) system that range from 7 tons to 30 tons for very large homes. To properly size your heating and cooling system, request a sizing calculation from your contractor or designer. The costs represented in the figure to the right do not include very large VRF systems.

Average Price Range



Factors that Influence Price

1. Size of the heating and cooling capacity. Since there is a wide range of equipment in this category, there is also a wide range of costs, but for the most common sized systems the total installed costs are as follows: less than 1 ton: $7,400, 1-2 ton: $10,300, 2-3 ton: $18,100, 3-4 ton: $23,000, 4-5 ton: $24,400, 5-6 ton: $29,000.[8]
2. Reusing the existing ducting versus needing new ducting
3. Cold climate refrigerant heat pumps (~2700 for 3 ton compressor) will cost more to purchase than warm climate (~$2000 for 3 ton compressor), standard efficiency heat pumps and air conditioners, while using 1/3rd less electricity.
4. A new 240V circuit. The cost of running a new circuit averages $1000.
5. Complexity of installation: length of refrigerant lines, modifications to walls for indoor units, etc.

Product Options

Type	Single zone 120V mini split system	DIY ductless single zone 120V mini split system	Single-zone 240V split system	Five-Zone 240V split system	VRF High Capacity Split System
Manufacturer and Product Name/Image	**LG** LS120HXV2 	**Mr. Cool** DIY Ductless Mini Split 	**Daikin** Atmosphera 	**Blueridge** BMKH4221 	**Mitsubishi** PURY-EP72TNU-A 
Voltage (V)	120	120	208/240	208/240	208/240
Ref. Type	R410a	R410a	R32	R410a	R410a
Heating Capacity (BTU/h)	13,000	12,000	4,400 – 19,500	40,000	80,000
Cooling Cap. (BTU/h)	12,000	12,000	4,400 – 12,500	36,000	69,000
Heating (HSPF2)	9.00	9.0	11.2	10.0	12.0
Cooling (SEER2)	19.0	18.9	27.4	21.0	23.0

Centrally Ducted Systems

Summary

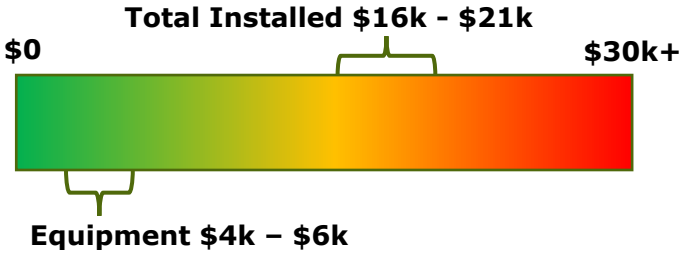
Ducted heat pump and air conditioning systems are usually driven by a central compressor that pumps air through ducts to vents in different areas throughout the building. These systems pair an outdoor heat pump unit with an indoor evaporator coil and air handler unit.

These types of systems are most relevant for homes with existing ducted systems. Important aspects of the design and installation of the new heat pump will include locating a space for the outdoor unit and replacing the indoor furnace with an air handler. If your home already has an air conditioning system and furnace, this replacement can be relatively straight forward.

The refrigerant R-410a has been widely used in HVAC systems, but centrally ducted systems are moving towards using R-454b which is a more environmentally friendly refrigerant. Manufacturers are developing and launching models compatible with the new refrigerant, but detailed specifications are not yet widely available.

Note that the price of the Goodman, Trane, and Gree products in the options below only reflect the heat pump equipment. The equipment costs shown in the figure to the right represent ducted systems sold as a complete package including the heat pump, air handler and other miscellaneous parts.

Average Price Range



Factors that Influence Price

1. Size of the heating and cooling capacity. Since there is a wide range of equipment in this category, there is also a wide range of costs, but for the most common sized systems the total installed costs are as follows: 1-2 ton: $16,200, 2-3 ton: $18,000, 3-4 ton: $20,800, 4-5 ton: $21,400.[9]
2. Reusing the existing ducting versus needing new ducting. The cost to replace your ductwork on average is $7,000.[10]
3. High performance cold climate refrigerant heat pumps will cost more than ones that use standard refrigerants
4. A new 240V circuit. The cost of running a new circuit averages $1000.
5. Modifications to fit in new air handler where the furnace is located

Product Options

Manufacturer and Model	Goodman GSZB403610	Trane 5TWR5018A1000A	Gree FLEXX60HP230V1BH	LG LV361HV
Image				
Dimensions (in) WxDxH	36 x 36 x 39	33 x 30 x 33	39 x 15 x 54	38 x 13 x 55
Ref. Type	R410A	R-454B	R410A	R410A
Breakers Size (Amps)	25	-	40	40
Heating Capacity (BTU/h)	36,000	18,000	35,000 – 60,000	40000
Cooling Cap. (BTU/h)	36,000	18,800	35,000 – 54,000	36000
Heating (HSPF2)	7.5	7.5-8.1	9.0	8.95
Cooling (SEER2)	14.3 – 15.2	14.3-16	16	16.25
Price ($)	$2,600	$4,000	$4,000	$4,800

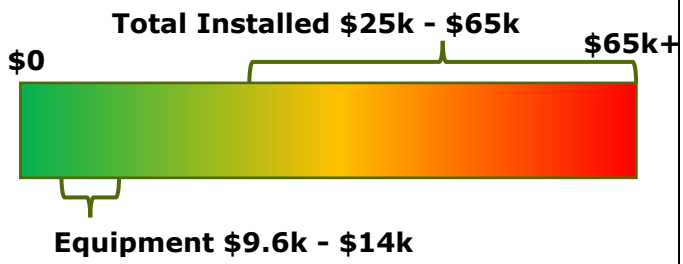
Hydronic Heat Pumps

Summary

There are different types of hydronic heat pumps, the two main categories are Split and Monobloc. Split types have an outdoor unit, and an indoor unit that houses a heat exchanger. Monobloc heat pumps have the heat exchanger built into the heat pump that sits outside. From there, the hot water is distributed throughout the home using radiant floors, radiators, fan coils, or baseboard heaters. When switching from a gas boiler to a heat pump, it is important to note that heat pumps will produce a lower temperature of water. Each type of distribution requires a different temperature, for example, radiant floors use a water temperature of around 120F, but baseboard heaters use a higher temperature, around 140F. If you have baseboard radiators, you may need to replace them to be compatible with heat pumps.

Hydronic heating / cooling can have a slower recovery and reaction to changes at the thermostat compared to alternatives like centrally ducted systems. However, it provides a comparatively consistent temperature. Hydronic heat pumps are also moving towards using lower global warming potential (GWP) refrigerants. Read more about hydronic systems in the Case Studies section of this report. The costs in the table below represent the cost for the heat pump itself. The price range to the right represents the full system costs: the heat pump, storage tank, and other miscellaneous equipment.

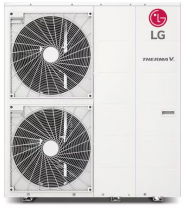
Average Price Range



Factors that Influence Price

1. Heating or cooling capacity of the heat pump
2. Type of refrigerant: low GWP refrigerants models are likely to be more expensive as the industry switches over
3. Type of heat pump: split type requires two pieces of equipment, where monobloc requires only one device
4. System functions: heating only, heating and cooling, domestic hot water or combined heating and domestic hot water. Having more functions will increase the design costs, installation cost and the auxiliary components needed (like valves, tanks, etc.)
5. Auxiliary equipment like a buffer tank with electric resistance, controllers, valves, etc.
6. A new 240V circuit. The cost of running a new circuit averages $1000.
7. Updates to the distribution system

Product Options

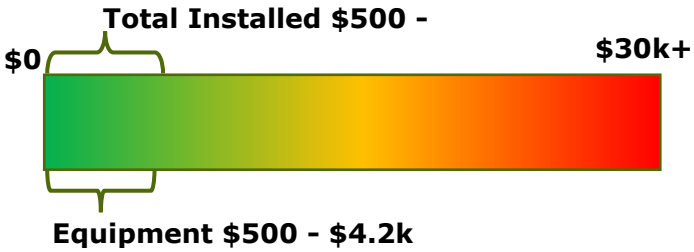
Manufacturer and Model	Harvest Thermal Combo DHW and Space Heating (no cooling)	MBtek Apollo EVI DC	Arctic Monoblock EVI	LG Therma V Monobloc	Chilltrix CX50
External Component Image					
Dimension (in) (HxWxD)	33 x 12 x 27 (compressor) 39 or 69 x 25 (tanks)	43 x 19 x 33 to 44 x 21 x 57	45 x 19 x 35 to 40 x 17 x 54	54 x 49 x 13	50 x 44 x 17
Ref. Type	R744 (CO2)	R410A	R410A	R32	R32
Breaker Size (Amp)	15	40 – 100	30 - 40	40	30
Heating Cap. (BTU/h)	33,000 – 72,000	42,000 – 71,500	28,300 – 58,000	55,000	37,600 – 57,000
Cooling Cap. (BTU/h)	NA	27,300 – 51,200	24,200 – 41,700	55,000	41,300
Heating (COP)	Up to 5.5	4.6	3.1 – 3.3	2.38	3.12 – 4.62
Cooling (COP)	NA	4.6	2.4 – 2.5	4.03	3.01 - 6.21
Max Water Temp.(F)	140	170	-	149	130
Price	$3,700	$6,300	$6,800	$7,800	$8,000

Window or Through-Wall Heat Pumps

Summary

Packaged terminal heat pumps are all-in-one HVAC units designed to heat and cool one to three rooms per unit. These ductless units can be wall-mounted (e.g., Ephoca), window-mounted, or placed in a wall cutout. The units listed offer dehumidifying capabilities and air filtration with washable filters. Window installations of heat pump units like Keystone, Midea, Gradient, and Ephoca (with an additional windowsill adapter) don't require an HVAC professional. Portable air conditioners with heat pumps are easy to install and are meant to be DIY. Through-the-wall installation of the Ephoca requires some construction, including two louvered penetrations through a wall and options like perforated panels or custom louvers. The Friedrich wall master requires an additional wall sleeve and minor construction to install the sleeve into the wall. Packaged units provide heating or cooling directly to the space, avoiding energy losses from ductwork but may have potential leaks if not properly sealed. R-32 refrigerants are the most environmentally friendly refrigerants in the market. Typically, to account for the heating and cooling of entire home, one unit will be installed in the common living area, then one for each bedroom.

Average Price Range



Factors that Influence Price

1. Heating or cooling capacity of the heat pump
2. Wall or window modifications: like adding a safety bar, caulking, etc. For models with “twin ducts” two louvered penetrations on the wall are necessary.
3. A new 240V outlet for the models that require them. The cost of running a new circuit averages $1000.
4. Accessories: mounting kits, drain kits or assembly adapter are also offered at an additional cost.
5. Labor costs to install the versions that have more construction work; however most are DIY.

