CENTRE FOR RESEARCH INTO ENERGY DEMAND SOLUTIONS

Does digitalisation save energy? Drivers, rebounds and policy options

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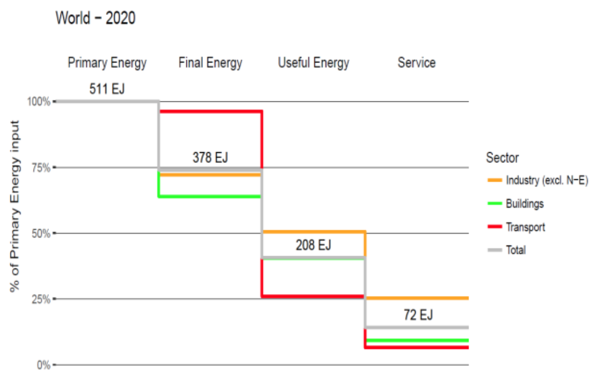
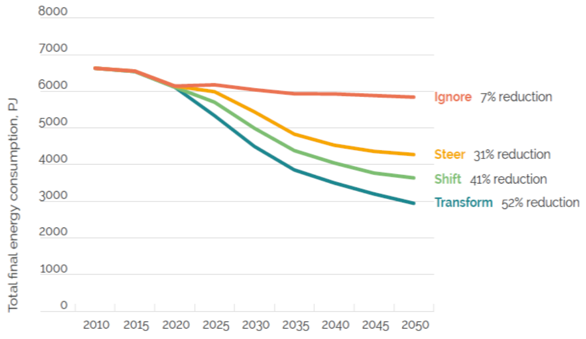
Low energy demand pathways

- Recent work has examined the contribution of measures to reduce energy demand to meeting Net Zero goals at a global (Grubler et al., 2018) and UK level (Barrett et al., 2022)
- These include energy efficiency improvements and changes in practices, such as reducing car use and flying less
- These measures deliver social, economic and environmental co-benefits that improve people's wellbeing (Creutzig et al., 2022)
- Analysis of these pathways shows that the UK could reduce its energy demand by 50% by 2050 (Barrett et al., 2022)



Source: Grubler et al. (2018)



Source: Barrett et al. (2022)

CREDS Digital Society Theme

1. What are the historical and potential future **impacts** of ICTs on sectoral and economy-wide energy consumption?
2. What **factors** and **mechanisms** explain those impacts?
3. How can the **future** energy-saving potential of ICT's be maximised?

https://www.creds.ac.uk/digital-society/

First-round projects

Sub-theme	Project
ICTs and energy productivity	Reviewing the evidence on ICTs and energy consumption (Sorrell, Hook, Court)
	Estimating historical impacts of ICTs and energy consumption (Sorrell, Chitnis, Taneja)
ICTs and business models	Digital platforms for the sharing economy (Foxon, Hiteva)
	Energy service business models for households (Foxon, Hiteva)
ICTs and user practices	Expectations for automated vehicles (Schwanen, Hopkins)
	Acceptance of smart homes (Sovacool, Furszyfer del Rio, Martiskainen, Energy Systems Catapult))
	Potential for teleworking (Sorrell, Hook)
	Diffusion of smart meters (Sovacool, Geels)

