

Reality Math

Dot Sulock, University of North Carolina at Asheville

Measuring Electricity

Purpose: Enable more reflection about electricity and its consequences.

1. Watts, Kilowatts, and Megawatts

In the recent past, electricity has pretty much been taken for granted. But now all sorts of questions about electricity are arising. How can we generate electricity without contributing to global warming? How can we generate electricity without creating air pollution leading to respiratory illnesses, mercury poisoning, increased heart attacks and strokes, decreasing visibility, and a host of other problems? Will electrical cars, buses, trucks, trains, and planes be part of the path to energy independence for the US? Thinking about these important questions requires a basic understanding of the units of electricity.

If you turned on a 100-watt light bulb, it would start drawing (downloading, sort of) electricity at the rate of 100 watts from the grid (the national system of electrical wires). If you turned on ten 100-watt light bulbs, they would need an electrical flow of $10 \times 100 = 1000$ watts to keep them shining. 1000 watts is 1 kilowatt (kW)

1,000,000 watts = 1 megawatt (MW)
1,000,000,000 watts = 1 gigawatt (GW)
1,000,000,000,000 watts = 1 terawatt (TW)

Typical Wattages of Various Appliances (from Energy Efficiency and Renewable Energy branch of US Department of Energy)

Here are some examples of the range of nameplate wattages for various household appliances:

Air Conditioner
Window Unit 600-1440
Central Air Conditioner – 3500
Aquarium = 50–1210
Clock radio = 10
Coffee maker = 900–1200
Clothes washer = 350–500
Clothes dryer = 1800–5000
Clothes iron = 1000–1800
Dishwasher = 1200–2400 (using the hot drying feature greatly increases energy consumption)
Dehumidifier = 785
Fans
Ceiling = 65–175
Window = 55–250
Furnace = 750
Whole house = 240–750

Hair dryer = 1200–1875
 Heater (*portable*) = 750–1500
 Microwave oven = 750–1100
 Personal computer
 CPU - awake / asleep = 120 / 30 or less
 Monitor - awake / asleep = 150 / 30 or less
 Laptop = 50
 Radio (*stereo*) = 70–400
 Refrigerator (*frost-free, 16 cubic feet*) = 725
 Televisions (color)
 19" = 65–110
 27" = 113
 36" = 133
 53"-61" Projection = 170
 Flat screen = 120
 Toaster = 800–1400
 Toaster oven = 1225
 VCR/DVD = 17–21 / 20–25
 Vacuum cleaner = 1000–1440
 Water heater (*40 gallon*) = 4500–5500
 Water pump (*deep well*) = 250–1100
 Water bed (*with heater, no cover*) = 120–380

http://apps1.eere.energy.gov/consumer/your_home/appliances/index.cfm/mytopic=10040

If you are vacuuming with a 1000-watt vacuum cleaner you are drawing 1000 watts = 1 kW from the grid for the vacuum cleaner until you turn it off.

1. If your refrigerator is running, you are using your laptop and running your clothes washing machine and central air conditioning, you need a flow of electricity from the grid of at least how many
 - (a) watts? Give the minimum answer.
 - (b) kilowatts (kW)? Give the minimum answer.
2.
 - (a) When your water heater is actually heating water, about how many kilowatts is it drawing from the grid? Give answer as the average of the maximum and minimum.
 - (b) What three appliances have the highest maximums in need for electricity? List from highest to lower.
3. Denver, CO replaced 13,000 traffic lights, each having three 150 watt incandescent bulbs, with traffic lights using 14 watt Light Emitting Diodes (LEDs). (Each light has only one bulb shining at any moment.)
 - (a) The original traffic lights drew how many kW from the grid in total?
 - (b) The replacement traffic lights drew how many total kW from the grid?

(c) The replacement LED lights drew how many fewer kW from the grid in total compared to the incandescent lights?

(d) What was the percentage saving in kW? (The kW saved were what percent of the original kW needed?)

2. US Total Residential Electrical Demand

The average rate of power required by a US household all the time is about 1 kilowatt, or 1000 watts. Sometimes the household will need much more power and sometimes much less, but averaged out across the day and night, US households draw about 1000 watts from the grid all the time.