Product Options

Type	Window	U-Shaped	Portable	Through wall	U-Shaped	Twin Ducts
Manufacturer and Product Name/Image	**Midea:** MAW12HV1CWT 	**Keystone** KSTAW12INV-HC 	**Toshiba:** Inverter RAC-PT1412HVWRU 	**Friedrich:** WallMaster WHT12A33A 	**Gradient:** Window Heat Pump 	**Ephoca:** Wall Mounted Pro 
Voltage (V)	120	120	120	240	120	120 and 240
Dimensions (in) W x H x D	19 x 14 x 22	19 x 14 x 22	20 x 35 x 17	27 x 16 x 21	Indoor unit: 24 x 24 x 8 Outdoor unit: 24 x 24 x 15	40 x 22 x 11
Ref. Type	R-32	R-32	R-32	R-32	R-32	R410a or R32
Heating Capacity (BTU/h)	10,000	10,000	12,000	8,900	3,000-8,000	3,900 - 14,500
Cooling Cap. (BTU/h)	12,000	12,000	14,000	11,100	8,600	3,300- 15,000
Heating (COP)	-	-	-	-	-	3.455
Cooling (COP)	13.3 CEER	-	10.8 CEER	9.4 EER	10.8 CEER	13.5 SEER
Price	$480	$530	$600	$1,530	$3,800	$4,200

Personal Heating Devices

Summary

If it's not the right time to upgrade your heater, or you're a renter with limited options, or you just want to keep that thermostat lower, consider heating your body directly, rather than the air around you!

Personal heating devices include socks, vests, gloves and more. Battery versions will give you more freedom to move around than a wired/plug-in style, but won't stay warm for as long, especially on high heat. Worried your pet will be cold while you're nice and toasty? Check out the heated pet bed in the table below.

There are a wide range of personal heating devices, and some are more quality than others. Make sure to check the reviews before you make a purchase.

Average Price Range

$0 **$30k+**

Equipment $30 - $200

Factors that Influence Price

1. Type of heating device
2. Battery vs. plug-in versions
3. Product Quality

Product Options

Manufacturer and Product Image	**K&H Pet Products** 	**Fun Chaser** 	**Pure Enrichment** 	**BIAL** 	**Gerbing** 	**Pure Enrichment** 	**GOTOBI** 
Description	Plug-In Heated Bed for Small Pets	Rechargeable Battery Heated Fingerless Gloves	Plug-In Foot Warmer	Rechargeable Battery Heated Slippers	Rechargeable Battery Heated Wool Socks	Plug-In Heated Vest	Rechargeable Battery Heated Vest
Temperature Range (F)	4 Watts of Heating	113-133	110-140	104-149	100-140	110-140	113-149
Other Details	5.5 ft cord	Battery Lasts 3-5 hours	10 ft cord	Battery Lasts 3-6 hours	Battery Lasts 3-7 hours	9 ft cord	Battery Lasts 4-9 hours
Price	$30	$15	$50	$80	$190	$40	$120

Heat Pump Water Heaters

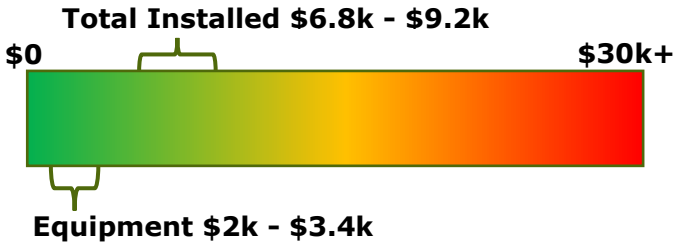
Summary

Heat pump water heaters come in different forms – either "unitary" meaning the heat pump (aka compressor) and tank are combined into one unit, or split (ECO2 below). The 240V integrated HPWHs are also called "hybrid" water heaters, where they have both a heat pump and back up electric resistance elements within them. The 120V HPWHs are available in both hybrid and heat pump-only models. Most HPWHs can operate efficiently in temperatures as low as 37°F outside before switching over to electric resistance heating. The ECO2 product shown below can as operate in temperatures as low as -30°F.

HPWHs are roughly two to three times more efficient than gas water heaters, but for the premium brand (ECO2) efficiencies can be up to five times more efficient than gas. The integrated heat pumps can also come with ducting to get enough air flow to the heat pump if it is in a confined space (like a closet). HPWHs can also be placed in a garage without ducting, but this may impact ambient garage temperatures or required run time of the unit.

The price range shown to the right is for the unitary type HPWHs.[11] If installing a split type, the cost to install will be $12,300-35,000[12] (including cost of equipment).

Average Price Range



Factors that Influence Price

1. Type of HPWH (integrated or split)
2. Tank capacity (typical sizes are 40 through 80 gallons)
3. Added features like leak guard and load shifting capabilities

Any work needed around the heat pump like:

1. Adding a new dedicated circuit (for the models that require them). The cost of running a new circuit averages $1000.
2. The routing of air ducts if required
3. Routing the condensate water line to the exterior of the building or into an existing drain
4. Piping reconfiguration
5. Any drywall repair work needed after adding the above items

Product Options

Type	**120V Hybrid HPWH** Shared, dedicated circuit	**120V HPWH** Shared circuit	**240V Hybrid HPWH**	**240V Hybrid HPWH**	**240V HPWH**
Manufacturer and Product Image	**Rheem** (various models) 	AO Smith 	**Steibel Eltron** Accelera 	**Bradford White** AeroTherm 	ECO2 GS5-45HPC 
Gallons	40, 50, 65, 80	66, 80	58, 80	50, 65, 80	43, 83
Dimension (in) (HxD)	63 to 75 x 21 to 25	62 to 69 x 27	61 to 76 x 28	60 to 71 x 22 to 25	33 x 12 x 27 (compressor) 39 or 69 x 25 (tanks)
Ref. Type	R134a	R-513a	R134a	R134a	R744 (CO2)
Breaker Size (Amps)	15	15	15	25	15
First Hour Delivery (gal)	45, 55, 63, 84	76, 93	50, 74	65, 79, 88	69, 121
Uniform Energy Factor	2.8, 3.0, 3.3, 3.5	3.2, 3.0	3.12, 3.61	3.44, 3.64, 3.59	3.66 – 3.80
Price ($)	$2000 - $3,000	$2,500 - $3,100	$2,600 - $2,900	$2,300 - $3,400	$5,700 - $7,000

Electric Pool and Hot Tub Heating

Summary

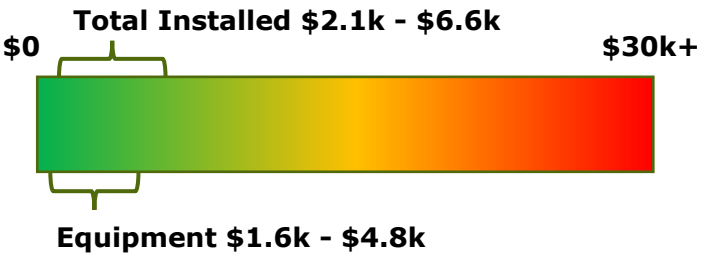
Utilizing a heat pump can be an effective way to address the energy demands of heating a pool or hot tub. These machines are highly efficient and can use much less energy to heat the same amount of water as their less efficient gas or electric counterparts. Coefficient of Performance (COP) is a useful metric that indicates the energy efficiency of the equipment. The higher the COP number, the better.

While some of the products in the table below are marketed more towards pools or hot tubs, note that they all have similar output temperatures and are not necessarily exclusive to one use over the other. Heat pumps marketed for hot tubs are generally smaller in physical size. Consider all available options for your specific scenario.

To right-size a heat pump pool heater, assume the heat pump must produce 4 to 6 BTU/hr for each gallon of heated water.[13] Installation costs will mainly depend on whether a 240V circuit is already available.[14]

Another important way to conserve energy and keep your bills lower is to use a well fitted pool cover so less heat escapes when the pool is not in use. Dark colored covers also provide more solar heat absorption.

Average Price Range



Factors that Influence Price

1. Size of your pool or hot tub
2. Lowest operating temperature
3. Self-installation vs. hiring a contractor
4. Whether a 240V outlet needs to be installed
   a. A new 240V outlet. The cost of running a new circuit averages $1000.
5. Coefficient of Performance (efficiency)
6. Convenience/comfort (e.g. time it takes to heat up, noise level of the compressor, etc.)

Product Options

Description	Pool	Hot Tub	Hot Tub	Pool	Pool
Manufacturer and Product Image	**FibroPool** FH120 	**Doheny's** Economy Side Vent HP 	**Swimmax** Inverboost 	**Arctic** 060ZA/B 	**AquaCal** HeatWave SuperQuiet SQ166R 
Heating Capacity (BTUh)	20,000	51,000	37,500	88,030	126,000
Coefficient of Performance	5.0	6.3	5.9	6.2	5.6
Lowest Operating Temp	16°F	42°F	10°F	-4°F	25°F
Water Output Temp	99°F	104°F	104°F	104°F	104°F
Price ($)	$1,600	$1,800	$3,500	$4,400	$4,800

Electric Ranges

Summary

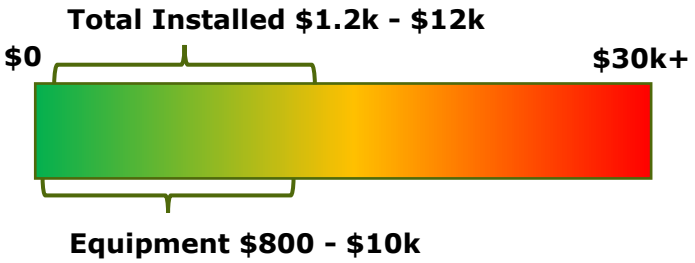
Induction ranges are faster, more efficient, offer more precise temperature control, and are easier to clean than their gas counterparts. [15] They're also safer because induction works by directly heating the metals in the pan, rather than heating the cooktop surface itself. Gas cooking appliances are usually only about 32% efficient, while induction cooking averages 85% efficiency. [16] This significantly reduces the waste heat produced, which also reduces the cooling load needed to offset a warm kitchen.

Electric resistance "radiant" ranges can also be an energy efficient replacement to your gas appliance. The electric coils are contained under a smooth glass top that is easier to clean and provides more consistent, even heating. These ranges are typically 75-80% efficient.[17]

As discussed in the Watt Diet section, one factor to consider when removing a gas appliance is whether a 240V outlet will be needed for your electric replacement. The cost of running a new outlet averages $1000. or more, depending on the complexity and distance from your panel. Remember to consider Watt Diet principles to avoid triggering a Utility Service Upgrade.

