Digitalisation, domestication, and impacts on climate change

Charlie Wilson

Oxford Energy Day

23 March 2022

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idoddle.org

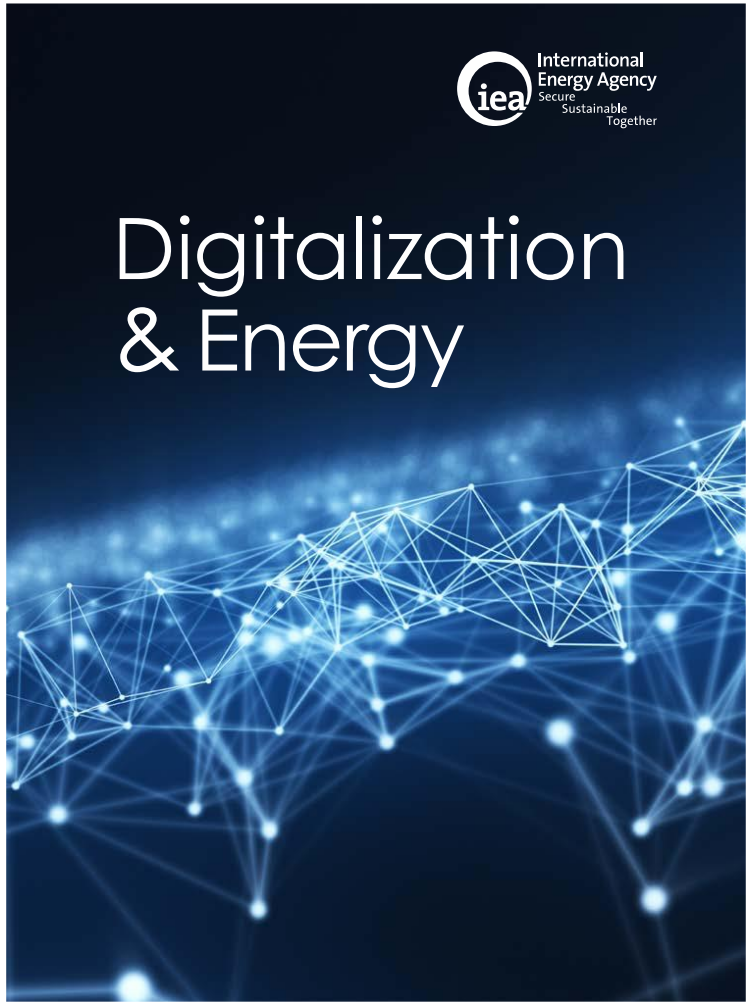
European Research Council

Consolidator Grant #101003083

Environmental *Change* Institute

School of Geography and the Environment

"Of the energy-using sectors, buildings are expected to be the most transformed by digitalisation in the near-term …"



- smart building controls to manage energy use
- smart heating and lighting systems to reduce energy use by 10% through sensors or learning algorithms
- increasing electricity consumption by appliances and small plug loads
- opportunities for smart demand response (curtailment or time-shifting)
- new opportunities for energy-service providers to manage energy use

Digitalisation in homes creates opportunities for decarbonisation

Manage, control, learn about energy
e.g., smart home technologies

Digitalisation in homes creates opportunities for decarbonisation

Substitute for physical activity
e.g., commuting, shopping trips

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e.g., smart home technologies

Integrate homes into renewable grids
e.g., smart EV charging, demand response, time-of-use tariffs

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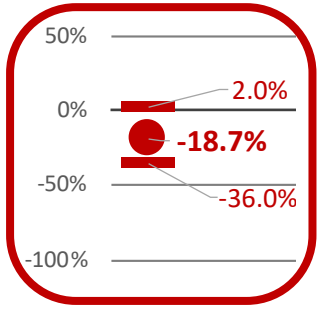

