

Design Guidelines for Home Electrification

Decarbonize without upgrading electrical service capacity

A guide for contractors, DIYers, and policymakers

Note:

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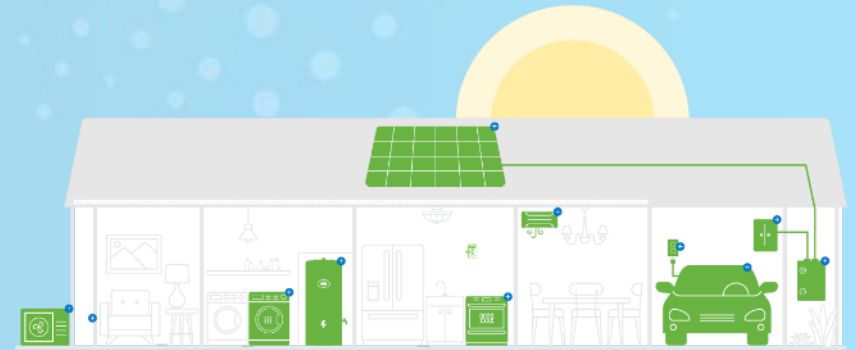


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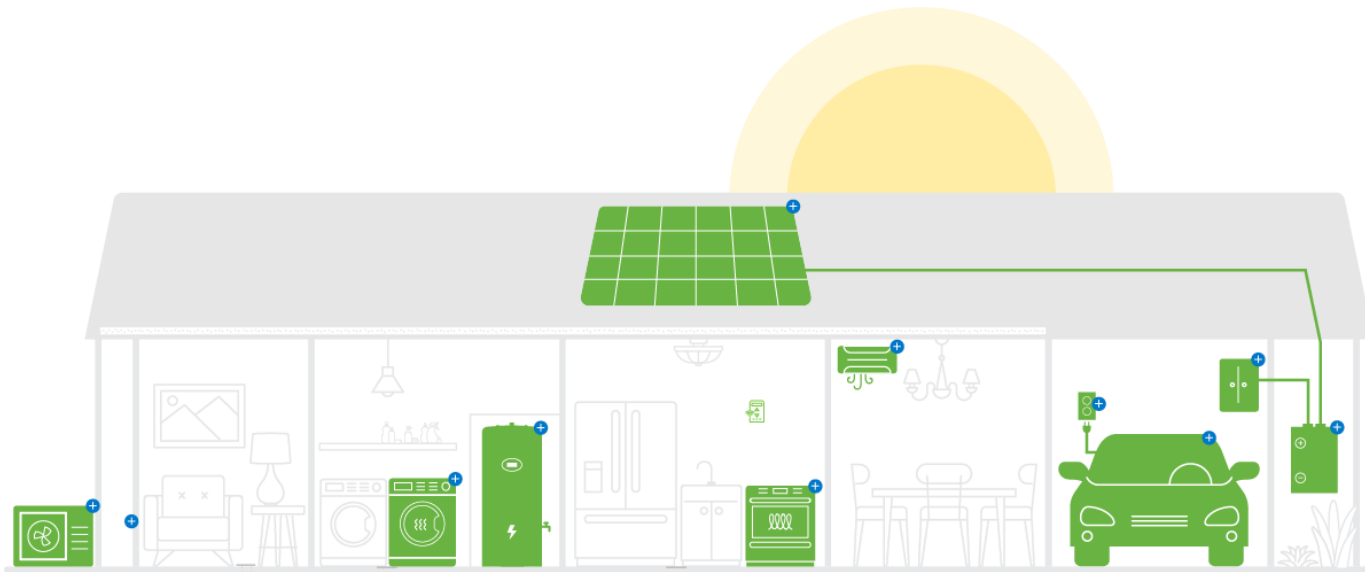
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Special thanks to Tom Kabat, David Kaneda, Farhad Farahmand, and Eric Morrill for their technical expertise.

Design Guidelines Overview



When considering total home electrification coupled with EV charging, the total size of the electrical panel and service should be considered to ensure lowest cost of electrification.

This document goes through a host of home types to help homeowner or contractor plan-ahead to enable the all-electric life without forcing a service upgrade.

Typical homes

We have not analyzed non-typical, high-load home equipment – home theaters, private tennis courts, crypto mining operations, etc.

Realistic equipment

While low-amp strategies, such as combo-washer dryers and 120V EV chargers can be useful in avoiding upgrades, we have used only standard equipment in our examples

