



# Power Efficient Design in Home Electrification

## A Retrofit Planning & Design Guide for Single-Dwellings

February 2025



**CONSORTIUM FOR  
POWER EFFICIENCY**



# Introduction

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**Electrifying existing homes** – for example, by installing heat pumps for space heating and cooling, electric water heaters, electric cooking appliances, and electric vehicle (EV) chargers – is key to reducing household energy bills, improve indoor comfort, and reduce greenhouse gas (GHG) emissions.

However, without careful planning for how to use the limited electrical capacity in our homes, such electrification **can often trigger electrical service and panel upgrades**. While some of these upgrades may come at a relatively modest cost (between \$2,000 and \$3,000), others can represent significant expenses (ranging from \$5,000 to upwards of \$20,000).

Thus, **it is important for tradespeople, energy advisors and other stakeholders involved in home electrification projects to help homeowners plan how to achieve full electrification of energy uses while avoiding costly electrical service upgrades**. For example, when adding home EV charging it is helpful to choose strategies (e.g. low power EV charging, or using EV energy management systems) that preserve electrical capacity to electrify other building loads (e.g. space heating, hot water and cooking). Ultimately, **this approach can save households money and speed the transition to zero carbon energy systems**.

This **Guide** describes **Power Efficient Design (PED) strategies** for existing single-family homes. It is intended to provide **actionable insights** to mechanical and electrical contractors, certified energy advisors, and other stakeholders involved in electrification projects. It is organized into four key areas of home electrification: electric vehicle service equipment (EVSE), space heating systems, domestic hot water heating, and cooking ranges.

**Power efficient design (PED)** strategies limit a home's peak electrical power usage, preventing overloads on systems like utility services, feeders, panels and circuits—avoiding the need for costly service upgrades.

**Electrification** is the process of replacing technologies or systems that rely on fossil fuels (e.g., gas or oil) with electric alternatives, such as heat pumps, electric water heaters, induction stoves, and EV chargers.

## This guide will help contractors:

- **Understand electrical service upgrades** and why it is often important to avoid them.
- **Use historical load data** rather than prescriptive CE Code calculations when assessing available electrical capacity.
- **Deploy PED strategies** in their home electrification projects and ensure each step does not become a barrier to subsequent electrification retrofits.
- **Use the Power Efficient Electrification Calculator (PEEC) tool** will help plan household electrification loads, evaluate trade-offs, and make informed decisions.

By taking a holistic and strategic approach, the path to full electrification becomes achievable without compromising future possibilities or escalating costs.

**In short**, this guide highlights **best practices for electrifying homes** efficiently, while preserving electrical capacity and avoiding electrical service upgrades.

# What is an Electrical Service Upgrade?

Electrifying end-uses in a home **increases the electrical load**. When electrical loads are added, electrical codes require load calculations to ensure sufficient capacity is available to serve them. In Canada, jurisdictions reference some version of the Canadian Electrical Code, Part I (“CE Code”), sometimes with amendments. If the added load exceeds this capacity, an electrical service upgrade becomes necessary.

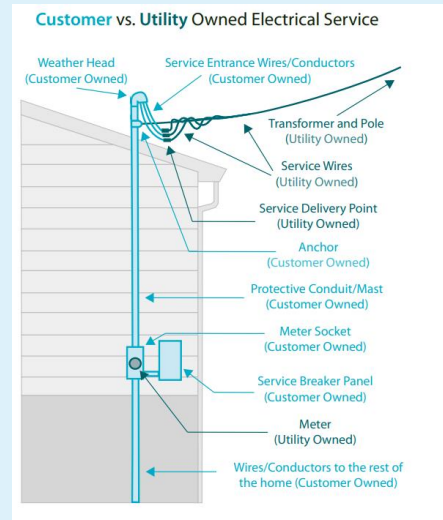
## Service upgrades can drive up renovation costs<sup>1</sup>

In an average-sized BC home, replacing a 100-amp electrical service with a 200-amp service can cost \$3,500 - \$7,000 (as of 2023) plus applicable fees from the electrical utility.

These costs can quickly escalate to \$15,000 or more if:

- A new service must be undergrounded;
- A new electrical pole is required (e.g. electrical lines passing over a neighbour’s property);
- The home has wiring that requires remediation.