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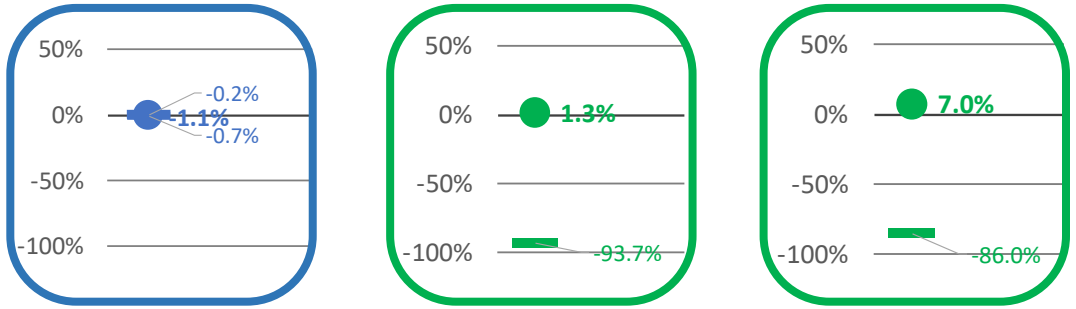

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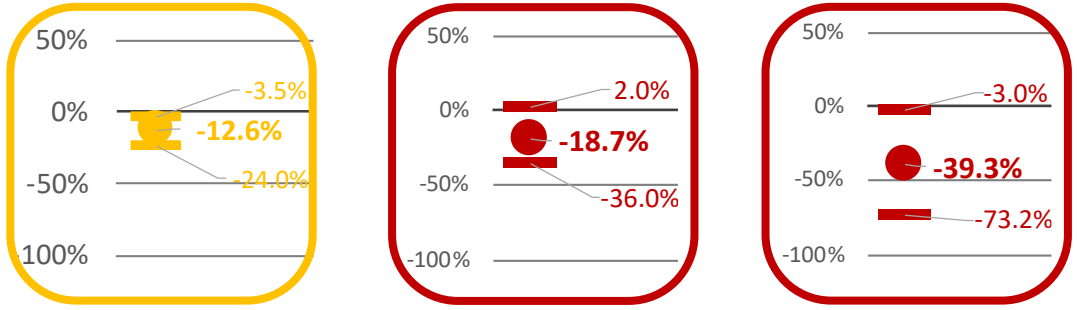

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Digitalisation has direct, indirect, and systemic impacts on energy

technology perspective

direct impacts

- embodied energy +
- operational energy +
- disposal energy +

Court, V. & S. Sorrell (2020). “Digitalisation of goods: a systematic review of the determinants and magnitude of the impacts on energy consumption“. *Environmental Research Letters* 15(4): 043001.

Digitalisation has direct, indirect, and systemic impacts on energy

technology perspective

user perspective

direct impacts

indirect impacts

single service

- embodied energy +
- operational energy +
- disposal energy +
- efficiency or optimisation -
- substitution +/-
- direct rebound +

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Digitalisation has direct, indirect, and systemic impacts on energy

technology perspective

user perspective

system perspective

direct impacts

indirect impacts

- single service
- complementary services
- economy-wide
- society-wide

embodied energy	+
operational energy	+
disposal energy	+
efficiency or optimisation	-
substitution	+/-
direct rebound	+
indirect rebound	+/-
economy-wide rebound	+/-
transformational change	+/-

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Global low energy demand scenario ‘assumes’ important enabling role for digitalisation in homes

Analysis of Grubler, A., C. Wilson, et al. (2018). "A Low Energy Demand Scenario for Meeting the 1.5oC Target and Sustainable Development Goals without Negative Emission Technologies." *Nature Energy* 3: 515-527.

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Global low energy demand scenario 'assumes' important enabling role for digitalisation in homes

changing thermal comfort 2020-2050 in global LED scenario	**decomposition factor (+/- impact on energy demand)**	***link to digitalisation …***		
		dependent on	**enabled by**	**possible without**
main measures				
heat pumps, fuel cells, micro-cogeneration systems	Structure (-)		improved controls	
stringent thermal efficiency standards for new builds and retrofits	Structure (-) * Intensity (-) *			historical trend
doubling of retrofit rates	Structure (-) Intensity (-)		targeting & learning	

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doubling of retrofit rates	Structure (-) Intensity (-)		targeting & learning	
additional measures				
floor area converges on 30m^2 per capita (with urban shift to multi-family dwellings)	Activity (+)			urbanisation trend
smart home systems manage and reduce demand (°C.DD/m^2)	Activity (-)	sensing, learning		
demand response with time-of-use (ToU) pricing and automation	Activity (-)	real-time price signals		
retrofit standardisation (Energiesprung)	Intensity (-)		3d scanning & design	
enforcement of efficiency standards	Intensity (-)		smart meter monitoring	