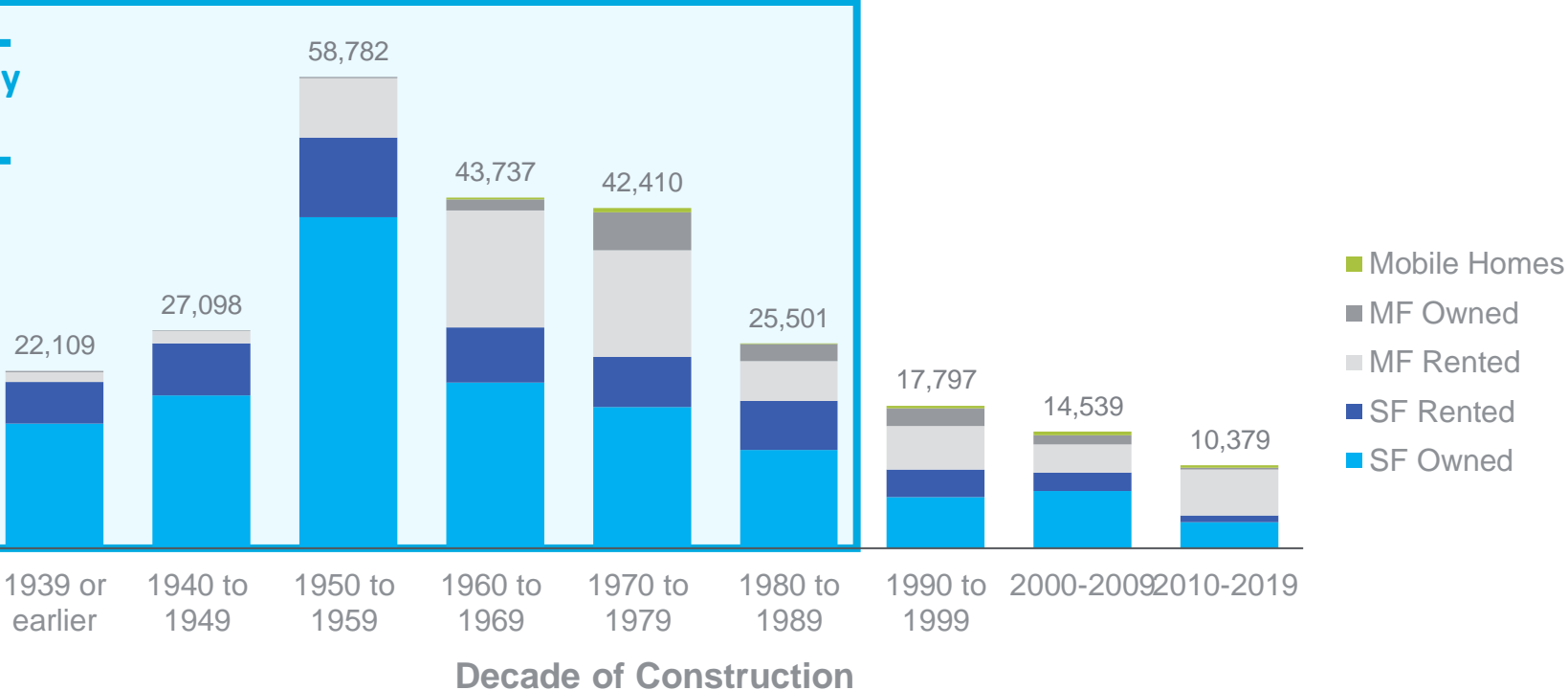
What Homes will Need This Guide?

Number of Households in San Mateo by Vintage, Type, and Tenure

This guide is primarily aimed at single-family homes built before the mid 1980s.

Single-family homes are often built with their own panels, whereas multi-family buildings have shared electrical and mechanical services.

In modern times, homes are built with 200A service – more than enough capacity to go all-electric with ease. This changed sometime in the 1980s. Older homes, which represent a majority of San Mateo County’s housing stock, will benefit most from this guide.



Three Reasons Panels are Replaced

Capacity Constrained

Capacity, measured in Amps, is too low to add equipment



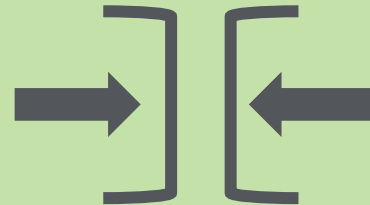
Max. 100A

Solutions to avoid upgrade:

- Circuit splitters
- Circuit pausers
- Smart panel
- Low-amp equipment

Space Constrained

There are no longer spare breaker spaces in the panel



Solutions to avoid upgrade:

- Subpanels
- Circuit splitters
- Smaller breakers
- Breaker re-use

Unsafe to Use

The panel is unsafe to work on, sometimes found on panels from the 1970s or earlier



Solutions to avoid update:

The panel must be replaced for your safety. However, it may be worth avoiding a service upgrade using solutions for capacity-constrained panels, and planning ahead by providing breaker space for an all-electric life.

Common Pitfalls

There are common mistakes that owners make while electrifying homes and vehicles which could result the need to upgrade the panel at a later date. While planning ahead is the best strategy, these issues have been identified as the most likely to create a need for a service upgrade at a later date:

Pools and Spas

Adding a heated pool or spa will often result in a 200A service size requirement by the time a house is fully electrified

Consider circuit sharing or pausing

Separate Oven & Cooktop

Due to the increased load and wiring needs of separate units, separating your range into two components will often require a complicated electric design or an upgrade above 100A service.

Consider buying a combination range

60-80A EV Charging

Including high-capacity EV charging will require careful design to stay under 100A.

Consider lower capacity home EV chargers, or a circuit pauser

Multiple EV Charging Circuits

Including multiple Level 2 EV charging stations may require multiple instances of circuit sharing to enable total electrification on 100A panels.

Consider circuit sharing or L1 charging

Going All-Electric on 100A

Solutions for homes with safe panels,
limited by 100 Amp service capacity

Typical Pre-1985 Single Family up to 3,400 sqft, 5-ton Heat Pump

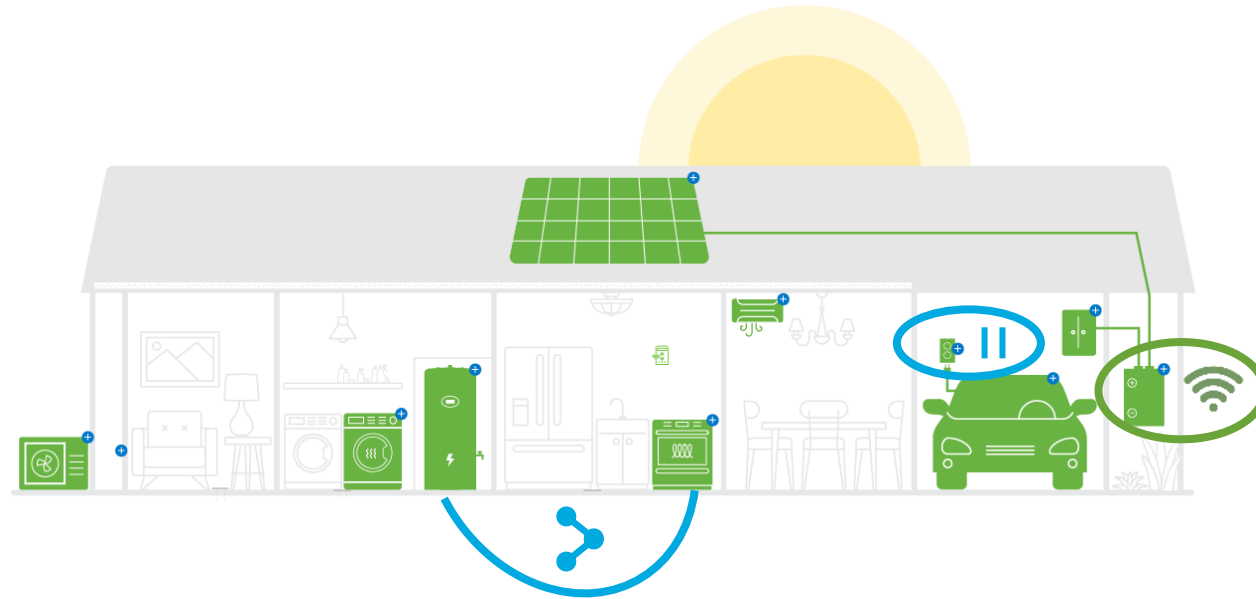
Home description:

- Up to 3,400 sqft
- 100A service and panel
- No pool or spa
- Slide-in range/oven combo
- One (1) 5-ton heat pump space heater

Summary:

It is relatively easy to electrify the typical single-family home up without upgrading above 100A service.

Larger homes or a larger, 5-ton space heater in a large home, will need two circuit controls



Option 1

Control 1



Use a circuit pauser on the Level 2 EV charger

Control 2



Use a circuit-sharing device with the Range and water heater

Option 2

Control



Use a smart panel

Typical Pre-1985 Single Family up to 2,500 sqft with Two (2), 3-Ton Condensing Units

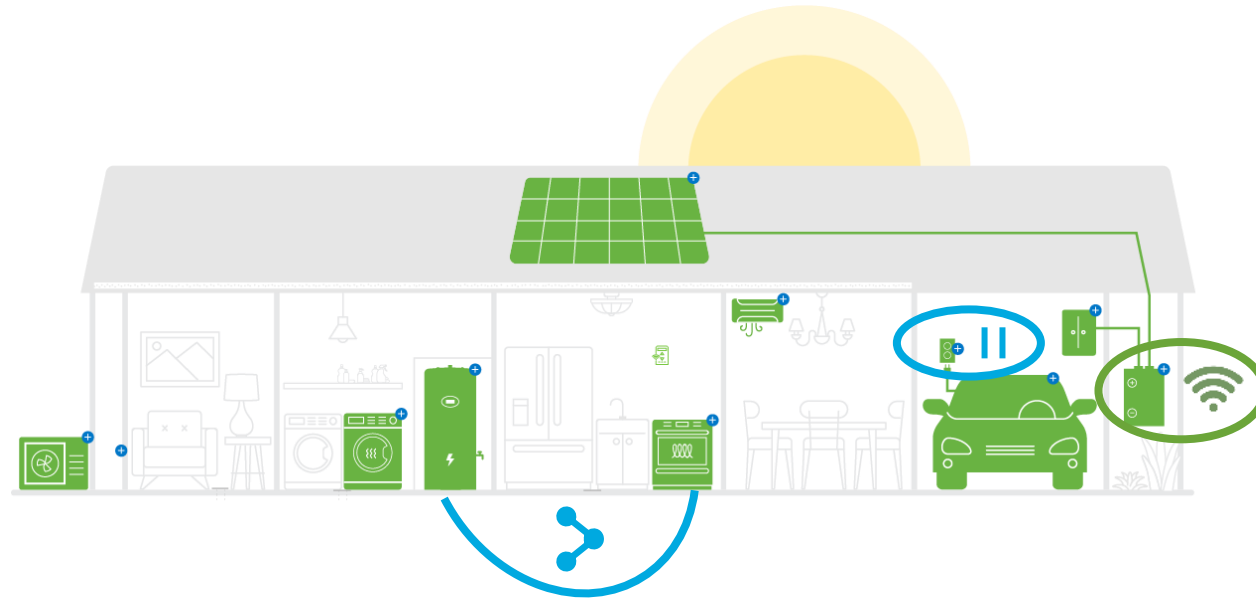
Home description:

- Up to 2,500 sqft
- 100A service and panel
- No pool or spa
- Slide-in range/oven combo
- Two (2) 3-ton heat pump space heater

Summary:

It is relatively easy to electrify the typical single-family home up without upgrading above 100A service.

Homes with two (2) 3-ton condensing units will need two circuit controls.



Option 1

Control 1



Use a circuit pauser on the Level 2 EV charger

Control 2



Use a circuit-sharing device with the Range and water heater

Option 2

Control



Use a smart panel

Staying under 100A with a Split Oven / Cooktop

Why the Split Oven /Cooktop can be difficult

Cooking equipment tends to demand the highest electric demand in an all-electric home. Combination, slide-in ranges are able to load share within the unit to ensure that the panel never sees a draw higher than roughly 8 kilowatts. Separate units are not yet capable of integrated power management across appliances. Circuit sharing between the two cooking appliances is also not an option – ovens and cooktops are often used in the same meal prep.

Make a decision on your home's priorities

If you have not already installed the separate appliances, is the separation a priority for you? It may be, but it will make electrification harder. If they are already separate, would you consider combining the two during a renovation? Is your kitchen built such that it is easy to combine these units?

How important is it for you to stay on your current 100A service? Is your electric service underground? If so, there is a cost component. Are there future renovations you are considering that would benefit from more service? An Accessory Dwelling Unit (ADU,) a heated pool, a spa?

I still want separate units, and I still want to stay under 100A

This is possible, but will require long-term planning and a skilled electrician. Two circuit controllers and a smart panel will be required. The square footage and electric draw of your space heating systems will also play a critical role. See the table below for example homes which can go all-electric, with two circuit controllers as listed to the right, based on maximum square footage and heat pump size. These are merely examples, and specific and precise calculations will be required to see what is possible at your particular home.