The products on this page are a small sample of the wide range of electric appliances available. They can vary by the number and size of burners, stove width, oven capacity, 120V or 240V, battery backup, freestanding or slide in, and more.

Average Price Range



Factors that Influence Price

1. Aesthetics (e.g. unique style, luxury brands)
2. Self-installation vs. hiring a professional
3. Whether a 240V outlet needs to be installed
4. A new 240V outlet. The cost of running a new circuit averages $1000.
5. Electric resistance vs. induction
6. Stove width and oven size
7. Whether additional labor is needed to deal with space constraints (e.g. narrow doorways, tight cabinets)

Product Options

Description	Glass Top Radiant	Glass Top Radiant	Induction	Induction	Retro Induction
Manufacturer and Product Image	**Whirlpool** WFES3330RS 	**LG** LSEL6335FE 	**Frigidaire** FCFI3083AS 	**Bertazzoni** PRO365INMXV 	**Big Chill** BCR130 
Width (inches)	30	30	30	36	30
Volts/Amps	240V/40A	208V/40A	208V/40A	240V/40A	240V/50A
Oven Size (ft^3)	5.3	6.3	5.3	5.9	4.0
Price ($)	$790	$1,300	$1,090	$5,700	$6,500

Induction Drop-In Cooktops

Summary

In some cases, it could make sense to install a drop-in induction cooktop, rather than investing in a full induction range. For example, if your stovetop and oven are separate and you don't use your gas oven very often, electrifying your stovetop would be the priority.

Self-installation may be difficult for these appliances.[18] Depending on the size of the existing cut out in your counter, a professional may need to assist with modification. Drop-in cooktops are also typically hardwired and may require installation of a 240V circuit. Remember to consider Watt Diet principles to avoid triggering a Utility Service Upgrade.

If you want to electrify on a tight budget, or if removing your gas stove is not currently an option, consider 120V countertop appliances such as:

- Slow Cooker
- Pressure Cooker
- Portable Induction Hot Plate
- Air Fryer
- Toaster/Countertop Oven

Average Price Range

Factors that Influence Price

1. Brand quality
2. Size of the entire cooktop area
3. Number of cooking elements ("burners")
4. Self-installation vs. hiring a professional
5. Whether a 240V outlet needs to be installed. The cost of running a new circuit averages $1000.

Product Options

Description	Single Burner Drop-In	Double Burner Drop-in	5 Burner Drop-In	4 Burner Drop-In
Manufacturer and Product Image	**Avantco** DC1800 	**True Induction** TI-2B 	**Empava** EMPV-36EC01 	**LG** CBIH3017BE 
Volts/Amps	120V/15A	120V/15A	240V/50A	240V/40A
Dimension (W x L) (in)	12.7 x 13.4	24.4 x 15	36 x 21	30.7 x 21
Price ($)	$140	$360	$760	$1,700

Plug-In Countertop Induction Cooktops

Summary

If you're new to cooking with induction, a plug-in cooktop can be an affordable way to introduce the technology into your home. All the models shown here are 120V appliances that only require a 15 Amp breaker and can be plugged into most outlets. Note that some models do require a 20 Amp breaker instead. Per the National Electric Code, most kitchens have 20 Amp circuits, but you should double check your electrical panel to confirm before purchasing a 20 Amp product.

Induction cooking works through low frequency electromagnetism that directly heats your pan, rather than the area around it. This means that pots and pans made of certain materials, like ceramic and copper, are not compatible with induction. In general, if a magnet sticks to your pan, it should work with induction.

Average Price Range

$0 **$30k+**

Equipment $60 - $300

Factors that Influence Price

1. Brand quality
2. Residential vs. commercial quality
3. Size of the entire cooktop area
4. Number of cooking elements ("burners")

Product Options

Manufacturer and Product Image	**IKEA** Portable Induction 	**Cheftop** True Induction 	**Waring Commercial** WIH200 	**NuWave** PIC Double 
Volts/Amps	120V/15A	120V/15A	120V/15A	120V/15A
Dimensions (WxL) (in)	11 x 13	24 x 13	11.5 x 11.75	24 x 14.1
Price ($)	$60	$120	$190	$250

Clothes Dryers

Summary

Prior to 2015, Energy Star did not rank residential clothes washers because their energy use was consistently high across the market. But with the last decade of advancements and innovations, Energy Star now hosts a robust list of efficient machines.

While traditional electric resistance dryers are more affordable upfront, they are more costly to operate than a heat pump dryer of similar size. Electric resistance dryers work by using a significant amount of electricity to boil water out of the clothes and send damp, hot air out through a vent.

Condensing and heat pump dryers are more energy efficient because they do not vent out the damp, hot air. Instead, the moisture is allowed to condense and exits through a drain line, while the air gets reheated and circulated through the clothes again to pick up more moisture. While often on the smaller side, combination condensing units are convenient because they wash/dry in one machine, and there are many plug-in 120V versions already available.

The products on this page are a small sample of the wide range of electric clothes dryers available. Note that lower annual energy use and shorter cycle times may be the result of a smaller capacity machine, rather than a more effective one. Remember to consider the Watt Diet principles and whether you'll need a 240V outlet.

Average Price Range

Total Installed $1.1k – $3.5k

$0 **$30k+**

Equipment $700 - $2.5k

Factors that Influence Price

1. Type of Dryer
   a. Electric Resistance, Combination, Heat Pump, Hybrid
   b. 120V or 240V
2. Laundry capacity (drum size)
3. Self-installation vs. hiring a professional
4. Whether it works on existing 120V outlet or whether a 240V outlet needs to be installed

Product Options

Type of Dryer	**Electric Resistance**	**240V Heat Pump**	**240V Hybrid Heat Pump**	**120V Heat Pump**	**Combination 120V Heat Pump Washer/Dryer**
Manufacturer and Product Image	**Whirlpool** WED5605MC 	**Beko** HPD24414W 	**Samsung** DV53BB89 	**Miele** TXI680WP 	**Samsung** WD53DBA900HZ 
Energy Use (kWh/year)	608	217	281	133	103
Drum Size (ft^3)	7.4	4.5	7.8	4.1	5.3
Volts/Amps	240V/30A	240V/4A	240V/14A	120V/15A	120V/15A
Vent	Vented	Ventless	Ventless	Ventless	Ventless
Price ($)	$710	$1,400	$1,600	$1,800	$2,200

Electric Barbeques

Summary

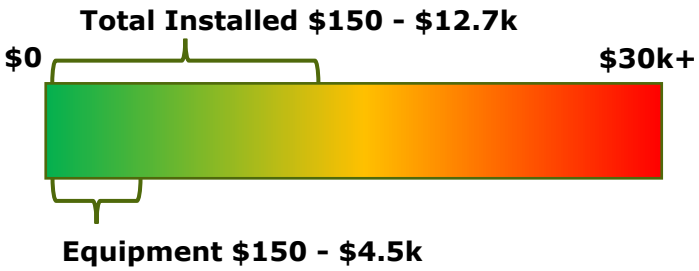
Electric BBQ grills heat up quickly, distribute heat evenly, and don't require refueling like charcoal and propane grills. Without an open flame, they are also safer and easier to use because they offer precise temperature control. Most models can even be used indoors in inclement weather or in high rise buildings where fire code restrictions prevent the use of typical combustion grills.

From 120V plug in alternatives that look like your traditional backyard grill to 240V built-in models, there are electric options for all your grilling needs. Tabletop models plug in wherever you take them, and some models come with an optional stand for additional convenience.

As illustrated by the sample products below, electric BBQ prices vary greatly. Some of the cheapest models might not be rated for outdoor use, so take care to look for products that suit your needs.

The installation cost for a built in BBQ is going to differ significantly depending on whether you are replacing an existing model, exclusively installing a grill, designing a full exterior kitchen, or any number of other complexities like needing 240V wiring.[19]

Average Price Range



Factors that Influence Price

1. Aesthetics (e.g. luxury brands, stainless steel)
2. Built in vs. Mobile/Portable
3. Self-installation vs. hiring a contractor
4. Whether a 240V outlet needs to be installed
5. Extra features (e.g. removeable grease tray, storage for utensils)
6. Cooking surface area
7. Standing vs. tabletop
   a. Permanent vs. detachable stands
   b. Sturdiness of stand

Product Options

Description	Standing/Mobile	Tabletop/Portable	Tabletop/Portable	Built-In	Standing/Mobile
Manufacturer and Product Image	**Americana** Electric Cart Grill 	**Kuuma** Profile 150 Electric 	**Kenyon** B70082 	**Kenyon** B70581 	**ElectriChef** Emerald 24" 
Cooking Surface (in^2)	200	145	~150	155	336
Volts/Amps	120V/13A	110V/15A	120V/11A	240V/6A	220V/20A
Price ($)	$226	$425	$1,480	$1,920	$4,514

Electric Outdoor Heaters

Summary

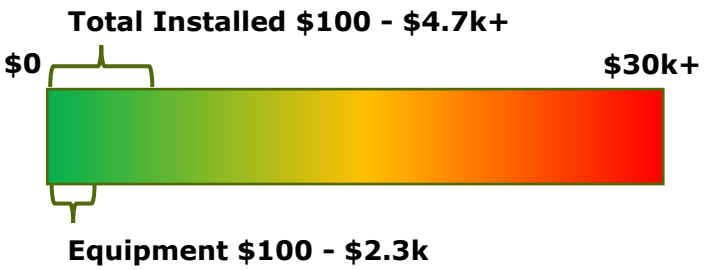
Keeping warm outside does not need to rely on an open flame. There are many electric equivalents that range from free-standing plug-in models to permanently mounted and hard-wired patio heaters.

Free standing models are typically 120V and can be moved around to anywhere there is a regular outlet. As featured in the table below, there are different styles, functions, and heat outputs within these models.

There is also variety of the mounted versions. Some can easily be installed using exterior brackets, while others are intended to be recessed within a wall or ceiling and will require substantially more time and labor. Some models may require hard wiring and a dedicated circuit, while others can plug into a nearby outlet.

*It's not safe to run your plug-in heater from an extension cord. If you don't have access to exterior outlets, consider installing a hard-wired heater or a 120V exterior outlet that will prove useful for more than just your electric patio heater.

