Digital systems and sustainability
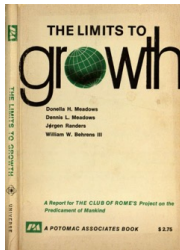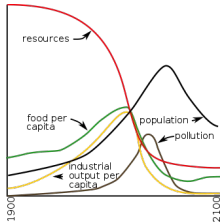
Martine Olivi

INRIA Sophia-Antipolis
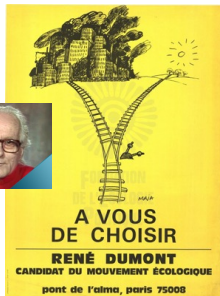
23 April 2024
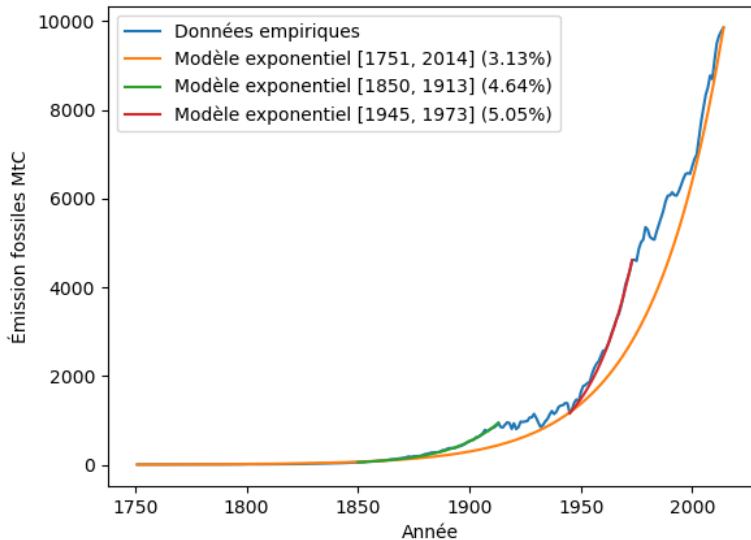
The 70s

Amoco Cadiz
oil spill in 78

Oil crisis in 73.
« En France, nous n'avons pas
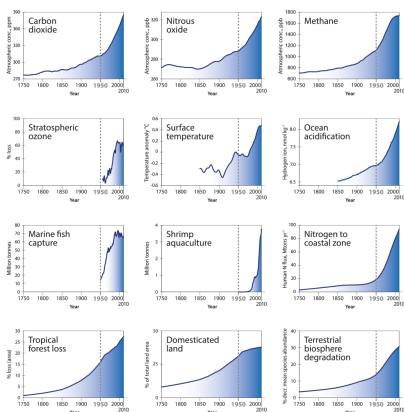de pétrole mais nous avons des
idées »

How unsustainable is current human development?
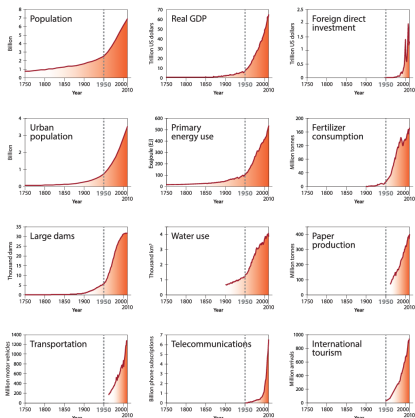
CO2 emissions from fossil fluids[⌘]

The great acceleration
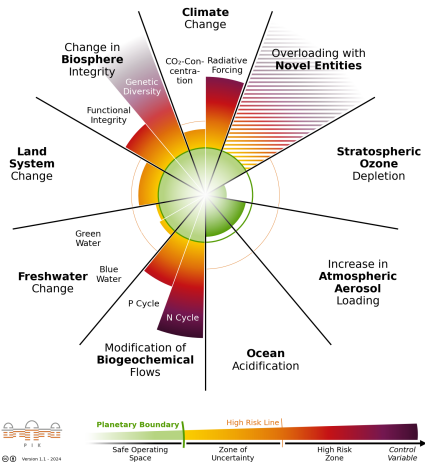
Earth system trends

Socio-economic trends

W. Steffen et al, *The trajectory of the Anthropocene: The Great Acceleration*, Anthropocene Review (2015)

The safe operating space for humanity[1]

6 of the 9 planetary boundaries already overstepped!