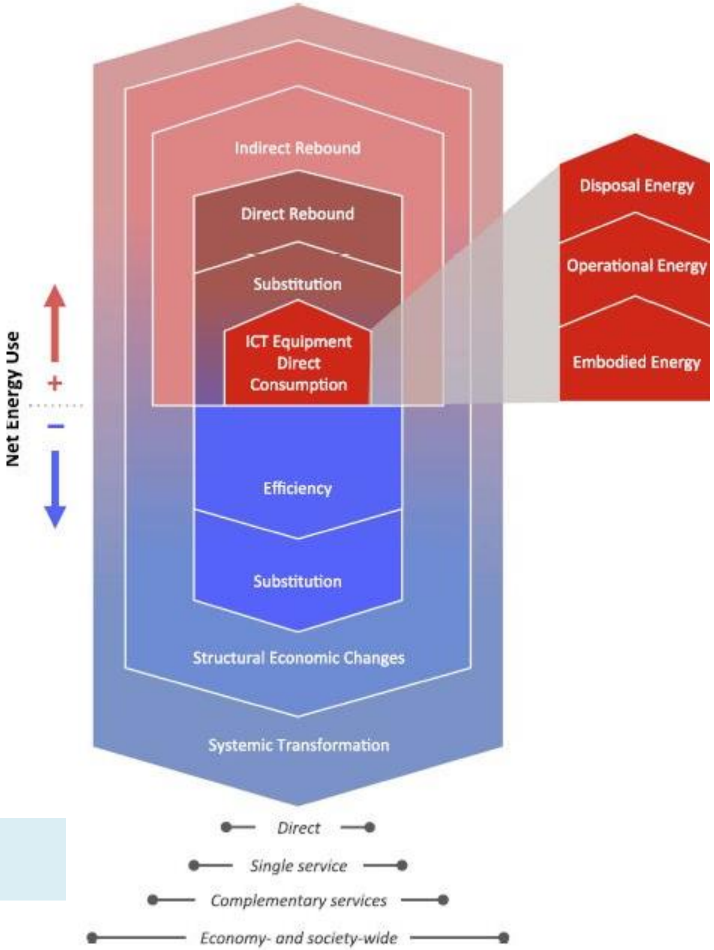
Second-round projects

Sub-theme	Project
ICTs and energy productivity	Teleworking and UK energy demand (Sorrell, Caldarola)
	Future impacts of ICTs and energy consumption (Foxon, Bergman)
ICTs and business models	Place-based business models (Hiteva, Mininni)
	Digital twins in the built environment (Lovell, Foxon)
	Social entrepreneurship at the grid edge (Johnson, UCL, KCL, Groningen)
ICTs and user practices	Energy and climate impacts of 5G (Williams, Sovacool, Foxon)

Guiding question

Is ICT net energy saving?