Oven kW	Range kW	Max Square Footage	Max Heat Pump Tonnage
8,000	7,600	3,200 sqft	3 tons
8,000	7,600	2,200 sqft	4 tons
8,000	11,600	1,800 sqft	3 tons

Option 1

Control 1



Use a circuit pauser on the Level 2 EV charger

Control 2



Use a circuit-sharing device with the Range and water heater

Option 2

Control



Use a smart panel

Going All-Electric on 200A

Solutions for larger homes or homes
with heated pools and spas

200A Single Family up to 5,000 sqft, with a Heated Pool

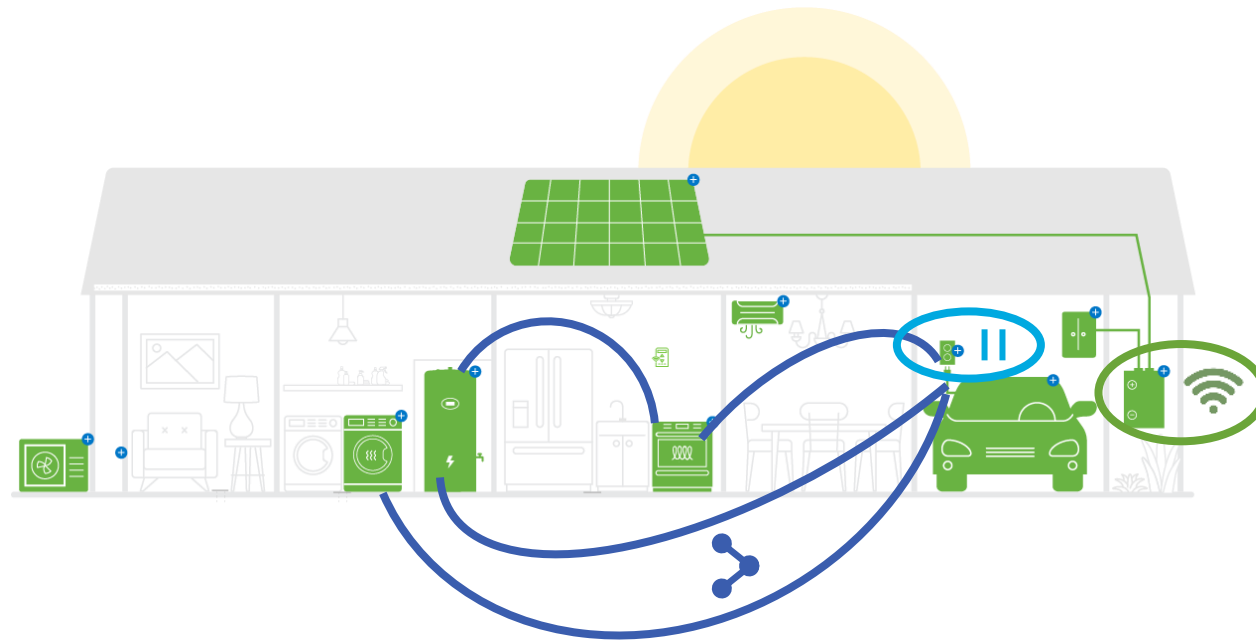
Home description:

- Up to 5,000 sqft
- 500A service and panel
- Heated pool or spa
- Slide-in range/oven combo
- Two (2) 3-ton heat pump condensing units

Summary:

It is relatively easy to electrify the typical single-family home up without upgrading above 200 service.

One circuit control or smart panel may be necessary in larger homes.



Option 1

Control



Use a circuit pauser on the Level 2 EV charger

Option 2

Control



Use a **circuit-sharing** device with
EV charger + range
EV charger + water heater
EV charger + clothes dryer
Range + water heater

Option 3

Control



Use a smart panel

Equipment Examples

Example technologies to electrify
without upgrading panels

Note: All equipment examples are
informational only and do not represent any
endorsement by Peninsula Clean Energy

120V Equipment Examples



120V technologies can save energy, save costs, avoid the need to call an electrician, and reduce the impact on the local workforce

Plug-in Heat Pump Water Heater (15A, 120V)



Image by [Rheem](#)

New to the market in 2021, low amp heat pump hot water heaters do not require a circuit upgrade and plug right into a normal 120V outlet.

Pros	Avoids infrastructure upgrade, no electrician needed
Cons	Reduced capacity (12,000 BTUh)
Market Readiness	Available from 1 manufacturer
Which Customer Types is This Applicable for?	Residential customers with 1 bedrooms or less, as well as commercial with low hot water demand, such as retail or office.
How Many Amps Does it Save?	30A
Co-Benefits	None
Customer Experience	Equal, unless a household of 4 or more
Incremental Cost	Incremental cost equivalent on equipment, savings on electric capacity.
Training Opportunities / Issues	Not well-tested. Released in 2020.
Hyperlink	Not yet available

120V Heat Pump Space Heaters



Image by (clockwise from top left) [Gradient](#), [Friedrich](#), [Epocha](#), [Honeywell](#)

120V heat pump space heaters provide efficient heating, low-to-no installation costs, and avoid the need for a dedicated 240V circuit.

Pros	Avoids infrastructure upgrade, no electrician needed
Cons	Reduced capacity (12,000 BTUh)
Market Readiness	Available from a few manufacturers
Which Customer Types is This Applicable for?	Residential customers who want to save money on their heat pump installation, want low electricity costs, and do not mind the aesthetics
How Many Amps Does it Save?	30A
Co-Benefits	None
Customer Experience	Increased noise
Incremental Cost	Savings on equipment, ,installation, and savings on electric capacity.
Training Opportunities / Issues	Market experience needed for the newer products.

Level 1 EVSE



Image by [ClipperCreek](#)

Level 1 chargers have a slower charge rate than level 2 chargers, but do not necessitate a dedicated circuit

Pros	Avoids need for dedicated circuit for EVSE
Cons	Slower charging rate than level 2 equipment
Market Readiness	Widely available
Which Customer Types is This Applicable for?	Customers with electric vehicles
How Many Amps Does it Save?	30A
Co-Benefits	None
Customer Experience	Potentially less convenient than level 2 EVSE
Incremental Cost	\$0. Less expensive than level 2 EVSE
Training Opportunities / Issues	None
Hyperlink	https://store.clippercreek.com/level1/level-1-12-amp-ev-charging-station-acs-15

Combo Condensing Washer/Dryer



Image by [LG](#)

Installing these units is a simple way to reduce amperage and save breaker poles at the panel. It is recommended to use the larger capacity 4.5 cu. ft. unit.

