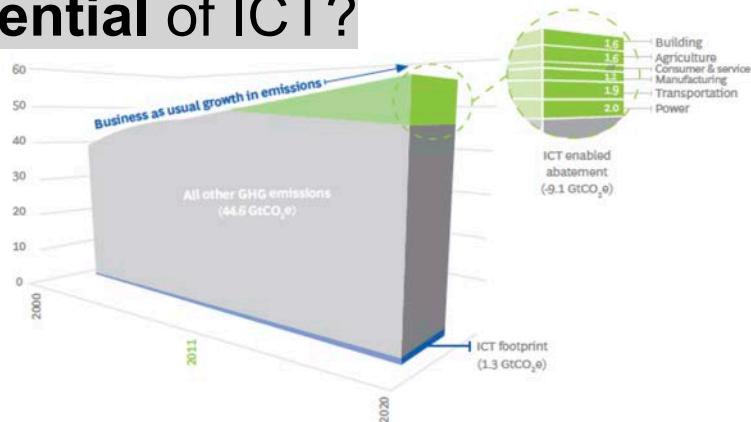
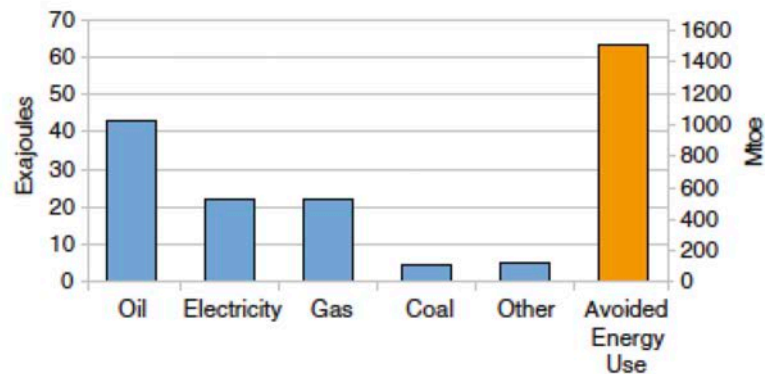


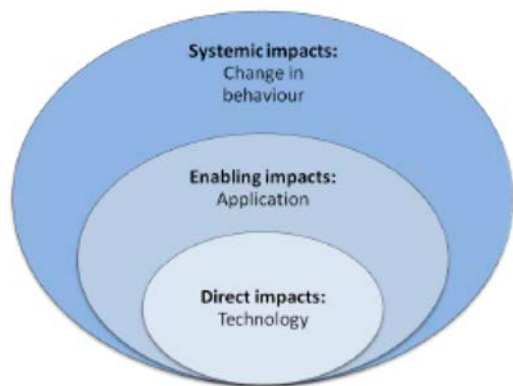
How does the CO₂ footprint of ICT compare with the CO₂ abatement potential of ICT?



How can we better understand the impact of ICT on energy use?

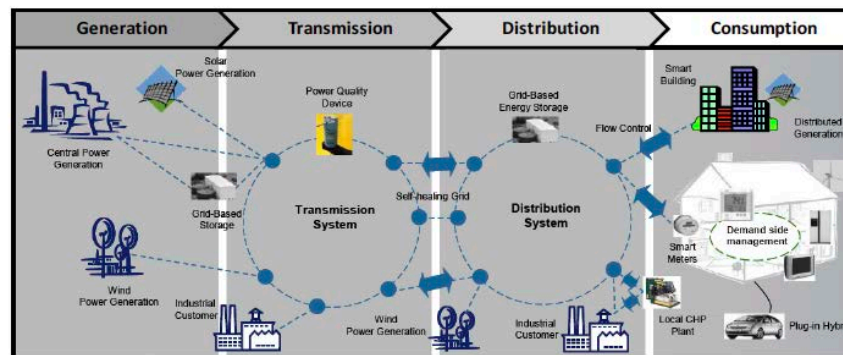


How can the positive and negative impacts of ICT on sustainability be structured and analyzed?



Does “smarter” imply “more sustainable”?

Figure 14. Smart grid technologies across the electricity sector value chain



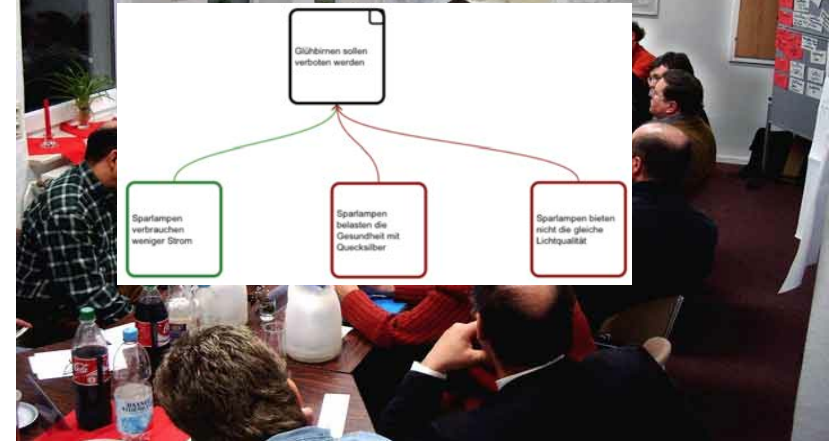
005

What could be a useful role of ICT in climate change adaptation?