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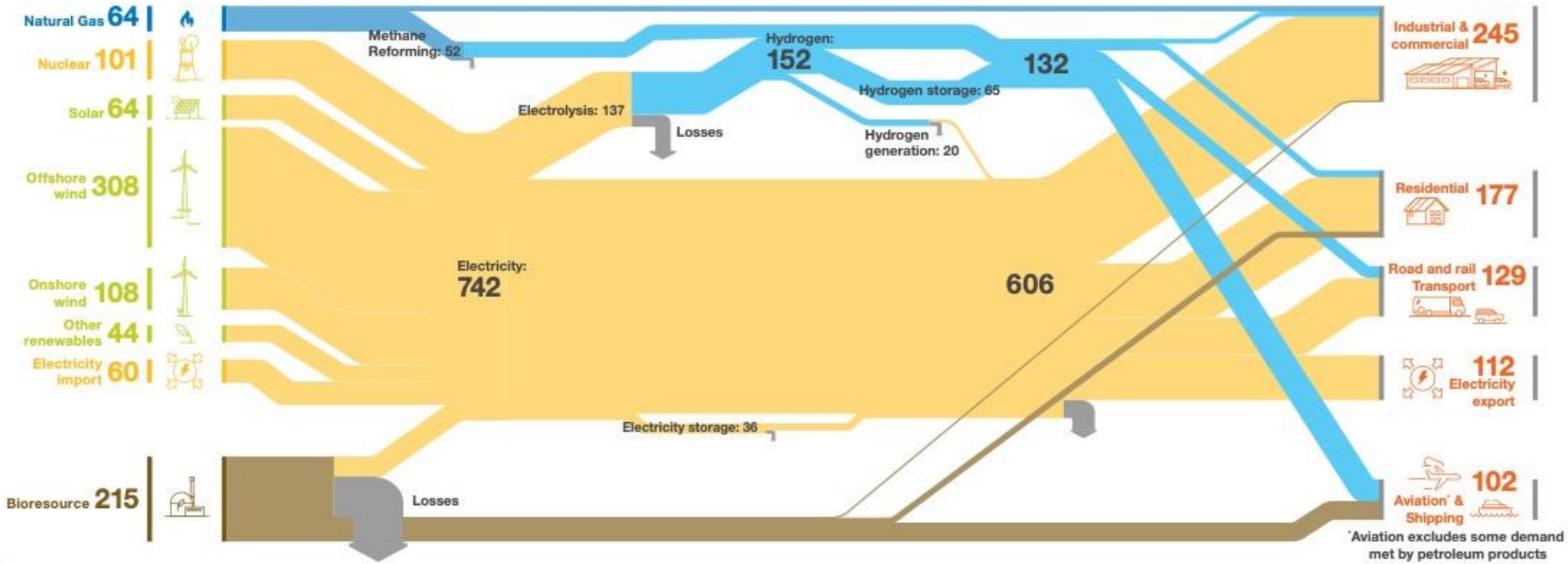
Scenario studies on the impact of digitalisation for energy and carbon emissions have a tendency towards optimism

2050 energy flows

Consumer Transformation

2050 energy flows in Consumer Transformation (TWh)

- Home heating, transport and industry largely electrified
- Hydrogen produced in the UK, primarily through electrolysis
- Electricity generation capacity is highest in this scenario
- Substantial increase in energy efficiency measures, lowest end-user energy demand
- Small amounts of natural gas used with CCUS to decarbonise industry, due to lower availability of hydrogen