Pros	Space-efficient, ventless design
Cons	Longer drying time, reliability (?)
Market Readiness	Models available from several manufacturers
Which Customer Types is This Applicable for?	Residential customers with modest laundry needs, especially those with space restrictions
How Many Amps Does it Save?	30A. Rated for 10A, but since it plugs into 120V circuit there is no need for a dedicated circuit and breaker
Co-Benefits	None for condenser dryer types, heat pump dryer types are gentler on clothes
Customer Experience	Reported reliability problems with combo units in general, longer drying times
Incremental Cost	\$0. This unit listed at \$2000 which is generally comparable to buying separate units
Training Opportunities / Issues	Simpler to install than typical setup, can be used anywhere that has water hook-up and 120V power
Hyperlink	https://www.lg.com/us/washer-dryer-combos/lg-LUWM101HWA-washer-dryer-combo-lgsignature

Countertop Microwave



Image by [Breville](#)

Microwaves on dedicated circuits can be replaced with countertop models with the same functionality, resulting in a free 20A circuit

Pros	Does not require a dedicated circuit, can be put away when not in use
Cons	Takes up counter space, doesn't have venting capabilities of over-the-range models.
Market Readiness	Widely available
Which Customer Types is This Applicable for?	Customers with microwaves on a dedicated circuit
How Many Amps Does it Save?	20A
Co-Benefits	None
Customer Experience	Same as built-in microwave
Incremental Cost	\$0
Training Opportunities / Issues	None
Hyperlink	https://www.breville.com/us/en/products/microwaves/bmo650.html

Electric Kettle



Image by [Bodum](#)

Substituting instant hot water devices with electric kettles is a straightforward way to reduce the amount of panel space dedicated to kitchen equipment.

Pros	Frees up amps by transferring equipment to plug load, kettle can serve multiple purposes
Cons	Less streamlined solution for those who want hot water in their sink
Market Readiness	Widely available
Which Customer Types is This Applicable for?	Customers with instant hot water devices
How Many Amps Does it Save?	20A
Co-Benefits	None
Customer Experience	See pros and cons
Incremental Cost	\$30
Training Opportunities / Issues	None
Hyperlink	https://www.bodum.com/us/en/11883-57us-melior?__store=us_en

Countertop Induction Hot Plate



Image by [IKEA](#)

120V induction hot plates may be the right solution for smaller kitchens. They save space, increase useable counterspace, and can easily be stored.

Pros	Does not require a dedicated circuit, can be put away when not in use
Cons	Requires storage
Market Readiness	Widely available
Which Customer Types is This Applicable for?	Customers with no space for a range, or with electric resistance range that want an induction option for some meals
How Many Amps Does it Save?	20A
Co-Benefits	None
Customer Experience	Top notch
Incremental Cost	\$0
Training Opportunities / Issues	None

120V Electric Fireplaces



Image by [Dimplex](#)

Electric fireplaces are good solutions for guest rooms or offices, where heating may rarely be needed. While they do not provide heat pump capability to increase efficiency, they do provide ambience and ease of installation.

Pros	Does not require a dedicated circuit, can be put away when not in use
Cons	Higher energy cost than heat pump, does not put off as much heat as a fossil fuel or wood-burning fireplace
Market Readiness	Readily available
Which Customer Types is This Applicable for?	Customers who want the ambience of a fireplace and may not use much heat in the associated room or space
How Many Amps Does it Save?	20A
Co-Benefits	Ambience
Customer Experience	Medium
Incremental Cost	\$0
Training Opportunities / Issues	None

120V Plug and Play Hot Tub



Image by [HotSpring](#)

Plug and play hot tubs are efficient, easy to install, and provide a relaxing experience. 120V hot tubs take longer to warm up, but provide the same level of experience as a 240V hot tub at a fraction of the cost.

Pros	Does not require a dedicated circuit
Cons	Takes longer to heat up to temperature, cannot operate high pressure jets and heater simultaneously
Market Readiness	Readily available
Which Customer Types is This Applicable for?	Customers who want a hot tub without calling an electrician
How Many Amps Does it Save?	20A
Co-Benefits	Peace, comfort, relaxation, and muscle relief
Customer Experience	Medium
Incremental Cost	Saves money
Training Opportunities / Issues	None

240V, Low-Watt, Equipment Examples

Low watt, 240V technologies can provide amenities above 120V while avoiding the high power use associated with typical 240V equipment

Low-Amp Heat Pump Water Heater (15A, 240V)



Image by [Rheem](#)

New to the market in 2020, low amp heat pump hot water heaters provide similar efficiency and form factor to 30A units, while avoiding costly electric upgrades.

Pros	Avoids infrastructure upgrade
Cons	Half the recovery in GPH in first hour as compared to 30A unit (16 gallons)
Market Readiness	Available from 1 manufacturer
Which Customer Types is This Applicable for?	Residential customers with 2 bedrooms or less, as well as commercial with low hot water demand, such as retail or office.
How Many Amps Does it Save?	15A
Co-Benefits	None
Customer Experience	Equal, unless a household of 4 or more
Incremental Cost	Incremental cost equivalent on equipment, savings on electric capacity.
Training Opportunities / Issues	Not well-tested. Released in 2020.
Hyperlink	https://s3.amazonaws.com/WebPartners/ProductDocuments/B68404C8-F5F0-4033-A295-761DCACBBE05.pdf

Slide-In Induction or Electric Range



Image by [Samsung](#)

Modern induction ranges with power management functionality have lower breaker requirements than traditional models. Manufacturers include: Samsung, GE, LG, Miele, and others.