Average Price Range



Factors that Influence Price

1. Heat Output/Area
2. Free Standing vs. Mounted
   a. Mounted *on* wall/ceiling vs. recessed *within* wall/ceiling
   b. Plug in vs. hard wired
3. Self-installation vs. hiring a contractor
4. Whether a 240V outlet needs to be installed. The cost of running a new circuit averages $1000.
5. Aesthetics/Extra Features
   a. For example, the marine-grade version of Bromic's Platinum Collection is roughly twice the price

Product Options

Description	Free Standing	Mounted	Free Standing	Free Standing	Mounted
Manufacturer and Product Image	**Hanover** 800-Watt Electric Patio Heater 	**RADtec** G15R 25" Golden Tube 	**EnerG+** 5100 Tabletop Patio Heater 	**Aura** Comfort Plus Patio Heater 	**Bromic** Platinum Collection 
Voltage (V)	120	110	110	120	240
Max Power (W)	800	1500	1500	1500	2300 – 3400 – 4500
Price ($)	$100	$190	$280	$500	$1,240 - $1,790 - $2,250

Electric Fireplaces

Summary

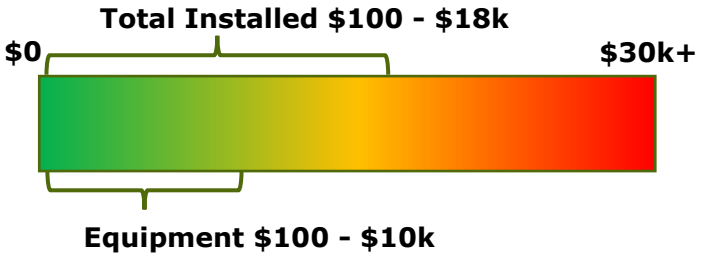
Electric fireplaces provide the ambience and aesthetic of a real fire, without the air pollution. Pregnant mothers and small children can enjoy these features without the health and safety risks of a real flame.

Electric fireplaces come in all sorts of configurations: from styles that imitate a wood pellet stove and plug into a regular wall outlet, to permanently built in, hardwired water vapor features that offer artistic, multicolored "flames," to custom inserts that retrofit an existing fireplace. These options come with a range of installation prices.[20]

Water vapor fireplaces create a fine mist that is lit with LED lights and agitated with an ultrasound vibrator. This creates a bouncing effect that makes for a realistic flame, especially when paired with optional crackling sounds. These fireplaces require a water source and usually have the option of either a direct connection or manually the adding water.

Most electric fireplaces offer supplemental heating, but some are purely decorative. Be sure to check the specifications of any products you intend to purchase. Also remember to consider the Watt Diet principles and whether you'll need a 240V outlet.

Average Price Range



Factors that Influence Price

1. Style of fireplace
   a. Freestanding, recessed, inserts, etc.
   b. Plug in vs. hard wired
2. Water vapor flames
   a. Water manually added
   b. Connected to a water line
3. Heat Output/Area
   a. Some models don't provide heating
4. Self-installation vs. hiring a contractor
5. Whether a 240V outlet needs to be installed. The cost of running a new circuit averages $1000

Product Options

Description	**Freestanding**	**Freestanding**	**Freestanding Insert** Water Vapor	**Built-In** Water Vapor	**Built-In** Water Vapor
Manufacturer and Product Image	**ClassicFlame** Electric Stove 	**FESTIVO** 36in Freestanding 	**Aquafire** Aquafire Lite 	**Dimplex Optimyst** GBF1000-PRO 	**Dimplex Optimyst** OLF86-AM 
Heating (BTUh)	5,200	3,400	No Heat	4,984	6,551
Heating Area	1000 ft^2	1000 ft^2	No Heat	400 ft^2	1000 ft^2
Max Power (W)	1500	1000	35	1460	1920
Volts/Amps	120V/12A	120V/12.5A	120V/2A	120V/15A	240V/10A
Price ($)	$100	$450	$1,400	$5,250	$10,000

Electric Vehicles

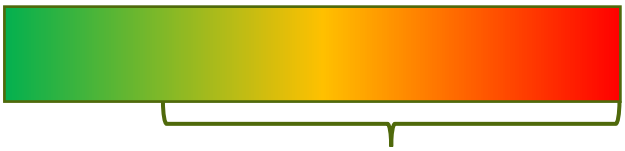
Summary

The electric vehicles (EV) described here will include a representative sample of **fully electric-powered vehicles.** EVs typically charge via at-home chargers or public charging stations. When selecting an EV, it is important to assess charging speed, battery capacity (range), and additional features to ensure they meet your needs. Some models offer bidirectional charging, allowing them to power your home during outages or discharge energy to the grid to offset electricity bills.

- EVs increase home electricity consumption
- On average, EVs are currently about 8% more expensive than gas counterparts (Cox Automotive, 2023)
- EV fueling costs are approximately 60% less than a gas-powered car saving an average of $600/yr (Consumer Reports)

Average Price Range

$0 **$120k+**



Equipment $29k - $120k

Factors that Influence Price

1. Size of vehicle (i.e. SUV vs compact)
2. Luxury vehicle vs. standard
3. Added auxiliary features
4. Extended battery range
5. DC fast charging vs. AC charging

Product Options

Manufacturer and Product Image	**Fiat** 500e Inspi(RED) 	**Hyundai** Ioniq 6 SE 	**Nissan** Ariya 	**Kia** EV6 	**Rivian** R1T 
Range	120 - 141 mi	240 - 360 mi	216 - 304 mi	252 - 310 mi	258 - 420 mi
Charger	CCS Type 1	CCS Type 2	CCS Type 2	CCS Type 2	CCS Type 1
Fastest Charging Time	6 hrs (AC), 35 min (DC)	6-7.5 hrs (AC), 1-1.2 hrs (DC)	10-14 hrs (AC), 1-1.5 hrs (DC)	6.3-8.7 hrs (AC), 1-1.2 hrs (DC)	8-12 hrs (AC), 1.2 hrs (DC)
Body Style	Hatchback Coupe	4-Door Sedan	SUV	Crossover SUV	Pickup
Bidirectional	No	Yes, V2L	No	Yes, V2L	Hardware Yes but not implemented in software to date
Features	Voice Command Integration, Safety cameras and sensors	H-track AWD, Onboard Power Outlet,	Hands-free driving, Voice Command Integration	Safety sensors w/emergency braking, blind spot monitor, Augmented Reality HUD	1764-pound towing,
Price ($)	$32k - $34k	$38k - $40k	$40k - $48k	$44k – $63k	$72k - $102k

Electric Vehicle Charging

Summary

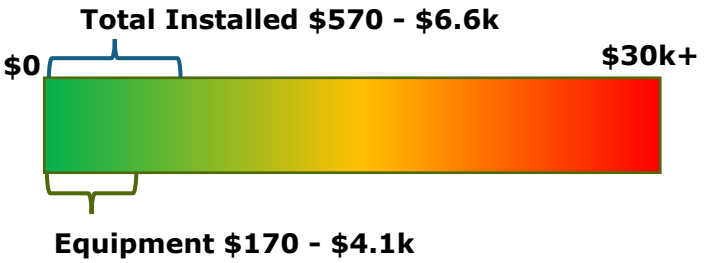
Electric vehicle chargers can be installed at home, either hardwired or plugged into an outlet. There are three "levels" of charging to consider:

- Level 1: Uses a standard 120V outlet and takes the longest time to charge.
- Level 2: Requires a 240V outlet, reducing charging time but putting more strain on your electrical panel.
- Level 3 (DC Fast Charging): Charges most EVs in approximately an hour and are typically found at public charging stations.

"Smart" chargers are also available which can adjust power usage as needed. More details on each charging option are provided below.

The cost to install a Level 2 EV charger ranges between $400 to $2,500 depending on your specific scope of work.[21]

Average Price Range



Factors that Influence Price

1. A new 240V circuit, if you install a Level 2 charger. The cost of running a new circuit averages $1000.
2. Level of Charging: both installation costs and hardware costs go up exponentially at Level 3
3. Bidirectionality: increases costs by a considerable margin, particularly with power outage protection
4. Charge Control: chargers with the ability to remotely turn down, turn off, or turn on EV charging increase cost of the charger
5. Monitoring Capabilities: charge monitoring and diagnostic tools increase price of the charger

Product Options

Manufacturer and Product Image	**EVDANCE** Level 1/Level 2 	**ChargePoint** Home Flex 	**Emporia** PowerSmart 	**Wallbox** Quasar 2 
Portable or Hardwired	Portable	Portable/Hardwired	Hardwired	Hardwired
Charger Type	J1772	J1772	J1772	CCS
Voltage	120/240	240	240	240
Amperage	16 - 40	16 - 50	6 - 48	48
Bidirectional	No	No	No	Yes, has universal compatibility
Features	Can do either Level 1 or Level 2 charging, 23ft cord	Charge monitoring through ChargePoint app, integration with Apple CarPlay and Android Auto, charge scheduling	Charge monitoring and control through the app, 24 ft cord, can derate charging to conserve panel health	Can utilize EV during power outage, compact design, 11.5 kW for charging and discharging
Price ($)	$170	$600	$600	$4,100

Solar Panels and Inverters

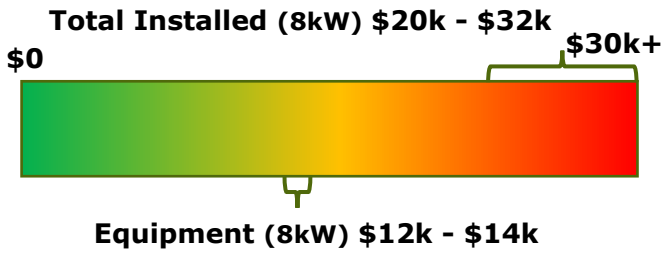
Summary

As you electrify your home, your electricity demands will increase. Installing solar panels can offset these new demands and make electrification more cost effective. Leading manufacturers now warranty their solar panels for 20-40 years and prices have dropped about 30% in the last two decades.

Most rooftop solar panels are about 20ft^2 and generate at least 400W per panel. A typical 1,200ft^2 single family home can offset their energy demands with a 4kW array, which would be ~10 panels. Offsetting a typical EV (driven ~12,000 mi/yr) would require an additional 2kW array. Note that the size of your array is constrained by the available capacity of your electrical panel.