Systematic reviews of the evidence base

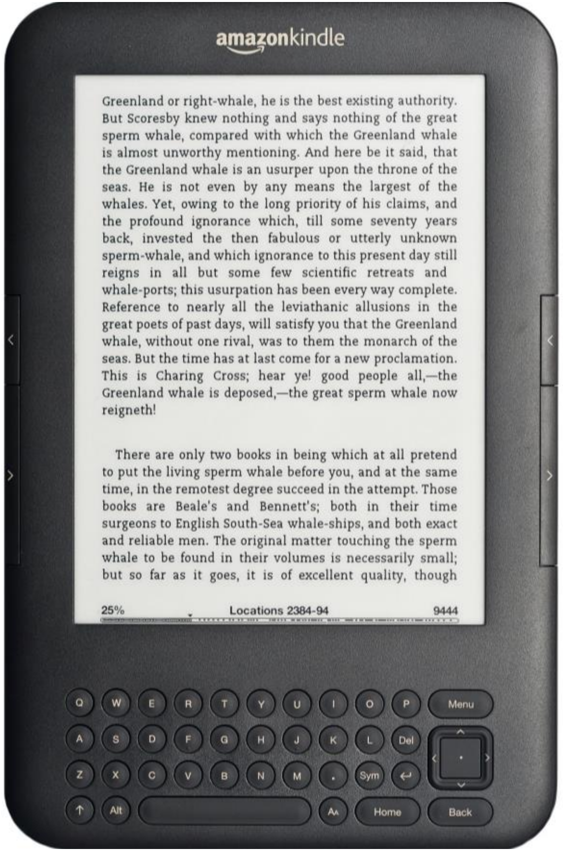


Classifying the energy impacts of ICTs

Pohl et al (2019)		Horner et al (2016)	Impact mechanism	E-books example
Direct impacts	Technology perspective	Direct	**Embodied energy (+)**	Energy used to manufacture the technologies and infrastructure needed to produce, deliver, store, download and read e-books (e.g., data centers, networks e-readers).
			Operational energy (+)	Energy used to operate an e-reader.
			Disposal energy (+)	Energy used to dispose of an e-reader.
Higher order impacts		Indirect: single-service	**Efficiency (-)**	(Does not apply in this example)
			Substitution (+ or -)	Life-cycle energy use saved by e-books substituting for traditional paper books.
	User perspective		**Direct rebound (+)**	Energy consumed in additional book reading, stimulated by lower cost and improved utility of e-books.
		Indirect: complementary services	**Indirect rebound (+ or -)**	Energy used in manufacturing and consuming goods, whose demand has increased because of the cost savings from substituting paper books with e-books.
	System perspective	Indirect: economy-wide	**Economy-wide rebound (+ or -)**	Energy used and saved in multiple markets because of economy-wide adjustments in prices and quantities (e.g., investments previously made in the paper industry are now redirected towards sectors with different energy intensities).
		Indirect: society-wide	**Transformational rebound (+ or -)**	Energy used and saved because of far-reaching changes in industrial and organisational structures and social practices

Energy saving potential of digital technologies

- Digital technologies have the potential to enable large energy savings in through:
- substituting for more energy-intensive goods and services (e.g. teleworking, teleconferencing);
- enabling the sharing of material goods (e.g. car clubs, ridesharing);
- optimising the control of buildings, industrial processes and other systems (e.g. building energy management systems, smart logistics);
- With potential for significant efficiency improvements in devices and networks.



Rebound effects of digital technologies

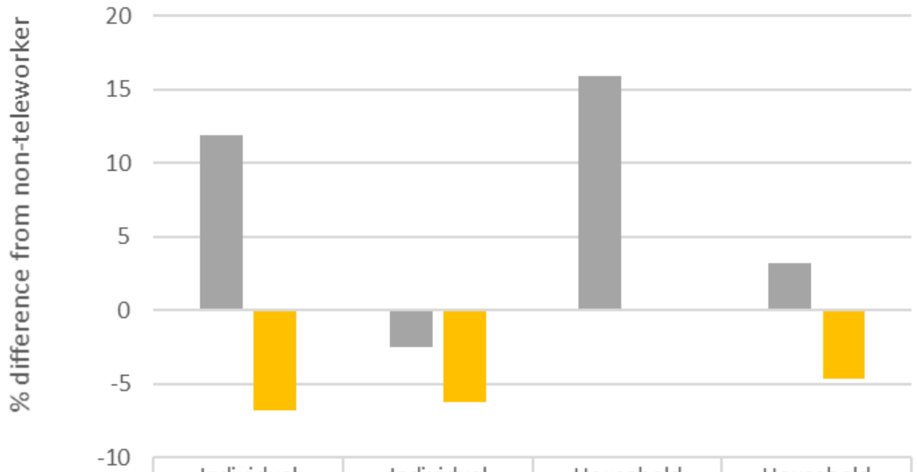
- Direct rebound: increases in the number, power, complexity and range of applications of those devices - encouraged in part by the efficiency improvements themselves
- Indirect rebound: new service demands enabled by digital technologies, e.g. video streaming
- Economy-wide rebound: new markets and industries enabled by technologies

Rebound effect from teleworking

- Based on analysis of data from English Travel Survey 2005-2019:
- Medium-frequency teleworkers (4.7% of sample) travel **farther** each week, despite taking fewer trips
- High-frequency teleworkers (1.3% of sample) travel **less far** each week
- Households with medium-frequency teleworks) travel **farther** each week.

