Second Inria-DFKI European Summer School on AI (IDESSAI 2022)

Track B: Trusted AI and Sustainable AI

Saarbrücken, Germany

Measuring the energy consumption of AI

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Objectives

1. Understand why tracking the energy consumption of AI is important.

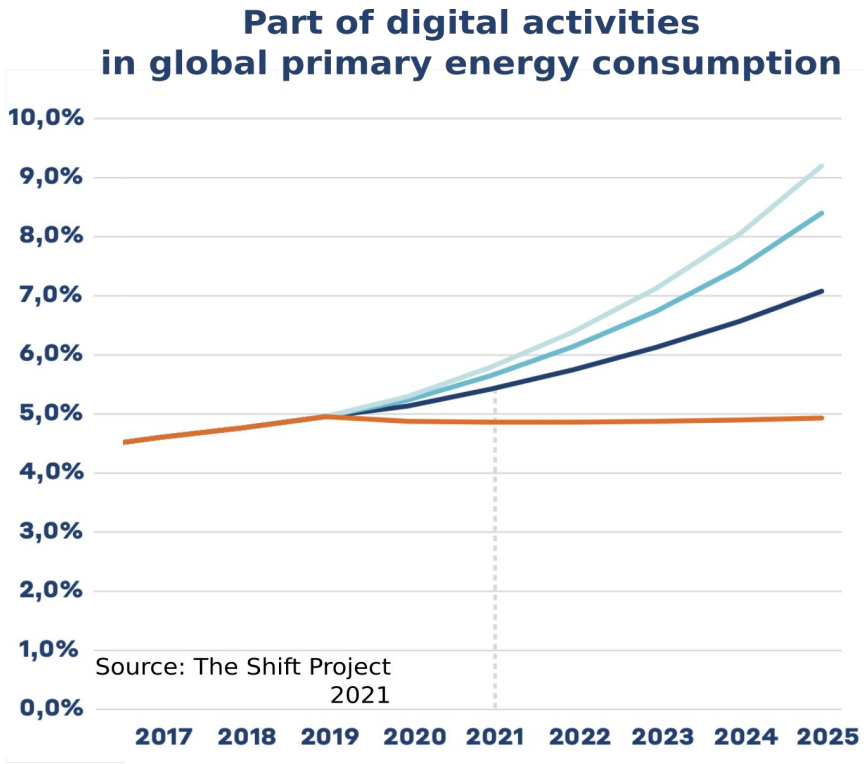
2. Be aware of existing hardware and software tools to measure the energy consumption of AI (and any kind of computing).

3. Develop a first experience on tracking the energy consumption and CO2 emissions of AI model training with software tools.

