Seminar HS2019

Distributed Systems Group
(Prof. Mattern)

Digitalization and the Rebound Effect

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Motivation – we need to halve our emissions each decade

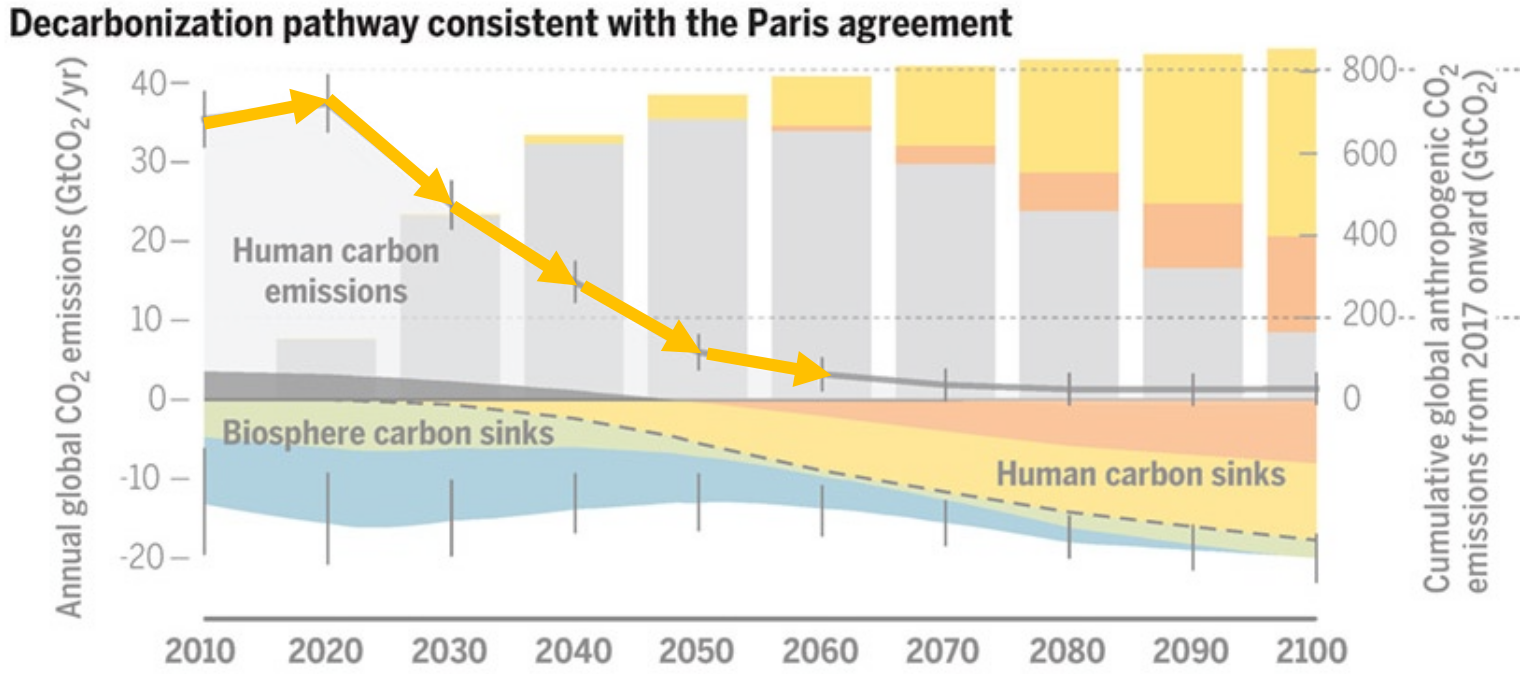
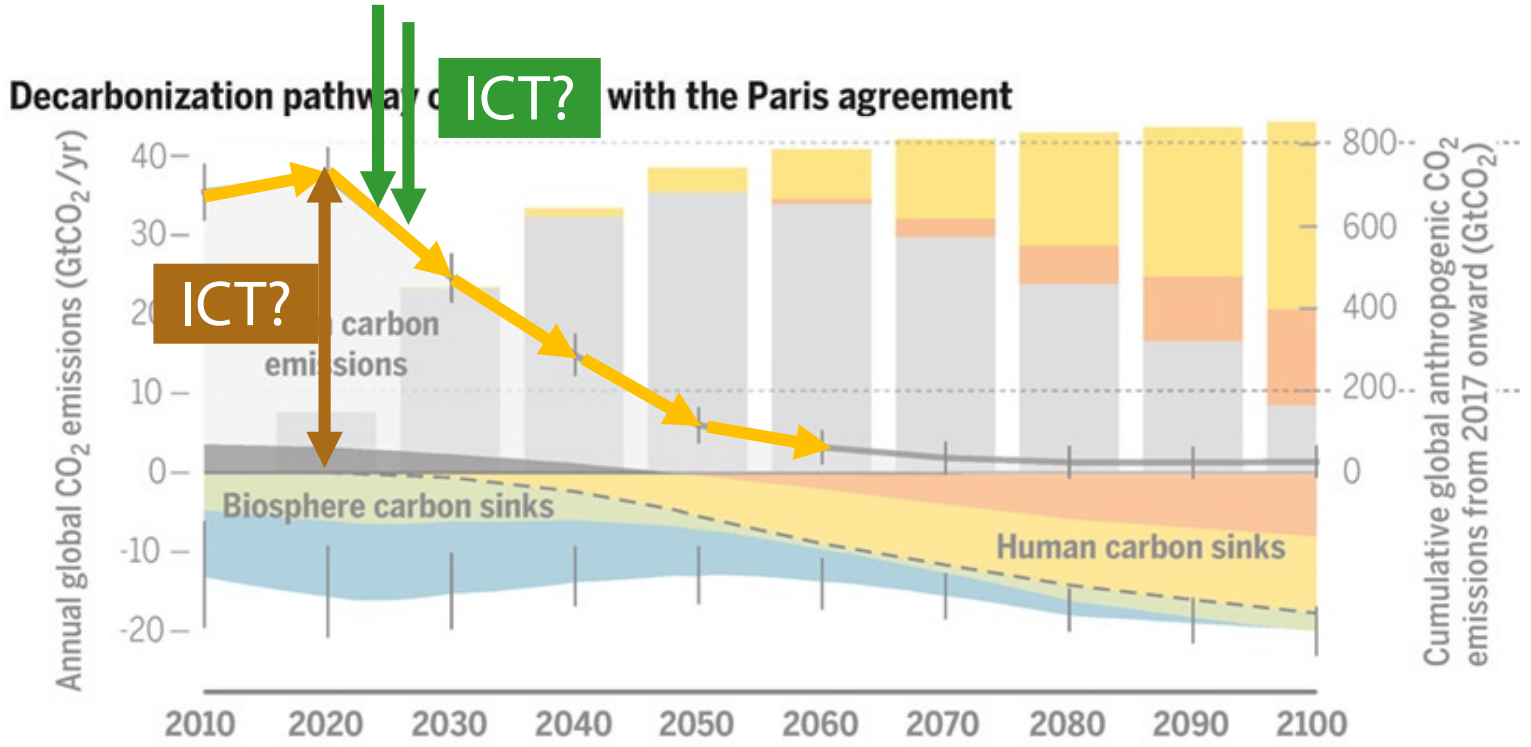


