Electrical Service & Panel Evaluation Guide

Overview

Electrical panels, also known as breaker boxes or distribution boards, divide incoming power from the utility into several circuits that feed power to the building's electrical appliances (lighting, outlets, HVAC, etc.).

Installation Considerations for Adding Electric Appliances

Generally, there are two limiting factors to adding electric appliances to your home:

1. **Electrical service capacity** – is the amperage delivered to the home sufficient to power the new appliances?
2. **Physical breaker space** – Is there enough room for new single- or double-pole breakers to be attached to the main bus bars?

When installing heat pumps to supplement or fully replace fuel heating systems, it is recommended to conduct a thorough electrical panel assessment. This includes evaluating the existing panel condition and size, completing a whole home electrical load calculation for the current loads, and completing a whole home electrical load calculation that considers the heat pump and supplemental electrical loads (if needed). This will help determine if any service or panel upgrades are needed, including whether a subpanel may be a beneficial consideration for the new heat pump system being installed.

In addition to heat pumps, these considerations should be applied to any electrical additions to a home.

Electrical Service Capacity

The electrical service to a home is typically between 100A and 200A but can be outside of this range depending on home age, home size, and the electrical demand of the home's appliances. It can be determined by checking a few different locations, including:

- The amperage rating printed on the home's electrical meter, which is typically located outside the home.
- The amperage rating printed on the label of the home's main electrical panel.
- The capacity of the main breaker.

Electrical Panel Breaker Space

When an electrical panel has no more room on the main bus bars to attach another circuit breaker, there are a couple of solutions that can be implemented.

The first solution would be to add a subpanel. A subpanel is a secondary electrical panel that is supplied power from the main electrical panel, typically with a 240V feeder breaker (add footnote: called a feeder breaker because it is feeding power to the subpanel). Another solution would be to use slim breakers. Slim breakers are more narrow breakers that can be installed side-by-side where a single breaker would be placed on the panel.

Once there is a subpanel or set of slim breakers installed, more circuits can be added. However, it is critical that the electrical service to the home will be sufficient to power these additional circuits.

Evaluation Process

To understand the electrical load and potential need for upgraded service, you must first perform a whole home load calculation. This load calculation sums the amperage of all the appliances in the home and then adds the new load of the heat pump to determine if the total amperage is less than the rating of the main breaker.

To understand the electric panel breaker space and potential need for panel upgrades, it is important to assess whether certain strategies can be implemented to avoid these upgrades. Methods for avoiding panel upgrades include installing high-efficiency equipment, lowering the home heating load, and optimizing breaker space.

To calculate the whole home electrical load per the National Electric Code (NEC) Article 220.82, follow the steps in the process laid out in the next couple sections below.

There is also a performance evaluation method described in the NEC Article 220.87 that may be used instead of a calculation if the conditions are met. Actual maximum demand may be used if:

1. The maximum demand data is available for a 1-year period.
2. 125% of the maximum demand plus the new load does not exceed the ampacity of the feeder or rating of the service.
3. The feeder has overcurrent protection and the service has overload protection in accordance with their respective NEC Article requirements.

Strategies to avoid electrical panel upgrades will be described in more detail following the electrical service evaluation and load calculation.

Electrical Service Evaluation – Load Calculation

Key Term

- **Volt-Ampere (VA)** – one Volt-Ampere (VA) is equal to one Watt (W), but it describes apparent power, not real power. VA is used for an assumption of power that *could* be drawn instead of a measure of actual power drawn.

Step 1: Calculate General Electrical Load Requirements

A. Take the **area of the home (sq ft)** and multiply the value by a general load assumption of **3 volt-amperes (VA) per sq ft** for lighting and general use receptacles to obtain the **Lighting & General Use Power (VA).**

$$\textit{\textbf{Lighting}} \,\&\, \textit{\textbf{General Use Power}}\ (VA) = \textit{\textbf{home area}}\ (sq\ ft) \times \frac{\mathbf{3}\ \boldsymbol{VA}}{\mathbf{1}\ \boldsymbol{sq\ ft}}$$

B. Count the **number of small appliance circuits in the home** and multiply the value by an assumption of **1,500 VA per circuit** to obtain the **Small Appliance Power (VA).**

a. This may include kitchens, entertainment centers, home offices, and washing machines. Clothing dryers are included in the next section.

b. If the electrical panel is well labeled, you can count the number of breakers that serve those areas. Otherwise, count the number of areas in the home that service these types of appliances.

c. For example, if the home has **one** kitchen, **one** entertainment center, **one** home office, and **one** washing machine, this will result in **four** small appliance circuits.