Pros	Energy efficiency, improved cooking dynamics and ease of cleaning
Cons	None
Market Readiness	Readily available from multiple manufacturers
Which Customer Types is This Applicable for?	Customers with slide-in ranges
How Many Amps Does it Save?	20A-40A
Co-Benefits	Improved indoor air quality
Customer Experience	Same as other units
Incremental Cost	\$0 versus comparable product.
Training Opportunities / Issues	None
Hyperlink	https://www.samsung.com/us/home-appliances/ranges/electric/ bespoke-6-3-cu-ft-smart-rapid-heat-induction-slide-in-range-with-air-fry-convection-in-white-glass-ne63bb861112aa

Level 2 EVSE Downsizing



Image by [ClipperCreek](#)

Level 2 charging equipment is available at a range of different amperages. Customers may consider downsizing their charging equipment to allow space for other electrical needs

Pros	Frees up panel capacity
Cons	Slower charge rate than higher-amp equipment
Market Readiness	Widely available
Which Customer Types is This Applicable for?	Customers with electric vehicles, especially those that have access to EV charging during the day
How Many Amps Does it Save?	30A, if downsizing from 50A to 20A breaker (see pt. 2)
Co-Benefits	None
Customer Experience	Adequate charging capacity for many EV owners
Incremental Cost	\$0
Training Opportunities / Issues	None
Hyperlink	https://store.clippercreek.com/lcs-15-12-amp-level-2-charging-station

Level 2 EVSE Downsizing, Pt. 2

Required Circuit / Breaker Rating	Charger Amperage	Estimated Driving Range Added Per Hour of Charging
20A	16A	12 mi (19 km)
30A	24A	18 mi (29 km)
40A	32A	25 mi (40 km)
50A	40A	30 mi (48 km)
60A	48A	36 mi (58 km)
70A/80A	50A	37 mi (60 km)

6.3 hours to 24kWh charge

Source: [chargepoint](#)

Range of popular EV models:
 Tesla Model 3: 315 miles
 Nissan Leaf: 150 miles
 BMW i3: 153 miles

Conservative estimate for overnight charging: 8 hours

During an overnight charge, a 16A charger will provide 96 miles of range while 40A charger will provide 240 miles of range.

By saving 30A of panel capacity, a customer can expect to lose about 144 miles of daily range regeneration.

This is less of a sacrifice for customers that have access to EV charging during the day, or for those that own EV's with a shorter range.

High-SEER Heat Pump Condensing Unit



Image by [Mitsubishi](#)

Customers may be able to downsize the breaker for their condensing unit by upgrading to a high-SEER heat pump model

Pros	Energy efficient, allows for retirement of gas furnace
Cons	None
Market Readiness	Widely available, mature technology
Which Customer Types is This Applicable for?	Customers with older or inferior condensing units
How Many Amps Does it Save?	10A
Co-Benefits	None
Customer Experience	No difference
Incremental Cost	\$1500
Training Opportunities / Issues	None
Hyperlink	https://www.mitsubishicomfort.com/residential/products/wall-mounted-heating-and-cooling

Combo Air-to-water Heat Pump



Image by [Daikin](#)

Air-to-water heat pumps offer a highly efficient turnkey solution for space conditioning and hot water needs in residential buildings. A single outdoor unit provides HVAC and hot water.

Pros	Compact design, energy-efficient, water heating and space conditioning functionality in one unit
Cons	Cost is currently not known
Market Readiness	Options available from several manufacturers, though not commonly used in the US
Which Customer Types is This Applicable for?	Customers with hydronic distribution systems (Chiltrix claims it can work with central forced air??)
How Many Amps Does it Save?	25A fuse recommended for outdoor unit
Co-Benefits	Air-to-water heat pumps offer a highly efficient turnkey solution for space conditioning and hot water needs in residential buildings. A single outdoor unit provides HVAC and hot water
Customer Experience	If used appropriately, same as separate heat pumps for space conditioning and DHW
Incremental Cost	Unknown
Training Opportunities / Issues	Uncommon design, possible contractor issues
Hyperlink	https://www.daikinmea.com/en_us/product-group/air-to-water-heat-pump-low-temperature/daikin_altherma_3.html

Energy Recovery Ventilation



Image by Mitsubishi Electric

Especially in homes that have undertaken envelope upgrades, ERV systems can allow for downsizing of HP capacity

Pros	Improves energy efficiency of HVAC system as a whole, can allow for downsizing HVAC equipment
Cons	Less benefit for homes with poor air sealing
Market Readiness	Available from multiple manufacturers
Which Customer Types is This Applicable for?	Customers that are also considering installing a heat pump
How Many Amps Does it Save?	5A, see notes
Co-Benefits	Improved indoor air quality
Customer Experience	Improved comfort
Incremental Cost	\$675
Training Opportunities / Issues	Mature technology, but not especially common in the United States
Hyperlink	http://www.mylinkdrive.com/usa/Ventilation/LOSSNAY_ERV/RVX_Series/LGH_F300RVX_E?product

Circuit Controllers



Circuit controllers can uncompromisingly leverage typical 240V equipment while avoiding panel upgrades

Smart Panels



Image by [Leviton](#)

Loads can be prioritized to ensure that panel capacity is not exceeded. These products also present a slew of co-benefits

Pros	Can control which loads interface with battery at any given time, provides granular info about electricity usage
Cons	Large initial investment for early retirement scenarios
Market Readiness	Emerging technology, new in 2019. Electrical codes are a barrier for electrification benefits
Which Customer Types is This Applicable for?	Any customer with an electrical panel
How Many Amps Does it Save?	No outright reduction potential with current electrical codes
Co-Benefits	TOU optimization, Avoided cost of additional controls and monitoring for customers considering battery storage.
Customer Experience	Emerging technology without substantial track record
Incremental Cost	\$500-\$3,000 over standard panel, less if considering PLP upgrade as baseline
Training Opportunities / Issues	Necessary contractor training will depend on manufacturer/equipment in question
Hyperlink	https://www.leviton.com/en/products/residential/load-centers

Circuit Sharers



Image by [BSA Electronics](#)

These devices allow a customer to share two 30A, 40A, or 50A devices on a single circuit