Image scource: (Rockström et al. 2017): A roadmap for rapid decarbonization, *Science*, 355 (6331)

Motivation – we need to halve our emissions each decade



Global stocktaking of human activities and economic sectors, including ICT

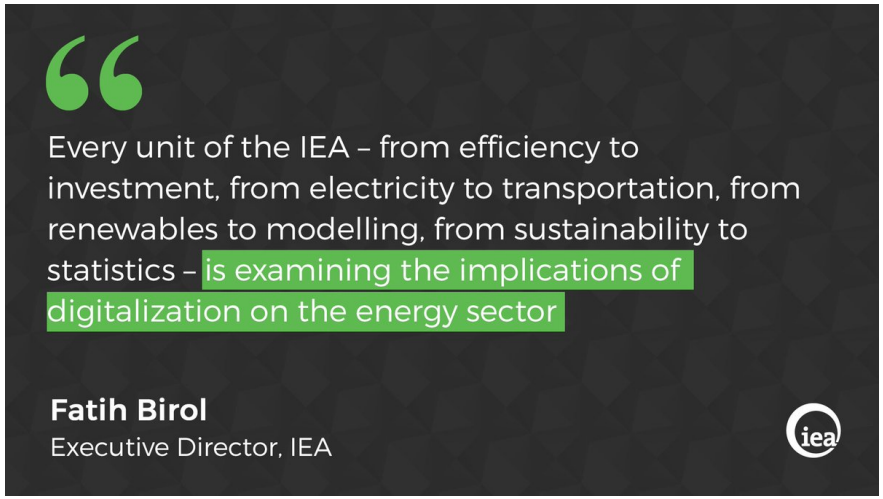
Is ICT a good lever to force down emissions in other sectors?