006

How can we use ICT to support structured debates?



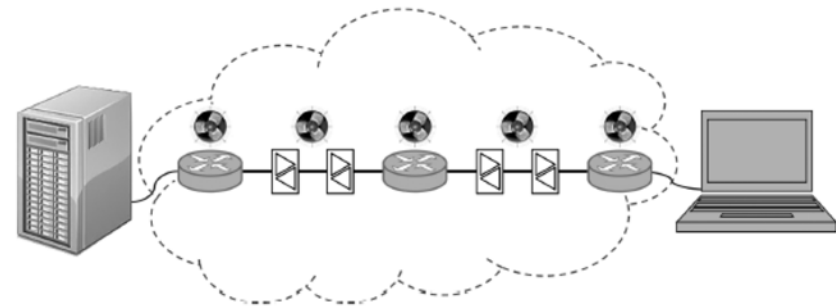
007

How can the discipline of software engineering contribute to sustainability?



008

How much energy per Gigabyte is needed for transferring data over the Internet?



101

What is the **minimum energy needed** to transfer data between two nodes of a wireless network?



Wi-Fi (2)



Bluetooth (3)

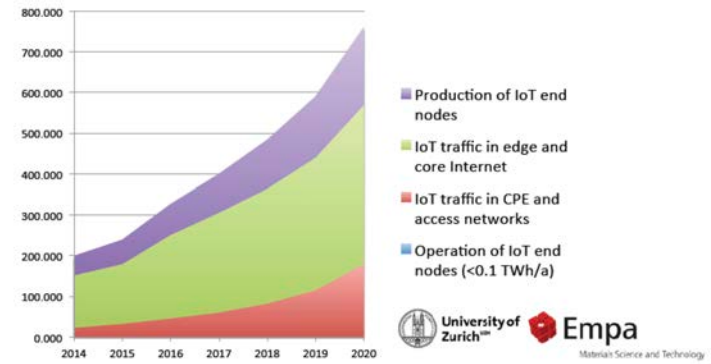


ZigBee (1)



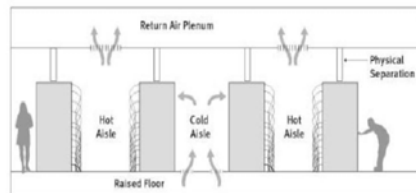
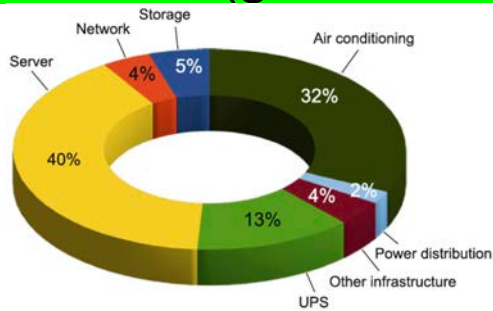
102

How much energy will be used by the **“Internet of Things”** in 2020 and beyond?



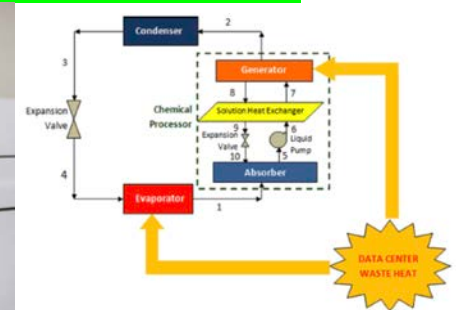
103

How much **electric energy is used** by data centers and how can it be reduced (green data centers)?



104

How can the **waste heat produced** by data centers be re-used?



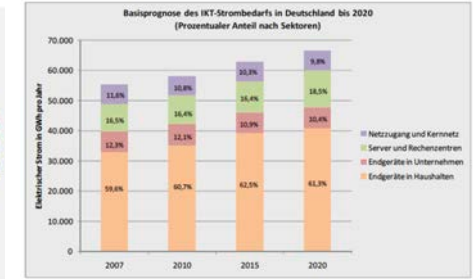
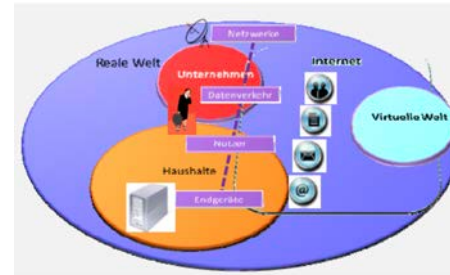
105

What is the potential to save energy by cloud computing?



106

How have energy efficiency and total energy demand of ICT been developing over time?



107

How will energy efficiency and total energy demand of ICT develop in the future?