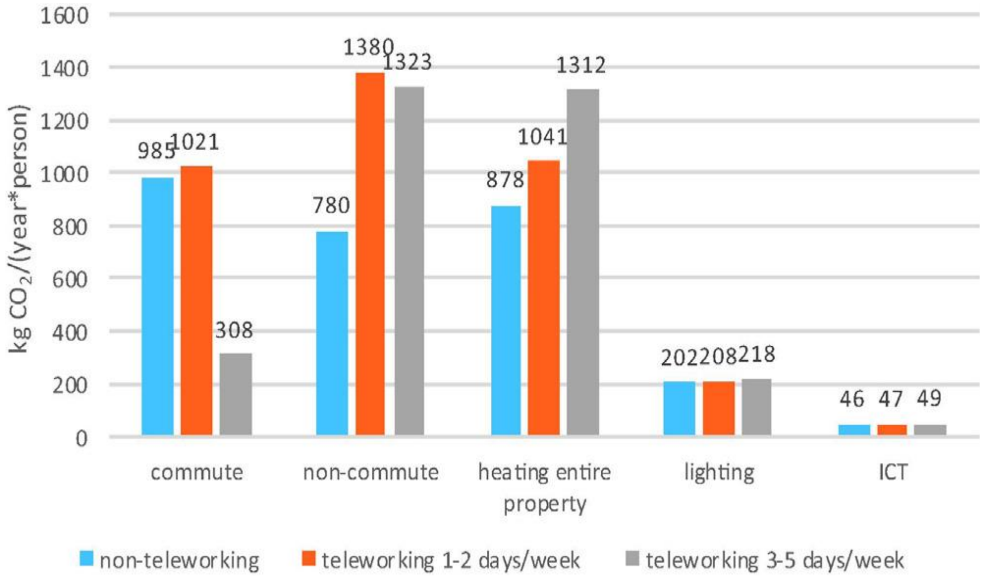
Suggestive evidence for residential relocation, induced non-work travel and intra-household dynamics

Source: Caldarolo and Sorrell (2022)



	Individual distance travelled	Individual number of trips	Household distance travelled	Household number of trips
Medium frequency	11.84	-2.5	15.94	3.18
High frequency	-6.8	-6.22		-4.64

Modelling transport and building energy use from teleworking



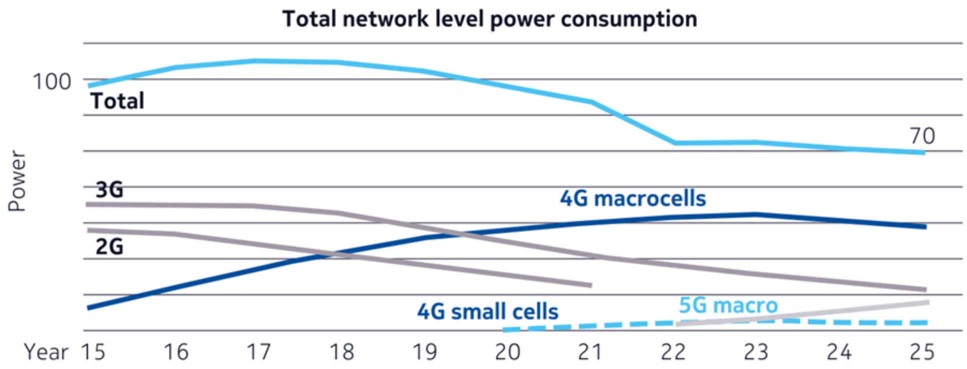
- Teleworkers also use additional energy at home, depending on frequency of teleworking and whether additional energy is for whole house or single room

Net CO2 emissions savings only if

- they telework 3–5 times a week;
- they heat their home office on teleworking days rather than their entire home;
- they heat this office for no more than 3 h to a temperature of no more than 21 ˚C
- they use air source heat pumps rather than other heating systems, such as gas boilers.