$$\textit{\textbf{Small Appliance Power}}\ (VA) = \#\ \textit{\textbf{of small appliance circuits}} \times \mathbf{1{,}500}\ \boldsymbol{VA}$$

Step 2: Calculate General Appliance and Motor Loads

A. Sum the **nameplate wattage rating as a VA value** of each appliance listed below to obtain the **General Appliance Power (VA)**.

a. Appliances (like microwaves) that are fastened in place and/or permanently connected.

b. Ranges, wall mounted ovens, counter mounted cooking units.
c. Clothes dryers that are not connected to the laundry branch circuit.

$$\boldsymbol{General\ Appliance\ Power\ (VA) = sum\ of\ appliance\ wattage\ ratings\ (VA)}$$

Step 3: Apply Demand Factors to General Appliance and Motor Loads

A. Start with the **General Appliance Power (VA)** calculated in step 2.
B. Apply demand factor percentages.
   a. The first 10,000 VA of the **General Appliance Power (VA)** are factored at **100%**.
   b. The remaining VA of the **General Appliance Power (VA)** are factored at **40%**.
C. Sum the two factored values to obtain the **Factored General Appliance Power (VA).**

Step 4: Identify Existing Heating and Air Conditioning Loads

A. Identify ***only*** the appliance from the list below with the **highest power rating**:
   a. **100%** of the **Air Conditioning Nameplate Wattage (W).**
   b. **100%** of the **Heat Pump Breaker Amperage (A)** when used without supplemental electrical heating.
      i. If using supplemental electrical heating, use **100%** of the **Heat Pump Breaker Amperage (A)** and **65%** of the **Supplemental Electrical Heating (W).**
   c. **65%** of **Space Heater Wattage (W)** if using less than four separately controlled units.
   d. **40%** of **Space Heater Wattage (W)** if using four or more separately controlled units.
   e. **100%** of the **Electrical Thermal Storage Nameplate Wattage (W)** or **Other Heating System Wattage (W).**
B. The appliance with the highest power rating will be factored by the corresponding percentage above and used as the **HVAC Power (VA)** in the total electrical load calculation.
   a. If the home has a gas or propane furnace, **100%** of the **Air Conditioning Nameplate Wattage (W)** will be used for this value.

Step 5: Sum All Loads and Convert to Amperage

A. Sum all calculated loads (VA) from steps 1, 3 and 4 to obtain the **Total Home Load (VA).** The **General Appliance Power (VA)** calculated in step 2 will not be used since we want the **Factored General Appliance Power (VA)** calculated in step 3.

  a. $\boldsymbol{Total\ Home\ Load}\ (\boldsymbol{VA}) = \boldsymbol{Lighting\ \&\ General\ Use\ Power}\ (\boldsymbol{VA}) + \boldsymbol{Small\ Appliance\ Power}\ (\boldsymbol{VA}) + \boldsymbol{Factored\ General\ Appliance\ Power}\ (\boldsymbol{VA}) + \boldsymbol{HVAC\ Power}\ (\boldsymbol{VA})$

B. Divide the **Total Home Load (VA)** by **240 volts**, as this is the voltage supplied to the home. The resulting value is the **Total Home Amperage (A)**, which can be compared to the service capacity.

  a. $\boldsymbol{Total\ Home\ Amperage}\ (\boldsymbol{A}) = \frac{\boldsymbol{Total\ Home\ Load}\ (\boldsymbol{VA})}{\mathbf{240}\ \boldsymbol{V}}$

Step 6: Repeat HVAC Load calculation Including the Heat Pump

A. Identify the **Heat Pump Breaker Amperage (A)** of the equipment you're installing.

B. If the heat pump is fully replacing the need for the existing electrical heating, include **100%** of the **Heat Pump Breaker Amperage (A)** and remove the supplemental heating power (**HVAC Power (W)**) from the **Total Home Load (VA)** calculation.

$$\boldsymbol{Total\ Home\ Load}\ (\boldsymbol{VA}) = \boldsymbol{Lighting\ \&\ General\ Use\ Power}\ (\boldsymbol{VA}) + \boldsymbol{Small\ Appliance\ Power}\ (\boldsymbol{VA}) + \boldsymbol{Factored\ General\ Appliance\ Power}\ (\boldsymbol{VA})$$

$$\boldsymbol{Total\ Home\ Amperage}\ (\boldsymbol{A}) = \frac{\boldsymbol{Total\ Home\ Load}\ (\boldsymbol{VA})}{\mathbf{240}\ \boldsymbol{V}} + (\boldsymbol{Heat\ Pump\ Breaker\ Amperage}\ (\boldsymbol{A}) \times \mathbf{100}\%)$$