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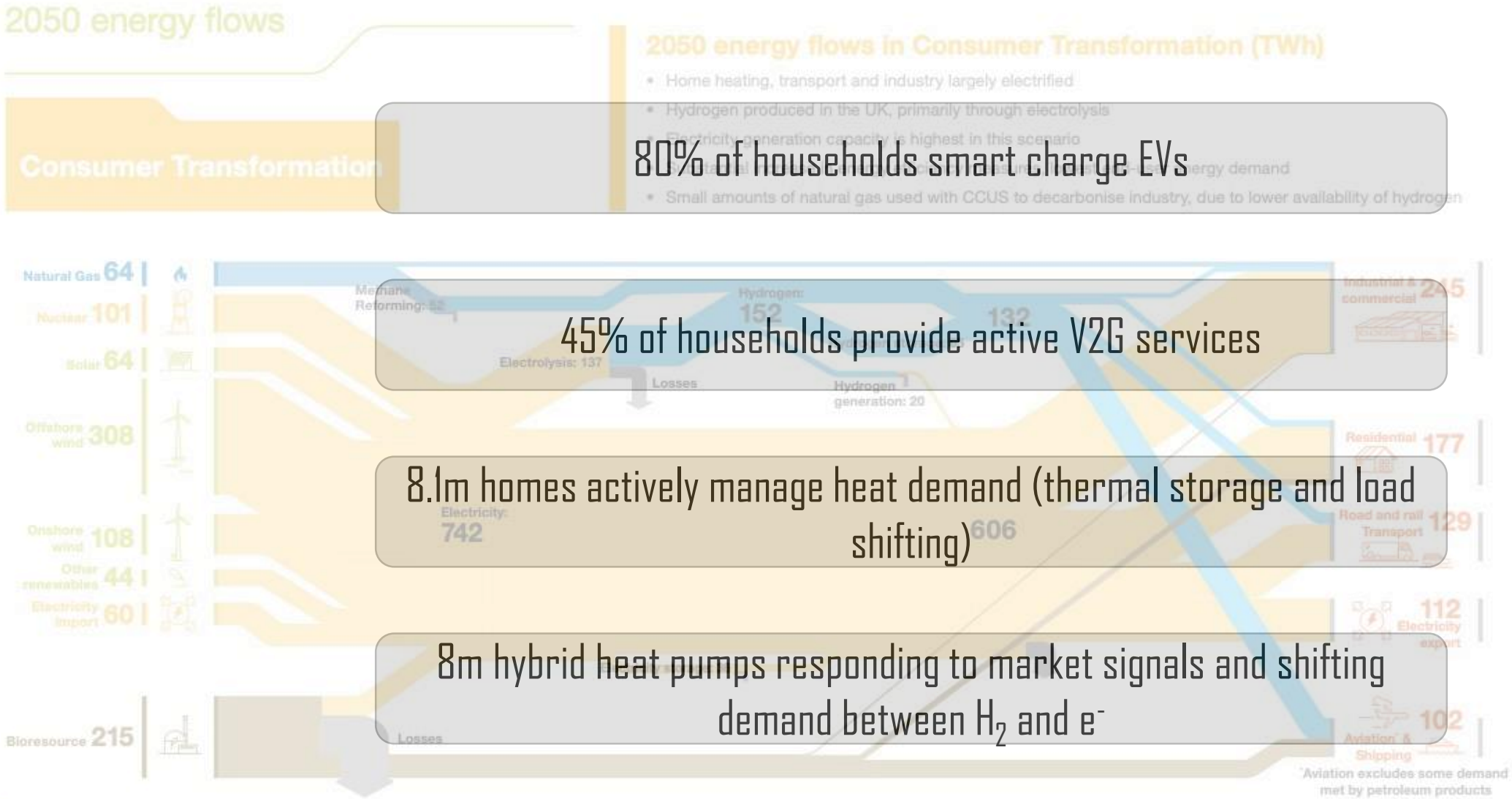

80% of households smart charge EVs

45% of households provide active V2G services

8.1m homes actively manage heat demand (thermal storage and load shifting)

8m hybrid heat pumps responding to market signals and shifting demand between H_2 and e^-

National Grid (2020). Future Energy Scenarios. London, UK, National Grid ESO.