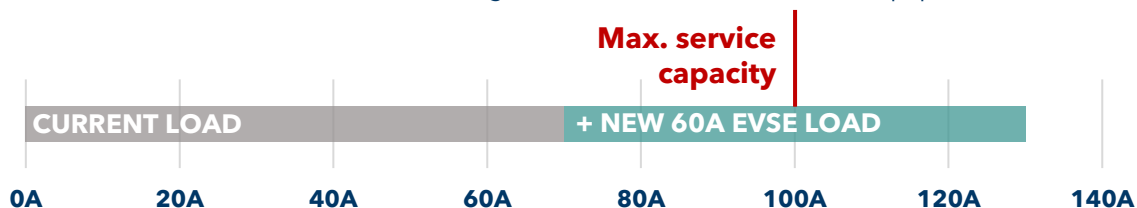
Thankfully, there are multiple power efficient design (PED) strategies that can be used in electrification projects to avoid electrical service upgrades.



! Actual costs will depend on project-specific factors and site location

With the right PED strategies, a service upgrade can often be avoided when electrifying loads.

To illustrate this, consider a single dwelling with a 100 A electrical service, where the homeowner wants to install a new 60 A Level 2 EV charger (i.e. electric vehicle service equipment, or EVSE).



Since the current load is 70 A, adding the desired 60 A EVSE would exceed the maximum service capacity. Unless a PED approach is explored, an electrical upgrade would be required to complete this project.

In this situation, **using a low-power EVSE or an EV energy management system (EVEMS)** would allow this upgrade to happen **without requiring a service upgrade** – saving the homeowner thousands of dollars. Indeed, it is possible to use an EVEMS that will not add any load to the building, saving all the remaining capacity to support any other electrification needs.

<sup>1</sup> From BC Housing’s [Homeowner’s Guide to Electrical Load Management](#) (2024)









# What is Power Efficient Design?

**Power efficient design (PED)** refers to strategies that limit buildings' instantaneous use of electrical power, to avoid exceeding the capacity of the existing electrical panel and/or service. Likewise, PED strategies also address the challenge of limited physical space on electrical panels by minimizing the number and size of breakers required.

In existing buildings, the **most straightforward PED strategy is to leverage historical load data** to determine available capacity when adding new loads. This low- to no-cost approach accurately identifies actual space capacity, rather than relying on a theoretical approach. Beyond this, PED strategies generally fall into two broad categories.

- 1) **Energy management systems** that can monitor and control electrical loads so as not to exceed capacity limits.
- 2) **Right-sizing loads and using efficient systems** (for example, space heating and domestic hot water heating) to reduce peak power consumption.

Together, those strategies can significantly reduce the load impacts of electrification retrofits. The table below gives a sense of the potential load impact of electrifying typical end-uses without PED strategies and the benefits of using PED strategies.

	EVSEs	Space heating	Domestic Hot Water	Appliances
<b>Potential load impact</b> (without PEDs)				
<b>With PED strategies</b>				

**Legend**      ● High impact    ◐ Moderate impact    ○ No impact

Without PED strategies, **EV charging** and **space heating electrification** retrofits will likely **use up the most electrical capacity**, more than electrifying domestic hot water heating and appliances.

Conversely, for all end uses, especially EV charging, **PED strategies will greatly reduce the required capacity**, potentially allowing for many – if not all – end uses to be electrified using the existing service.

# Using Historical Demand

The CE Code, Part I, provides **two methods for determining the electrical capacity** available for adding new loads:

- 1) Calculate the theoretical electrical load of the dwelling, as would be done for a new construction, under Rule 8-200, or
- 2) **Use the historical load demand** from the most recent 12-month period, under Rule 8-106 8).

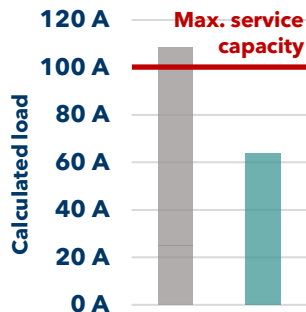
By reflecting the **actual energy usage of the dwelling**, the historical loads approach can identify available capacity for adding new loads without requiring costly electrical service upgrades. In contrast, the theoretical load calculation may overestimate the demand, leading to unnecessary investments in panel and service upgrades.