C. If the heat pump will be supplemented by electrical heating, include **100%** of the **Heat Pump Breaker Amperage (A)** and **65%** of the supplemental heating power (**HVAC Power (W)**).*

$$\boldsymbol{Total\ Home\ Load}\ (\boldsymbol{VA}) = \boldsymbol{Lighting\ \&\ General\ Use\ Power}\ (\boldsymbol{VA}) + \boldsymbol{Small\ Appliance\ Power}\ (\boldsymbol{VA}) + \boldsymbol{Factored\ General\ Appliance\ Power}\ (\boldsymbol{VA}) + (\boldsymbol{HVAC\ Power}\ (\boldsymbol{W}) \times \mathbf{65}\%)$$

$$\textbf{Total Home Amperage }(A) = \frac{\textbf{Total Home Load }(VA)}{\mathbf{240\ V}} + (\textbf{Heat Pump Breaker Amperage }(A) \times \mathbf{100}\%)$$

*Make sure to include the **65%** of the supplemental heating power in the **Total Home Load (VA)** sum before converting to amperage (A). The **Heat Pump Breaker Amperage (A)** can then be added to the result of the **Total Home Amperage (A)** to get the final full load.

D. If the heat pump will be supplemented by a gas or propane furnace, include **100%** of the **Heat Pump Breaker Amperage (A)** and remove the **Air Conditioning Nameplate Wattage** (**HVAC Power (W)**).

Step 7: Assess Need for Electrical Service Upgrades

A. Identify the need for electrical service upgrades.
   a. If the **Total Home Amperage (A)** is greater than the **amperage service to the home (A)**, the electrical service will need to be upgraded.
   b. If the **Total Home Amperage (A)** is less than the **amperage service to the home (A)**, the electrical service will not need to be upgraded.

Electrical Service Evaluation – Load Calculation Example

Home Information

Current Equipment Values:

- Total amperage service to the home: **200 A**
- **2,500 sq ft** single-family home
- **3** appliance circuits
- **5,000 W** range
- **1,000 W** dishwasher
- **5,600 W** clothes dryer
- **4,000 W** air conditioner is the largest HVAC load
- Gas or propane furnace as auxiliary heat
- **30 A** Air Conditioner Breaker

New Equipment Values:

- **40 A** Heat Pump Breaker (air conditioner replacement)
- Gas or propane furnace as auxiliary heat