Another important consideration is the type of inverter. Solar panels produce electricity in DC (direct current) and an inverter is required to convert this to AC (alternating current) to run your home outlets. Inverters have their own efficiencies and features. For example, string inverters connect all the solar panels to a single inverter, whereas microinverters are connected to each individual panel. Another feature is "islanding." For utility worker safety, when the main grid goes down, solar panels automatically stop pushing electricity into the grid. With islanding inverters, when the grid goes down your solar array can switch over to directly power essential circuits or charge a home integrated backup battery. Installation cost estimates are based on contractor bids for the entire solar system.[22]

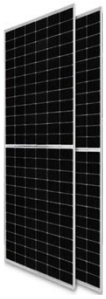
Average Price Range



Factors that Influence Price

1. How much power you want to generate
   a. Bids range from $2,492/kW to $3,989/kW
   b. Prices in the Average Price Range above are for an 8kW array (~2,000 ft^2 home)
2. Whether you want to incorporate battery backup as part of a whole home resiliency package
   a. Islanding capabilities
3. Complexity of the roof
   a. Panels can also be installed on carports, door awnings, patio shade fixtures, etc.
4. Length of warranty on panels & components
5. Efficiency of panels and inverters

Product Options

Description	**Islanding Capable Microinverter**	**Single Phase Inverter**	**One Sided** (25 year warranty)	**One Sided** (40 year warranty)	**Bifacial** (30 year warranty)
Manufacturer and Product Image	**Enphase** IQ8 Series 	**SolarEdge** SE3800H-US 	**Canadian Solar** HiKu7 Mono PERC 	**SunPower** Maxeon 6 	**JA Solar** JAM72D30/MB 530 
Power Output (W)	DC input: 235-500+ AC output: 240-380	DC input: 5,900 AC output: 3,800	645-675	450-475	525-550
Efficiency	97.5%	99.2%	20.8-21.7%	22.3%	20.3-21.6%
Size (LxWxD) (in)	8.3 x 6.9 x 1.2	17.7 x 14.6 x 6.8	93.9 x 51.3 x1.38	80.6 x 40.9 x 1.38	90 x 44.7 x 1.38
Price ($)	$150-$180	$1,370	$300-$650	$565-$730	$406-$528

Plug-In Solar Panels

Summary

Plug-in or "balcony" solar has quickly gained popularity in Germany, and now the Bay Area has access to some of the first plug-in solar panels in the U.S. through a new nonprofit, Bright Saver! Check out their customer testimonial to the right, and their demonstration photos below.

Backyard solar (bottom row) is considered an impermanent appliance in most municipalities and doesn't require a permit. Bright Saver expects most customers to save $30-60 per month. A professional electrician will handle the installation to ensure all safety requirements are met.

Average Price Range

Total Installed (800W) $2,200

$0 — **$30k+**

Equipment (800W) $1,850

Customer Testimonial

Terry D. explains why he got a plug-in solar array:
"I've wanted rooftop solar for a long time but I need to replace my roof and I'm in my 70s - will I live long enough for the investment [in rooftop solar] to pay off?"
- Terry (left) and his backyard solar array in Oakland (right).

"We are starting a movement to make solar accessible to everyone. These plug-in panels are for homeowners and renters and they can go just about anywhere - the backyard, the side of a house, a deck, and they pay for themselves from day one."
- Cora Stryker, Bright Saver cofounder (pictured top left in demonstration photos)

Find them at BrightSaver.org/getsolar for a free consultation.

Product Option (Only Bright Saver is Available in the U.S.)

	Bright Saver	indielux	EPP Solar
Manufacturer and Product Image			
Power Output (W)	Two 400W Panels	Two 410W Panels	Two 435W Panels
Efficiency	23.5%	-Not Listed-	22.3%
Size (LxWxD) (in)	76 x 41 x 1	70 x 41 x 1.38	68 x 45 x 1.18
Price ($)	$1,849	Not Available in the U.S.	Not Available in the U.S.

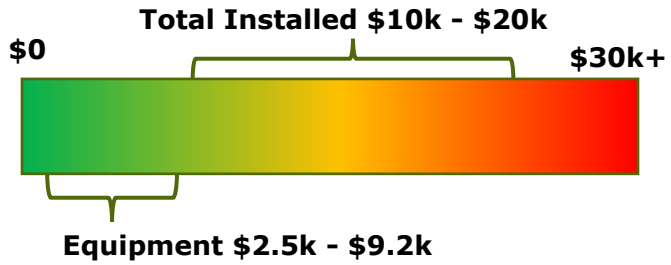
Energy Storage

Summary

Energy storage describes any product that has the capacity to take self-generated energy (I.e. solar) or energy from the grid and discharge it during outages (or in some cases during time-of-use hours) to power the whole home. It is important to note that these products are different than standard batteries. They are specifically designed to be integrated into the grid and your home and have built-in controllers for regulating the charging and discharging of the battery.

- All battery systems must be installed by a qualified technician
- Installation typically takes a full day
- Some systems will automatically boot up during an outage and others will need a manual switch by the owner
- For most of the products provided, additional capacities are available

Average Price Range



Factors that Influence Price

1. Installation difficulties increase price (panel capacity limits, electrical wiring needs), this is an order of magnitude more significant for price increases than other factors
2. Higher battery capacity increases price
3. Automatic start up for outages increases price
4. Packaged systems are typically cheaper than buying each part of your battery backup system separately

Product Options

Manufacturer and Product Image	**Lithium Valley** LV-BST-L2.56Ba 	**Goal Zero** Haven 4kWh 	**Enphase** Encharge 10 	**LG** RESU Prime 16H 	**Tesla** Powerwall 
Capacity	2.56 kWh	4kWh	10 kWh	16 kWh	13.5 kwh
Rated Output Power	10.4 kVA	3.6 kVA	3.8 kVA	7.0 kVA	5.0 kVA
Breaker Needed	60A	Comes with Subpanel	20A	40A	30A
Max number of Modules per Site	4	4	4	2	10
Features	Cold climate tolerant, high depth of discharge, real-time monitoring	Automatic power switching during outages for up to 10 circuits, automatic startup	Generator compatibility, passive cooling, advanced monitoring system	High voltage DC architecture, modular control unit, built-in seismic protection	AC coupled, compatible with most solar arrays, cheaper by kWh than most
Retail Price ($)	$2,500	$3,800	$8,960	$9,000	$9,200

Electric Generators

Summary

Electric generators enhance resilience by providing essential backup power during outages. Electric generators are high-capacity batteries that can provide power to a range of devices (devices with 12V car ports that use DC power or devices with 120V plugs typical in a home). To recharge the internal battery, power may be input from various sources such as solar, car batteries, or directly from the grid. Electric generators that have solar charging available directly connect to solar panels and draw power from them to recharge. An AC inverter is a feature in all the generators listed below. The batteries go up in cost as their capacity increases, which is measured in Watt-hours. For example, the Goal Zero Yeti 500X could power a 10-Watt lightbulb for 50 hours or could charge a 12W smart phone 42 times. The largest two batteries shown below have a higher rate of power supply which enables them to power more energy consuming devices. As another example, the Goal Zero Yeti 6000X could run an average full-sized fridge (100W) for 60 hours

Average Price Range

$0 **$30k+**

Equipment $500 - $4k

Factors that Influence Price

4. Battery capacity desired: the battery capacity of a single generator can be expanded by buying additional equipment.
5. Charging time: generators with a faster charging time will be a higher price.
6. Solar Panels: all models listed below are sold separately from the solar panels. The price of the solar panels varies depending on the watts of solar power it can provide, which is proportional to how quickly it can recharge the generator.
7. Watt-hours: the higher the Watt hours a single generator can provide, the higher the price for one piece of equipment. Small portable generators range from 500Wh to 2,000 Wh. Medium sized generators range from 2,000 to 10,000 Wh. While Large generators range from 10,000 to several hundred thousand Wh.

Product Options

Manufacturer and Product Name/Image	Pecron E600LFP 	Goal Zero YETI 500X 	EcoFlow River 2 Pro 	Goal Zero YETI 1500x 	Pecron E3600LFP 	Goal Zero YETI 6000x 	EcoFlow DELTA Pro 3 
Solar Charging	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Battery Capacity (Wh)	614	497	1,800	1,516	Expandable Capacity 3,072 base to 15,360	6,071	Expandable Capacity 4,000 base to 48,000
Output Voltage (V)	120 60 Hz (VAC), 12 (VDC)	5,9,12,20 (VDC),120 (VAC)	12.6 (VDC) 120 V 50-60 Hz (VAC)	5,12,50 (VDC) 120 (VAC)	12 (VDC), 100V~120V Pure Sine Wave (VAC)	5,12,13 (VDC) 120 (VAC)	12 (VDC) 100-240Vn 50-60 Hz (VAC)
Full Charge Time With 120 VAC Input (Hrs)	3.3 hrs Voc 32V~95V / 300W Max / 15A Max	4.5	1	3	1.3 Hours - 30A AC Cable / 2 Hours - 15A AC Cable	12	.8 (50 Min.)
Price	$300	$500	$600	$1,300	$1,600	$3,000	$3,700

Chapter 4: Watt Diet Technologies

As discussed in Chapter 2, electrification of your home can put extra strain on your panel, and in some cases, can push your panel past the limitations of safe operability or connectivity. In these cases, we need to utilize the Watt Diet Approach to reduce that strain through careful panel planning and load management techniques.

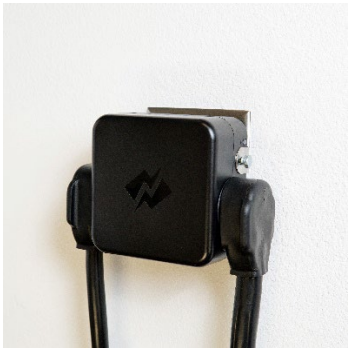
One way to achieve this is by implementing low-power appliances to replace old, inefficient electrical appliances in the home. We can think of this as like counting calories in a standard diet. If we add electrical demand, or calories, we must then remove them from somewhere else in our diet. For instance, if we remove a gas furnace and put in a 240V heat pump to heat our home, we can replace our 240V electric dryer with a 120V one to keep our overall demand roughly the same. We can also utilize this strategy by replacing two devices with one that does both functions such as a combination washer/dryer.

In other cases, we may need to utilize Home Energy Management Solutions, or HEMS. We can think of these as a dietary coach, enforcing the diet when the panel would like to access more power than it should. HEMS can allow us to have more than the maximum demand of the panel connected to a circuit or the whole panel so long as there are ways to safely monitor and control loads whenever they put the panel close to those limitations. Examples of these are circuit pausers, smart panels, or smart electric vehicle chargers, which can turn down or turn off appliances when the panel is close to tripping a breaker.

Lastly, we may be within our power budget, but we just need more space to connect all our new appliances. In this case we need space saving solutions such as subpanels and circuit splitters.

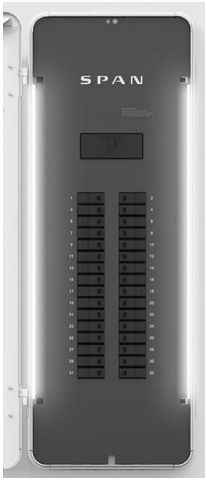
In this chapter, we will cover these Watt Diet technologies that will enable you to electrify your home with your existing electric panel.