## How the chosen method can impact the results ...

Consider a **1940s electrically heated single-family dwelling in Montréal**, where the homeowner is looking to install a heat pump to reduce energy costs and provide summer cooling. The dwelling currently has a 100 A electrical panel.

**Based on the theoretical load calculation**, this dwelling is considered to have a load of **110 A**.

This calculation shows that **there is not sufficient capacity to install the heat pump** and indicates that the current panel is undersized. To install the heat pump and comply with the CE Code, the electrical service, and panel, would need to be upgraded.



**If instead, historical loads are used** to determine the available capacity per Rule 8-106 8), this dwelling is considered to have a load of **65 A**.

This means **there is still 35 A of available capacity** on the consumer's service (per the CE Code Part 1) likely sufficient to install the heat pump without any changes to the electrical service.<sup>2</sup>

This difference underscores the importance of selecting the appropriate method based on context and data availability.

**Many utilities provide energy usage data through their online customer portals** on an hourly basis:



Access to hourly energy use over the last 12 months, and more.



Access to hourly energy use over the last 12 months, and more.



Énergie NB Power

Access to 15-minute energy use over the last 12 months, and more.

However, **this data does not represent the actual peak load** unless a 15-minute interval is available (generally considered appropriate for determination of maximum demand loads).

To account for potential load diversity when using hourly interval, electrical safety authorities – such as Technical Safety BC (TSBC) in British Columbia and Ontario's Electrical Safety Authority (ESA)<sup>3</sup> – recommend including a supplementary safety factor of 25%. Requirements may also vary depending on the local municipal authority.

Therefore, before beginning work in a jurisdiction where the electrical safety authority has not published such interpretation, installers should confirm specific local requirements.

<sup>2</sup> Some utility tariffs require you to notify the utility when adding loads. Electrical contractors and engineers should be aware of these tariff clauses).

<sup>3</sup> In TSBC's [IB-EL 2022-01 Information bulletin](#) and Ontario's ESA [Bulletin 8-3-15](#).

# Power Efficient Electrification of End Uses

## Electric Vehicle Service Equipment (EVSE)

Most existing buildings were not designed to support EV charging. In a residential setting, **two types of EV chargers (i.e. EVSE) can be installed.**

- **Level 1 EVSE**, which use standard 120V outlets, offer charging speeds suitable for users with driving needs under 60 km per day or 450 km per week. They are an affordable, power-efficient option for charging.
- **Level 2 EVSE** provide faster charging (208V/240V, 20A-100A), sufficient to meet daily driving requirements of the vast majority of drivers.

In both cases, the CE Code specifies that the EVSE must be supplied by a separate branch circuit that supplies no other loads and that the new load must be accounted for using a 100% demand factor, unless an EV energy management system is used.<sup>4</sup>

 Research indicates that **most urban households receive adequate home charging performance from an L1 charger or a low-power 20 A Level 2 charger.**<sup>56</sup>

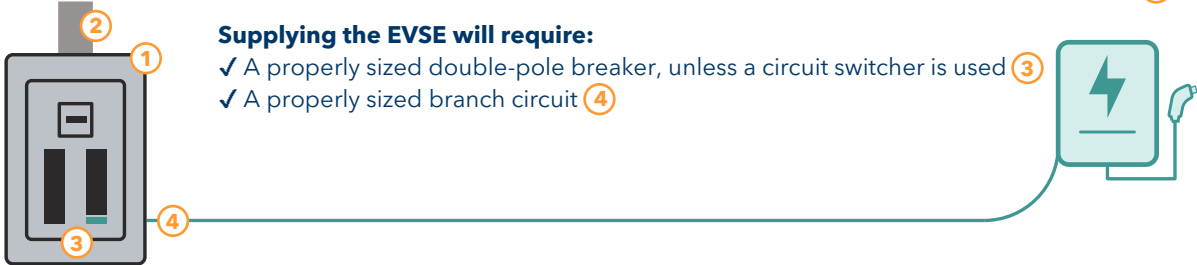
Unless EVEMS is used, Level 2 chargers represent a larger load. Even when spare capacity is available, these loads can quickly exhaust it and limit future electrification opportunities. If implementing EV charging without an EVEMS, always consider using **low power charging** (e.g. 20A Level 2, or Level 1).

