Dagstuhl Seminar: Greening Networking Towards a Net Zero Internet

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September 29 – October 02, 2024
https://dirk-kutscher.info/events/dagstuhl-greening-networking/

- Academics
  - Networking
  - Distributed Systems
  - Sustainability
- Network vendors
- Network operators
- Application Service Providers

Dagstuhl Seminar 24402

Greening Networking: Toward a Net Zero Internet

(Sep 29 – Oct 02, 2024)

Motivation

What is “Sustainability”?

> Meeting the needs of the present
> without compromising the ability of future generations to meet their own needs
> [UN Brundtland Commission, 1987]

Specifically associated with environmental sustainability and “carbon footprint”

- The amount of carbon emitted from burning fossil fuels to generate power

Reducing carbon footprint to Net Zero to combat climate change is considered one of mankind’s “Grand Challenges”

Dimensions of the problem

We picked 3 dimensions - others could be discussed if anyone interest to bring some up and time allows

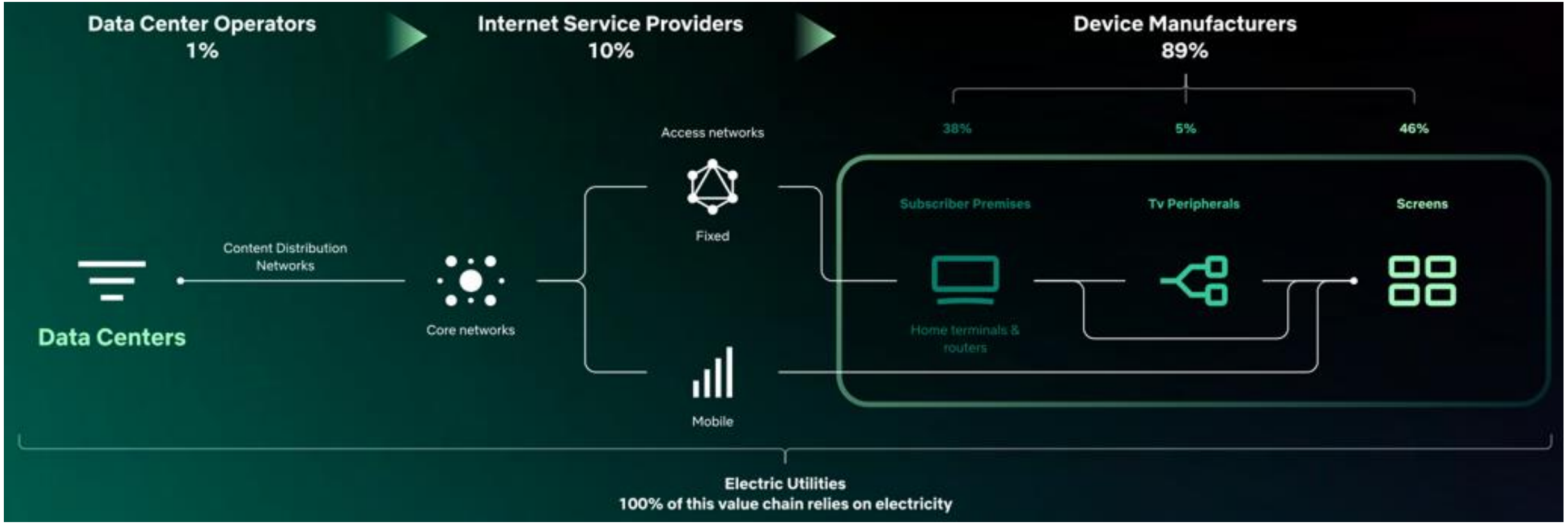
1- Applications, systems, and stakeholders such as Web, streaming, AI

2- Networking Technology

3- “Lifecycle” and control loop aspects for energy consumption management

Other dimensions: network decomposition as edge/WAN/DC (somewhat subsumed into 2); time horizon (as what impact can be had now, in 2 years, in 5 years), etc…