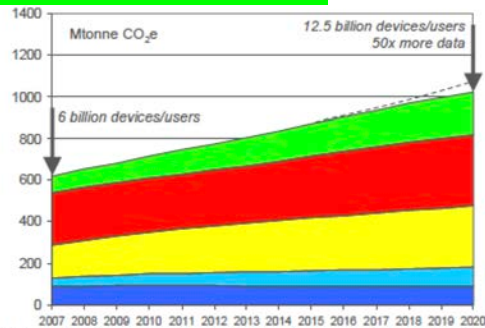
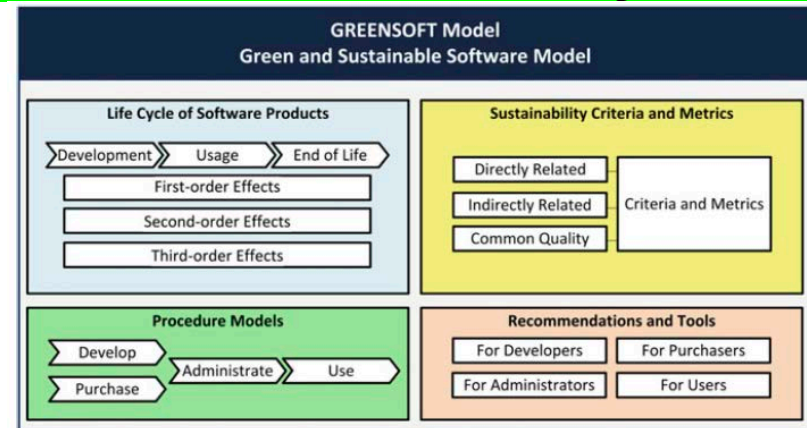


Figure 2. The carbon footprint development of the main ICT subsectors 2007-2020.

120

How can software engineering contribute to sustainability in ICT?



121

How can methods of HCI contribute to sustainability in ICT?

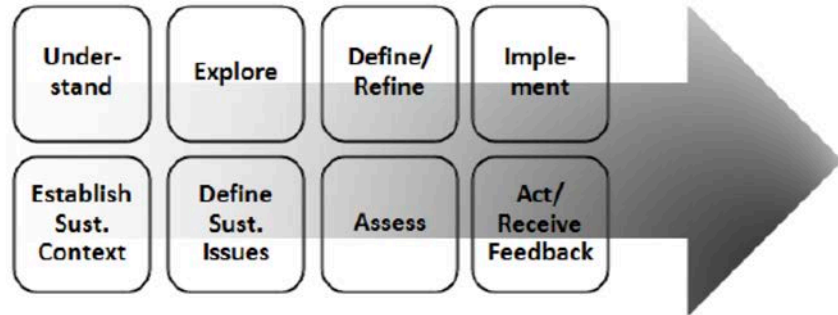
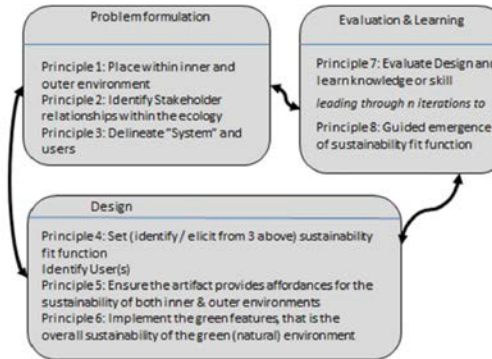


Fig. 5. A reference design process for sustainability (from [22])

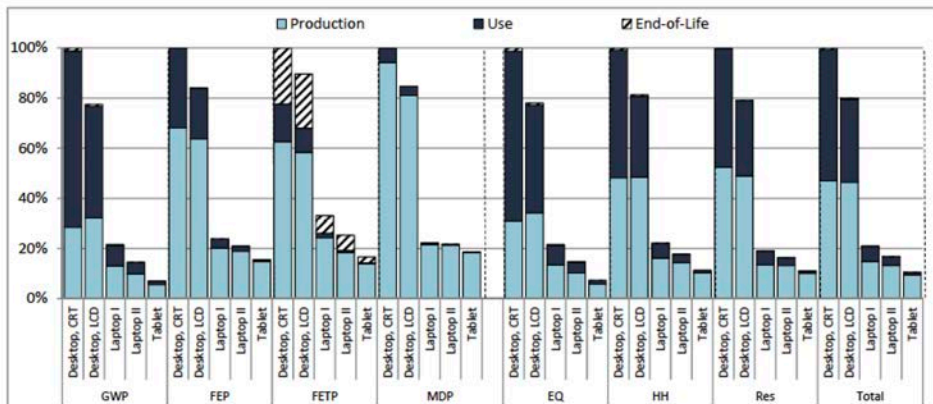
122

How can information systems be designed to be more sustainable? ("green information systems")



140

Does it take more energy to produce or to use an ICT device?



141

What factors are influencing hardware obsolescence?



Sammlung von Elektroschrott in Berlin: Kabelbruch inklusive

Getty Images

142

What are the most critical material resources contained in ICT hardware?



143

Under what social conditions are the materials for ICT hardware mined and how can conflict minerals be avoided?



144

How much WEEE (Waste Electrical and Electronic Equipment) is produced and how can it be managed? (in particular: WEEE from ICT hardware = "e-waste")



145

How does formal and informal e-waste recycling take place around the world and how can it be made more sustainable?