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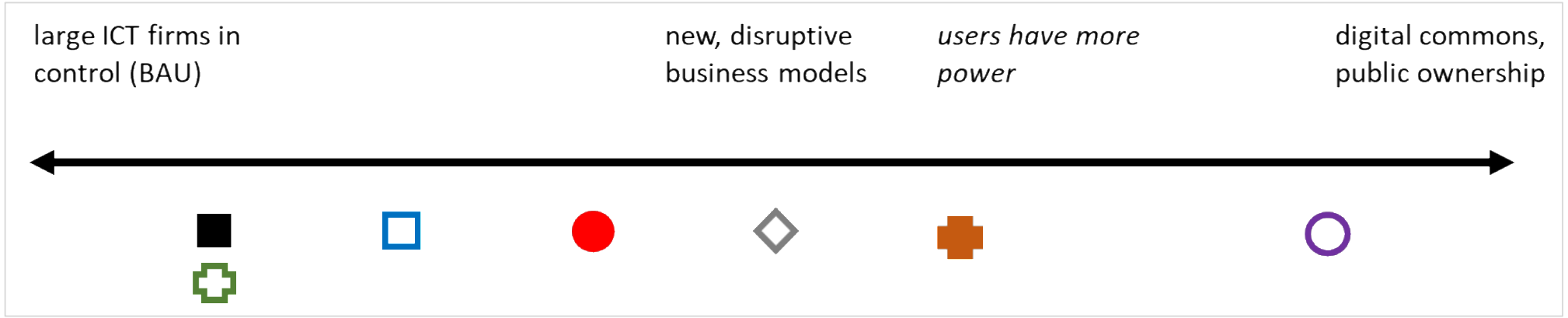
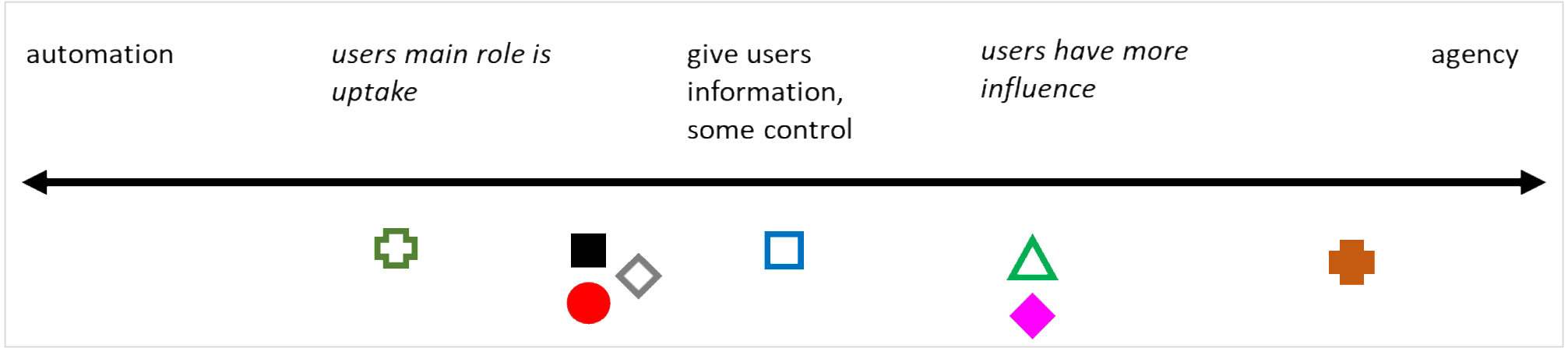
Scenario studies vary in how they represent agency, control, and users … but all make coarse, simplifying assumptions.

business models, users, and data



control, automation, user behaviour



Bergman, N. and T. Foxon (2021). Drivers and effects of digitalisation on energy demand in low carbon scenarios. *SPRU Working Paper Series*. Brighton, UK, Science Policy Research Unit (SPRU), University of Sussex.

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Domestication involves three types of learning and control about technologies, about users, and about domestic life.

Hargreaves, T. and C. Wilson (2017). Chapter 6: Control of Smart Home Technologies. *Smart Homes and Their Users*. T. Hargreaves and C. Wilson. London, UK, Springer International Publishing: 91-105.

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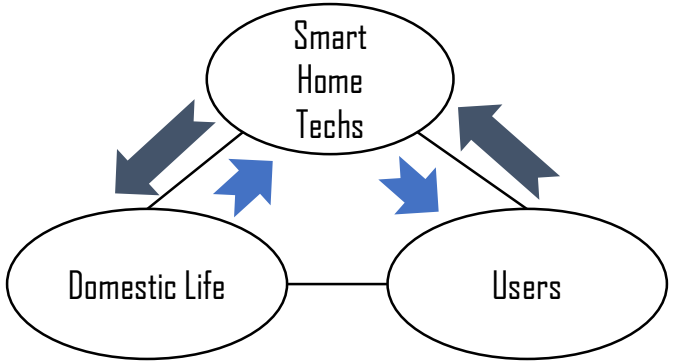

Artefactual Control

Smart home technologies are used to enable or support certain household functions.