Power Efficient Equipment



Circuit Sharing and Circuit Pausing

Electric Vehicle Smart Chargers



Smart Electrical Panels

Subpanels

Summary

Subpanels are an additional panel to your main panel. They are typically smaller in size and have less breaker slots than a traditional main panel. The options below are compatible with tandem breakers, which provide more spaces for circuits, compared to typical breakers. There is also one "smart" panel listed that is able to manage loads on your existing main panel.

Subpanels can be useful where appliances are located a considerable distance from the main panel (as in the case of an accessory dwelling unit) or where your main panel breaker slots are full, and you need breaker spaces for additional circuits. However, if your panel is at electrical capacity, then you cannot add more circuits or a subpanel (solutions to this specific issue are discussed further in other sections of this report).

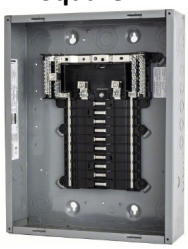
- Subpanels are a solution for adding more *physical space* to your electrical panel in order to add more breakers and circuits
- Subpanels do not address *electrical capacity* constraints on the panel
- Installing a subpanel will require a licensed electrician
- Equipment and installation costs range from $1000-$3000

Average Price Range

Factors that Influence Price

1. Need for new wiring
2. Permits
3. Difficulty of installation site (panel location, obstructions, etc.)
4. Number of circuit slots in panel
5. Weatherization needed (outdoor/wet environment vs. indoor/dry)
6. Inclusion of ground bar
7. Some drywall work, if mounting subpanel flush with and interior wall
8. "Smart" load management capabilities (like the Lumin panel, which is more expensive than typical subpanels)

Product Options

Type	Tandem Breaker Compatible	Tandem Breaker Compatible	Tandem Breaker Compatible	Tandem Breaker Compatible	Load Balancing Smart Panel
Manufacturer and Product Image	**Eaton** 	**Siemens** 	**Square D** 	**Siemens** 	**Lumin** 
Location	Indoor	Indoor	Indoor	Outdoor	Outdoor
Dimension (in)	11W x 13H x 3.56D	15.4W x 13H x 5.3D	14.25W x 17.94H x 3.75D	15.75W x 28.06H x 4.69D	17.5W x 17.5H x 4.0D
Number of Slots	6	8	12	12	0 (manages loads on main panel)
Number of Circuits	12	16	24	24	12
Amps	125	125	125	100	200
Volts	120/240	120/240	120/240	120/240	120/240
Price ($)	$40	$60	$130	$170	$2500

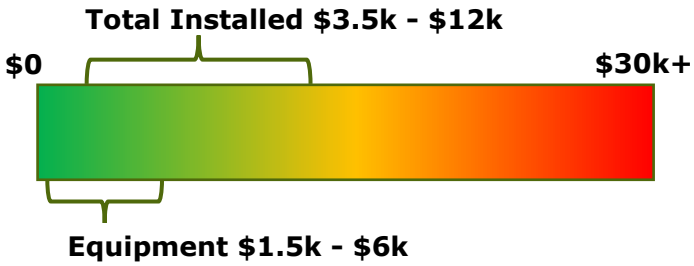
Smart Panels

Summary

Smart Panels describe any electrical panel that can monitor and control loads. Typically, the physical installation of smart panels is on par or easier than standard panels, especially if the panel is older. But, installing a smart panel can sometimes be a lengthier process due to the need to connect to an internet service. Although smart panels usually come with a much larger price tag, they may have benefits that offset it. Namely, some smart panels can act as a Home Energy Management system (HEMs) that can adjust the power of devices so they never exceed the maximum amperage of your electrical panel. This can help to avoid costly service upgrades.

- All panels included here can expand capacity and protect against circuit overload
- All panels have circuit prioritization during overcurrent events or outages

Average Price Range



Factors that Influence Price

1. Built-in functionality, load management abilities without additional hardware
2. Ease of Installation: the more difficult the installation (i.e. panel does not fit where existing panel is located, wiring needs adjustment for new panel, etc.) the pricier the install
3. Size of Panel (number of circuits)

Product Options

Manufacturer and Product Image	**Ecoflow** Smart Home Panel 2 	**Leviton** LP420-BPD 	**Span** Panel 	**Square D** Q1 Load Center 	**Koben** Genius 
Number of Circuits	12	42	32	61	24
Amperage	100	200	200	200	250
Load Management	Limited	Only with compatible smart breakers	Yes	Limited	Yes
App	Ecoflow App	My Leviton App	Span Home App	Sense Pro App	Genius Q App
Warranty	10 years	10 years	10 years	10 years for most components, lifetime for others	10 years, 3 years for internal PCB
Features	Generator compatibility	Has little to no smart functionality without smart breakers, plug-on breakers that avoid pigtails	Compatible with tandem and quad breakers, solar, central batteries	Integration of solar, battery management, generator	Can coordinate solar, generator usage, can schedule circuit shutoffs through app
Retail Price ($)	$1,900	$200 + $64/breaker	$3,500	$3,500	$5,550

Circuit Sharers and Circuit Splitters

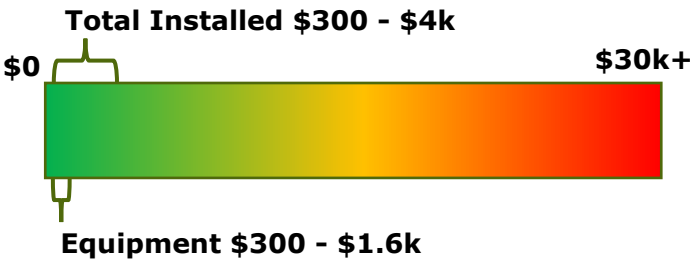
Summary

When considering smart solutions for circumventing a panel upgrade, some of the most useful and cost-effective options are circuit splitters and circuit pausers.

Circuit splitters encompass any device that can increase the number of devices that can connect to a given circuit on your panel. For 120V outlets, there are many common devices that can be found in most households that provide this function, for example, a power strip. Once you get to 208V and above, it becomes challenging to safely connect multiple devices to a single outlet, which is where these specialty devices come into play. Most have built-in overcurrent protection to protect your panel.

Circuit pausers may also be able to split a circuit, but the defining feature of a circuit pauser is the ability to automatically detect the power used by an appliance and either "tune down" the appliance or shut it off all together to prevent a breaker from flipping. Some can readminister power to the device again automatically as well once conditions improve on the panel or individual circuit.

Average Price Range



Factors that Influence Price

1. Hardwired vs external plug, hardwiring involves additional labor
2. More functionality, i.e. turning down power instead of just turning on/off
3. Voltage, 240V devices are typically more expensive than 120V devices

Product Options

Manufacturer and Product Image	**Lumin** Edge 	**BSA Electronics** Dryer Buddy Plus 	**NeoCharge** Smart Splitter 	**SimpleSwitch** 240 
Voltage	120	240	240	240 / 120
Splitter	No	Yes	Yes	Yes
Pauser	Yes	No	Yes	Yes
App	Lumin App	None	NeoCharge App	None
Electrician needed?	No	No	No	Yes
Features	Monitors and controls power to loads automatically through app, compatible with all 120V devices	Automatically switch off one load to prevent overcurrent, LED display with usage data, customizable plugs	Works with most all 240V devices, auto-switching on/off, power derating for EV chargers	Hardwired, auto-switching on/off, can monitor whole panel health with CTs (additional $315)
Retail Price ($)	$200	$340	$400	$750

Chapter 5: Case Studies

How a Dangerous Gas Leak Became a Catalyst for an All-Electric Retrofit: Williams Home

The Williams fully electrified their 1905, 1,350 square foot home in 2023. Initially, a solar PV system was installed with the help of a federal tax credit. Two years later, the Williams found out they had a gas leak in three different places in their home due to the aging gas pipes. This was the push for them to take the leap and retrofit their home to be fully electric, and the homeowner notes that she has "never looked back".

The Williams have since expanded their solar system and qualified again for additional federal tax credits. The heat pump water heater also qualified for their local city's rebate program. The homeowner states that "I am a single mom and the rebates really helped."

Figure 2: The 1950s Williams home.

Figure 3: The new electric stove with freshly baked cookies, the heat pump water heater fitting within the existing water heater closet, and the homeowner enjoying their new all electric lifestyle!

The new heat pump water heater cost $6,500 to install and fit within the existing water heater closet adjacent to the carport. The new electric stove fit in the same place as the old gas stove and cost $2,000 to install. All the gas lines were safely cut and capped.

Retrofitting your home to use a heat pump instead of a gas furnace offers the benefit of both heating and cooling. Before the retrofit, the Williams' home did not have air conditioning, so by replacing their old furnace with a new, efficient heat pump, they also gained the benefit of air conditioning. Having a centralized system with ducting also allows the addition of an air filter to purify the air. The homeowner notes that

after the retrofit, “the whole air system in the house feels noticeably cleaner.”

The cost to retrofit the HVAC system was $24,000 for a 3-ton 2-zone system. Since the ducting of the old furnace was 30 years old, they also replaced the ducting as a part of their heat pump installation. The new heat pump was installed in the attic, with nontoxic insulation in the floor of the attic, metallic sheets lining the rafters were installed to provide a passive energy strategy that helps reduce the need for cooling in the hottest months and heating in the coldest months.

The solar PV system helps offset the costs of the new electric use and cost $25,000 to install. The solar array was placed with maximal sun exposure, on the different planes of the roof, with enough panels to cover the electricity use for the entire home. For example, in June of 2024, the Williams home used 202 kWh of electricity, but their utility bill was negative $38. In the past 18 months, the solar array helped the Williams save 17.02 tons of CO2, equivalent to planting 288 trees.

Figure 4: The new HVAC system installed in the attic, with ample insulation around the heat pump itself, and on the lining of the rafters.

Figure 5: The solar array on all planes of the roof to maximize solar production to offset utility bill costs.

In total, the cost to electrify the Williams home was $57,000, providing the family peace of mind by safely eliminating gas from their household. The benefit of financial incentives from both the federal government and the local city, and reduced utility bills make electrification financially within reach for an “ordinary single-mom teacher like me” says the homeowner; above all she is “proud to contribute to a better heritage of earth, sky and water for generations ahead”.

Leaving a Legacy of Clean Energy by Going All-Electric: Reuscher Home

In 2020, a Bay Area homeowner began their journey to retrofit their 1944, 2,700 square foot home with all-electric systems. Concerned about the future of the planet and wanting to leave a better world for their children and grandchildren, they decided to make their home part of the solution. Already equipped with solar panels installed in 2010 and an electric car (with Level 2 charging) since 2012, transitioning to an all-electric home was the next logical step.

