

Modeling the digital sectors production system: a timely and interdisciplinary endeavour

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Context



Copper mine in Gobi desert (Mongolia)

Context



Taihang mountain (China)

Context

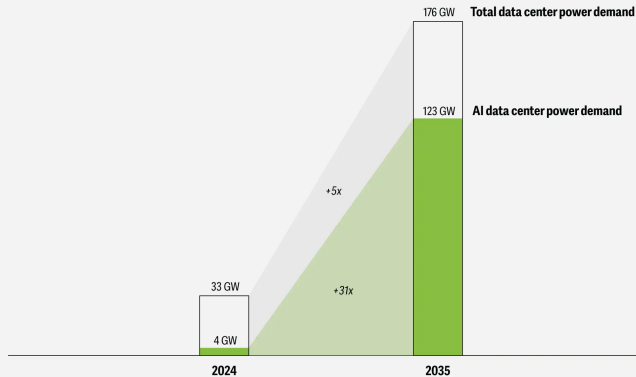


Colossus xAI datacenter (Memphis, USA)

Context

Figure 1

US power demand from AI data centers is expected to boom



Source: Deloitte analysis of data from DC Byte, Wood Mackenzie, S&P Global, Lawrence Berkeley National Laboratory, Center for Strategic and International Studies, and Wells Fargo.

Wait.

How much materials/fuel/real estate/labor... is
that?

LCA solution

Goal and scope



e.g. LCA of a car of typology X, assuming a use for Y years, produced in country Z, ect.

LCI - Life Cycle Inventory

For each stage of a product life cycle (e.g. resource extraction, manufacturing, use, etc.) data on **emissions into the environment** (e.g. CO₂, benzene, organic chemicals) and **resources used** (e.g. metals, crude oil) are collected in an inventory.



Each emission in the environment and resource used are then characterised in term of potential impact in the LCIA, covering a number of impact categories.

LCIA - Life Cycle Impact Assessment



CLIMATE CHANGE



EUTROPHICATION



LAND USE



RESOURCE DEPLETION



ACIDIFICATION



OZONE DEPLETION



ECOTOXICITY



IONISING RADIATION



PHOTOCHEMICAL OZONE FORMATION



WATER DEPLETION



HUMAN TOXICITY

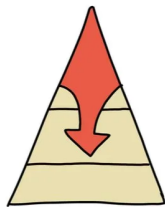
Areas of protection

Human health
Ecosystem health
Natural resources

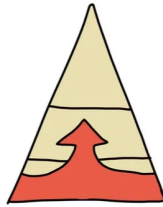
Interpretation

LCA limits

- Focused on the past
- Isolated studies
- Strong hypotheses
(generalization)



top-down



bottom-up

Systems thinking



DISCONNECTION



INTERCONNECTEDNESS



LINEAR



CIRCULAR



SILOS



EMERGENCE



PARTS



WHOLE



ANALYSIS



SYNTHESIS



ISOLATION



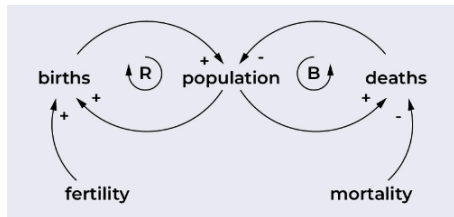
RELATIONSHIPS

Different systemic approaches

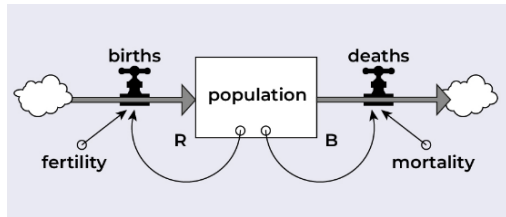
	Causal loop diagrams	Stocks and flows	Agent-based modeling
Expression	Graphical	Mathematical	Computational
Time	Non-temporal	Temporal	Temporal
Unit	System	System	Individuals
Approach	Top-down	Top-down	Bottom-up
Use	Represent the relationships between variables, identify feedback loops	Simulate the behavior of a system, identify critical points	Simulate the behavior of a system, identify emergent behaviors

Laetitia Bornes, Catherine Letondal, and Rob Vingerhoeds, "Systemic Sustainable HCI", in:
DIS Conference, ACM, July 2024, DOI: 10.1145/3643834.3661618

Different systemic approaches



Causal loop

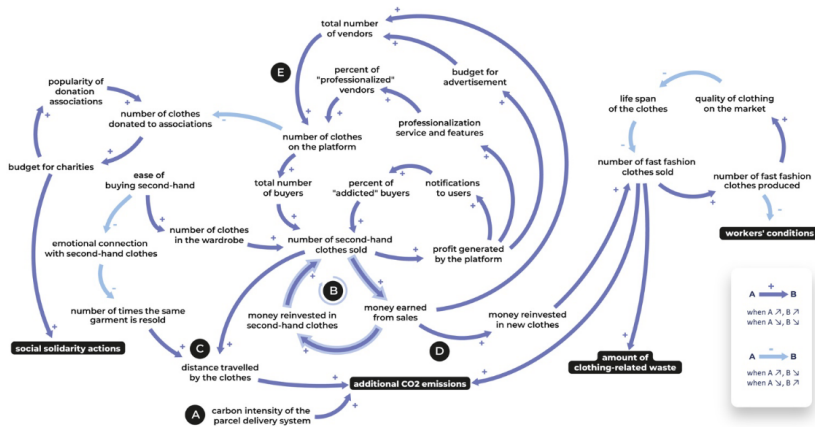


Stock & flow

Understand the Present: Making the Invisible Visible

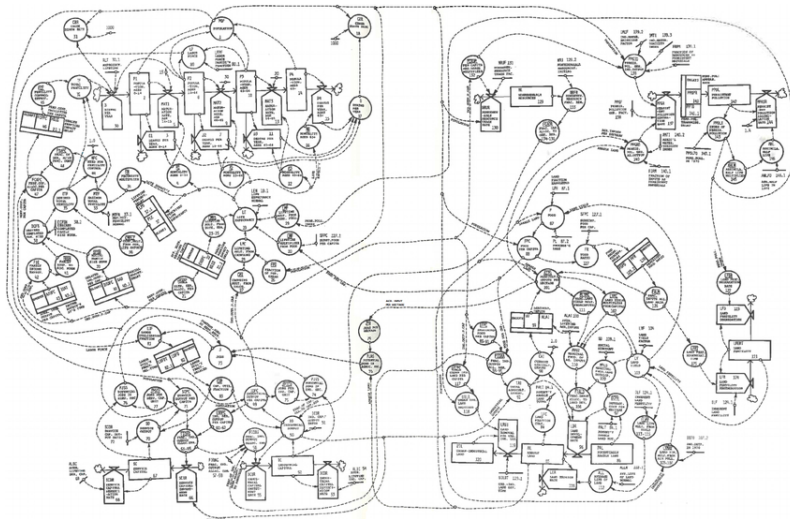


Understand the present: Causal loop diagrams



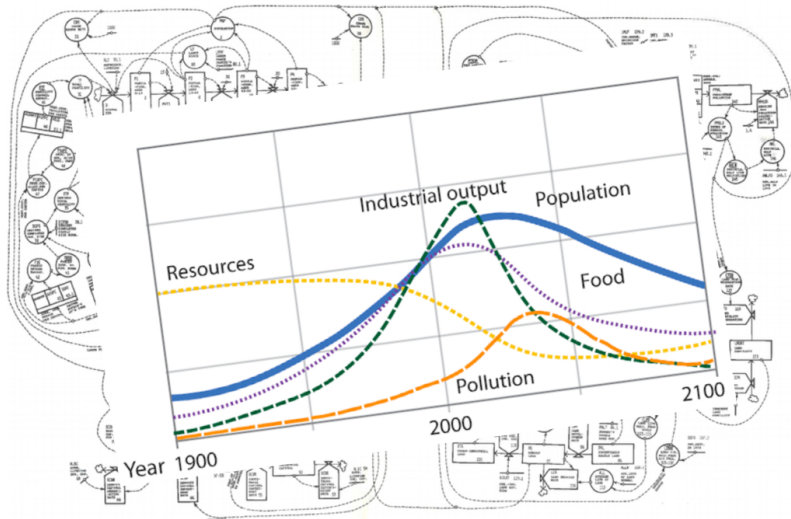
David Ekchajzer et al., "Decision-Making under Environmental Complexity: The Need for Moving from Avoided Impacts of ICT Solutions to Systems Thinking Approaches", in: *ICT4S* (2024)

Anticipate the Future: World 3



Donella H. Meadows et al., *The Limits to Growth*, New York: Universe Books, 1972

Anticipate the Future: World 3



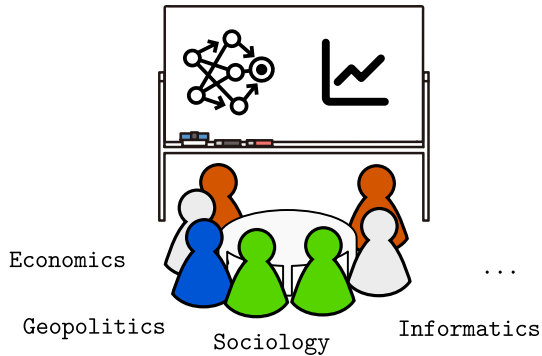
Donella H. Meadows et al., *The Limits to Growth*, New York: Universe Books, 1972

Anticipate the future: Back to our introduction case

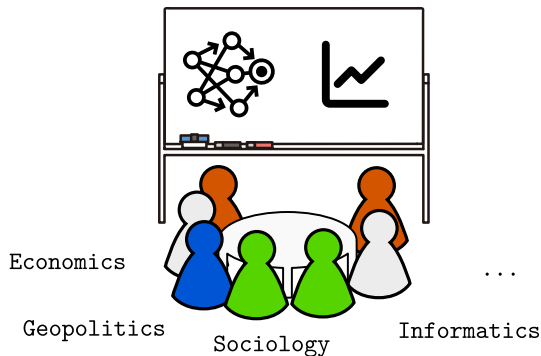
By 2055, our societies will need to mine as much material as since the dawn of humanity.

-- Olivier Vidal et al.

A collective work



A collective work



How can we model the role and interactions of the digital sector in order to visualize and predict its holistic environmental and social impacts?

References

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- [] *The Systems Thinker*, The Systems Thinker, URL: <https://thesystemsthinker.com/> (visited on 12/03/2025).