[1]Rockstrom, Steffen et al, 2009

Are digital technologies sustainable?

Global GHG emissions of ICT sector

- 2-4 % of the word carbon footprint
- Annual growth: 6% (double every 12 years)
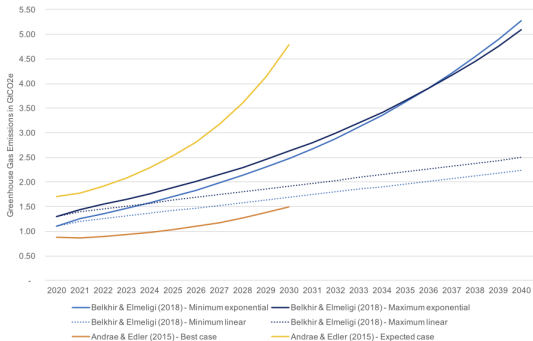
Projections of ICT's GHG emissions from 2020, Freitag et al.[link], 2021

All sectors of the global economy must keep their GHG emissions in line with the Paris Agreement.

What emits the most greenhouse gases
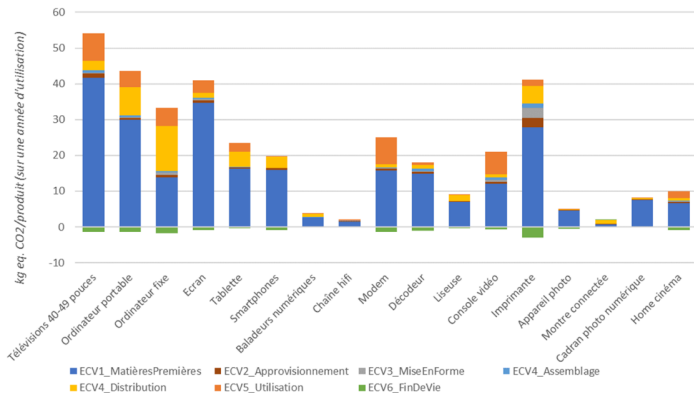
ARCEP-ADEME report (France)

Life cycle of ICT equipments
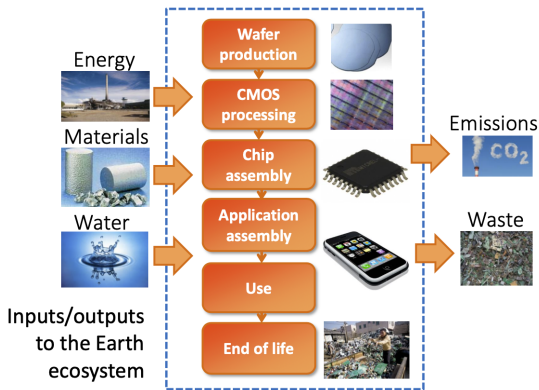
From D. Bol, S. Boyd and D. Dornfeld, *Application-aware LCA of semiconductors []*, in Proc. IEEE ISSST, 2011

ICT's impact concerns at least 5 of the 9 planetary limits!

More and more!
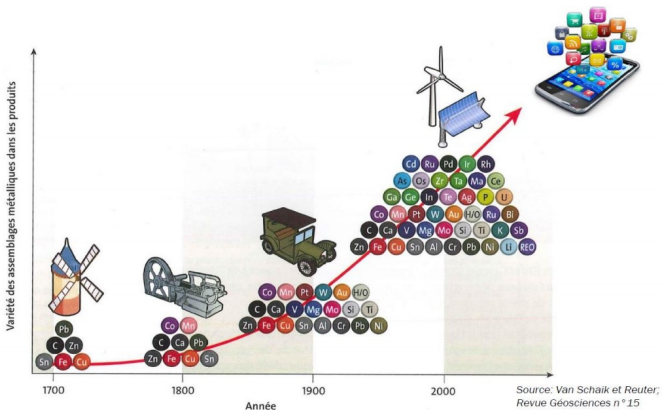
The quantity of chemical elements in current technologies exploded!

