ICT and Environement

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1 Power and Energy

Energy characterizes the resulting work or heat on a system, e.g. one calorie (4,18 J) is the amount of energy required to increase the heat of one gram of water by one degree celsius.

The power is the flow of energy during a conversion, e.g. a 20 kW engine is delivering energy twice as fast as a 10 kW one.

Power is measured in W or kW, while energy is in kWh or Joule[1]

1.1 A simple example

I like a lot large American fridges that produce ice, a must in the coming global warming era ☺.

Pick such a big fridge on the Darty store and report its reference as well as the consumption: `https://www.darty.com/nav/achat/gros_electromenager/refrigerateur_congelateur/refrigerateur_americain/index.html#dartyclic=X_gros-elec_refr_refr-amer`.

1. Report the exact model and URL to access its description.
2. Report the energy consumption figure provided on the Web site.
3. Compute the instantaneous power consumption, explaining how you proceeded and which hypotheses you make.

2 Your laptop

2.1 Tools to be installed

We need one tool to measure the energy consumed by your laptop and one tool to ignite (stress) the CPUs. For energy measurements, we rely on a software measurement tool (as opposed to an external watt-meter), which means that we can measure internal components of your device (e.g. cpu or ram) but not the full device (that would include the power unit, fan, etc).

2.1.1 Windows

Energy consumption
Open hardware monitor : `https://openhardwaremonitor.org/`

[1] or calory or toe for tonne of oil equivalent. Obviously, a conversion formula exists between all these energy units.

Stressing the CPU
CpuStres: `https://docs.microsoft.com/en-us/sysinternals/downloads/cpustres`

2.1.2 Mac OSX

Energy consumption
Use the following command:

```
sudo /usr/bin/powermetrics --samplers cpu_power,gpu_power
```

and look for the line "Intel energy model derived package power". You can control the number of measurements by adding –n 10 for 10 measurements for example.

Stressing the CPU
Use the stress command

2.1.3 Linux

Energy consumption
For a Linux box, the following command might do the job:

```
cat /sys/class/power_supply/BAT0/power_now
```

Alternatively, you can also install the turbostat tool from the inux-cpupower package. A typical usage is:

```
/usr/sbin/turbostat  --interval 1 --show CPU,Busy%,PkgWatt,CorWatt,RAMWatt -out
    turbostat.txt
```

The first line of each run provides the average CPU usage over all cores along with the . You can filter them with:

```
cat turbostat.txt  | awk '{print $2,$3,$4,$5}'  -o turbostat_data.txt
```

More info on: `https://manpages.debian.org/testing/linux-cpupower/turbostat.8.en.html`.

Stressing the CPU
The stress command (stress package)

2.2 Charging the computer

Take the specification of your laptop, and especially the battery and the charger.

1. Report the energy capacity of the battery and the charger power.
2. Provide an estimate of the charging time.
3. Why is it likely to be longer than this estimate in practice?

2.3 Stressing CPU and Network

1. Let us consider a CPU oriented workload.
   (a) Turn off all applications in your machine.
   (b) Use CPUSTRES (or stress) to stress from 0 (inactive) to N cores, N being the number of cores you have on your computer, by adjusting the number of active threads. Report in a table the measured energy consumption as well as the CPU utilization. Is energy usage proportional to the load?

2. Let us now consider a network oriented workload.
   (a) We are going to do several back to back transfers of the same file to have time to see the energy that stabilizes. We simply do a loop. Use Powershell and run the following command:

```
for ($num = 1 ; $num -le 10 ; $num++){ wget https://webusers.i3s.unice.fr
 /~urvoy/1g.img}
```

   For Mac/Linux:

```
for i in {1..10}; do curl https://webusers.i3s.unice.fr/~urvoy/1g.img -o /
 dev/null; done
```

   Report the energy consumption as well as the CPU utilization and the rate achieved by the curl transfer.
   (b) Do you expect the discrepancy between what you measure with the tool you use (openhardware monitor, turbostat or powermetrics) and what could be measured with an external watt-meter to be smaller or larger than in the CPU intensive workload case (obtained with CPUSTRES or stress)?

