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Energy Literacy Begins with Units That Make Sense: The Daily Energy Unit D

It is amazing how much we learn to perceive things through units that become common in our lives. On a cool autumn morning, you look at the thermostat in the United States and from experience you know how to choose the perfect coat for 52 °F. However, if you hear the temperature in Gallargues-le-Montueux, France, reached 46 °C (this past July), you probably have to Google a temperature conversion to change it to Fahrenheit (115 °F) to understand it. When you go to work and drive on a road posted at 35 mph, you know what that speed feels like, but what if you were in Europe and it was posted in kph? Or what if a European tells you the mileage for her car in liters per 100 km, and you struggle to relate that to numbers you know based on miles per gallon. We develop a sense of things based on experience with certain units, and when those are different, you lose your perception of the quantity.

Most of us do not have a basic sense of the amount of energy we consume for different activities in our lives. One reason is that we find it difficult to compare things that have different units, even if they describe the same property (such as temperature), and units of energy are particularly challenging! We often make comparisons based on something we can relate to, such as saying how many football fields we could cover or how many Olympic size pools we could fill. It is more difficult to relate energy units within one context, such as energy for our apartment or house, to other things in our life, such as fuel for our car. We need common units to be able to become literate in the amount of energy we consume for different activities in our lives, especially if we are going to substantially reduce our energy consumption.

Consider the myriad of energy and power (energy per time) units we experience in our life that can include calories (cal), Calories (Cal, or 1 kcal equal to 1000 cal), watts (W), kilowatt hours (kWh), British thermal units (BTU), horsepower (hp), and megajoules (Mj). For example, the following list includes some energy and power units for a few things in our lives:

Daily food for a human= 2,000 Cal
Daily food for a horse: 20,000 kcal
Daily average energy for a house= 30 kWh
Power per solar panel = 250 W
Energy in a gallon of gasoline = 114,000 BTU
Power for an average car (gasoline)= 120 hp
Electricity, USA daily per capita = 91 kWh
Energy, USA daily per capita = 840 Mj

With all of these different units, it seems impossible to compare energy used for these different activities. For example, is our household energy use of 30 kWh per day, or ~900 kWh per month, more or less than the energy used for commuting to and from work each day? We could spend an afternoon calculating these and other unit conversions and then trying to make sense of it all, or we could more simply choose a common unit for all of these numbers. For example, if we use kWh for a single day, we have

Food for a human= 2.3 kWh
Food for a horse: 23 kWh
House energy = 30 kWh
Energy from 1 solar panel = 1 kWh
(Gallon of gasoline = 33 kWh)
Energy for an average car (gasoline)= 2160 kWh
Electricity, USA per capita = 91 kWh
Energy, USA per capita = 240 kWh

Note that these units are in energy use per day (kWh/d), which has units of power, and a gallon of gasoline is included as a reference point. Some of these units makes sense to compare, but for others, such comparisons are awkward. For example, the 120 hp engine from your car translates to an engine rated at 2160 kWh, but you would not (I hope) operate your car all day at its maximum power. These units of kWh also span different time frames (you do not eat continuously all day), and some units lack a more personal connection, such as food units in kWh.

To make comparison of energy units easier, and to express them in terms of something to which we can all relate, I propose a new unit called the daily energy unit, D. One thing that all people in all countries share is needing to eat every day. Therefore, we can define 1 D as the average energy in the food consumed by a healthy, well-fed person each day (2000 Cal = 2000 kcal = 8.4 Mj = 2.3 kWh), which is about the energy needed to power a 100 W lightbulb all day (2.3 kWh/24 h). For the cases described above, with an adjustment on vehicle use, we now can express everything in units of D as

Food for a human = 1 D
Food for a horse = 10 D
House energy used = 13 D
Average energy from 1 solar panel = 0.43 D
(Gallon of gasoline = 14 D)
Light duty vehicles, based on average gas use = 21 D
Electricity, USA per capita = 40 D
Energy, USA per capita = 104 D

Now we have everything in our life expressed in units that will have meaning for our daily activities. Of course these numbers will vary depending on your particular situation. Maybe you need to eat less than the stated average and you consume 0.9 D, or you have been on vacation and eating 1.5 D? Want to lose a pound of fat? You will need to lose 1.75 D (3500 kcal/lb of fat, or 3.9 D/kg). Do not forget that it is easier to gain a D than to lose one! A practical unit for power

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for a horse is based on the average daily food consumed by a horse (10 D), or 10 times that needed by a human. The D unit comparison shows just how amazing gasoline is in terms of energy storage! A gallon of gas contains 14 D (3.7 D per liter), so using a gallon of gas for your daily commute can consume about as much power as your home for a day. The daily average vehicle energy use in the list above is calculated for all light duty transportation vehicles divided by the number of people in the United States, which indicates ∼1.5 gallons of gas used daily per person. What is a reasonable amount of energy consumption for a person in a modern, industrial world? The Swiss Federal Institute of Technology in Zürich (ETH Zurich) has proposed a 2000 W society, or about 20 D. Currently, each person in Switzerland consumes about 53 D, or approximately half that of a person in the United States.

Going solar? While the amount of solar energy you can capture with a standard solar panel varies by location, for a standard 250 W panel you might obtain an average of 0.43 D, which means you need ∼30 panels on your roof just to break even with your home energy use. Have an electric car? You will need 2.3 D (assuming 5.4 kWh for 18 miles) compared to the same commute using a gallon of gas (14 D), or another five or six solar panels for that daily commute.

Using the D unit to quantify your energy use can bring a tangible sense of energy use to everything we do on the basis of something we all understand: how much food we need to eat every day. Unlike temperature in Fahrenheit, Celsius, or Kelvin, the one thing we have in common is needing to eat. Starting to use the same units for energy for food, heating, transportation, and everything else in our lives will enable us to appreciate the magnitude of this journey we are undertaking to totally transform our energy infrastructure to be based on solar, wind, and other forms of renewable energy.

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