4. Promote a controlled and frugal development of AI.

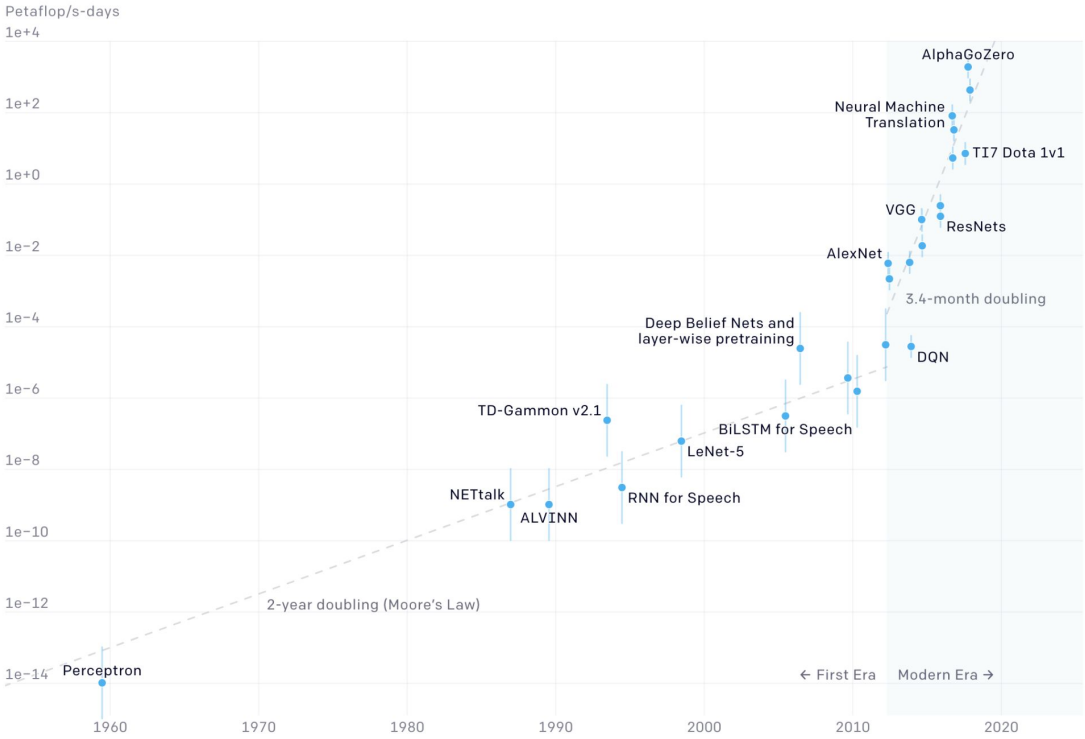
Computing voraciously craves for energy!

- Three top Lines = Mode "business as usual".
- As the curve steepens = More energy demand and more CO2 emissions.



AI craves for energy too!

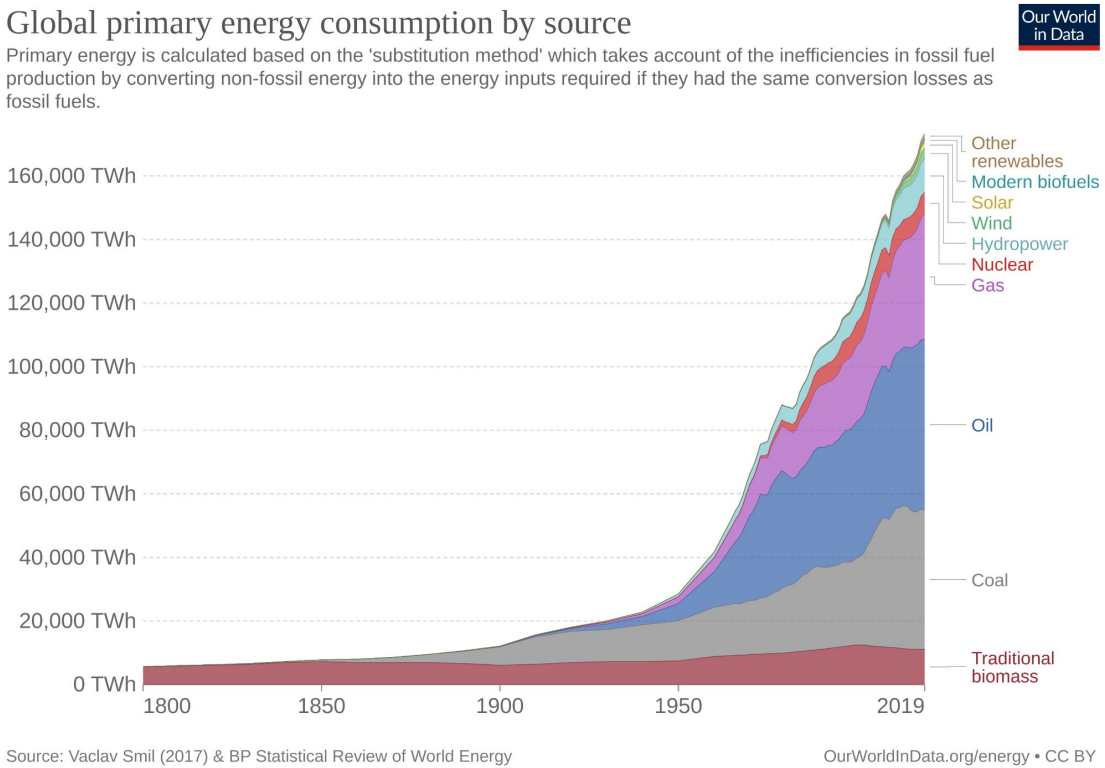
- Y axis = Computing demand = energy demand
- AI contributes to **steepen** the energy curve (previous slide)
- More energy demand = more energy consumption = more CO2 emissions



