Electric Utility Service Entrance Equipment Sizing Calculations

An Online Continuing Education Course for Engineers

Course Number: E-3084

Credit: 3 Hours / 3 PDH / 3 CPD

Electric Utility Service Entrance Equipment Sizing Calculations

Lee Layton, P.E.

Table of Contents

Section **Page**

Introduction

Electric utilities must size equipment to ensure safe, reliable service that meets the needs of the electric consumer. This course discusses load sizing on the utility *secondary*, which is the low-voltage, end-use supply to the customer. This typically includes voltages of 600-volts and below. This contrasts with the utility *primary*, which includes voltages from 5 kV up to about 35 kV.

Unlike the NEC rules that electricians use to size end-use equipment, utilities must develop their own standards to meet the needs of the consumer. This course presents general guidelines to size equipment; however, there are many other concepts and processes used by different utilities to meet these objectives. Suggestions on how to size electrical utility equipment for residential, commercial, and industrial equipment are included. The sizing rules presented are from the perspective of the utility, and they are not related to the NEC rules.

Correctly sizing electric utility service entrance equipment is important for the safe and efficient operation of the electric system. One of the first items that a utility must determine is how much load to expect at a given consumer site. The utility must balance the capital investment required with the needs of the consumer. Under-sized supply equipment may damage consumer equipment and create undesirable service standards. Over-sizing equipment wastes valuable utility resources and ultimately results in increased cost for the consumer.

The most difficult part of correctly sizing equipment is answering the question, “What is the actual load to be served?” Oftentimes, not much is known about the consumer’s electrical loads—especially residential loads—and even less is known about their load profile (i.e., how they are using their equipment), so the utility must estimate the expected load and its characteristics. This tends to be less of a problem for large industrial plants, though it can still be difficult to get a definitive load profile from the consumer.

The course provides several methods, guidelines, “rules of thumb,” and other concepts to help the utility size their loads. We will look at ideas about how to estimate load, size distribution transformers, size service entrance conductors, and determine the short circuit currents available at the consumer’s service entrance. Chapter One begins with load estimating.

Chapter 1: Estimating Residential Loads

The method for determining demand is different for residential and commercial customers. For residential customers, tables based on historical data and empirical formulas, and other "rules of thumb" are used to estimate demand.

Most single-family residential houses built today have either a 200-amp or a 400-amp circuit breaker panel. Unfortunately, there is little correlation between panel size and the actual load in a residential dwelling, and most panels are grossly oversized. For instance, a 400-amp panel can supply a load of up to 77 kVA, and it is unlike many homes will have a load requirement exceeding 25 kVA. So, basing the utility equipment on the panel size will likely result in a gross over-investment in utility supply equipment.

> The NEC requires residential load panels to be de-rated by 20% so a 400-amp panel can supply:
>
> 400 * 0.80 * 0.240 kV = 77 kVA

To prevent over-investment in service supply, utilities have developed several methods to estimate the load in a residential dwelling based on anticipated loads, the square footage of the home, or by just making a good guess by looking at the size of the house. The following tables show one such method used to estimate residential loads. These tables were developed specifically for the southeastern United States, but they are probably sufficiently accurate for other parts of the country as well.

The "big three" residential energy loads

Table 1, shown below, assumes a certain amount of *baseload* exists in every home regardless of the size of the home. Baseloads include lights, refrigeration, and miscellaneous loads, including plug loads (e.g., TVs, computers, printers, chargers, etc.). After the baseload, values for other large loads such as electric ranges, water heaters, clothes dryers, air-conditioning, and heating loads are added to the baseload.

Table 1 Residential Connected Loads							
Consumers	Base Load			Other Load		Heat Load	
	Lights Refrig. Misc (LRM) kVA	LRM + Range *or* Water Heater kVA	LRM + Range & Water Heater kVA	Clothes Dryer Add kVa	HVAC Add %HVAC kVA	Strip Heat Add AC Load +50% kW	Resistance Heat Add % of kW
1	1.3	4.2	5.4	2.0	100%	50%	80%
2	2.1	6.1	8.2	2.7	98%	35%	70%
3	2.8	7.7	10.4	3.4	96%	25%	60%
4	3.4	9.0	12.4	4.0	94%	20%	50%
5	4.0	10.3	14.4	4.6	92%	20%	50%
6	4.6	11.5	16.3	5.1	90%	20%	50%
7	5.2	12.6	18.1	5.6	88%	20%	50%
8	5.7	13.7	19.8	6.0	87%	20%	50%
9	6.4	14.6	21.4	6.4	86%	20%	50%
10	6.9	15.5	22.9	6.8	86%	20%	50%
12	8.1	17.4	26.0	7.7	86%	20%	50%
15	9.9	20.1	30.7	8.9	86%	20%	50%