**To install a Level 2 EVSE:**

- ✓ Calculate spare capacity using **historical loads** (if not available, use theoretical calculation)
- ✓ Suggest the lower amperage EVSE suitable for the household's needs
- ✓ Ensure the panel has a free double-pole breaker space, if not, consider a circuit switcher **1**
- ✓ Ensure the electrical service has enough spare capacity, if not consider an EVEMS or a circuit switcher **2**

**Supplying the EVSE will require:**

- ✓ A properly sized double-pole breaker, unless a circuit switcher is used **3**
- ✓ A properly sized branch circuit **4**

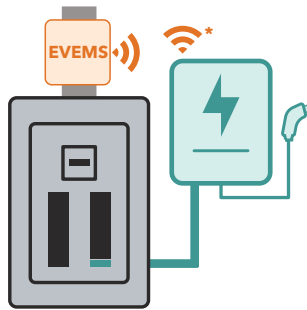


<sup>4</sup> Per CE Code, Part I, Rule 8-200 1) a) vi) and 86-300 1)

<sup>5</sup> Aviv Fried et al. 2024. [Sufficiency of level 1 charging to meet electric vehicle charging requirements](#). Environ. Res.: Infrastruct. Sustain.0

<sup>6</sup> [EV Charging Performance Requirements](#), Clean Air Partnership (2021)

If the electrical service does not have sufficient spare capacity, consider **using an EVEMS or circuit switcher to minimize additional loads (or avoid them entirely)**.<sup>7</sup> Two options are particularly appropriate for single dwellings:

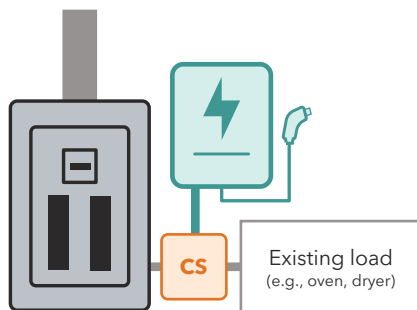


**Service/feeder EVEMS monitoring devices** can be installed on the service/feeder serving the dwelling's main panel. They monitor the real-time load on the service/feeder, and control EVSE loads so that they do not exceed the service/feeder capacity. Use of such service monitoring devices avoids the need to include EV loads in load calculations.<sup>8</sup>

- On/off controls using hardwired communications allow for the use of lower cost "dumb" EVSE

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- Some systems are predicated on use of networked charging stations (e.g. that can communicate through wireless; ethernet cable; etc.). These can enable load-sharing across a branch circuit (e.g. all vehicles in a 2-4 car garage can have their own charging station, sharing a branch circuit); some also perform service/feeder monitoring.



**Circuit switching (CS) devices** share a branch circuit between an EVSE and another secondary load, like an oven or dryer. Only the larger of the two loads needs to be included in load calculations.<sup>9</sup> This device eliminates the need for a new circuit breaker.

Some manufacturers offer plug-in solutions while others are hard-wired.

**Hard-wired**



**Plug-in**



<sup>7</sup> Per CE Code, Part I, Rule 8-106 10) and 11)

<sup>8</sup> Per CE Code, Part I, Rule 8-106 11)

<sup>9</sup> Per CE Code, Part I, Rule 8-106 2)

# Heating Electrification

Electrification retrofits often replace gas or oil furnaces and boilers – which typically use minimal electricity (just for fans or pumps) – with an electric heat pump. The impact on the electrical load and system requirements varies widely based on factors like local climate, dwelling size, equipment specifications and whether air conditioning (AC) is already installed.

**To install an electric heat pump heating system:**

- ✓ Calculate spare capacity using **historical loads** (if not available, use theoretical calculation)
- ✓ Ensure the panel has sufficient spare breaker spaces, if not, consider a panel upgrade ①
- ✓ Ensure the electrical service has sufficient spare capacity, if not consider a service upgrade ②

**Supplying the new system might require:**

- ✓ Adding new circuit breakers to the electrical panel ③
- ✓ A new branch circuit (possibly two, based on system) ④

**Avoid oversizing: properly size the heating and cooling equipment.** Fossil fuel heating systems are often oversized and upgrades to the building envelope may have reduced the heating demand. **If you simply replace fossil fuel systems with electric equipment of the same size, you risk oversizing.** Oversizing both results in excess power requirements and can lead to inefficient operations. To get it right, **use CSA F280-12** to calculate the proper size for residential heating and cooling systems. This ensures the new equipment matches the building's actual needs.