Image scource: (Rockström et al. 2017): A roadmap for rapid decarbonization, *Science*, 355 (6331)

‘Digitalization and Energy’ – a report by the IEA (International Energy Agency)

April 2017 workshop

1st draft August; published November



http://www.iea.org/digital/

Sectors for abatement

IEA report - sectors

- Energy Demand
  - Transport
  - Buildings
  - Industrial production
- Energy Supply
  - Oil and Gas
  - Coal
  - Power Grid

Slightly different organisation

Transportation

Buildings

Industry

Energy

Savings through ICT: mechanisms vs. sectors

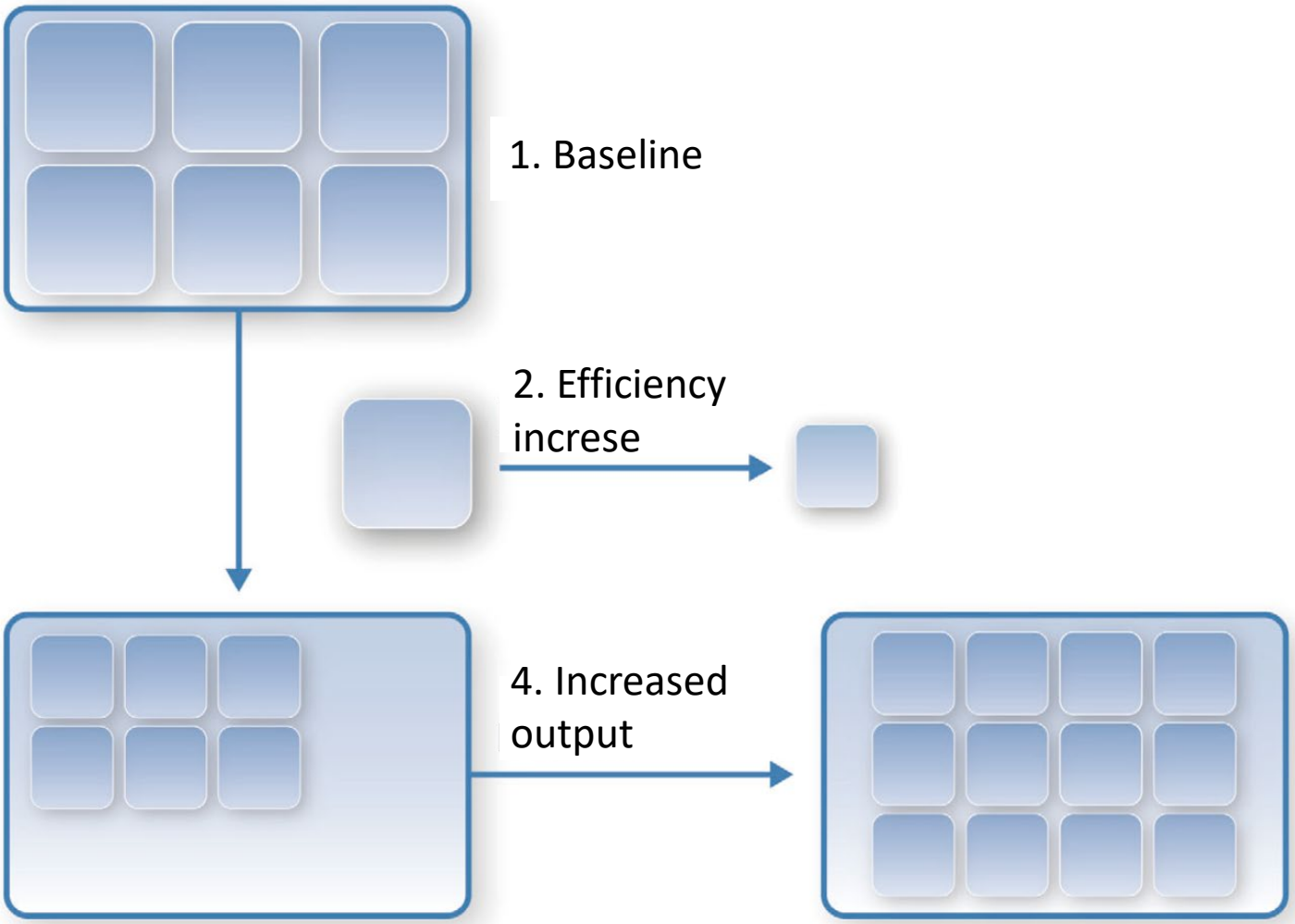
	Substitution / Dematerialization	Increased Efficiency	Awareness and decision support
			