Figure 6: The all-electric retrofitted home.

Before the home’s electrification retrofits, there was a major remodel of the home in 1995, that included a 200 amp panel upgrade, insulating the walls, and installing double pane windows. Fully electrifying their home happened in stages over

the course of three years. The journey began in 2020 with installing a heat pump water heater and a new sub-panel to deliver power to the water heater. This initial phase cost approximately $8,000 and included additional electrical work of installing a 240V outlet for the future induction stove. In 2021, the homeowner upgraded to an induction stove, which cost $10,000. The installation was straightforward, with the new stove fitting perfectly into the existing kitchen setup, and the homeowner notes it is much easier to clean compared to the previous gas stove.

Figure 7: The new electric induction stove, the heat pump air handler and heat pump water heater, and the electric car charger next to the subpanel for the water heater.

A major upgrade came in 2022 with the installation of a ducted heat pump HVAC system that cost $17,000. This system replaced an older gas furnace, providing not only efficient heating but also the added benefit of air conditioning during hot months. The new system also operates more quietly than the old gas furnace. In 2023, a second ducted heat pump HVAC system was installed for $25,000. This additional system was necessary to ensure even heating and cooling throughout the entire house, given its size and layout, and it ended up being easier to install two separate systems rather than expanding the first one. Both systems are Mitsubishi MXZ-SM36NAM with 36,000 BTUs of heating, or 3 tons each.

Figure 8: The heat pump air handler in the attic, and the heat pump compressor sitting on the outside of the house.

By eliminating gas use, the homeowner significantly reduced their carbon footprint. The new heat pumps provided efficient heating and cooling, and the induction stove improved the cooking experience with faster, cleaner operation. With the transition to all-electric systems, the homeowner eliminated their gas bills. While electricity bills vary based on factors like electric vehicle usage and seasonal changes, the overall impact has been positive. The solar panels, installed in 2010 and expanded in 2021 with a rough total cost of $35,000, help offset the electricity costs, making the transition more financially manageable. June through August the solar array produces more electricity than the home uses, even when the homeowner does most of their EV charging at home.

How to Retrofit an Eichler Home

Eichler homes, built by real estate developer Joseph Eichler in California during the 1950s and '60s, are iconic examples of Mid-Century Modern architecture. Known for their roomy designs, these homes typically feature large windows, clean lines, and an emphasis on indoor-outdoor living with open-air foyers and abundant natural light. Essential characteristics include small windows facing the street and large windows overlooking a backyard, post-and-beam construction, center courtyards with roofed atriums, entry courts, carports, and a unique "front-to-back" layout with living spaces at the rear. Eichler built over 11,000 of these distinctive houses in the San Francisco Bay Area and Los Angeles[23].

Eichler homes typically have hydronic radiant heating (loops of piping in the floor to provide heating), served by a gas boiler, often need insulation because of their open floor plans and large windows, and did not have air conditioning when first constructed. This section will focus on how to electrify a gas boiler for hydronic heating.

To electrify an Eichler home with a hydronic heating system, consider replacing the natural gas-powered boiler with an air-to-water heat pump. These efficient electric devices use a refrigerant to extract heat from outdoor air, which is then used to warm or cool water that circulates through radiant floors, baseboard heaters, or other hydronic fan coil units. Using a heat pump can be three to five times more efficient than using a gas boiler and reduces a home's overall greenhouse gas emissions. The setup involves an external unit, typically a large box with a fan and compressor, and an indoor buffer tank that acts as a thermal battery, helping the system run more efficiently. This configuration is particularly suitable for California's temperate climate and can seamlessly integrate with existing radiant floor systems. While the installation of these systems can be complex and costly, often requiring skilled contractors with expertise in plumbing, HVAC, and electrical work, the investment can lead to significant energy savings and improved efficiency. For homes with higher-temperature radiators (instead of a radiant floor), modifications or installing new low-temperature emitters may be necessary to fully benefit from the heat pump's capabilities, since heat pumps produce water at a lower temperature than gas boilers.

Retrofitting an Eichler home involves several components and costs. Overall retrofitting an Eichler home heating system can cost $25,000 - $65,000[24]. Breaking down the costs, from a reputable sales representative and contractor that installs radiant systems, here are the following components of the cost to retrofit a boiler system:

- Cost of the heat pump: Spacepak 5-ton and 3-ton variants, are priced at $9,500 and $7,500 respectively.
- Additional equipment such as piping, valves, and a circulator add around $1,300.
- Heating-only systems may include a 13-gallon buffer tank for $800 or a 60-80-gallon Triangle Smart Tank for $1,500-$2,300.
- Labor costs for heating and domestic hot water systems range from $20,000 to $30,000, doubling the materials cost of $11,000-$13,000.
- Installing air conditioning requires extra equipment, if there is a lack of floor insulation (because of condensation issues). Air handler installation costing $5,000 in equipment and an additional $5,000 in labor.
- Removing the old boiler and hot water tank and installing a 5-ton Spacepak heat pump and buffer/triangle tube combined tank, ranges from $12,000 to $16,000.
- Skilled technicians are paid $200 per hour. An example retrofit might include an R32 small unit for $6,000, a circulator for $300, and a dual-purpose tank for $1,400, totaling $7,700.

Electrifying a Boiler for Radiant Floor Heating: Eichler Home Retrofit

A Bay Area homeowner electrified their Eichler home gas boiler that previously supplied water heating and space heating for their 2,100 square foot home. To accomplish this, instead of providing both space heating and domestic hot water heating with one piece of equipment, these two loads were broken into two systems. The water heating is now provided

by a typical Rheem heat pump water heater. The space heating and cooling is provided by a Chilltrix 2.8 ton "air to water" or "hydronic" heat pump, which is on the small side for a 2,100 square foot home, however this home is well insulated so it provides adequate heating and cooling. The system also has a 37 gallon buffer tank. Since the climate of the Bay Area is more temperate, the homeowner and the contractor decided not to hook up the electric resistance back up elements in the buffer tank, which are only needed in colder environments.

Figure 9: The outdoor Chiltrix hydronic heat pump and in the inside buffer water storage tank.

The home has a radiant floor, which works well with a hydronic heat pump that supplies 110F hot water. The homeowner also installed fan coil units to supply hot and cold air to areas of the home that do not have a radiant floor.

Providing cooling with a radiant system can introduce condensation, which can lead to mold growth and can cause a radiant unit to malfunction. The homeowner decided to have the new system provide cooling as well, but opted to monitor condensation levels within the slab. Given the city's relatively low humidity, there have not been problems with condensation to date. However, there are controls that you can install that will raise the temperature of the water in the radiant floor to prevent condensation.

The home was also upgraded with new double pane windows and attic insulation, which further improves the overall efficiency of the home, and helped to reduce the size of the heat pump required. The cost to retrofit this homeowner's gas boiler system to an efficient hydronic heat pump was $30,000, of which $5,000 was for installing the fan coils. In the winter of 2022, which was colder than normal for the area, the hydronic heat pump consumed between 630 and 870 kWh per month. The cost to operate the heat pump was estimated to be between $155 to $215, which is similar to what the homeowner would have paid for gas.

The homeowner cautions that finding skilled and available contractors to retrofit the gas boiler with a hydronic heat pump system for radiant floor heating can be challenging due to the specialized nature of this work. If retrofitting the existing boiler system is too complex, or if the radiant floor system has been corroded beyond the point of repair, you can install mini split heat pumps to provide heating and cooling for the home. Mini split heat pumps are more common than hydronic heat pumps, therefore it will be easier to source a contractor and be an overall less costly project.

Electrifying an Eichler with Solar Thermal: Matthey Home

The Matthey's fully electrified their 1,700 square foot, 1957 Eichler home in 2021. Their journey started in 2012, when they replaced the home's original electrical panel, a 1950s-era 100-amp Zinsko panel due to safety concerns, with a new 200-amp panel and a utility service upgrade. They also updated some of the house wiring and added a 100-amp subpanel to the garage on the opposite side of the house, anticipating getting an electric vehicle in the future, totaling about $8,000.

Figure 10: The Matthey Eichler home.

The water heating system underwent several retrofit phases. Initially, the home had a 40-gallon gas-fired tank water heater (separate from their radiant floor boiler). In 2013, the owners added a solar thermal system, a SunEarth CopperHeart CP-40 “batch heater”, costing about $7,000, and replaced the old water heater with a new 50-gallon gas-fired model. By 2021, to complete the transition to an all-electric home, the owners converted the gas tank water heater to electric (by shutting off the gas to it and adding an electric element inside of it) and supplemented by a small tankless water heater from Stiebel Eltron. The cost for the tankless unit and associated installation was around $500.

Figure 11: The solar thermal panel on the roof.

The solar thermal panel produces hot water from the sun, only boosted by the modulating electric tankless water heater as needed after very cloudy days. The now-electric tank water heater (sitting between the tankless water heater and the solar thermal panel) ensures that the tankless is always fed at least slightly-preheated water, to keep its maximum power requirement below the 50 amps available.

At the time when they installed the solar thermal system in 2013, heat pump water heaters on the market in the U.S. were only half as efficient as today, and their long-term reliability unproven. The homeowner states that if they were to retrofit their home today, they would likely go with more solar PV on the roof and get a heat pump water heater instead.

For their heating and cooling system, the home initially relied on a 1980s-era gas-fired boiler connected to a radiant floor, which was oversized and did not include cooling. In 2019, the owners installed a single-head ductless mini-split heat pump system for $8,000, choosing this option over radiant floor heating due to limited availability and high costs associated with installing an air to water heat pump.

Figure 12: The min-split heat pump outdoor and indoor units.

The home’s solar 6 kW PV installation, which cost approximately $30,000 (or $20,000 after incentives and combining some of the work with re-roofing), offsets 100% of the home’s energy consumption. The home is fully electric, including cooking, laundry drying, and two Level 2 electric vehicle chargers. The owners have noted substantial benefits from switching to induction cooktops: “It’s night and day. Induction is so much faster; I don't understand why anyone would want anything else. Super-easy to clean too. We love it.”

The transition to an all-electric home was not without challenges, notably in finding suitable contractors and navigating the costs of various systems. However, the benefits have been considerable. The homeowner now enjoys low utility bills, enhanced environmental sustainability, and increased safety by eliminating gas use. The electrification has also led to improved comfort and convenience, particularly through the efficient performance of electric cooking and the dual functionality of the heat pump system. Overall, the Matthey’s shift to an all-electric home has proven to be both a financially sound and environmentally responsible decision, and on a deeper level, the homeowner states that “it’s a liberating feeling not being directly dependent on fossil fuels anymore”.