Under the CE Code, all heating loads from central systems must be calculated using a 100% demand factor – typically a significant load.<sup>10</sup> The table below highlights different retrofit approaches by comparing them in relative terms, helping to clarify trade-offs.

**Air-source heat pumps (ASHPs), including cold-climate models,** are a power-efficient strategy to replace gas and oil heating. In milder climates — like Vancouver and Toronto (CZ 4 and 5) — an ASHP without supplementary electric resistance heat significantly reduces power requirements. In colder climates, the supplementary heat might be required.

**While an ASHP with electric resistance supplementary heat is very efficient from an energy perspective,** it will likely add a load higher than an electric resistance furnace (or equivalent if equipment are interlocked<sup>11</sup>).

**Dual-fuel (or hybrid) systems,** where an ASHP is used with the **existing gas system** as a backup, can enable significant electrification while controlling electrical loads when spare electrical capacity is limited. This approach can reduce fossil fuel use by up to 80% or more. Given the [current incentives to electrify oil systems](#), high costs and potential provincial phase-outs, we do not recommend existing fuel oil systems to be converted to dual-fuel.

**Ground-source heat pumps (GSHPs)** are a power-efficient electrification strategy especially in colder climates where using an ASHP would require supplementary heat. Drawing heat from the ground, a GSHP maintains its efficiency and capacity through the winter. GSHP systems are more expensive to install than ASHP, but support from utility programs<sup>12</sup> can make the business case more viable, even in retrofits.

**Incorporating a small electric resistance heater to handle peak loads can improve overall cost-effectiveness,** while keeping the overall load impact low. This approach balances power efficiency and budget, making it a smart choice for many projects.

<sup>10</sup> Per CE Code, Part I, Rules 8-200 1) a) iii) and Section 62

<sup>11</sup> Per CE Code, Part I, Rules 8-106 3)

<sup>12</sup> Like Hydro-Québec's [LogisVert](#), which offers \$750 per MBH installed (or \$9,000 per ton)

# Domestic Hot Water Electrification

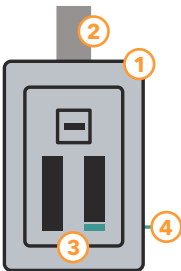
The most common domestic hot water electrification retrofit is replacing a gas water heater, with an electric one. As a result, electrifying hot water heating often necessitates installing a new circuit, which is generally the most significant challenge in this type of retrofit.



If switching from a tankless water heater to a storage model, **space could be an issue**. Ensure there's enough room to accommodate the latter.

## To install an electric or heat pump water heater:

- ✓ Calculate spare capacity using **historical loads** (if not available, use theoretical calculation).
- ✓ Ensure the panel has a free double-pole breaker space, if not, consider a panel upgrade. **1**
- ✓ Ensure the electrical service has **2.5 to 5A in spare capacity**, if not consider a service upgrade **2**



## Supplying the new water heater will require:

- ✓ Adding a new 15 to 30A circuit breaker to the electrical panel **3**
- ✓ A properly sized branch circuit\* **4**

\* This may not be the case with a 120 V heat-pump plug-in water heater, see call-out box at the bottom of this page.



Under CE Code, when adding the equipment, the additional load is considered with a 25% demand factor.<sup>13</sup> This is likely a modest addition meaning the new equipment will usually fit within the existing electrical capacity.

The exact service, panel and circuit requirements will depend on the equipment's specific electrical requirements but will typically fall within the ranges presented in the table below. Instantaneous electric water heaters are excluded from this approach, as they draw significantly more power than storage models, contradicting the goal of power-efficient design.



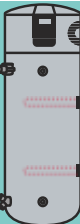
**Traditional electric resistance storage water heaters** use two electric resistance elements – that cannot operate simultaneously – to heat water. Depending on the model, this option can be the most power intensive.

- ✓ Tank capacity between 30 and 60 gal.
- ✓ Required spare capacity between 3 and 5 A.
- ✓ Required breaker and circuit between 20 and 30 A (240 V).



**Power efficient electric resistance storage water heaters** reduce power requirements by distributing the heating load across three smaller elements.

- ✓ Tank capacity of 60 gal.
- ✓ Required spare capacity of 4 A.
- ✓ Required breaker and circuit of 20 A (240 V).