Experiences feed back to shape how smart home is configured and used.

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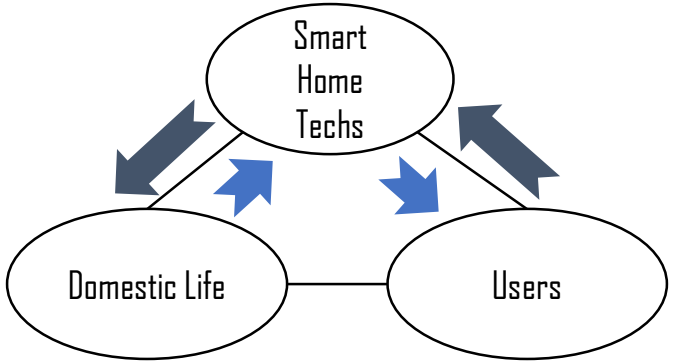

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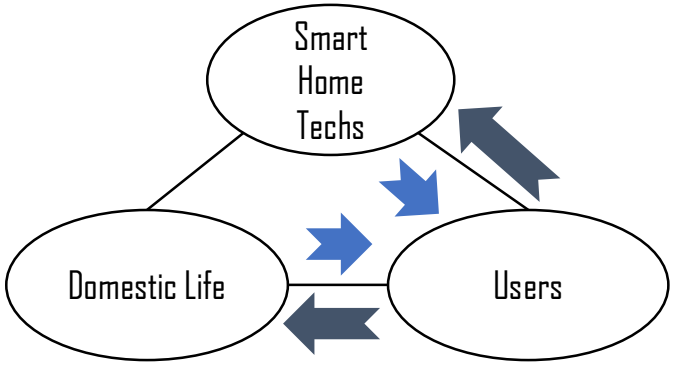

Perceptual Control

Users learn through trying out smart home technologies as a novel way of helping (or hindering) domestic life.

Experiences feed back to shape users' feelings of being more in (or out of) control.

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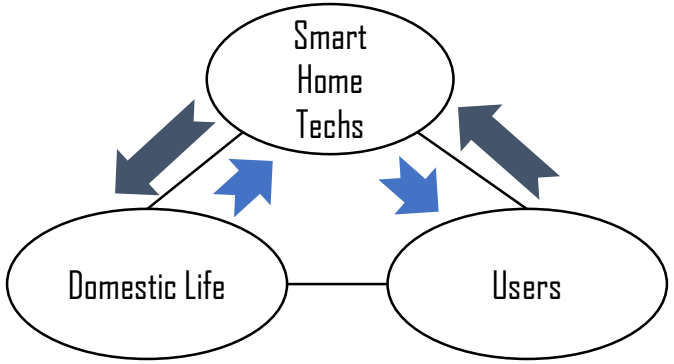

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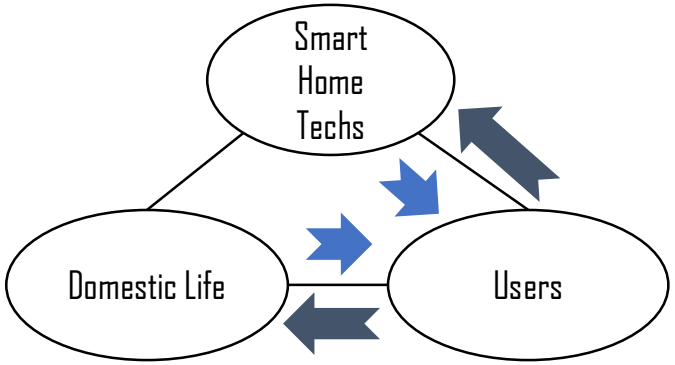

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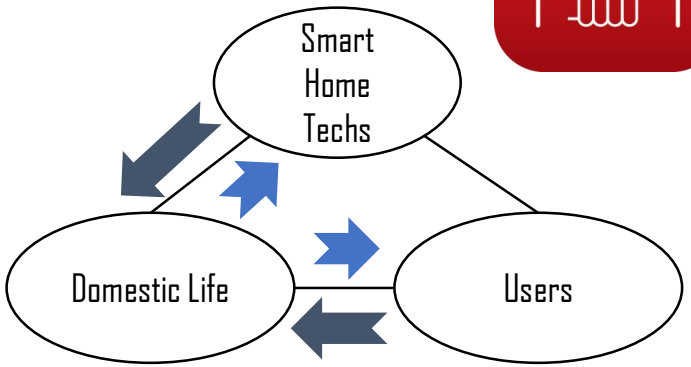

Relational Control

Smart home technologies may affect relationships between household members and between activities.