Number of metals in phones:

Landline phone (1950): **12**; First mobile phone (1990): **30**; Smartphone: more that **50**.

Supply of raw materials issue
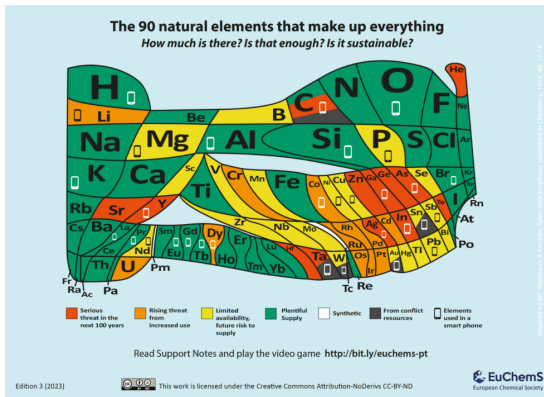
- Tantalum, Indium, Gallium, Germanium, are critical elements:
  - Used in green and digital technologies
  - Recycling rate less that 1%

- Tantalum, Gold $\hookrightarrow$ Conflict resources

All that for just this!

Palabora copper mine (South Africa) and satellite view ©Dillon March.

Photographers raise awareness

Pollution: nickel mining waste, New-Caledonia
© Adam Dean/NYT-REDUX-REA 2022

Children labor: cobalt mining, DRC
© JUNIOR KANNAH AFP 2016

Health impact: gold mining, Burkina-Faso
© Olivier Girard for CIFOR 2013

Can digital science help us build a sustainable world?

5G: a shift toward green telecommunications?
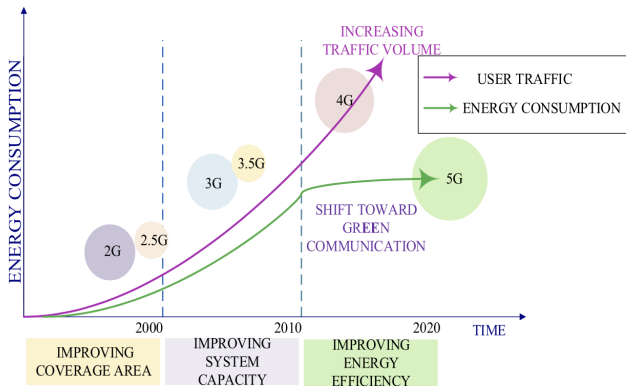
A. Abrol, R. K. Jha: Power Optimization in 5G Networks, IEEE Access 2016

Energy consumption/Gbit will be divided by 10 in 2025; 20 in 2030

↪ **Energy efficiency**

Beware of the rebound effect!

- 5G users consume 2.7 times more data than 4G users. Opensignal, 2020[link]
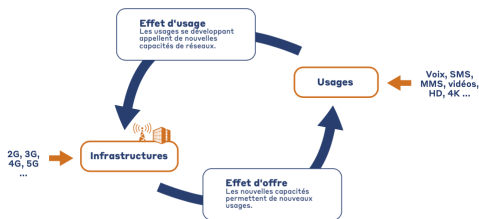
Positive feedback, Shift project (2018)

Efficiency must go hand in hand with sobriety!

- Growth of ICT's carbon footprint due to 5G deployment in France[2]: **18% to 45%** between 2020 and 2030.

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[2]Haut Conseil pour le Climat, 2020[link]

5G what for?

- **Companies**:
    - Answer traffic increase
    - Save energy
    - Allow for new applications:
      health, autonomous vehicle, connected objects

        $\hookrightarrow$ This amounts to a choice of society!

- **The government**: progress and nation's competitivity

      $\hookrightarrow$ Sobriety left to the responsability of users

Sobriety conflicts with the business model!