Electrifying Without Increasing Power Supply: Schmidt Home

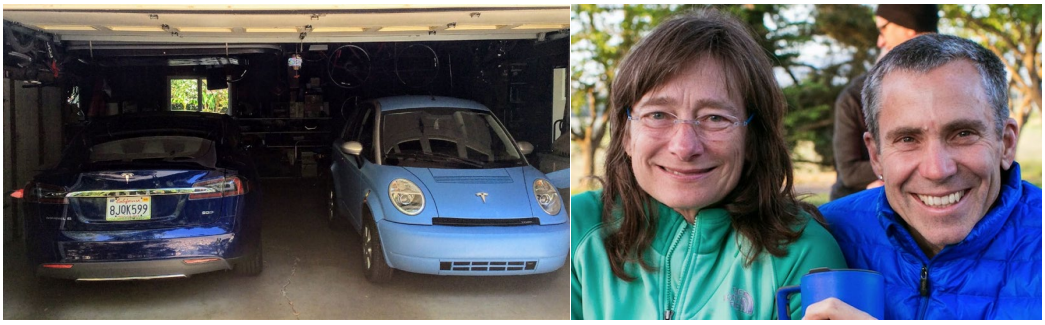


Figure 13: The NeoCharge allows two electric vehicles to be plugged in at the same time at the Schmidt's home, where one car is charged completely then it automatically switches over to the other car to charge (Images courtesy of Steve Schmidt).[25]

Lisa and Steve Schmidt, two "early adopters" in Silicon Valley's all-electric retrofit program and well-known energy consultants, run their large 4,000 square foot Los Altos Hills family home on a standard 200 Amp panel, even as they have retrofitted chargers for two electric cars, an electric motorcycle, an induction range, a combined washer-condensing dryer, two heat pump water heaters and three heat pumps for space heating and cooling. The trick to avoiding upsizing their power supply from 200 Amps to more (e.g. 400 Amps) was using NeoCharge plugs. These plugs are designed to share power between two 240V devices using one plug. The NeoCharge controls power use, so one electric car waits for the other to charge, or the water heater waits while the induction stove cooks, then resumes heating the water in the storage tank when the stove is done. This power sharing strategy avoided the need for an expensive panel and service line wire upsize.

Figure 14: At the Schmidt's home, the Bosch electric induction stovetop[26] *is shared on the same circuit as the Rheem heat pump water heater*[27] *using the NeoCharge (middle) (Images courtesy of Steve and Lisa Schmidt).*

Their other strategy was selecting low power appliances. Rather than using a 7,000 Watt electric resistance laundry dryer and triggering a wiring upgrade, they bought 700 Watt condensing washer/dryer, so efficient with its power demand that it can plug into any existing 120V outlet. Lisa loves it-- *"The condensing Washer/Dryer is just outstanding. It washes quickly and does a better job than my old washer and dryer—the clothes come out cleaner and very dry. I'm thoroughly impressed."* They also avoided extra power by not installing resistance strips in their new HVAC systems and opted for one of the new 120 volt heat pump water heaters. Steve and Lisa have now been using the strategy of power-sharing between their stove and water heater, and between their two EVs for four years now with no issues. Steve states that the power sharing *"works great because we have NEVER noticed it."* That is just one of the many benefits of using this technology, the ability to set and forget, along with an easy installation, and avoiding any unnecessary wiring, electric panel or service upgrades.

Go for the Green: Combining Space Heating and Water Heating into one Efficient System

In 2024, a Palo Alto resident completed a major retrofit of his 1951, 2,130 square foot home by installing the Harvest Thermal system, a comprehensive green solution that combines heating, cooling, and domestic hot water into one system. The retrofit, which cost $50,000, involved removing the old equipment— a gas water heater, and electric heating with no air conditioning —while also upgrading other electrical components in anticipation of an electric stove and EV charging. The panel did not need upgrading, and the project included removing asbestos from the attic, installing new ducts, and addressing space issues with equipment layout. While the gas stove still remains to be replaced for the home to become fully all-electric, working with Harvest Thermal helped set up the home for future full electrification.

The home uses a Harvest Classic system that is unique compared to a typical heat pump system. The Harvest Classic system is a combined solution for space heating and domestic hot water, featuring a SANCO2 heat pump water heater, a Harvest Pod, an Airscape air handler, and a large water storage tank acting as a thermal battery (Figure 20). This system also included a 3-ton reversible air conditioner (or heat pump) using the Ecoer EODA18H-2436B.

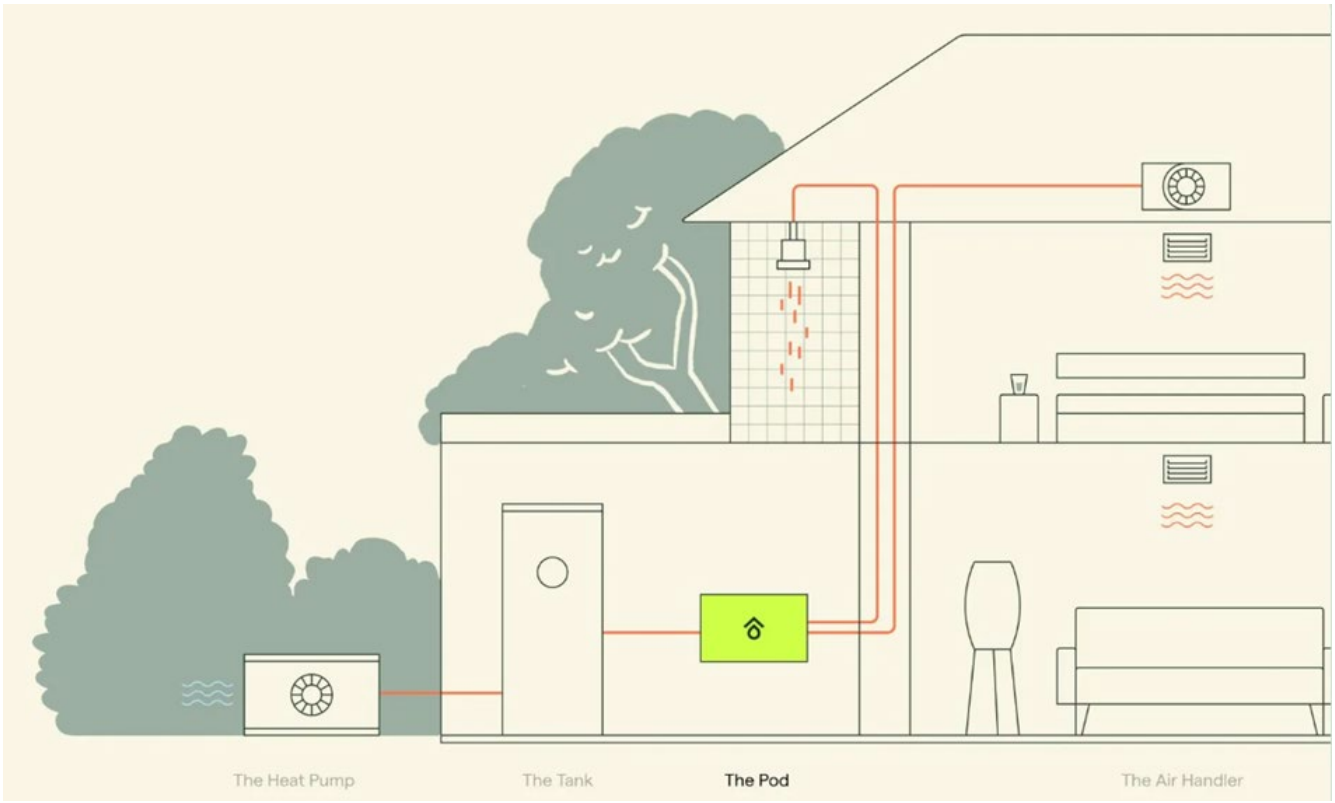


Figure 20: The Harvest Thermal System components (Image Credit: Harvest Thermal https://www.harvest-thermal.com/product)

The Harvest Pod manages the system by predicting hot water usage and adjusting energy storage for maximum efficiency by shifting energy use from high cost and high emissions time periods to low cost and low emissions period, but without sacrificing comfort. It also has the benefit of using CO2 as a refrigerant, which has a low global warming potential and operates in temperatures as low as -25°F, along with a lower amperage requirement (15 amps at 240 volts) compared to traditional systems, saving electrical panel capacity for other home electrification projects.

The homeowner first heard about Harvest Thermal at an Earth Day event when they were exploring various heat pump options. Before this, the homeowner completed an online home electrification assessment from QuitCarbon. After consulting with a Clean Energy Coach at QuitCarbon, the homeowner decided on the Harvest Thermal system, which they felt offered the most comprehensive, efficient solution for their needs. The homeowner notes that while it was a premium option, it was worth the investment for both sustainability and long-term efficiency.

Figure 21: The Harvest Thermal pod[28] and the SANCO2 heat pump water heater[29] that is used by the Harvest Thermal system.

The biggest challenge during the retrofit was the layout and fitting of the new equipment in the existing exterior closet, which housed the old 40-gallon water heater and old air handler. The new water storage tank was 119 gallons, so the HVAC ducting and air handler had to be moved slightly within the closet to fit the new storage tank to provide enough space for it to be serviced.

Since the retrofit, the homeowner has appreciated the consistency in comfort and efficiency the system provides. Unlike the previous gas and electric systems, the new system delivers more consistent heating, maintains a narrower temperature band, and has improved overall comfort. Gas systems are typically less comfortable because they are either on or off, providing very hot air in intermittent bursts. A heat pump comparatively is designed to run more continuously, providing the exact temperature needed. The homeowner also stated that the new system offers peace of mind knowing that the combined system (that serves both water heating and space heating) will be managed efficiently for many years into the future and is a more sustainable system compared to the previous gas system.

The homeowner took a proactive approach to finding the right contractor for the job. They decided on a contractor that was willing to train with Harvest Thermal to install the system. Harvest Thermal also provided strong ongoing support, checking in before, during, and after installation, and assisting with rebates.

In terms of the bigger picture, the homeowner believes people need clear guidance when considering such a significant retrofit. They recommend electrification guides and resources from a Utility or City to present the steps clearly, providing the necessary information on specifications and important terminology, and helping homeowners understand where they can DIY versus when to hire professionals. From there, homeowners need help to implement solutions for their specific home. This detailed attention could best be done by a consultant or contractor, where they can walk the homeowner through the process. Overall, the homeowner is proud of his green investment and recommends a thoughtful, step-by-step approach for others considering similar retrofits.

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