Pros	Allows for double duty from single 30A, or 50A outlet
Cons	Cannot utilize both pieces of equipment at once. Requires nearby location for easy wiring
Market Readiness	Available from multiple manufacturers
Which Customer Types is This Applicable for?	Customers with electric vehicles and electric dryer units
How Many Amps Does it Save?	50A
Co-Benefits	Some units provide additional safety by including a breaker within the device
Customer Experience	Alleviates need for installing additional circuit or regularly plugging and unplugging dryer
Incremental Cost	\$200-\$400
Training Opportunities / Issues	None
Hyperlink	https://www.bsaelectronics.com/collections/dryer-buddys

Circuit Pausers



Image by [Simple Switch](https://www.simpleswitch.io)

Circuit pausers read the instantaneous electric demand of the entire home, then discontinue use of the associated appliance when peak load is measured

Pros	High savings on panel capacity
Cons	Uncommon in practice, may need innovate electrician
Market Readiness	Available from multiple manufacturers
Which Customer Types is This Applicable for?	Customers with electric vehicles, or other electric equipment, who are close to capacity on their appliance
How Many Amps Does it Save?	Up to 50A
Co-Benefits	
Customer Experience	
Incremental Cost	\$750-\$1,750
Training Opportunities / Issues	None
Hyperlink	https://simpleswitch.io/collections/all

Commercial Kitchen Smart Circuits

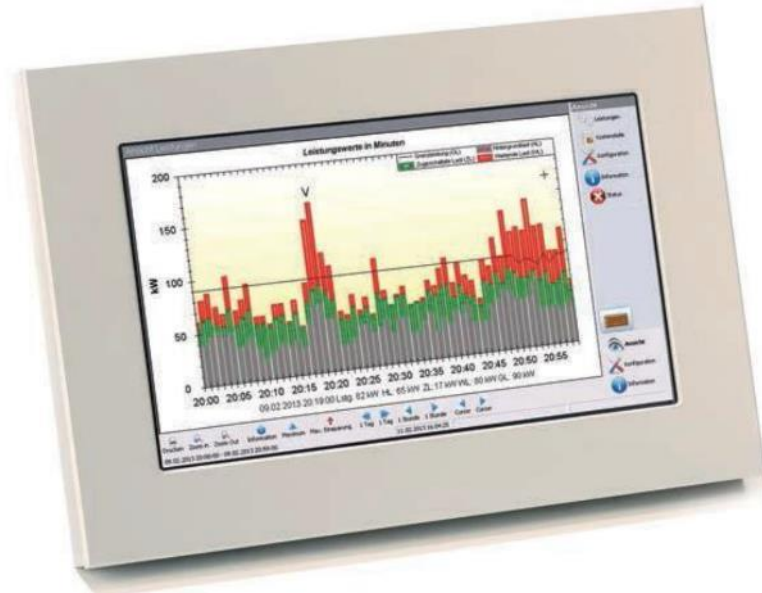


Image by [Bodum](#)

European smart circuit systems are capable of reducing connected loads by up to 50%. Micro-second control allows power to be shared between kitchen equipment.

Pros	Reduced peak loads, peak demand, and ampacity without impacting cooking temperatures and process.
Cons	Not available in US market as of 12/30/2020
Market Readiness	Not available in US market. Market ready for years in Europe. Requires UL listing.
Which Customer Types is This Applicable for?	Commercial kitchens
How Many Amps Does it Save?	200A
Co-Benefits	Opportunity for demand response programs
Customer Experience	Same as typical design
Incremental Cost	Unknown
Training Opportunities / Issues	Yes
Hyperlink	

Breaker Consolidation



Space constrained breakers can benefit from breaker consolidation strategies

Skinny Breakers

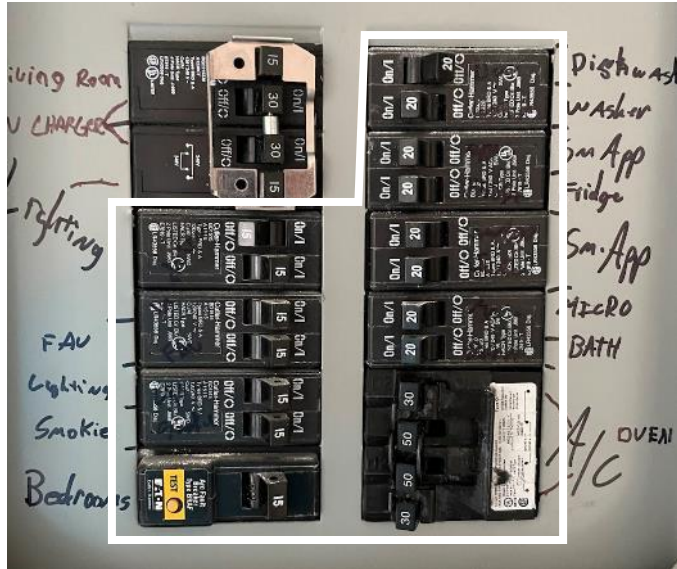


Image by Doug Kot

Thinner breakers enable two circuits in the space that may have been reserved for a single breaker. This can essentially double the available breakers per vertical panel-inch.