			
			
			

Savings through ICT: mechanisms vs. sectors

	Substitution / Dematerialization	Increased Efficiency	Awareness and decision support
	Telepresence Teleworking Virtual conferences	Fleet route optimization Autonomous vehicles	Mobility footprint app Real-time navi (Waze) Sharing economy
	Online shopping	Smart heating	SM in-home display Normative feedback Sharing economy
	3D printing Virtual goods (stream) Electronic media	Smart heating Smart logistics Drones/Robots	Integrated supply chain
	(renewable integration)	Automatic dem. resp.	User demand response Gas-leakage discovery

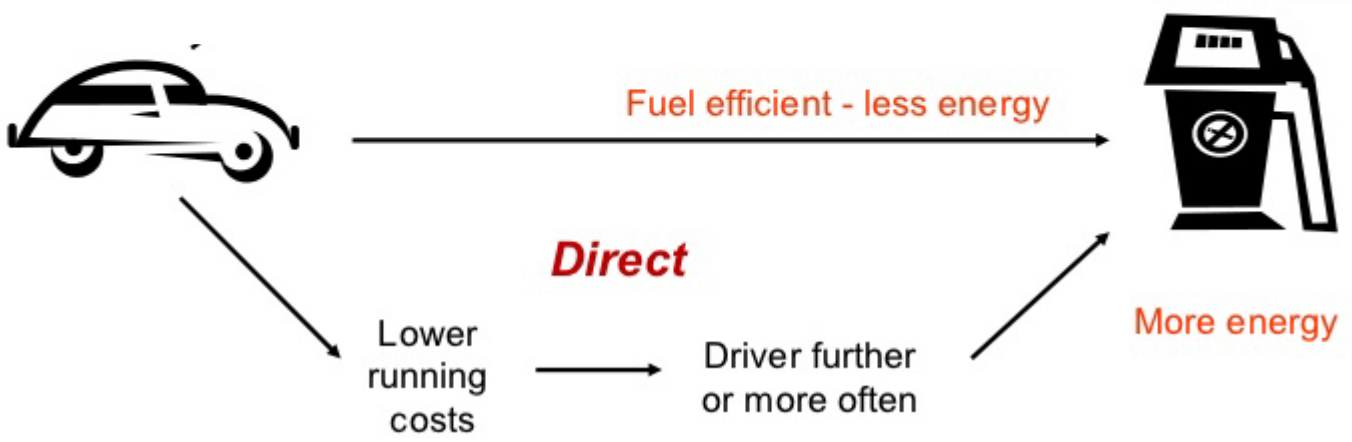
Blue: Domains that will be addressed in the seminar

But: rebound effect!