Source: https://openai.com/blog/ai-and-compute/

Let's just decarbonize the electricity production :)

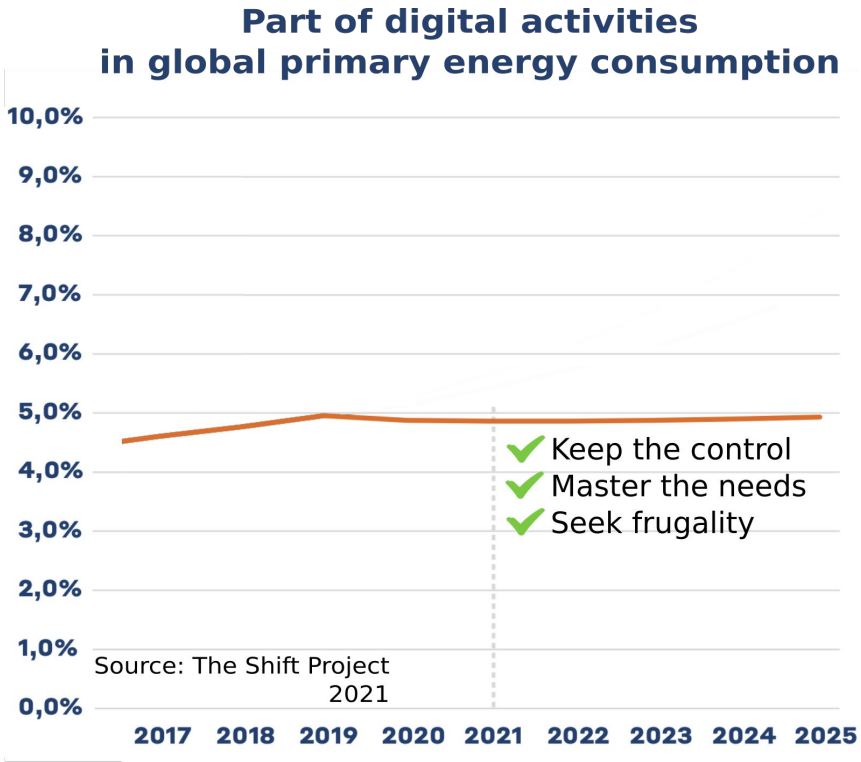
- Only about **16%** of electricity production came from **low-carbon** sources in 2019[1]
- **Low-carbon sources are harder to deploy.** They depend on specific conditions (wind, sunlight, geology) or use rare or dangerous materials (nuclear)
- The increase in energy demand surpasses the creation of low-carbon energy sources
- Can we decarbonize the remaining 84%?



[1]: https://ourworldindata.org/energy-mix

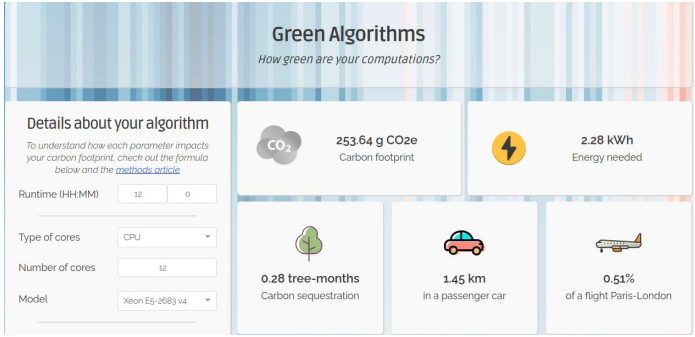
Why is it important to track the energy consumption of AI?

