MEASUREMENT OF ENERGY CONSUMPTION

INTRODUCTION:

Energy is the ability to do work—or put another way, to create change—via physical or chemical processes and resources. When it comes to the energy in your home, the work done results in power to your electric devices (e.g. lightbulbs, television) and heat from your gas-powered appliances (e.g. furnace, water heater)

There are many different types of energy, including chemical, thermal, nuclear, electrical and gravitational, which fall into two main categories of energy: potential and kinetic. The types of energy that flow through your home are, for the most part, chemical, thermal and electrical. Chemical and thermal energy are potential and kinetic, respectively, and electrical energy is a little bit of both. Let's take a closer look at these different energy types.

WHAT IS ENERGY MEASURED IN?

Electricity's main unit of measurement is power, which is the rate of energy consumption. If a watt (power) is one joule per second, then a joule of electrical energy is one watt-second. In the next section, we'll cover what power is measured in with more detail. As far as natural gas goes, you can use joules to measure the amount of thermal energy your oven requires to bake a cake, or furnace requires to heat your home. But on natural gas-powered appliances, you'll likely see a BTU (British Thermal Unit) rating and not a joule rating. For ease of conversion, one BTU is equal to 1,055 joules. If your furnace has a BTU rating of 100,000 BTU/hour it uses 105,500,000 joules of energy per hour.

Units of Measurement:

The energy is measured in various units by various industries or countries, in much the same way as the value of goods is expressed in Dollars in the U.S. and Yen in Japan and Pounds in Britain.

The table below identifies different units for measuring energy. A lot of it also has some historical context. Our early studies of energy involved heating things up, so we name units based on how hard it was to heat things.

UNITS FOR MEASURING ENERGY:

Different Units for Measuring Energy

Unit	Definition	Used In	Equivalent to
British Thermal Unit BTU	A unit of energy equal to the amount of energy needed to raise the temperature of one pound of water by one degree Fahrenheit. Equivalent to energy found in the tip of a match stick.	Heating and Cooling industries	1 BTU = 1055 Joules (J)
calorie or small calorie (cal)	The amount of energy needed to raise the temperature of one gram of water by one degree Celsius.	Science and Engineering	1 calorie = 0.003969 BTUs
Food Calorie, Kilocalorie or large calorie (Cal, kcal, Calorie)	The amount of energy needed to raise the temperature of one kilogram of water one degree Celsius. The food calorie is often used when measuring the energy content of food.	Nutrition	1 Cal = 1000 cal, 4,187 J or 3.969 BTUs
Joule (J)	It is a smaller quantity of energy than calorie and much smaller than a BTU.	Science and Engineering	1 Joule = 0.2388 calories and 0.0009481 BTUs
Kilowatt Hour (kWh)	An amount of energy from the steady production or consumption of one kilowatt of power for a period of one hour.	Electrical fields	1 kWh = 3,413 BTUs or 3,600,000 J
Therm	A unit describing the energy contained in natural gas.	Home heating appliances	1 therm = 100,000 BTUs

Energyusage

A Python package that measures the environmental impact of computation. Provides a function to evaluate the energy usage and related carbon emissions of another function. Emissions are calculated based on the user's location via the GeoJS API and that location's energy mix data (sources: US E.I.A and eGRID for the year 2016).

Energy Report

The report that will be printed out will look like the one below. The second and third lines will show a real-time reading that disappears once the process has finished evaluating.

```
Location:                                                                Pennsylvania
--------------------------------------------------------------------------------
------------------------------  Final Readings  -------------------------------
--------------------------------------------------------------------------------
Average baseline wattage:                                                 1.86 watts
Average total wattage:                                                   19.42 watts
Average process wattage:                                                 17.56 watts
Process duration:                                                           0:00:01
--------------------------------------------------------------------------------
------------------------------   Energy Data    -------------------------------
--------------------------------------------------------------------------------
                          Energy mix in Pennsylvania
Coal:                                                                       25.42%
Oil:                                                                         0.17%
Natural Gas:                                                                31.64%
Low Carbon:                                                                 42.52%
--------------------------------------------------------------------------------
------------------------------    Emissions     -------------------------------
--------------------------------------------------------------------------------
Effective emission:                                              4.05e-06 kg CO2
Equivalent miles driven:                                          1.66e-12 miles
Equivalent minutes of 32-inch LCD TV watched:                    2.51e-03 minutes
Percentage of CO2 used in a US household/day:                           1.33e-12%
--------------------------------------------------------------------------------
------------------------- Assumed Carbon Equivalencies -------------------------
--------------------------------------------------------------------------------
Coal:                                                          995.725971 kg CO2/MWh
Petroleum:                                                    816.6885263 kg CO2/MWh
Natural gas:                                                  743.8415916 kg CO2/MWh
Low carbon:                                                             0 kg CO2/MWh
--------------------------------------------------------------------------------
-------------------------     Emissions Comparison     -------------------------
--------------------------------------------------------------------------------
                     Quantities below expressed in kg CO2
        US                      Europe                  Global minus US/Europe
Max:    Wyoming       9.59e-06 Kosovo        9.85e-06 Mongolia        9.64e-06
Median: Tennessee     4.70e-06 Ukraine       6.88e-06 Korea, South    7.87e-06
Min:    Vermont       2.69e-07 Iceland       1.77e-06 Bhutan          1.10e-06
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Process used:                                                        1.04e-05 kWh
```

The report is divided into several sections

- **Final Readings**: Presents an average of:
    - *Average baseline wattage*: your computer's average power usage minus the process, ran for 10 seconds before starting your process
    - *Average total wattage*: your computer's average power usage while the process runs
    - *Average process usage*: the difference between the baseline and total, highlighting the usage solely from the specific process you evaluated

    - *Process duration*: how long your program ran for

- **Energy Data**: The energy mix of the location.
- **Emissions**: The effective CO_2 emissions of running the program one time and some real-world equivalents to those emissions.
- **Assumed Carbon Equivalencies**: The formulas used to convert from kWh to CO_2 based on the energy mix of the location (for international locations, see below for more information).
- **Emissions Comparison**: What the emissions would be for the same energy used in a representative group of US states and countries. Note that if these locations are specified as described below these default values are not shown.
- **Process used**: The amount of energy running the program used in total.

Limitations

- Due to the methods in which the energy measurement is being done (through the Intel RAPL interface and NVIDIA-smi), our package is only available on Linux kernels that have the RAPL interface and/or machines with an Nvidia GPU.
- A country's overall energy consumption mix is not necessarily representative of the mix of energy sources used to produce electricity (and even electricity production is not necessarily representative of electricity consumption due to imports/exports). However, the E.I.A. data is the most geographically comprehensive that we have found. We are working on obtaining even more accurate data.