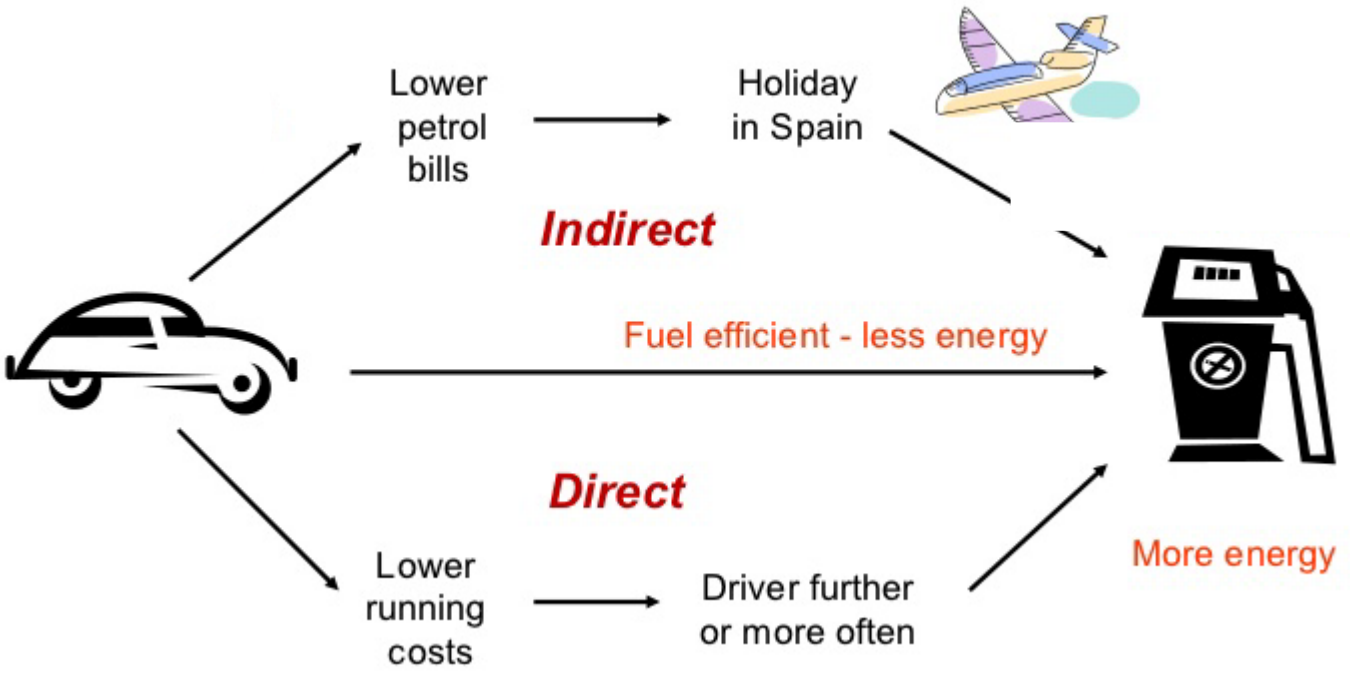
Source: (Santarius 2012) Der Rebound-Effekt: Über die unerwünschten Folgen der erwünschten Energieeffizienz

Direct and indirect rebound – illustration



Steve Sorrell: Jevons' Paradox revisited: The evidence for backfire from improved energy efficiency, *Energy Policy* 37(4), 1456-1469

Direct and indirect rebound – illustration



Steve Sorrell: Jevons' Paradox revisited: The evidence for backfire from improved energy efficiency, *Energy Policy* 37(4), 1456-1469

Why attending this seminar?

1. Interest in the topic
   - environmental impact of digitalization / ICT
   - climate crisis in general
   - deploying digitalization for a more (environmentally) sustainable society
   - understanding the (slippery and ubiquitous) rebound effect, which is particularly relevant for digital technologies

2. Familiarization with scientific work
   - reading & reviewing scientific literature
   - delivering a scientifically sound presentation
   - producing a scientific report

2. You need the ECTS points

Grading & organizational

- 1 student per topic
- Deliverables
  - 40-45 mins presentation & discussion
  - 4-8 page scientific report
- grade-relevant
  - presentation & discussion
  - report
  - discussion of other topics
- dry run 7-4 days before the talk possible
  - detailed feedback from me
- report due 3 weeks after talk

Schedule for each seminar

- presentation
  - 40-45 minutes
- discussion
  - 20-30 minutes
- constructive critique of the presentation
  - 10 minutes
- outlook to next week
  - 3 minutes, w/o slides
  - student presenting next week

Do not forget to

Talk

- Define what you are talking about
  - do not assume audience knows the topic or its jargon
  - use abbreviations only if necessary, and only after defining them
- Be critical and sophisticated!
  - there are often alternative views, interpretations, or assumptions in the literature
  - leadings to different, sometimes opposite results
  - understand where the differences stem from, and present both sides,
  - together with your position, if appropriate

Report

- be exhaustive, but not boring
  - discuss – even at length – where necessary
  - but come quickly to the point whenever possible
- English is different than German
  - usually short sentences are better
  - active voice is better than passive
    - "The fact that the energy consumption of data centers is growing has been shown by many recent studies." vs.
    - "Several recent studies have shown that the energy consumption of data centers is growing."
- References are part of the text and must be clean!