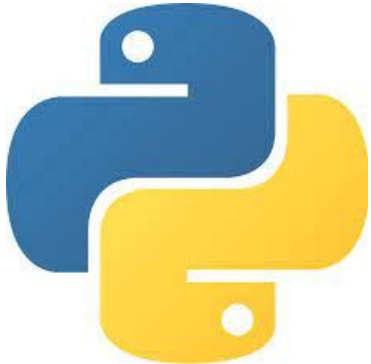
- Master the needs: **Be judicious** to whether we really need to deploy energy hungry AI
- Step to keep the control: know how much energy AI consumes **(this course!)**
- Seek frugality: Seek for **low energy consumption**



How can we measure energy of AI (Or any kind of computing)?

- **Estimations** from **hardware characteristics**
  - Green Algorithms:
  - https://www.green-algorithms.org/)
- **External measurements**
  - Outside the hardware, wattmeters
- **Software power models** (based on hardware counters)
  - Python libraries help to use hardware counters





Wattmeters and Software tools

Wattmeters

Pros:

- Plugged on the power supply
- Independent of the hardware used

Cons:

- Harder to install and to get data from
- May reflect external factors
- It's yet another gadget

Software Tools

Pros:

- Easier to use and get data from
- Doable via software (Python Packages)

Cons:

- Estimations of the actual energy consumption
- Rely on specific hardware (Intel RAPL, and Nvidia-Smi)

Software tools

- Two main interfaces: Intel RAPL[1] (CPU) and nvidia-smi[2] (GPU)
- Python packages base on these tools

RAPL: Accessing hardware counters through the powercap[3] Linux interface

```
(base) dancarastan@dancarastan-Precision-7560:~$ sudo cat /sys/class/powercap/intel-rapl/intel-rapl:0/energy_uj
150019843670
```

nvidia-smi: System management interface

```
(base) dancarastan@dancarastan-Precision-7560:~$ nvidia-smi --query-gpu=index,power.draw --format=csv
index, power.draw [W]
0, 15.69 W
```

1- Khan, Kashif Nizam, et al. "RAPL in Action: Experiences in Using RAPL for Power measurements." ACM Transactions on Modeling and Performance Evaluation of Computing Systems (TOMPECS) 3.2 (2018): 1-26.
2 - https://developer.nvidia.com/nvidia-system-management-interface
3 - https://www.kernel.org/doc/html/latest/power/powercap/powercap.html

Python Packages

- CodeCarbon (https://codecarbon.io/)
- Experiment-impact-tracker (https://github.com/Breakend/experiment-impact-tracker)
- CarbonTracker (https://pypi.org/project/carbontracker/)
- Etc.

- The packages deal with the hardware counters (RAPL, nvidia-smi) for you
- Easy to use “out of the box”
- Easy to integrate in AI code (Tensorflow, PyTorch, etc.)
- Needs some diving in the code if you want more control
  - **That's what we will do with CodeCarbon :)**

Let's get into practice!

Hands-on material: (https://github.com/danilo-carastan-santos/ai-energy-consumption)

1. **Grid5000 Connection**

   1.1 ssh nancy.g5k

   1.2 oarsub -t inner=3749035 -l host=1 -r 'now,13:30'

   This command will print a number JOB_ID

   1.3 oarsub -C JOB_ID

2. **Requirements and installation procedure** (https://github.com/danilo-carastan-santos/ai-energy-consumption/blob/master/requirements.org)

3. **Four sections** (1a, 1b, 1c, 2a) and **Six Questions** (Q1, Q2, Q3, Q4, Q5, Q6)

Thank you!

Let's keep in touch!

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