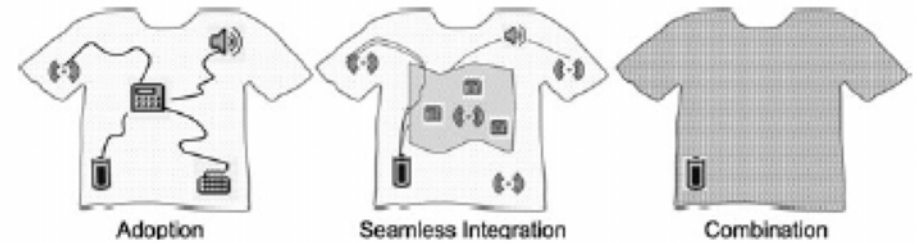
146

How and to what extent can WEEE be reduced through **secondary use** of devices?



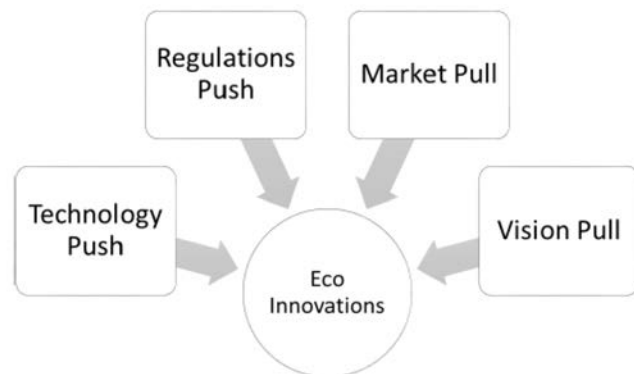
147

Will **e-textiles** become a problem for textile recycling and disposal?



160

How can **sustainable business models** be established in the ICT sector?



161

How is the ICT sector shifting to **renewable energy sources**?



What determines “Green ICT” adoption in business?



How can individual users reduce their ICT footprint?

Greenhouse gas emissions (g CO₂ equivalents) for a 200-page document

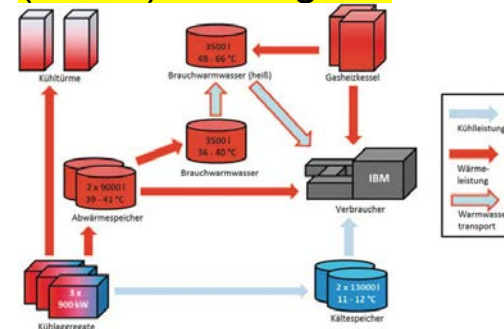
Activity	Device	Desktop	Laptop	Tablet	Separate monitor	Personal printer	Central printer
Download from Internet		0.3-1.0					
Read on screen (10h)		200-300	25-40	8-11	10-40	-	-
Print out		-	-	-	-	100-400	50-90
Production of fresh fiber paper, A4, 80g/m ²		-	-	-	-	1600-1900	
Production of recycled paper, A4, 80g/m ²		-	-	-	-	600-1100	
Share of manufacture and disposal of device		120-250	100-200	25-100	100-550	400-7000	150-750

Example: Downloading 200 pages from the Internet and reading them on a laptop using an external monitor generates at least $(0.3+25+100+10+100=235.3)$ g CO₂eq. Printing them out on fresh fiber paper (single-sided) on a personal workplace printer generates at least $(100+1600+400=2100)$ g CO₂eq. In general, the environmental impact of the equipment in question can be reduced by extending the service life of the device; this explains a part of the ranges in the bottom line. Double-sided printing halves the values for paper production. Sources: own calculations based on the ecoinvent database and [1-5].

How can videoconferencing be used to avoid CO₂ emissions caused by business travel?



How can we control the heating and cooling system of an office building to better integrate it to a (future) smart grid?



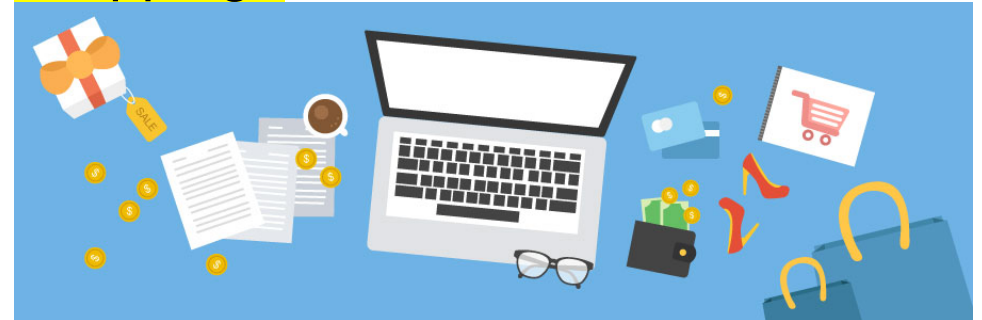
202

Is it more sustainable to read **from screen or from paper?**



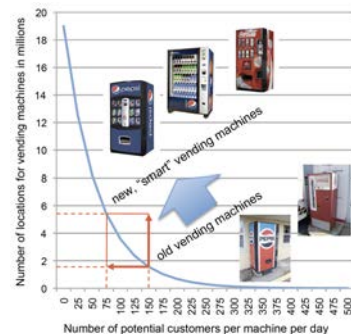
203

Is **online shopping** *more or less* sustainable than conventional shopping?



204

What happened to the electricity demand of **vending machines** when they became “smarter”?



205

How can we use ICT to support **sustainable supply chain** management?