Seminar topics

I. Setting the stage
   1. Digitalization
      - mechanisms for energy saving
      - sectors of energy saving
   2. Rebound effects
      - definition & types
      - relevance for digitalization
   3. The direct environmental impact of ICT

II. Savings vs. rebound in
   4. Teleworking
   5. Online shopping
   6. Electronic media
   7. Sharing economy
   8. Autonomous vehicles

III. Wrapping up & zooming out
   9. Applications with little or no rebound
   10. New technologies & affluence: energy, paper, now data?
   11. Is rebound unavoidable? Countermeasures? Policy measures?

Topic 1: Mechanisms & sectors for energy saving

- International Energy Agency, Digitalization & Energy study, 2017.
  - chapter 1 Intro
  - chapter 2 Impact of digitalization on energy demand in transport, buildings and industry
  - section 3.3 Impact of digitalization on power sector
- Global e-Sustainability Initiative, #SMARTer 2030 study, 2015.
  - an industry study, crappy method
- Lorenz M. Hilty, Bernard Aebischer, and Andrea E. Rizzoli, Modeling and evaluating the sustainablity of smart solutions, Environmental Modelling & Software 56, pp. 1–5, 2014.
  - criticism of the methodologies used above
- Vlad C. Coroama and Mattias Höjer, Assessing GHG Benefits Induced by ICT Services in Practice: A Case Study and Resulting Challenges, Proceedings of ICT for Sustainability (ICT4S) 2016, pp. 29–35, 2016.
  - challenges in assessing energy savings induced by ICT/digitalization
  - only section IV relevant
- Andy Stephens and Veronika Thieme, Framework for Assessing Avoided Emissions. Accelerating innovation and disruptive low- and zero-carbon solutions. Part 2: Draft methodology for calculating avoided emissions, 2018.

Topic 2: Rebound effects

- Blake Alcott, Jevons' paradox, Ecological Economics, 54 (1), pp. 9–21, 2005.
  - article discussing Jevons' 1865 book 'The Coal Question'
- J. Daniel Khazzoom, Economic Implications of Mandated Efficiency in Standards for Household Appliances, The Energy Journal, 1 (4), pp. 21–40, 1980.
  - over 100 years after Jevons, re-launches the concept of rebound
- Steve Sorrell, Jevons' Paradox revisited: The evidence for backfire from improved energy efficiency, Energy Policy, 37 (4), pp. 1456–1469, 2009.

- Mathias Binswanger, Technological progress and sustainable development: what about the rebound effect?, Ecological Economics, 36 (1), pp. 119–132, 2001.
  - different types of rebound effects, including time rebound
  - relevance to digitalization
- Miriam Börjesson Rivera, Cecilia Håkansson, Åsa Svenfelt, and Göran Finnveden, Including second order effects in environmental assessments of ICT, Environmental Modelling & Software, 56, pp. 105–115, 2014.
  - list of rebound types
  - relevance to digitalization

Topic 3: Direct environmental impact of ICT

- Ward Van Heddeghem, Sofie Lambert, Bart Lannoo, Didier Colle, Mario Pickavet, and Piet Demeester, Trends in worldwide ICT electricity consumption from 2007 to 2012, Computer Communications, 50, pp. 64–76, 2014.
  - worldwide energy consumption, future trends
- Ralph Hintemann and Simon Hinterholzer, Energy Consumption of Data Centers Worldwide – How will the Internet become Green?, Proceedings of ICT for Sustainability (ICT4S) 2019.
  - trends in worldwide data center electricity consumption
- Vlad C. Coroama and Lorenz M. Hilty, Assessing Internet energy intensity: A review of methods and results, Environmental Impact Assessment Review, 45, pp. 63–48, 2014.
  - energy intensity along the networks
- Vlad C. Coroama, Daniel Schien, Chris Preist and Lorenz M. Hilty, The Energy Intensity of the Internet: Home and Access Networks, ICT Innovations for Sustainability, pp. 137–155, 2015.
- Daniel Schien, Vlad C. Coroama, Lorenz M. Hilty and Chris Preist, The Energy Intensity of the Internet: Edge and Core Networks, ICT Innovations for Sustainability, pp. 157–170, 2015.