Source: Shi, Sorrell and Foxon (2023), Energy and Buildings 287

Reviewing the energy use implications of 5G



Source: Nokia (2016) - Nokia: Nokia 5G Network Energy Efficiency White Paper

Source: Williams et al. (2022), Renewable and Sustainable Energy Reviews

- Lack of **whole-network assessments,** and often a lack of disclosure of key assumptions and data
- **Embodied energy** routinely overlooked
- **Direct rebound effects** rarely explicitly acknowledged, but arguably implicitly accounted for
- Lack of 'user-centric' work focusing on how 5G might change device use to be more or less energy-intensive; lack of attention paid to encouraging less energy-intensive user behaviour or designing less energy-intensive services
- Scale of 5G **'enablement effect'** remains unclear, wouldn't necessarily justify higher direct energy use

Future impacts of ICT

Anticipating future impacts of ICTs on energy consumption

- The Future Impacts project focuses on how the adoption of information and communications technologies (ICTs) could affect energy demand, as part of the transition to a net zero carbon economy.
- Drawing on an analysis of UK and global net zero scenarios, we identify direct effects, indirect (efficiency and rebound) effects and impacts on economic growth of digitalisation on energy demand
- Published: Noam Bergman & Timothy J. Foxon (2022): Drivers and effects of digitalization on energy demand in low-carbon scenarios, Climate Policy

Results – direct ICT energy use

- A huge increase in the **number** of ICT devices is expected in coming years. This might be partially offset by **saturation** (Global North).
- **Intensity of use** is increasing, as is cloud computing, requiring more **data centres** and other **infrastructure**, using more energy.
- **Efficiency** of devices is increasing, but **embodied energy** is an important part. Integration / **convergence** of different devices into one, especially smart phones, reduces energy.
- **Longevity** and **repairability** can reduce energy demand, while **Rapid innovation cycles** shorten lifetime but increase efficiency.

Results – home energy use

Vision of smart homes – quality of life and reduced energy demand.

- **Behaviour change** reduces demand through information provision, increased control, smart tariffs and 'encouragement'.
- **Automation** increases efficiency of heating and appliances.
- Comfort and convenience could have **rebound** effects of increased consumption due to ease of use.
- Energy savings are **not prioritised** for smart appliances and devices.

Perhaps 'smartness' is not the top priority in saving energy?

Results – transport

1. **Virtual meetings** reduce travel and therefore energy demand: telecommuting, video conferencing, but also leisure travel and more.

2. Smart, data-rich systems:
   reduced congestion, integrated travel, smart ticketing, logistics…
   → **Mobility as a service**, increased vehicle occupancy

3. Automated vehicles – will they reduce or increase energy use?

Behaviour and rebound effects are often not well integrated.
What determines how we travel and how much we travel?

Results – economic growth

1. Effects are portrayed primarily as positive.
   - data creates value, driving economic growth.
   - shorter innovation cycles = new technologies to market faster
   - material light businesses drive growth
   - digital skills, flexibility and comfort increase productivity.
2. Some negative
   - potential job losses due to automation ; increased inequality
   - economy wide rebound

Governance of digitalisation (1)

Maximising the potential of ICTs requires '**responsible**' digitalisation rather than '**selfish**' digitalisation (Noussan and Tagliapietra 2020).

A shared evolution towards optimising a digitalised system, considering community benefits, not just additional services to individuals.

- Responsible: Increased occupancy and better use of public transport; more localisation and flexible working reduces need to travel.
- Selfish: Maximising individual benefits reduces the cost of travel by car, supported by AVs; could increase energy demand.

Some scenarios claim the benefits of RD without supporting governance

Governance of digitalisation (2)

What might responsible digitalisation look like? Some ideas…

- Focus on pathways promoting wellbeing and environmental protection, rather than merely green growth.
- New business models, e.g. focusing on data as a common good; ‘digital commons’, rather than a few ‘superstar’ companies
- Focus on empowering users and providing information, rather than focus on automation and circumventing users

Key messages

- Increase in number and usage of ICT devices will drive direct increase in energy demand
- Efficiency improvements, substitution by digital services and enabling behaviour change could drive reductions in energy demand, but these may be offset by stimulating increases in service demands, e.g. ‘mobility as a service’ improving efficiency but stimulating more car journeys
- Potential for stimulating economic growth through productivity improvements, but automation could lead to increased job losses and inequality
- Net zero scenarios should pay more attention to drivers of underlying service demands, political choices and plausibility of both technical and social changes