Step 1: Calculate General Electrical Load Requirements

A. $\boldsymbol{Total\ Lighting\ \&\ General\ Use\ Power\ (VA) =\ 2,500\ sq\ ft\ \times \frac{3\ VA}{1\ sq\ ft}}$

$\boldsymbol{Total\ Lighting\ \&\ General\ Use\ Power\ (VA) =\ 7,500\ VA}$

B. $\boldsymbol{Total\ Small\ Appliance\ Power\ (VA) = 3 \times 1,500\ VA}$

$\boldsymbol{Total\ Small\ Appliance\ Power\ (VA) = 4,500\ VA}$

Step 2: Calculate General Appliance and Motor Loads

A. $\boldsymbol{Total\ General\ Appliance\ Power\ (VA) = 5,000\ VA + 1,000\ VA + 5,600\ VA}$

$\boldsymbol{Total\ General\ Appliance\ Power\ (VA) = 11,600\ VA}$

Step 3: Apply Demand Factors to General Appliance and Motor Loads

A. $\boldsymbol{Total\ General\ Appliance\ Power\ (VA) = 11,600\ VA}$

B. $\boldsymbol{10,000\ VA\ \times 100\% = 10,000\ VA}$

$\boldsymbol{1,600\ VA\ \times 40\% = 640\ VA}$

C. $\boldsymbol{Total\ Factored\ General\ Appliance\ Power\ (VA) =\ 10,000\ VA + 640\ VA\ = 10,640\ VA}$

Step 4: Identify Existing Heating and Air Conditioning Loads

A. **4,000 W** air conditioner is the largest HVAC load and will be factored at **100%**.

B. $\boldsymbol{HVAC\ Power\ (VA) = 4,000\ W\ \times 100\%}$

$\boldsymbol{HVAC\ Power\ (VA) = 4,000\ VA}$

Step 5: Sum All Loads and Convert to Amperage

A. $\boldsymbol{Total\ Home\ Load\ (VA) = 7,500\ VA + 4,500\ VA + 10,640\ VA + 4,000\ VA}$

$$\boldsymbol{Total\ Home\ Load\ (VA) = 26,640\ VA}$$

B. $\boldsymbol{Total\ Home\ Amperage\ (A) = \frac{26,640\ VA}{240\ V}}$

$$\boldsymbol{Total\ Home\ Amperage\ (A) = 111\ A}$$

Step 6: Repeat the Calculation with the Heat Pump Included

A. $\mathbf{Heat\ Pump\ Breaker\ Amperage\ (A) = 40\ A}$
B. *Since the heat pump will be supplemented by a natural gas or propane furnace, we will use the calculation from step 6-D.*
C. $\boldsymbol{Total\ Home\ Load\ (VA) = 7,500\ VA\ + 4,500\ V + 10,640\ VA}$
$\boldsymbol{Total\ Home\ Load\ (VA) = 22,640\ VA}$

$$\boldsymbol{Total\ Home\ Amperage\ (A) = \frac{22,640\ VA}{240\ V} + (40\ A \times 100\%)}$$

$$\boldsymbol{Total\ Home\ Amperage\ (A) = 134\ A}$$

Step 7: Assess Need for Electrical Service Upgrades

A. Since the **Total Home Amperage (134 A)** is less than the **amperage service to the home (200 A**), the electrical service will not need to be upgraded.

Electrical Panel Evaluation

How to Avoid Electrical Panel Upgrades

If adding a heat pump or other new electrical appliance will exceed the electrical panel service capacity, there are actions that can be taken to lower the electric load of the house. The following section describes methods to free up electrical capacity as well as lower the required load of the appliance being installed. These strategies can help avoid the need for a panel upgrade.

Install efficient, right-sized equipment

When adding a new heat pump, energy efficiency should be the first step to ensure that future systems are sized correctly and optimized for space and use. Upfront costs to improve energy efficiency will often result in reduced maintenance costs and lower energy bills over time. It's also important to consider other electrical systems, such as solar panels or electric vehicle chargers, to ensure that scheduling can optimize the investment (ie. The homeowners may choose to do solar PV, battery, or car charger(s) first if they were already considering, or these options should be considered if the electric panel and service is upgraded for a heat pump).

Upgrading lighting to LEDs is an easy and cost-effective way to save energy and lower demand. Kitchen appliances, such as induction cooktops and high efficiency refrigerators, have a larger initial investment but can still save energy and reduce operational costs. Larger appliances, such as heat pump water heaters, require lower electrical loads from the home's panel than those with resistive loads.

Reduce the home heating load

Improvements to the building envelope are not only an effective strategy to increase energy efficiency but can also lower the heating load and reduce the necessary space heating power. Air sealing, window and insulation improvements, and duct sealing all reduce air leakage that either loses conditioned air to the outside or introduces unconditioned air into the space. The better sealed and insulated the home is, the less energy it takes to heat or cool the interior space.

Additionally, the heating and cooling equipment can be more accurately sized for the space when it doesn't have to make up for losses caused by a leaky building envelope. This means less capacity is needed on the electrical panel while also providing the benefit of lower operational costs.

Optimize breaker space

Condensing, combined washer/dryer (also called ventless washer/dryer) are popular world-wide and are designed specifically for retrofits. They can plug into any 120V outlet in a house, while 240V dryers (resistance, heat pump, and condensing) require a larger, 240V dedicated circuit.

Combining the range and oven can also save breaker space. The NEC requires twice as much power allocated to a separate oven and range (19,200W) as compared to a combined range and oven (9,600W). Similarly, avoid attaching a microwave oven to the wall, which triggers an extra, dedicated circuit; just place the microwave on the countertop or cabinet.

Use circuit-sharing plugs (e.g. NeoCharge, Dryer Buddy, SplitVolt, or hard wired SimpleSwitch) so one existing high voltage (240VO outlet can power two appliances that don't need to run simultaneously. For example, a circuit-sharing plug could be used for a car charger and a laundry dryer or a water heater and a range.

In older homes, where less efficient appliances were once common, the circuits were upsized appropriately to fit these appliances. One way to utility old wide breaker spaces is to replace them with tandem breakers that are thin and can serve two circuits from one single pole breaker space. Another method is to combine circuits in a sub panel that then lands on only one pair of poles in the main panel. Automatic Circuit Sharing (ACS) devices also make double use of a breaker space by serving two devices that take turns using the power. If space is very tight, gathering several small circuits onto a sub panel is a way to create more panel pole space.

Sources:

HVAC - Electrical Panel Assessment | Building Science Education (energy.gov)

https://www.redwoodenergy.net/watt-diet-calculator

https://www.redwoodenergy.net/research/a-pocket-guide-to-all-electric-retrofits-of-single-family-homes

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National Electric Code (NEC) Article 220.82