Topic 4: Teleworking

- H. Scott Matthews and Eric Williams, Telework Adoption and Energy Use in Building and Transport Sectors in the United States and Japan, Journal of Infrastructure Systems, 11 (1), pp. 21–30, 2005.

- B. Koenig, D. Henderson, and P. Mohktarian, The Travel and Emissions Impacts of Telecommuting for the State of California Telecommuting Pilot Project, Transportation Research Part C: Emerging Technologies, 4 (1), pp. 13–32, 1996.

- Christian Fuchs, The implications of new information and communication technologies for sustainability, Environment, Development and Sustainability, 10 (3), pp. 291–309, 2008.

- Patricia L. Mokhtarian, A Synthetic Approach to Estimating the Impacts of Telecommuting on Travel, Urban Studies, 35 (2), pp. 215–241, 1998.

- Kurt W. Roth, Todd Rhodes, and Ratcharit Ponoum, The energy and greenhouse gas emission impacts of telecommuting in the U.S., 2008 IEEE International Symposium on Electronics and the Environment, pp. 1-6, 2008.

Topic 5: Electronic media

- Mohammad A. Achachlouei and Åsa Moberg, Life Cycle Assessment of a Magazine, Journal of Industrial Ecology, 19 (4), 2015.
  - Part I: Tablet Edition in Emerging and Mature States, pp. 575–589.
  - Part II: A Comparison of Print and Tablet Editions, pp. 590–606.

- Vlad C. Coroama, Åsa Moberg and Lorenz M. Hilty, Dematerialization Through Electronic Media?. In: Lorenz M. Hilty and Bernard Aebischer (Eds.), ICT Innovations for Sustainability, pp. , Springer, pp. 405–421, 2015.

- Arman Shehabi, Ben Walker and Eric Masanet, The energy and greenhouse-gas implications of internet video streaming in the United States, Environmental Research Letters, 9, 2014.

- The Shift Project, Climate Crisis: The Unsustainable Use of Online Video, report, 2019.

Topic 6: Online shopping

- Deepak Sivaraman, Sergio Pacca, Kimbrly Mueller and J. Lin, Comparative Energy, Environmental, and Economic Analysis of Traditional and E-commerce DVD Rental Networks, Journal of Industrial Ecology, 11 (3), pp. 77–91, 2007.

- Hanne Siikavirta, Mikko Punakivi, Mikko Kärkkäinen and Lassi Linnanen, Effects of E-Commerce on Greenhouse Gas Emissions. A Case Study of Grocery Home Delivery in Finland, Journal of Industrial Ecology, 6 (2), pp. 83–97, 2002.
- Eric Williams and T. Tagami, Energy Use in Sales and Distribution via E-Commerce and Conventional Retail: A Case Study of the Japanese Book Sector, Journal of Industrial Ecology, 6 (2), pp. 99–114, 2002.

- JohanVisser, Toshinori Nemoto and Michael Browne, Home Delivery and the Impacts on Urban Freight Transport: A Review, Procedia: Social and Behavioral Sciences, 125, pp. 15–27, 2014.
- Oliver Bates, Adrian Friday, et al, Transforming Last-mile Logistics: Opportunities for more Sustainable Deliveries. In: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18), ACM, Paper 526, 14 pages.

Topic 7: Sharing economy

- Harald Heinrichs, Sharing economy: A potential new pathway to sustainability, Gaia 22 (4), pp. 228-231, 2013.

- Raza Hasan and Mehdi Birgach, Critical success factors behind the sustainability of the Sharing Economy, In: Proceedings of the 14th IEEE International Conference on Software Engineering Research, Management and Applications (SERA), 2016.

- Chris J. Martin, The sharing economy: A pathway to sustainability or a nightmarish form of neoliberal capitalism?, Ecological Economics, 121, pp. 149–159, 2016.

- Maria J. Pouri and Lorenz M. Hilty, Conceptualizing the Digital Sharing Economy in the Context of Sustainability, Sustainability, 10 (12), 2018.