1 megawatt (MW) = 1000 kW

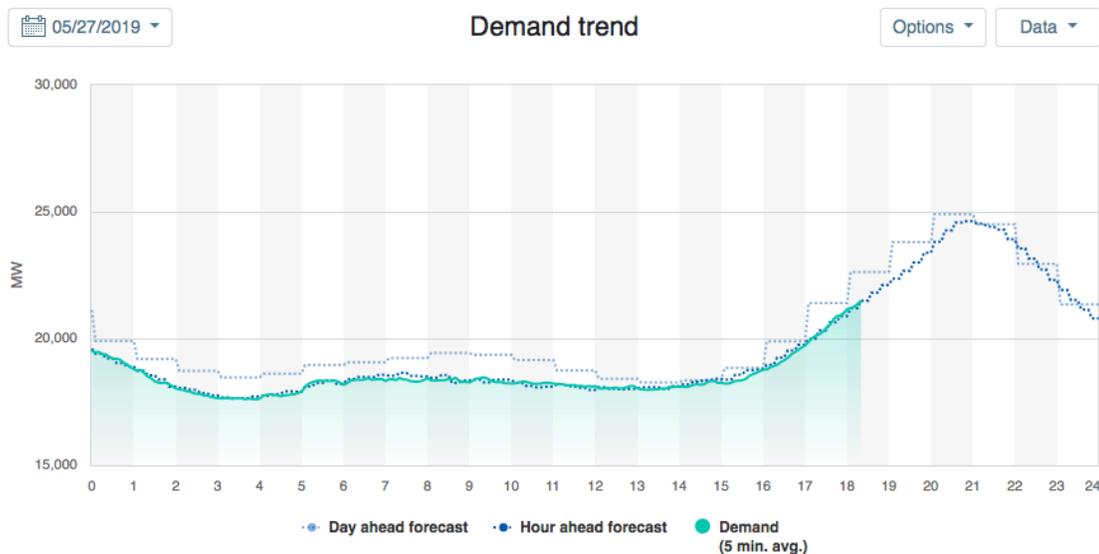
1 gigawatt (GW) = 1000 MW

4. (a) 1 MW could meet the average electrical demand of how many households?
- (b) 1 GW could meet the average electrical demand of how many households?

3. California Independent System Operator (ISO) Homepage

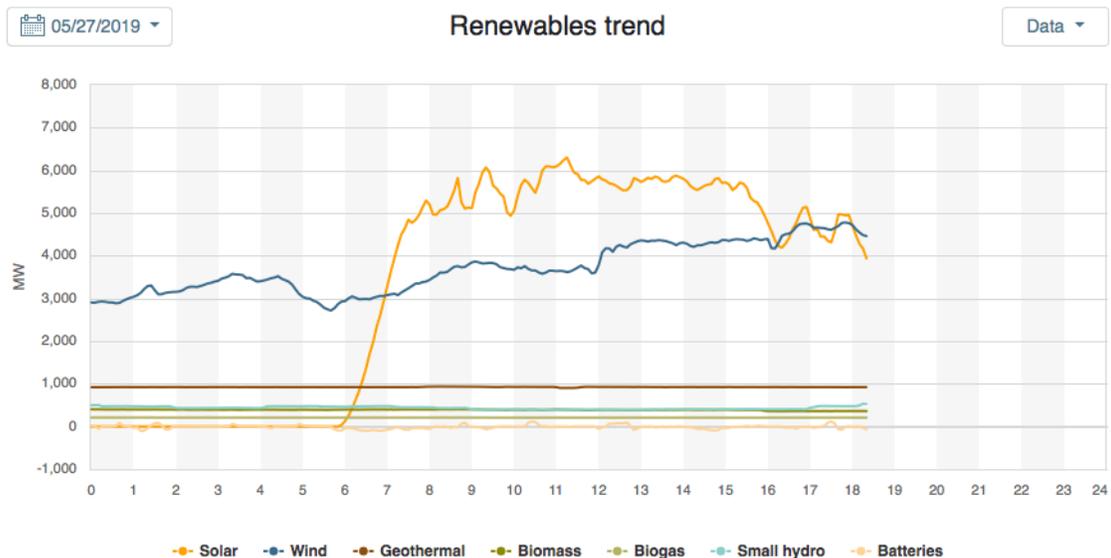
California is a very progressive state when it comes to energy. The state's electrical companies maintain a fascinating website at

<http://www.caiso.com/outlook/outlook.html>



5. Here is a graph downloaded from "Demand" at the website for CAISO.

- (a) What day was this graph downloaded?
- (b) What time (Pacific Daylight Time) was the graph downloaded?
- (c) What is the peak load anticipated in MW?
- (d) When is the peak load anticipated (Pacific Daylight Time)?
- (e) Name five uses of electricity that you think contribute to the peak load at that time.
- (f) Do you think it would be right to say that the average demand for electricity in California this day was about 20,000 MW? Explain.



Here is a graph downloaded from “Supply” at the CAISO website on the same day and time.