Are the environmental benefits of IA solutions well assessed?
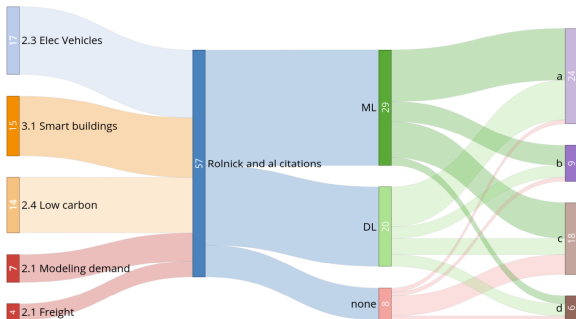
Env. assessment:

a. No mention

b. General mention

c. A few words

d. Evaluation

Sankey diagram of parts of Rolnick's paper references in terms of environmental evaluation. Ligozat & all, 2022

Half of them do not include any environmental assessment!
None of them take into account the impact of machine learning!

AI: a hot topic!

$\sqrt{}$ Very attractive field (scientific interest and funding)

$\times$ The law of the instrument:

I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail. Maslow.

- Risk of wasting time on false solutions
  $\hookrightarrow$ Better assessing IA solutions
- Undone computer science
  $\hookrightarrow$ Funding Undone Computer Science[3]

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[3]Undone Computer Science. Nantes, 5-7 Feb. 2024

Elephant in the room!

Image generated by ChatGPT 4.0 and DALL-E 3.0.

Our growth economy is unsustainable!

- Growth of the digital sector means more raw material, more equipment, more data centers, more submarine cables, ...
- Technological efficiency goes hand in hand with increased use[4]
- We cannot only count on technologies
- Recycling in a growing economy does not help so much

$$\hookrightarrow \text{Green growth is an oxymoron}$$

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[4]Combaz & Bol, Le numérique dans l'anthropocène, JRES 2021

Shall we go for sufficiency?

An economic model that balances between essential human needs and planetary boundaries
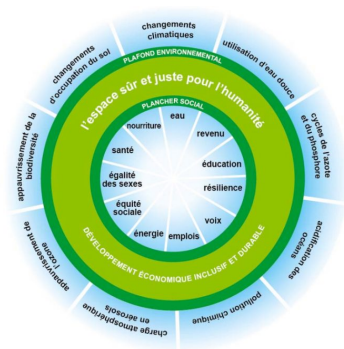
A Safe and Just Space for Humanity. Kate Raworth.

- Provides an end goal for the transition
- Addresses the **systemic and global** character of the ecological crisis

Toward sustainable ICT

- Individual action: keep equipments as long as possible
- Laws: limit data consumption, number of screens, deployment of superfluous new technologies, advertising.
- Democratic ownership of technological choices
- ~~Dematerialization~~ ↪ Lowtechization
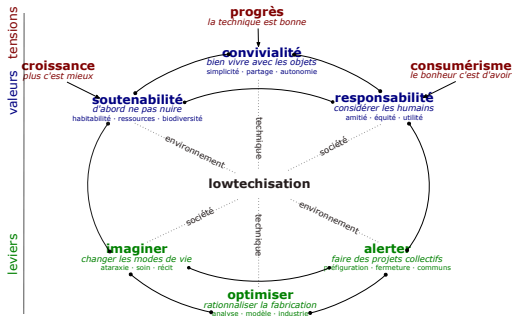
From a course at UTC🔗. Stéphane Crozat

Research is on the way!

We are not alone!

- **EcoInfo**[⊘] - CNRS GDS
  - ↪ Reduce the (negative) environmental and societal impacts of ICT
  - ↪ Organize training weeks
- **Labos 1point5**[⊘]
  - GDR CNRS, INRAE, ADEME, Inria, Sorbonne University
    - ↪ Understand/reduce the carbon footprint of research activities
  - Reflection team (monthly seminar[⊘])
- **Archipel**[⊘]: community on the challenges of the Anthropocene

  ... Atécopols[⊘], OTECCA[⊘],...

- **SEnS workshop**[⊘]: a framework for a collective reflection (1 day-10 people)

Open positions in the field of sustanability digital sciences!