How can we use ICT to support corporate environmental or sustainability management?



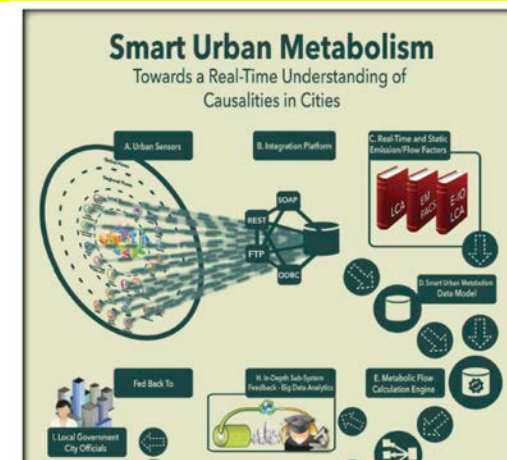
How can we use ICT to support corporate sustainability reporting?



How can sustainability goals be integrated in business process modelling?



How could ICT be used to create smart and sustainable cities?



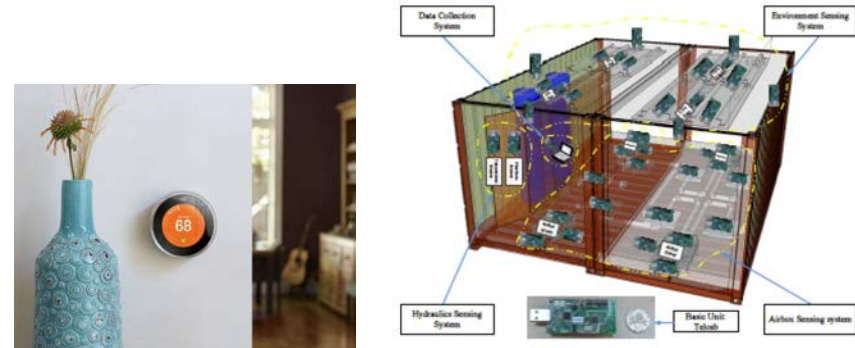
210

What are the main opportunities and risks of **self-driving cars** with regard to sustainability?



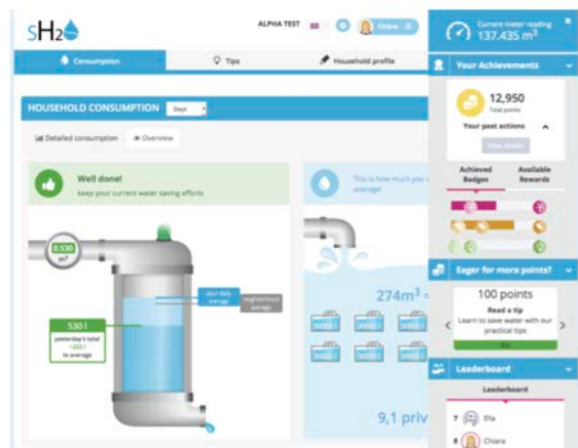
211

How can ICT be used to create **smart and sustainable homes**?



212

How can ICT contribute to better **water management?** (“smart water”)



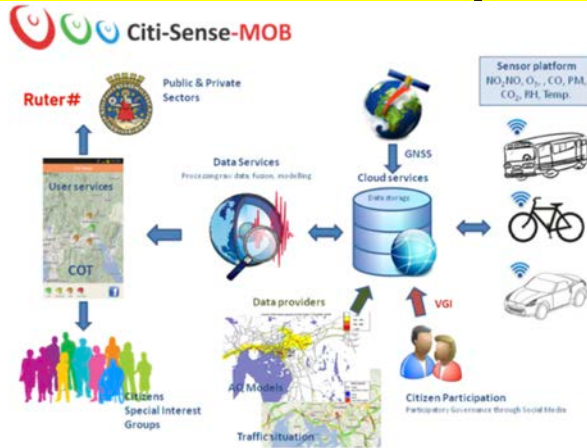
213

How can ICT contribute to better **waste management and recycling?**



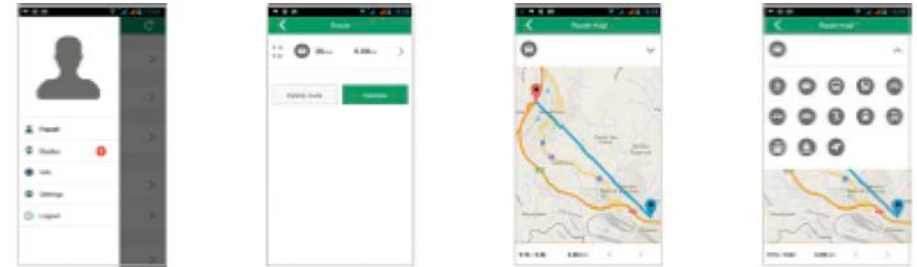
214

How can ICT applications support sustainable transport?



215

Is it effective to use ICT systems and gamification to persuade users of sustainable practices?



216

How can ICT be used to better coordinate energy supply and demand?