Experiences feed back to reinforce or undermine the use of smart tech for organising & scheduling at home.

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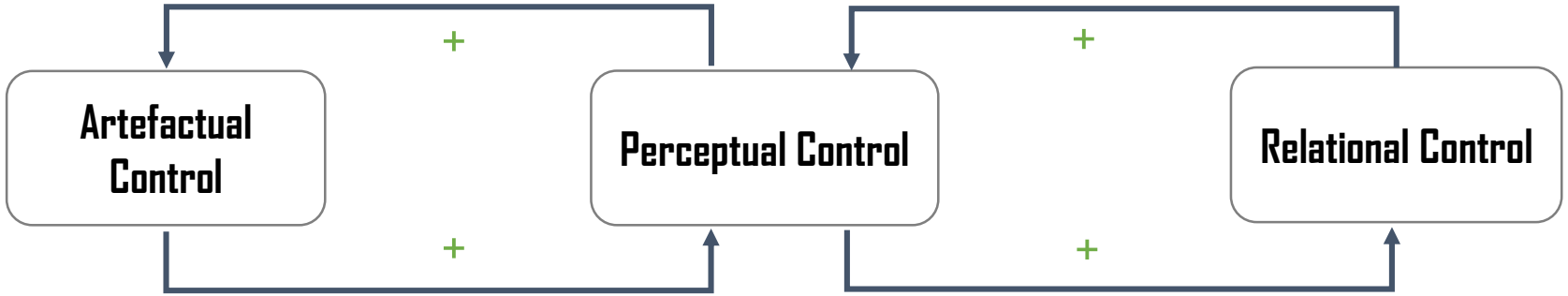
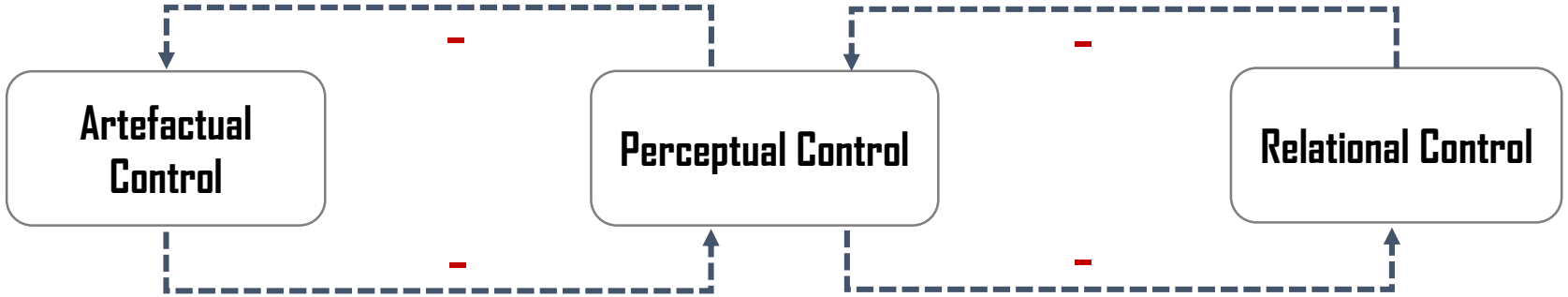
Positive and negative feedback loops between different forms of control shape domestication or rejection.

DOMESTICATION
positive feedback between types of control



REJECTION
negative feedback between types of control



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Positive and negative feedback loops between different forms of control shape domestication or rejection.