6.
 - (a) About when did the sun rise (Pacific Daylight Time)?
 - (b) Did the wind increase or decrease as the day went by?
 - (c) At what time (Pacific Daylight Time) did the supply of solar power peak?
 - (d) At that peak solar time, what was the supply of solar power in MW?
 - (e) At the peak solar time, solar provided what percent of total electricity for California? (Need to look at the previous graph also.)

(f) At the peak wind time, wind provided what percent of total electricity for California? (Need to look at the previous graph also.)

(g) Geothermal energy constantly provides about what percent of California electricity. (Need to look at your answer to 5. (f))

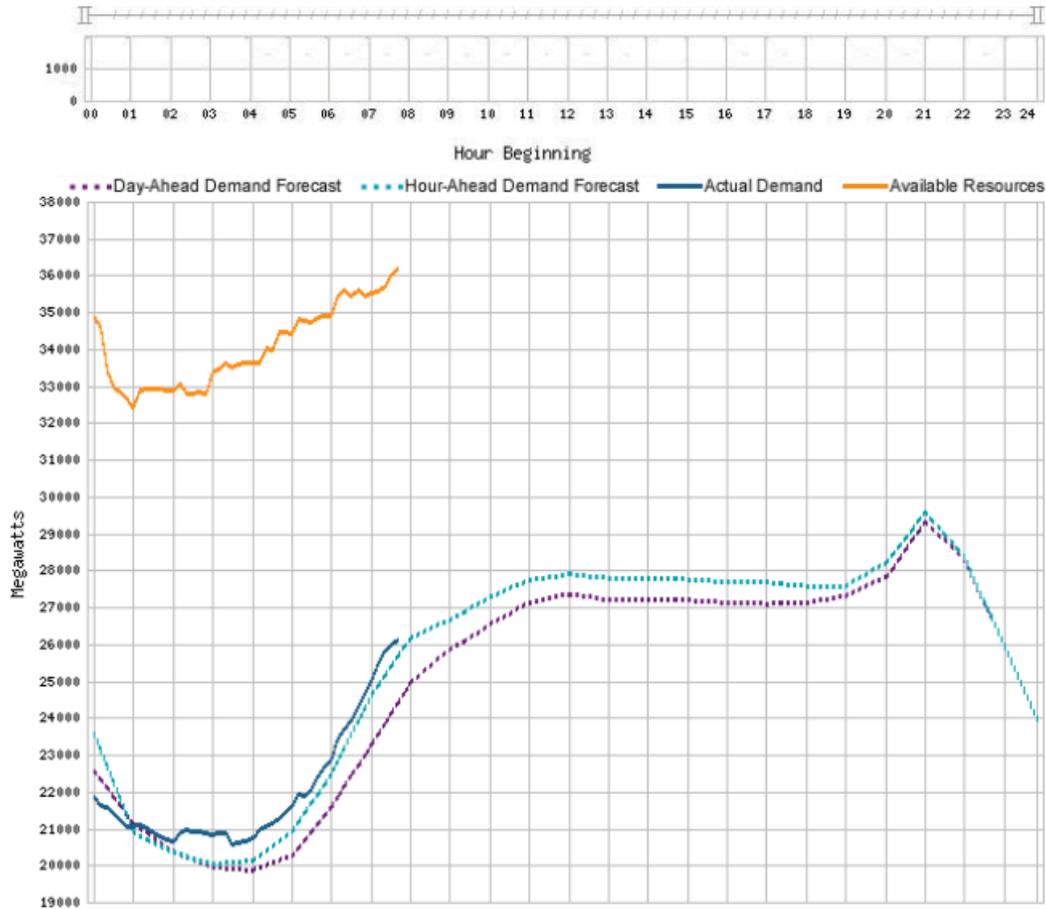
California has a population of about 40 million. Average household size in the US is 2.6 people. So California has about $40/2.6 = 15.4$ million households.

7. (a) 15.4 million households need about how many MW of power?
- (b) California's electrical demand is more than that, as you saw in 5. (f). Where does the rest of the electricity go? Name five things not in households that require electricity?

The graph on the next page came from the CAISO website May 6, 2013.

8. (a) What was the peak demand anticipated that day?
- (b) Do you think California's efforts to use less electricity are working? Explain.

CAISO May 6, 2013



Go to the CAISO website and click on “Demand.”

<http://www.caiso.com/outlook/outlook.html>

9.
 - (a) What is the projected maximum need today?
 - (b) Today’s maximum is what percent of the maximum on May 27, 2019?
 - (c) Give one possible reason for the difference in these maximums.

Click on “Supply.”

10.
 - (a) Is geothermal still constantly supplying 1000 MW?
 - (b) What percent of today’s maximum demand does geothermal supply?