**Heat pump water heaters** are highly efficient, consuming about one-third of the power of traditional electric resistance water heaters. To ensure occupant comfort, most products come with a heating element to ensure adequate recovery time.

- ✓ Tank capacity between 40 and 80 gal.
- ✓ Required spare capacity between 2 and 5 A.
- ✓ Required breaker and circuit between 15 and 25 A (240 V).



**Retrofit-ready 120 V plug-in heat pump water heaters** are becoming increasingly popular in the U.S. to replace a gas counterpart. Given their lower power requirement, they can likely be added with no impact on the electrical load calculation. However, their use is more challenging in colder climates, where they may not maintain optimal performance, leading to longer hot water recovery times.

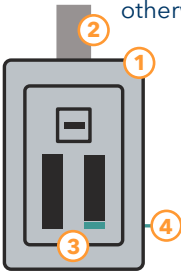
<sup>13</sup> Per CE Code, Part I, Rules 8-200 1) a) vii)

## Other Appliances

The most common electrification retrofit for appliances is replacing a gas range with an electric range.

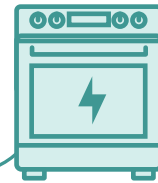
### To install an electric range:

- ✓ Calculate spare capacity using **historical loads** (if not available, use theoretical calculation).
- ✓ Ensure the panel has a free double-pole breaker space, **①**  
if it does not, and a 32A EVSE (40A circuit) is installed, consider a circuit switcher  
otherwise, consider a panel upgrade.
- ✓ Ensure the electrical service has **25A in spare capacity**, **②**  
if it does not, and a 32A EVSE (40A circuit) is installed, consider an EVEMS or a circuit switcher  
otherwise, consider a service upgrade.



### Supplying the new electric range will require:

- ✓ A new 40A double-pole breaker **③**
- ✓ A properly sized branch circuit **④**



Under CE Code, when adding the equipment, the additional load is 6 kW with a 100% demand factor, plus 40% of any amount that exceeds 12 kW.<sup>14</sup> The latter is determined by a product's specifications.



Per CE Code, Part I Rule 26-744 4) and 5) **free-standing electric ranges** having a calculated demand of 50A or less (under 12kW) **are permitted to be connected to a branch circuit rated at 40A.**

<sup>14</sup> Per CE Code, Part I, Rules 8-200 1) a) iv)

# Find Efficient Pathways

On behalf of the Consortium for Power Efficiency, a **Power Efficient Electrification Calculator (PEEC)** – inspired by the US equivalent<sup>15</sup> – was developed to identify the most efficient pathways for home electrification retrofits.

This tool, which reflects load calculations specified in the 2024 Canadian Electrical Code (CSA 22.1-24) estimates the additional electrical capacity required for various end-uses during electrification and how this may impact the service capacity.

It also allows contractors to test the impact of PED strategies, and how they can be used to preserving existing electrical infrastructure.



## Use PEEC to plan ahead!

The PEEC tool can also help contractors anticipate the impact of future electrification needs, making it easier to explain key decisions to homeowners, ensuring they understand options and potential trade-offs for **future upgrades**.

## Key Takeaways: Implementing PED



### Guidance for Contractors

- **Use historical loads** to determine available electrical capacity before planning upgrades.
- **Clearly explain to homeowners** that service and panel capacity are limited resources.
- **Help households plan for the future.** Ask if they intend to electrify other end uses. Help them consider how PED strategies today can support further future electrification.
- **Ask homeowners if they want to reserve capacity** for future needs like EV charging or building electrification (e.g., heat pumps, induction cooking).
- **Evaluate PED strategies** with tools like the Watt Diet Calculator to identify cost-effective and efficient pathways.



### Guidance for Homeowners

- Work with contractors to assess your current electrical capacity by **providing historical loads** (access to customer portal)
- Understand that **your home's electrical service and panel have limits**; talk to your electrician or contractor about how to plan for future retrofits with these in mind
- **Consider future needs**, like EV charging, heat pumps, or induction cooking, and discuss reserving capacity for these loads.
- **Plan your electrification journey** to minimize disruptions and costs.
- **Ask about PED strategies** to avoid costly upgrades while optimizing efficiency.

<sup>15</sup> The [Watt Diet Calculator](#) developed by Redwood Energy



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