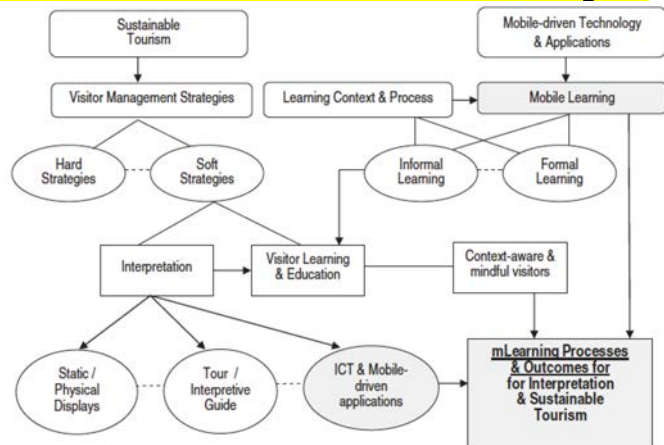


217

How can we apply ICT to support sustainable consumption?



How can we apply ICT to support education for sustainability?



How can we apply ICT to support sustainable agriculture?

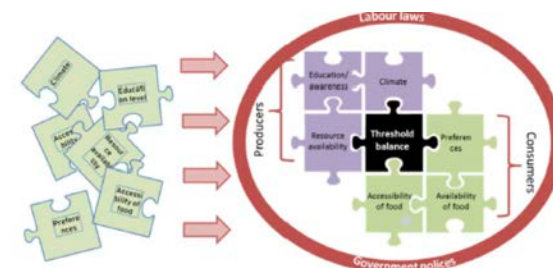
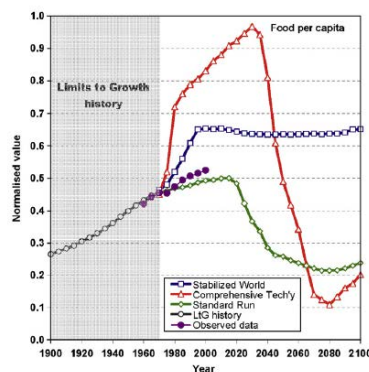
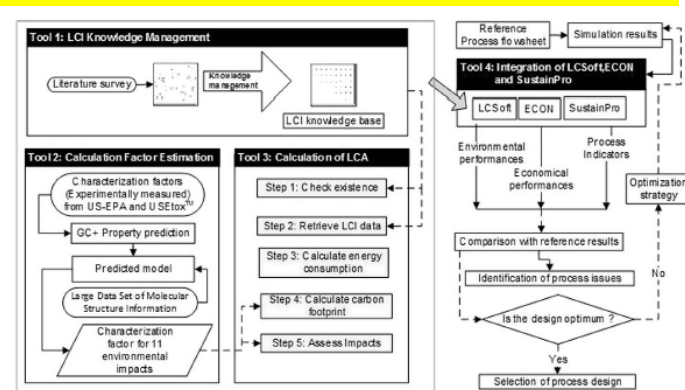


Fig. 2. Decoding the factors that impact the decision to produce and consume

How can we use computer-based modelling and simulation to support decision-making for sustainability?

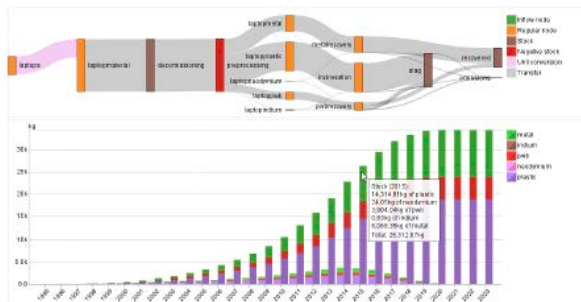


How can we support methods of Life-Cycle Assessment (LCA) and eco-innovation with ICT?



222

How can we support methods of Material Flow Analysis (MFA) with ICT to improve our understanding of the social metabolism?



223

How can we systematically process uncertain knowledge about material flows in the environment?

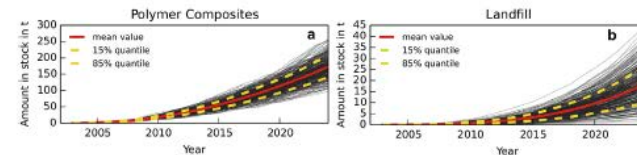


Fig. 10. a): Growth Scenario – CNTs bound in products containing polymer composites as stock of the technosphere (a) and in landfills (b) over time.

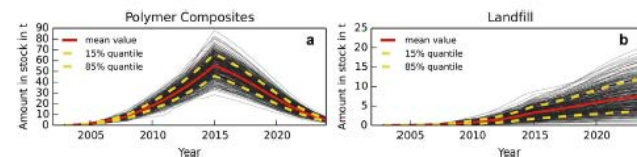
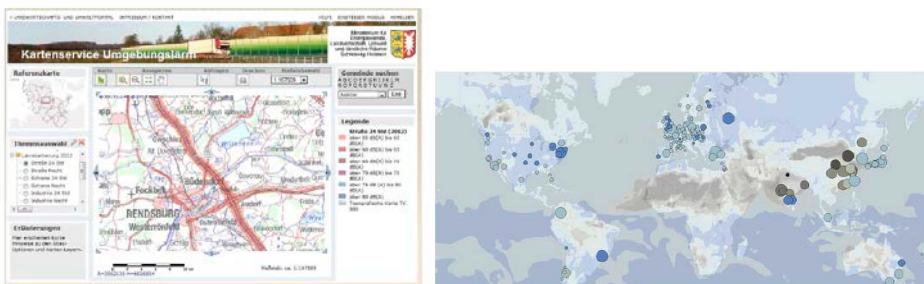


Fig. 11. a): Production stop in 2015 scenario – CNTs bound in products containing polymer composites as stock of the technosphere (a) and in landfills (b) over time.