2.4 From kWh to CO_2

Let us consider the energy stored in the battery of your computer when the latter is full (or simply consider a Mac book Pro 13" `https://www.apple.com/macbook-pro-13/specs/`).

We need to convert electricity to CO_2 emission in the sense that electricity is an energy carrier. Hence, some primary energy has been transformed into electricity and this process has generated, as a by-product, CO_2.

We are going to consider two sources of information:

- The European Environment agency:
  `https://www.eea.europa.eu/data-and-maps/data/co2-intensity-of-electricity-generation`
  for historical data from 1990 to 2017
- The electricity map Website:
  `https://app.electricitymap.org/map` for present data.

1. Let us first focus on France and Germany using the electricity map website:
   - Describe how the energy mix of France and Germany evolves during the course of a day (use a 24h representation of the data).

- What is the difference between "Low Carbon" and "Renewable" energy?
- Compute the CO_2 emission estimates for charging your computer in these two countries and report it in a table.

2. On the long term perspective (1990 to 2017), how did the energy mix of both country evolved?

3 Transfers over the Internet

3.1 Carbonalyzr

Install the Carbonalyzr plugin in Chrome or Firefox. It aims at assessing the amount of energy required to browse the Internet (including streaming).

Report the energy footprint for the different regions in the world available in the tool, for:

1. A YouTube video which is long enough and available at widely different bitrates.
2. The Gmail page (unless you don't have a Gmail account. Then pick your favorite mail provider).
3. The web page of Le Monde newspaper `https://www.lemonde.fr`

Do not forget to reset the tool in between two tests and not have several tabs opened but only for the test.

3.2 Your traffic

Install Wireshark (`https://www.wireshark.org/`) and capture your traffic for one hour. Do not hesitate to watch videos, Netflix (I won't reveal that you have a subscription ☺), surf on ALL your social networks (do not feel guilty!!). One you have collected the trace, we are going to analyze them as follows:

1. Use the Conversation tool of the Statistics menu. Go on the TCP tab and sort the connections by size.
2. For the 10 largest connections, which fraction of bytes do they represent?
3. Also, where do they come from? Use `https://ip-api.com/` to have an estimate of the physical location and `https://bgp.he.net/` to know who is the owner of the server, e.g. Amazon Web Services.
4. Use the Carbonalyzr internal parameters from Figure 1 to compute an approximate Carbon footprint related to your trace. Use the complete trace and not the 10 most popular connections: you can obtain the global amount of bytes by using the "Capture File Properties" of the Statistics menu.
5. Discuss the Network Intensity of Figure 1 with respect to the Figure 3 (slide 50 of course) of "Aslan, J., Mayers, K., Koomey, J. G., France, C. Electricity intensity of Internet data transmission : Untangling the estimates. Journal of Industrial Ecology 22.4 (2018) : 785-798."

Facteurs d'impact utilisées :

Intensité énergétique Centre de données = 0.0773 kWh/GB;

Intensité énergétique Réseaux = 0.163 kWh/Gb;

Intensité énergétique Équipement utilisateur = 0.00021 kWh/min;

Intensité Carbone par défaut = 519 gCO_2e q/kWh;

Intensité Carbone Union Européenne : 276 gCO_2e q/kWh;

Intensité Carbone France : 34,8 gCO_2e q/kWh;

Intensité Carbone États-Unis : 493 gCO_2e q/kWh;

Intensité Carbone Chine : 681 gCO_2e q/kWh;

Figure 1: Carbonalyzr internal parameters (source: G. Roussilhe)

4 Towards a complete Carbon Footprint of your computer environment

Let us assume that you have the following equipment:

- A laptop
- A smartphone
- A 32" screen

We are going to use the ecodiag tool to obtain a carbon footprint of your set-up. Let us consider two lifetime for your devices: 2 years and 6 years.

1. Use the ecodiag `https://ecoinfo.cnrs.fr/ecodiag-calcul/` tool to compute the carbon footprint of each device;
2. Comment on:
   - on the relative impact of each equipment
   - as well as on the impact of the lifetime on the production/use share.