Using Table 1, the first selection is made in the “Base Load” column. The choices are:

- Lights, refrigerator, and miscellaneous loads (LRM)
- LRM plus an electric range or electric water heater
- LRM plus an electric range and electric water heater

The next significant load is an electric clothes dryer. If an air-conditioner exists, the kVa of the air-conditioner is added to the baseload. The kVA for air-conditioning loads can be found in Table 2 based on the air-conditioning tonnage. For instance, if the dwelling has a 3.0-ton air conditioner, the anticipated load of the air conditioner is 6.1 kVA.

If the air-conditioning tonnage is unknown, a gross estimate can be found by using a factor of 0.34 kVa per 100 square feet of cooled floor space. For instance, if the house has 3,000 feet of cooled space, the air-conditioning load will be 10.2 kVa. This completes the calculation for the summer load.

Table 2
Air Conditioning and Heating Loads

AC (Tons)	AC Load (kVA)	Strip Heat (kW)
0.5	1.0	2.0
1.0	2.4	4.0
1.5	3.4	6.0
2.0	4.4	8.0
2.5	5.2	10.0
3.0	6.1	12.0
3.5	7.0	14.0
4.0	8.0	16.0
5.0	10.0	20.0

Note: If AC tonnage is unknown, estimate load based on the square footage of the home by using: 0.34 kVA per 100 ft^2. And for resistance heat use: 0.67 kW per 100 ft^2.

Now that we have determined the summer load, the impact of the heat load needs to be considered for the winter load. The winter load includes the base load as well as the heat load. If the house has a heat pump, then the heating load is the air-conditioning load, plus one-half of the strip heat load. For an electric furnace, the load is assumed to be 80% of the resistance load of the furnace. If the load of the electric furnace is unknown, it can be estimated by using a factor of 0.67 kW per 100 square feet of heated floor space. (Note that kW is used for the heat load since the heat load is purely resistive, and it will have a 100% power factor. For other loads, kVa is used, and to obtain kW; the power factor must either be known or assumed.)

Electric utilities design their systems, assuming there is diversity in the loads. *Diversity* essentially says that the load on an electric utility system is not the sum of all loads on the system because not every appliance will be on at any one time. Normally electric utilities will connect several houses to one distribution transformer, and the expected load on the

transformer can be determined by using Table 1 and basing the calculation on the number of houses connected to the transformer.

Table 1 accounts for diversity by discounting the load impact of each successive residential load. For instance, the LRM load for one residential dwelling is 1.3 kVa, and by extension, we would assume that the load for 10 dwellings would be 13 kVa. However, the anticipated LRM load of 10 dwellings is only 6.9 kVa. Therefore, the diversity factor of the load is 6.9/13 or 53%. Diversity factors are built into all load columns in the table.

Example. What is the anticipated summer load for one house with natural gas appliances and central air-conditioning? The house has 4.0 tons of air-conditioning.

In this example, we assume that the range, water heater, and dryer are natural gas, so the only loads to consider are the basic residential loads and the air-conditioning load. The basic load, from Table 1, is the LRM load of 1.3 kVA. The air-conditioning load is found in Table 2. For 4.0 tons of air-conditioning, the load is 8.0 kVA. Therefore, the total load is 1.3 + 8.0 or 9.3 kVA.

Example. What is the anticipated load for one all-electric h with a 4.0-ton heat pump?

Since this is an r heater, and dryer loads are presen dryer. For the summer load, the heat pu ditioning, which is 8.0 kVa. The winter heating in the heat pump. From Tabl 6 kW. However, per Table 1, the heat ct of the strip heat on the total demand. l winter demands.

Lo
LR
Clo
Hea
Strip 0)
Tota