DOMESTICATION
positive feedback between types of control

confidence and trust in smart home system to benefit household

impetus to continue learning about potential usefulness

+ + + +

Artefactual Control → **Perceptual Control** → **Relational Control**

useful & useable functionality empowers households

enhanced ability to schedule activities by whole household

REJECTION
negative feedback between types of control

Artefactual Control **Perceptual Control** **Relational Control**

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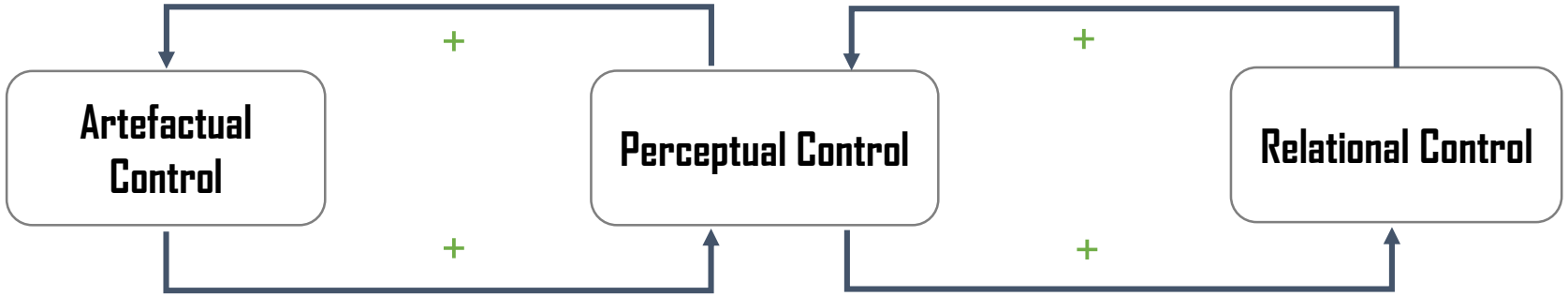

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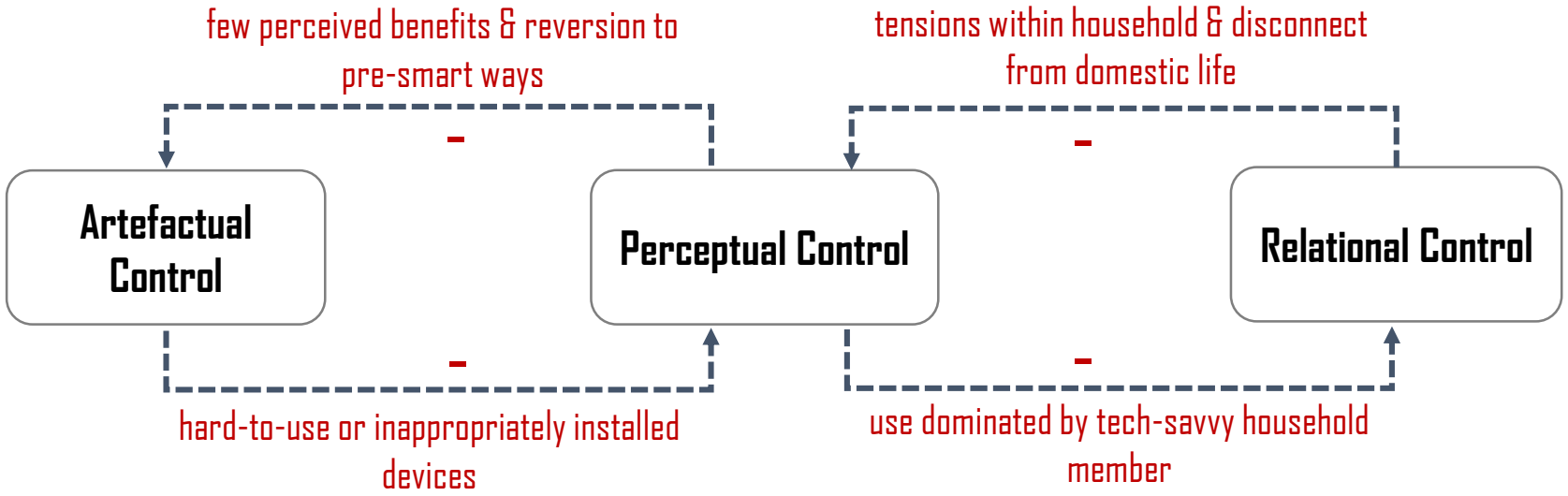

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How will agency and control play out for system benefits (public purpose) as opposed to private functional benefits?

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