Topic 8: Autonomous vehicles

- Jeffery B. Greenblatt and Samveg Saxena, Autonomous taxis could greatly reduce greenhouse-gas emissions of US light-duty vehicles, Nature Climate Change 5, pp. 860–863, 2015.
- Austin Brown, Jeffrey Gonder and Brittany Repac, An Analysis of Possible Energy Impacts of Automated Vehicles, In: Gereon Meyer and Sven Beiker (Eds.), Road Vehicle Automation, pp. 137–153, Springer, 2014.

- Lawrence D. Burns, A vision of our transport future, Nature 497, pp. 181-182.
- Joschka Bischoff and Michal Maciewski, Simulation of City-wide Replacement of Private Cars with Autonomous Taxis in Berlin, Procedia Computer Science, 83, pp. 237–244, 2016.

- Corey D. Harper, Chris T. Hendrickson, Sonia Mangones and Constantine Samaras, Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions, Transportation Research Part C: Emerging Technologies, 72 (1), pp. 1–9, 2016.
- Christina Pakusch, Gunnar Stevens, Alexander Boden and Paul Bossauer, Unintended Effects of Autonomous Driving: A Study on Mobility Preferences in the Future, Sustainability 10 (7), 2018.
- Robin Chase, Will a World of Driverless Cars Be Heaven or Hell?, 2014.

Topic 9: Applications with little or no rebound

- Vlad C. Coroama, Lorenz M. Hilty and Martin Birtel, Effects of Internet-Based Multiple-Site Conferences on Greenhouse Gas Emissions, Telematics & Informatics, vol. 29, no. 4, pp. 362-374, 2012.

- Lorenz M. Hilty, Why energy efficiency is not sufficient – some remarks on "Green by IT, Proceedings of the 26th Environmental Informatics Conference (EnviroInfo), pp. 13-20, 2012.
- M. Takashi and H. Asano, "Japanese Vending Machine and Display Cooler Energy Use Affected by Principal-Agent Problem", in Quantifying the Effects of Market Failures in the End-Use of Energy, pp. 108–119, International Energy Agency, 2006.

- Joseph C. von Fischer et al., Rapid, Vehicle-Based Identification of Location and Magnitude of Urban Natural Gas Pipeline Leaks, Environmental Science & Technology, vol. 51, no. 7, pp. 4091-4099, 2017.
- Vlad C. Coroama and Mattias Höjer, Assessing GHG Benefits Induced by ICT Services in Practice: A Case Study and Resulting Challenges, Proceedings of ICT for Sustainability (ICT4S) 2016, pp. 29–35, 2016.
  - in particular section III

Topic 10: New technologies, affluence, sufficiency

- Astrid Kander, Paolo Malanima and Paul Warde, Power to the People: Energy in Europe over the Last Five Centuries, Princeton University Press, 2013.

- Lauri Hetemäki, Riitta Hänninen and Alexander Moiseyev, Markets and Market Forces for Pulp and Paper Products. In: Eric Hansen, Rajat Panwar, Richard Vlosky (Eds.), The Global Forest Sector – Changes, Practices, and Prospects, pp. 99–127, CRC Press, 2013.
  - in particular section 5.2 on the influence of digital media

- Nathaniel C Horner, Arman Shehabi and Inês L Azevedo, Known unknowns: indirect energy effects of information and communication technology, Environmental Research Letters, 11, 2016.

- Tilman Santarius, Digitalization, Efficiency and the Rebound Effect, 2017.

Topic 11: Is rebound (of digitalization) unavoidable? Policy measures?

- Tilman Santarius, Hans Jakob Walnum and Carlo Aall, From Unidisciplinary to Multidisciplinary Rebound Research: Lessons Learned for Comprehensive Climate and Energy Policies, Frontiers in Energy Research, 2018.

- Edgar G. Hertwich, Consumption and the Rebound Effect: An Industrial Ecology Perspective, Journal of Industrial Ecology, 9 (1-2), pp. 85–98, 2004.

- Kenneth Gillingham, Matthew J. Kotchen, David S. Rapson and Gernot Wagner, The rebound effect is overplayed, Nature 493, pp. 475-476, 2013.

- David Font Vivanco, René Kemp, Ester van der Voet, How to deal with the rebound effect? A policy-oriented approach, Energy Policy, 94, pp. 114–125, 2016.

- Jack H. Townsend and Vlad C. Coroama, Digital Acceleration of Sustainability Transition: The Paradox of Push Impacts, Sustainability 10 (8), 2016.