Pros	Avoids infrastructure upgrade, can avoid panel replacement, aesthetic benefit to only one panel.
Cons	N/A
Market Readiness	Widely available
Which Customer Types is This Applicable for?	Customers with spare service capacity but limited on breaker space in the panel
How Many Amps Does it Save?	0
Co-Benefits	None
Customer Experience	Equal
Incremental Cost	Negligible
Training Opportunities / Issues	N/A

Slot management

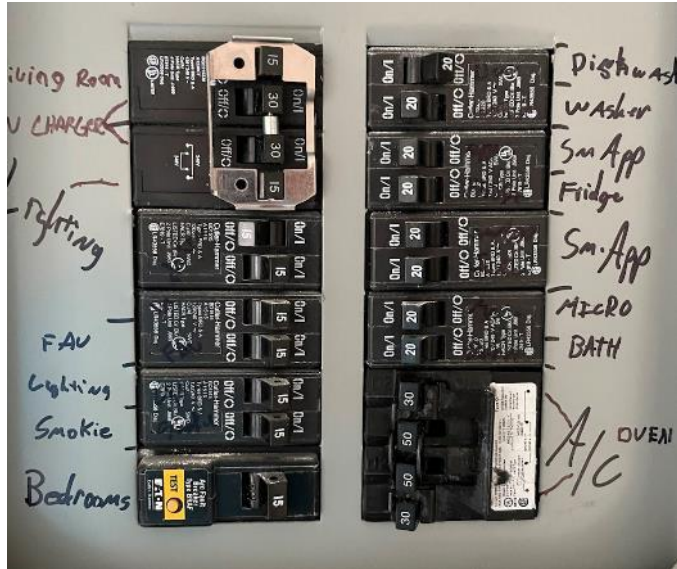


Image by Doug Kot

Slot management requires a whole-panel approach by the electrician, to determine how to best use space. Treating a panel like a jigsaw puzzle can avoid the need for a new panel.

Pros	Avoids infrastructure upgrade, can avoid panel replacement, aesthetic benefit to only one panel.
Cons	N/A
Market Readiness	Widely available
Which Customer Types is This Applicable for?	Customers with spare service capacity but limited on breaker space in the panel
How Many Amps Does it Save?	0
Co-Benefits	None
Customer Experience	Equal
Incremental Cost	Negligible
Training Opportunities / Issues	N/A

Radiant Baseboard Re-Capture

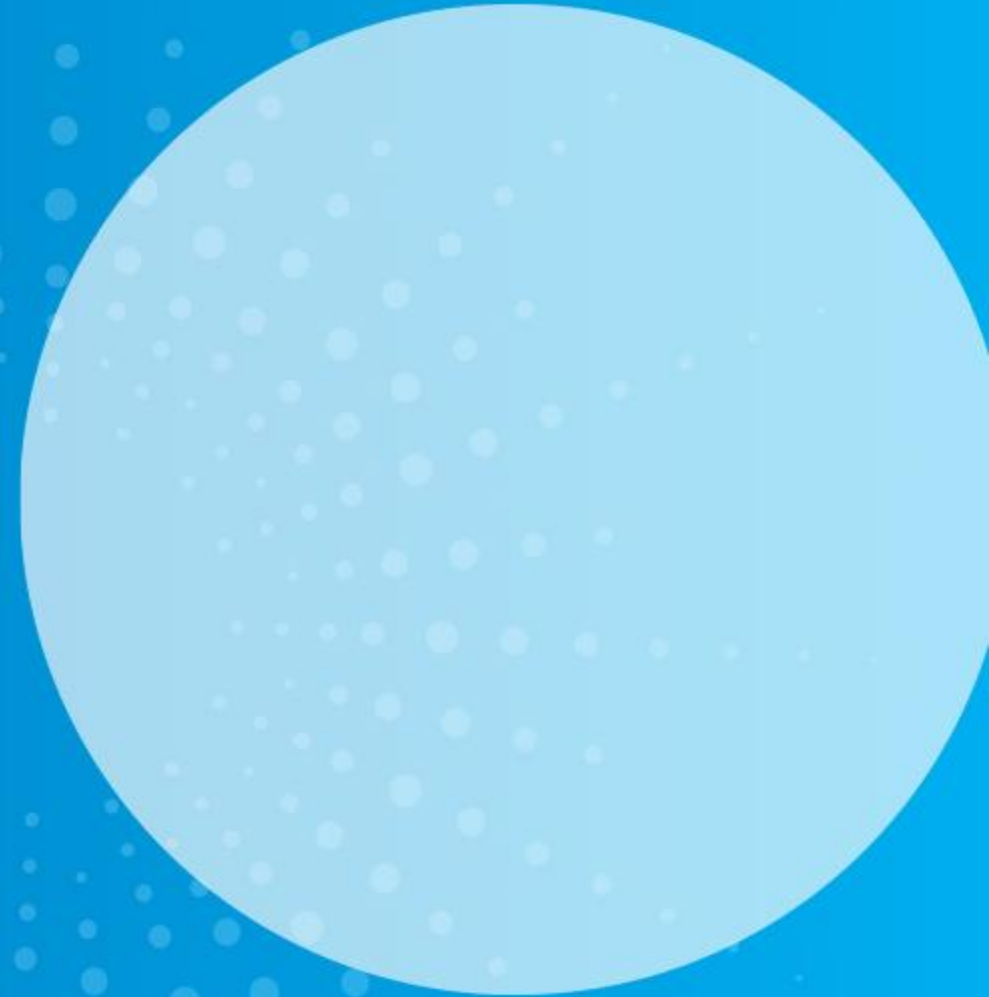


Customers with other means of space heating may consider retiring their radiant heaters. This a straightforward way to free up panel capacity and a breaker space

Pros	Costs nothing, frees up a breaker space
Cons	Customer must have other means of heating
Market Readiness	N/A
Which Customer Types is This Applicable for?	Customers with radiant heating on a dedicated circuit
How Many Amps Does it Save?	20A per circuit
Co-Benefits	None
Customer Experience	Increased comfort if replaced with heat pump
Incremental Cost	None
Training Opportunities / Issues	None
Hyperlink	N/A

Resources

Space constrained breakers can benefit from breaker consolidation strategies.



Other Resources

[All-electric retrofit guides](#) and the **Watt Diet calculator** from Redwood Energy:
<https://redwoodenergy.net/all-electric-retrofits/>

[Smart grid technologies](#) — Rewiring America

[Load sharing & related devices](#) — Canary Media

[PG&E class on How to electrify without upgrading your panel](#)

[Building Electrification Institute](#)

Electrification Retrofit Consultants & Contractors in California

There are many, but here are a few to get you started:

- [All-Electric California](#)
- [Electrify My Home](#)
- [QuitCarbon](#)
- and many others at the **Switch Is On Contractor Directory:**
<https://switchison.cleanenergyconnection.org/>