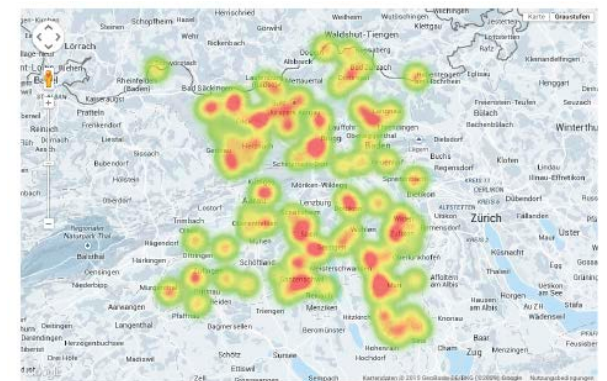
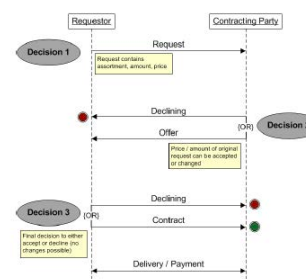
224

How can we use ICT to support environmental monitoring?



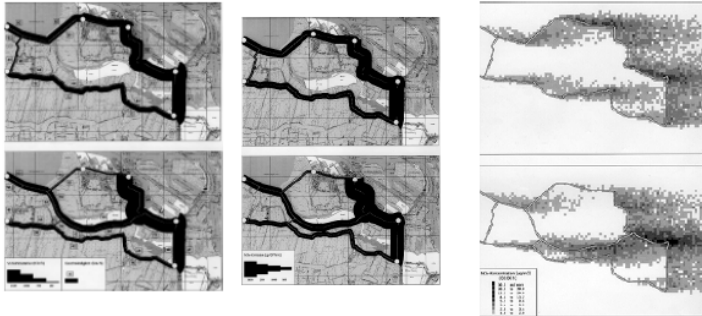
225

How can we use agent-based computer models to better understand the behavior of markets?



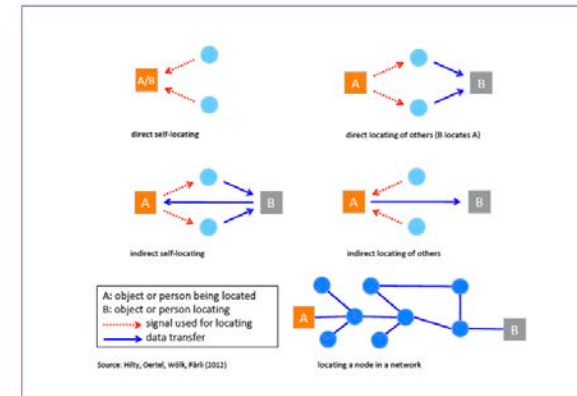
226
(***)

How can we use simulation models to better understand the behavior of traffic systems and the resulting environmental impacts?



227

What are the main societal opportunities and risks of tracking and tracing technologies?



228

How can we use ICT to increase democratic participation in decision-making?

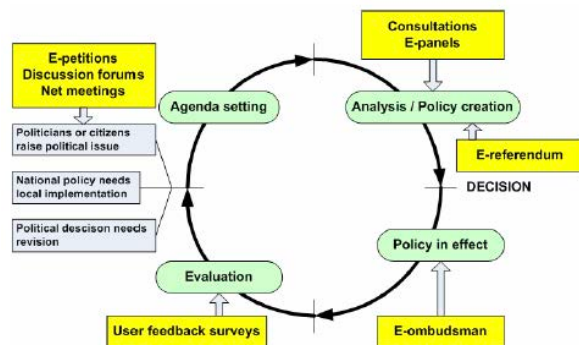


Figure 1. The model of political decision making process in eDemocracy [13]

240

How can we systematically assess the enabling effects of a given ICT application with regard to sustainability?

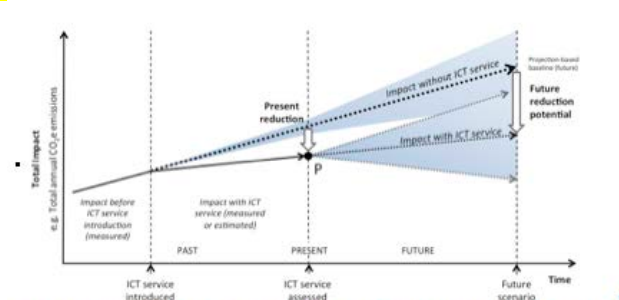
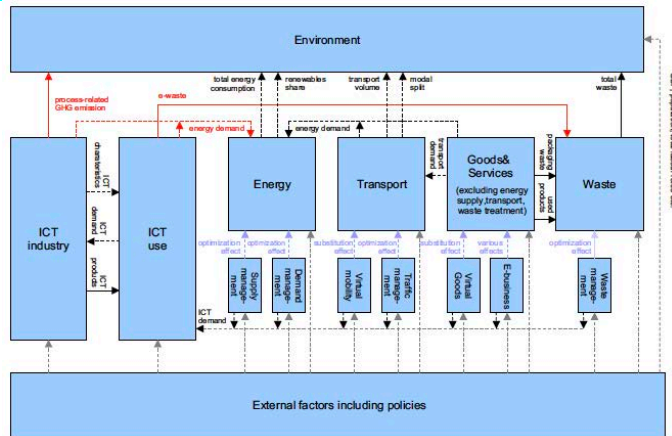