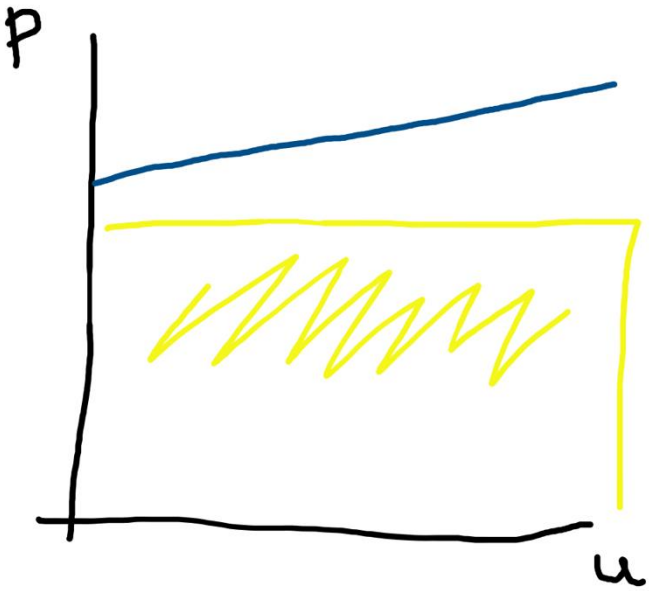
Understanding Energy Consumptions in Systems: Video Streaming



Source: Netflix Environmental Social Governance Report 2023

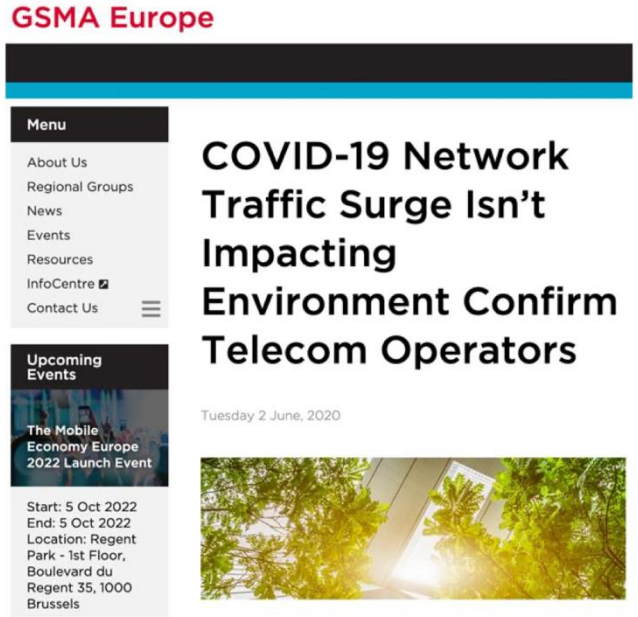
Energy Proportionality in Reality

Low Energy Proportionality



$$P_T = P_b + u \cdot P_u$$

bristol.ac.uk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Upcoming Events

The Mobile Economy Europe 2022 Launch Event

Start: 5 Oct 2022
End: 5 Oct 2022
Location: Regent Park - 1st Floor, Boulevard du Regent 35, 1000 Brussels

COVID-19 Network Traffic Surge Isn't Impacting Environment Confirm Telecom Operators

Tuesday 2 June, 2020

"their monthly carbon footprint would be 9.4 kg CO2e. Simply turning off the video, however, would reduce the monthly emissions to 377 g CO2e."

Renee Obringer, et al. **The overlooked environmental footprint of increasing Internet use**. *Resources, Conservation and Recycling*, 2021; 167: 105389
DOI: 10.1016/j.resconrec.2020.105389

Dan Schien, Bristol University

Attributional vs. Consequential Carbon Emission

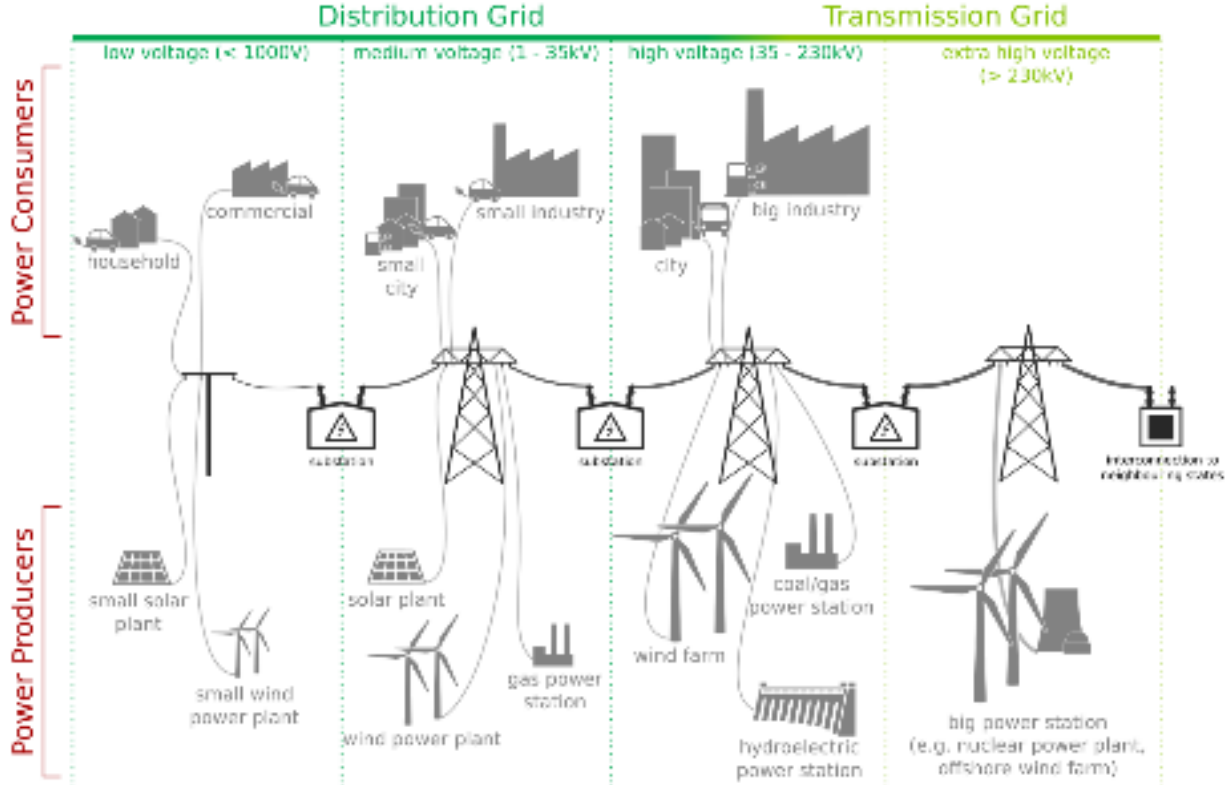
- Traditional attributional accounting is often applied in reporting the carbon emission impact of an isolated unit
  - Company or specific sector
- However energy saving and carbon reduction measures in one unit or sector could lead to an overall increase in the larger socio-economic system
  - When a data centers switches to renewable energy
  - While the overall amount of available renewable energy does not change,
  - So that other consumption would consume less carbon-neutral energy.

Motivation: *From „Supply follows Demand“ to a flexible energy system*

UNIVERSITY OF PASSAU
Faculty of Computer Science and Mathematics

Guaranteed electricity supply through central generators

Integration of distributed actors (renewable energies, flexible consumers)



“If used together, sector-coupling **flexibility and** [European] **transmission** can **reduce** total **system costs by 37%** [of total system costs 699 billion €/a].”
Tom Brown et al., KIT 2018

T. Brown, D. Schlachtberger, A. Kies, S. Schramm, and M. Greiner, “Synergies of sector coupling and transmission reinforcement in a cost-optimised, highly renewable European energy system,” *Energy*, vol. 160, pp. 720–739, 2018.

ICT Systems and the Grid: Flexibility Requirements vs. Flexibility Potentials

- Flexibility Requirements
  - Myopic optimizations in individual systems
  - Concentrating load and reducing overall energy consumption
  - Can lead to unexpected and unwanted peaks, exceeding planned power budgets
- Flexibility Potentials
  - Adaptive systems that can respond to cost indications and changing energy budgets
  - Ability to plan ahead on macro level and to adapt on micro-level

- Scenarios
  - Data Center co-colocated with renewable energy sources
  - Workloads that follow energy availability (geographically)

First Take-Aways

- **Greening Networking vs. Sustainability**
  - Credible efforts in this space seem to require holistic perspective
  - Networking just a small piece in bigger picture
  - Networks are often critical infrastructure: availability important
  - Suggested perspective: Networked Systems (including AI, cloud computing, mobile networks etc.)
- **Interaction of Networked Systems with energy sources (grid, local renewable energy)**
  - Flexibility potentials
  - Cross-discplinary approach highly recommended
- **Tech won’t save us**
  - Credible work should consider socio-economic factors and constraints
  - Example: current AI hype-cycle and its proclaimed energy demands
  - Short term privatized profits – long-term societal debt

Outcomes

Dagstuhl press release

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Greening Networking – towards a carbon emission free Internet

Michael Gerke
2024-10-02
Categories: News Seminars Press release

Computer scientists and engineers from 11 countries on 3 continents have come together to reduce the carbon footprint of the future Internet at Schloss Dagstuhl this week.

As climate change triggered by CO2 emissions dramatically impacts our environment and our everyday life, the Internet has proved a fertile ground for solutions, such as enabling teleworking or teleconferencing to reduce travel emissions. It is also a significant contributor to greenhouse gas emissions, e.g., through its own significant power consumption. It is thus very important to make networks themselves "greener" and devise less carbon-intensive solutions while continuing to meet increasing network traffic demands and service requirements.

Computer scientists and engineers from world-leading universities and international companies, such as Ericsson, NEC, Netflix, Red Hat, and Telefonica came together in a Dagstuhl Seminar on “Greening Networking: Toward a Net Zero Internet” at Schloss Dagstuhl – Leibniz Center for Informatics in northern Saarland in Germany, between September 29th and October 2nd, 2024. Organized by leading Internet researchers from the Hong Kong University of Science and Technology (Guangzhou), the University of Oxford, the University of Oslo, and the University of California, Santa Cruz, they met to identify and prioritize the most impactful networking improvements to reduce carbon emission, define action items for a carbon-aware networking research agenda, and foster and facilitate research collaboration in order to reduce carbon emissions and to positively impact climate change.

Report work in progress

2 Table of Contents

Matrix of Potential Research Topics and their Estimated Impact

Identifier	Idea	Impact	Time Frame	Grid dynamics
1	**Applications, Systems, Stakeholders**			
1.0	Trust models - increasing transparency by enabling trustworthiness: of veracity/integrity of generated/exported/aggregated data; of confidentiality of data use (i.e., for intended purpose only); What support is needed/can be provided by federation and regulation (see also 2.1.4, 3.2.4)	High	Medium	N/A
1.1	AI			
1.1.1	Carbon monitoring: Observability (measuring Joules consumptions on hardware); Tools for measuring energy / carbon emissions from training: `https://codecarbon.io/` `https://github.com/powerapi-ng/pyJoules`	High	Now	Medium
1.1.2	Training: More efficient ML distributed computing and transport protocols (collective communication, in-network aggregation, multi-destination delivery); In-network ML training: moving training closer to the edge; Flexible edge intelligence (Training at the server side as energy is available; at the user side, energy constrained) [6, 5].	Medium	Short	Low
1.1.3	Training: Workload adaptivity (pruning, sparsification, compression, knowledge distillation) depending on observed utilization/-cost (also: mitigating traffic spikes); Focus on aggregation using historical data from previous rounds - ensure that resource limited devices can use a trained model; Can save computation energy and communication overhead.	High	Now	Low
1.1.4	Control: Deterministic networking for training; Decision making tools (e.g., use multi-agent reinforcement learning) to enable users to better select what to train and when to train, what inference model to use (energy impact)	Medium	Short	Medium
1.1.5	Inference: Preload models at the edge for inference: consolidate requests for AI models based on predicted / forecasted demand to a few edge nodes; Offloading inference to network devices: e.g. mitigating DDoS within the network can be done easily with limited cost in resources and power.	Medium	Short	Medium
1.1.6	Model: Use Neuromorphic computing, an innovative and energy-saving machine learning algorithm for the future [3].	Medium	Long	Low
1.1.7	Power: Co-locating DC and workloads to renewable energy sources (windmills)	High	Medium	High
1.2	Streaming			
1.2.1	Reduce idle power consumption in caches (e.g. try to dynamically disable some DRAM). About Grid dynamics: idle periods of content servers typically align with the low-power consumption period. It helps shift the overall consumption, but not shifting the demand.	High	2-10 years	See "idea"
1.2.2	Find the right balance between various network constraints and the number of cache servers needed. We need a framework to understand the optimal design for a given network topology and traffic pattern. For example, reduce cache hit rate target; right now it's about 95% for Netflix. Maybe that's too much? It could be that with smaller caches, we could have a net benefit in transmitting more over the network to reduce the HW costs of the caches. The trade-off to be looked at is the energy of adding more caches vs the amount of traffic that has to be carried through the network.	High	0-1 year	N/A
1.2.3	[illegible]	Medium	[illegible]	Unclear

More Information

https://dirk-kutscher.info/events/dagstuhl-greening-networking/

https://www.dagstuhl.de/en/seminars/seminar-calendar/seminar-details/24402


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