Figure 4-Assessment of the enablement effect-E(S,X)-of an ICT service S, which is already in-use when the assessment is performed. The figure refers to the overall effect of all instances of the service. The (real) situation that includes the service is compared to a (hypothetical) reference situation in which the service does not exist. For future assessments, both systems are projected into the future, with increasing uncertainty.

300

(**)

How can we better understand the dynamics of positive and negative impacts of ICT on the environment?



301

(**)

How can we better understand rebound effects of ICT and other technologies?

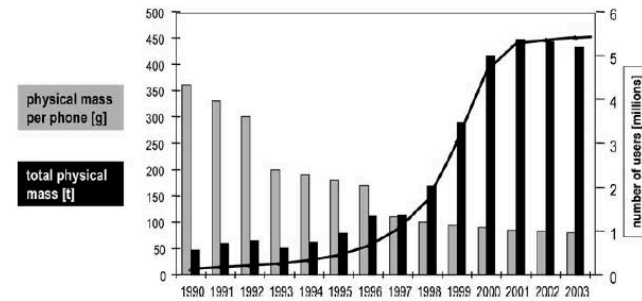


Fig. 5 Development of the physical mass of mobile phones sold in Switzerland. The bars denote the mass per phone in grammes and the total mass in metric tons, respectively. The line shows the number of users in million persons. Source Hilty et al. (2005a)

302

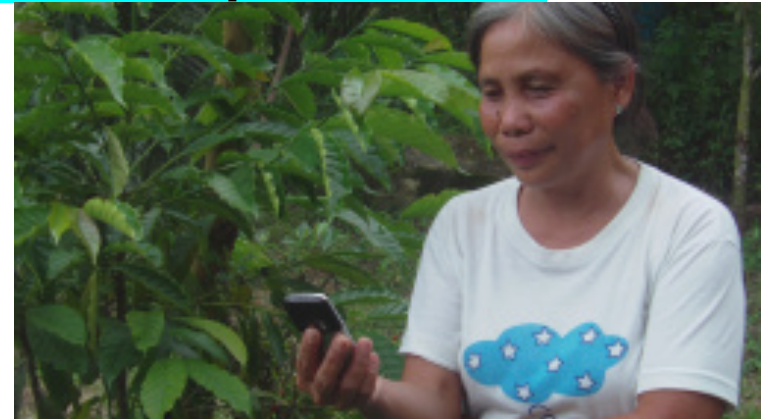
How can ICT contribute to empower women in developing countries?

Personal Trajectory Map 2



303

How can ICT contribute to empower small local producers?



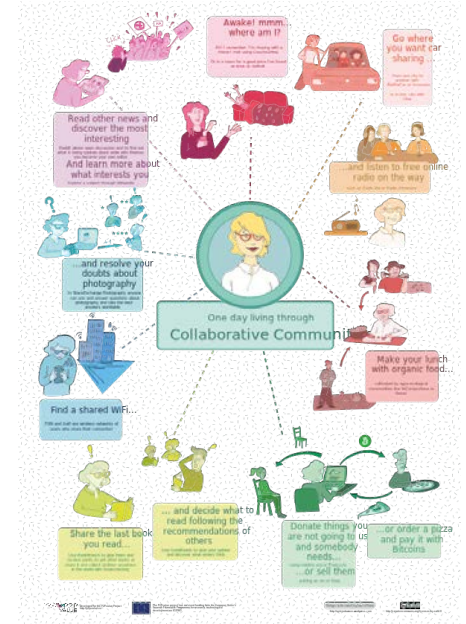
304

What is the role of the mobile phone and mobile services in developing countries?



305

How can ICT support a sharing economy?



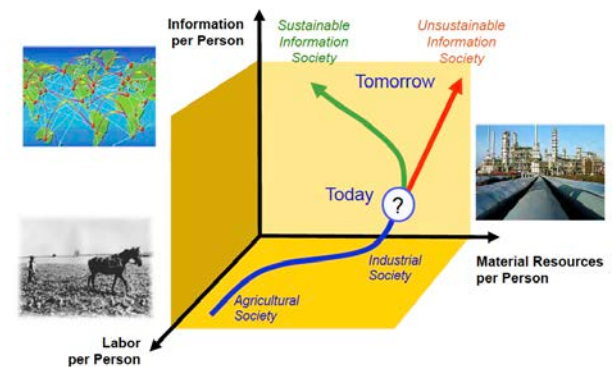
306

How can ICT provide opportunities for education in developing countries?



320

How would a sustainable information society differ from today's society?



Your Research Question:
