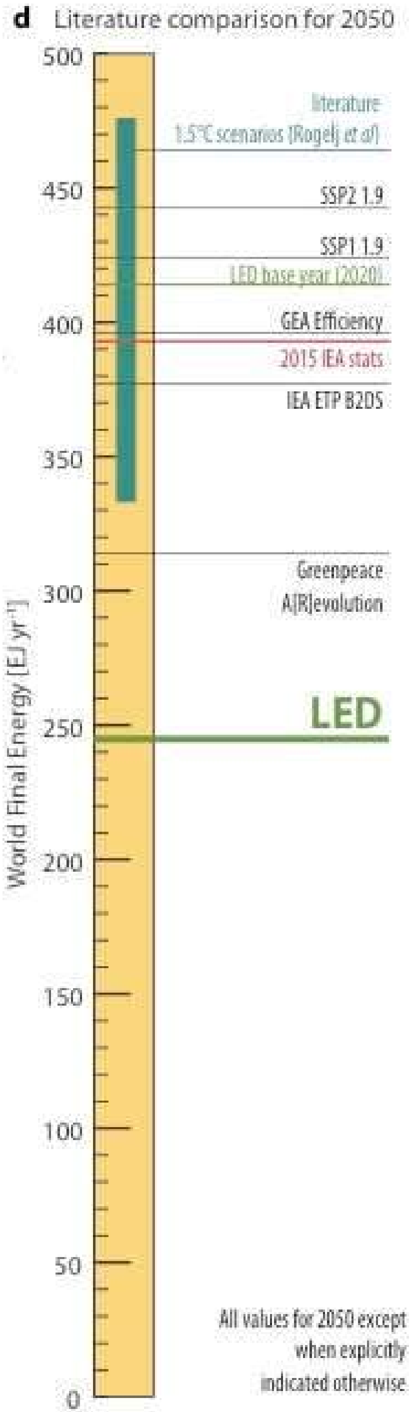

Transforming energy demand to meet the 1.5°C target and Sustainable Development Goals without negative emission technologies

Charlie Wilson

International Energy Agency, November 2018

acknowledging: **Arnulf Grubler and colleagues at IIASA**

IIASA International Institute for Applied Systems Analysis

Tyndall°Centre for Climate Change Research

SILCI Social Influence and *disruptive* Low Carbon Innovations

overview

- challenging the conventional wisdom on 1.5^{o}C

- why disruptive innovations are important
- why granularity is important
- why energy-service efficiency is important

- how we developed the LED scenario
- energy demand in the LED scenario
- implications of the LED scenario

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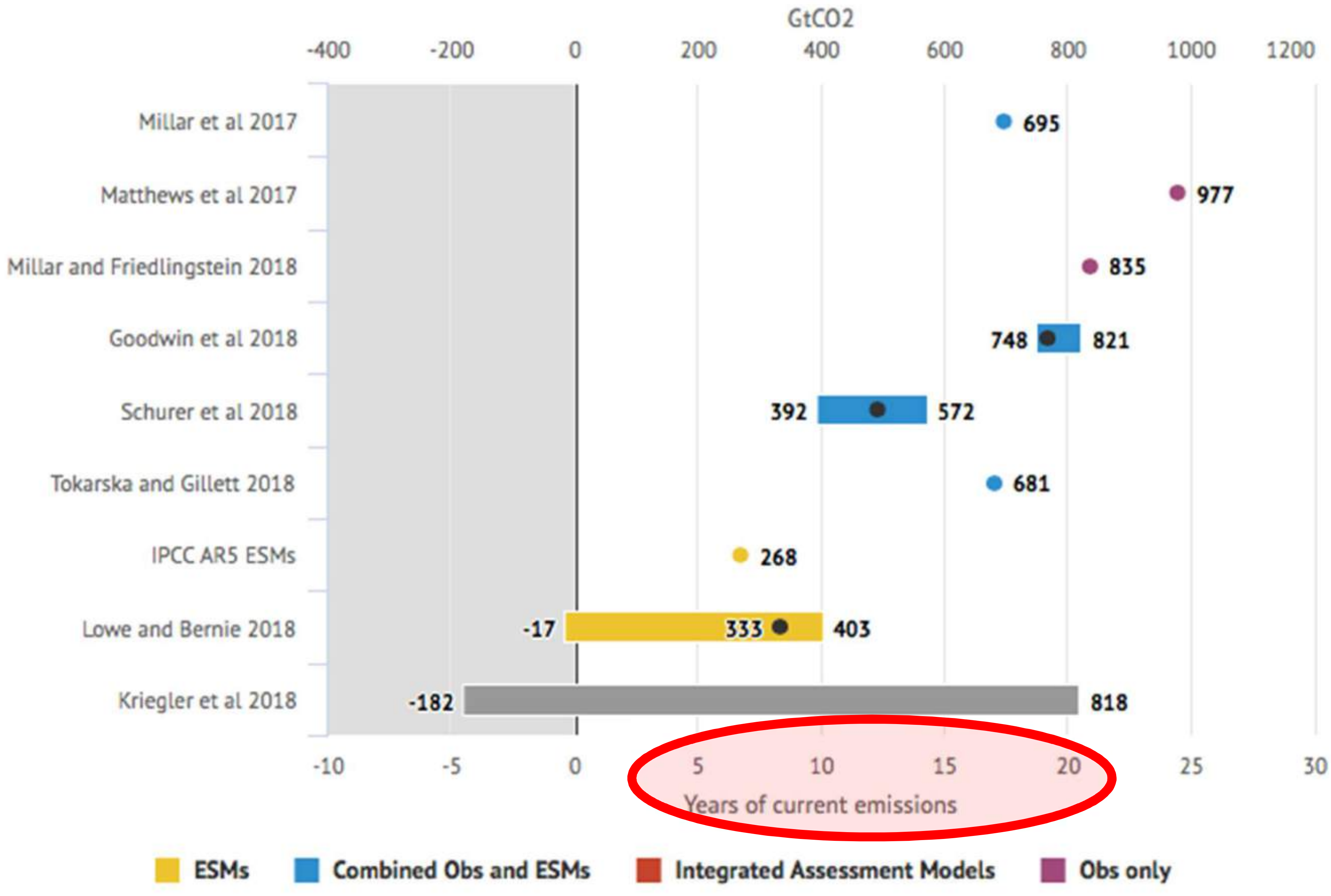
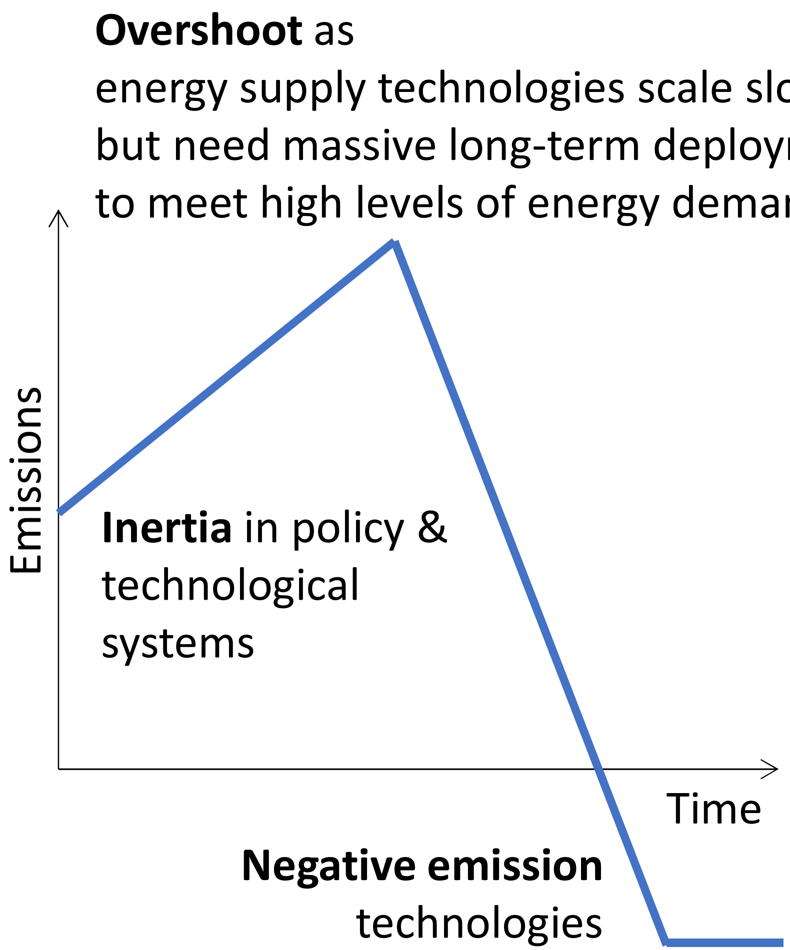
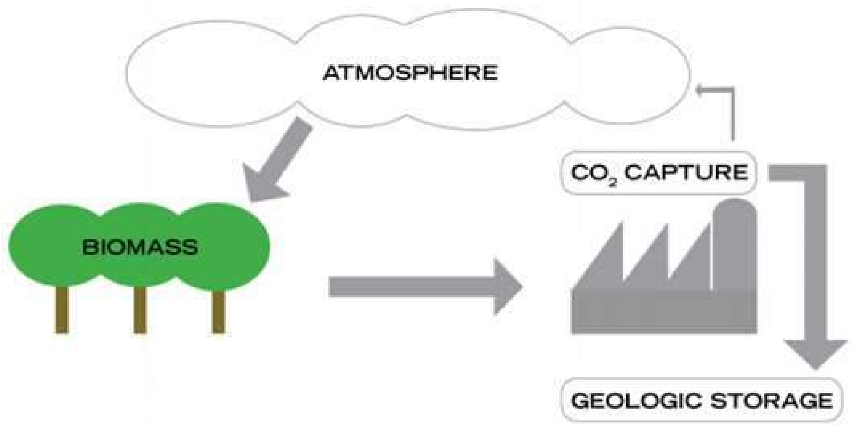
Remaining carbon budget for a 50% chance of less than 1.5C warming



Hausfather, Z. (2018). “How much ‘carbon budget’ is left to limit global warming to 1.5C?”. *Carbon Brief*. 9 April 2018.

Conventional wisdom for meeting the 1.5°C target says …





Is the conventional wisdom for meeting the 1.5^{o}C target right?

Problems with conventional wisdom ...

- Negative emission technologies are unproven, **risky** & conflictual
- Scenarios and modelling are **biased** towards supply-side solutions
- 1.5^{o}C requires rapid transformation which is inescapably **socio**-technical
- Potential for the emergence of **novelty** is under-explored

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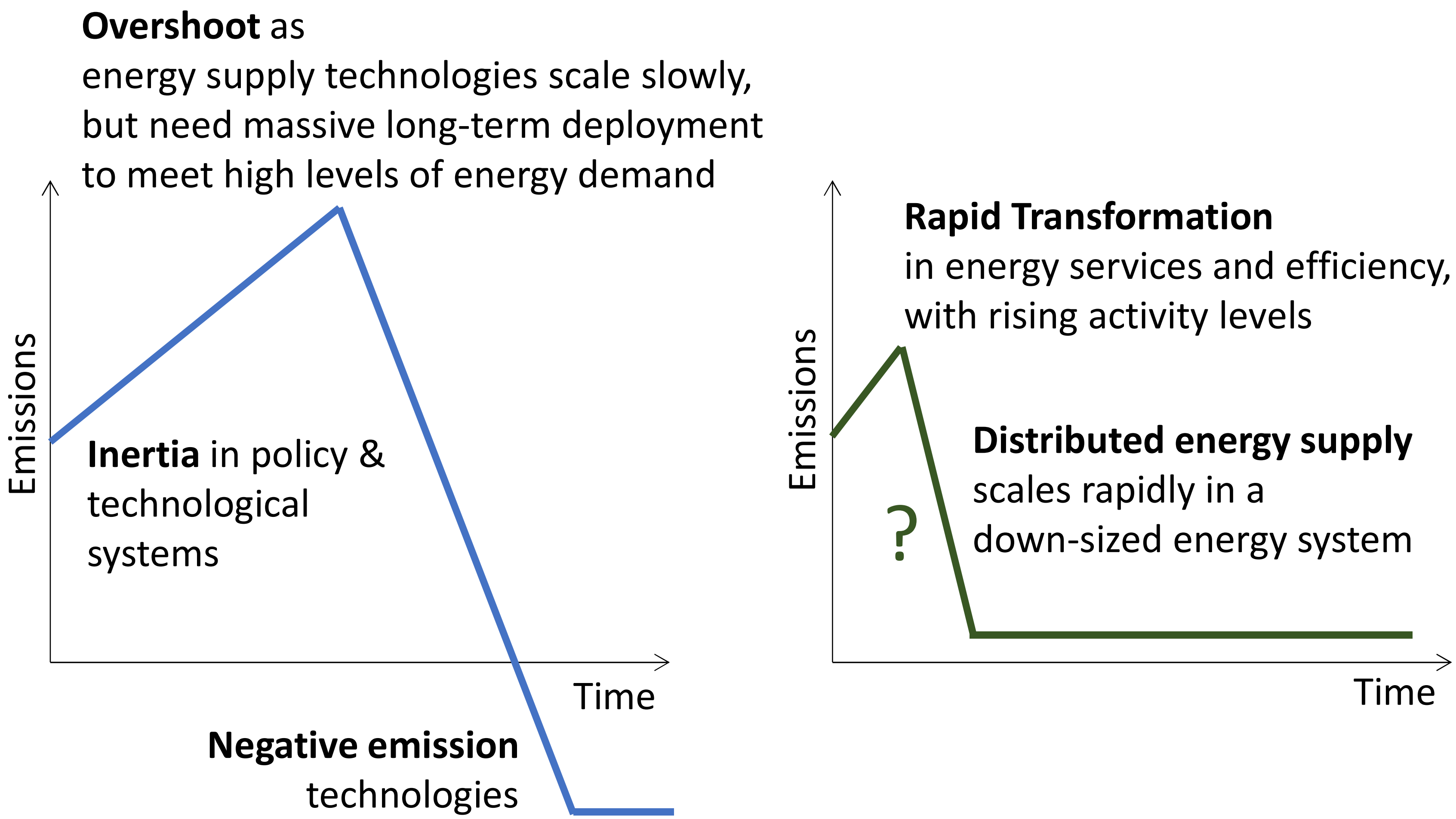
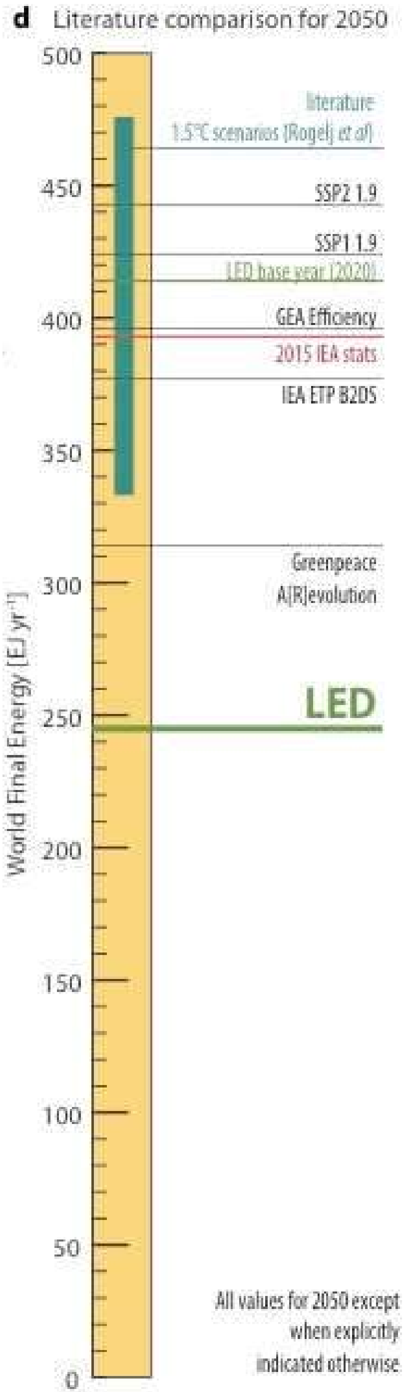
- Potential for the emergence of **novelty** is under-explored

In response ...

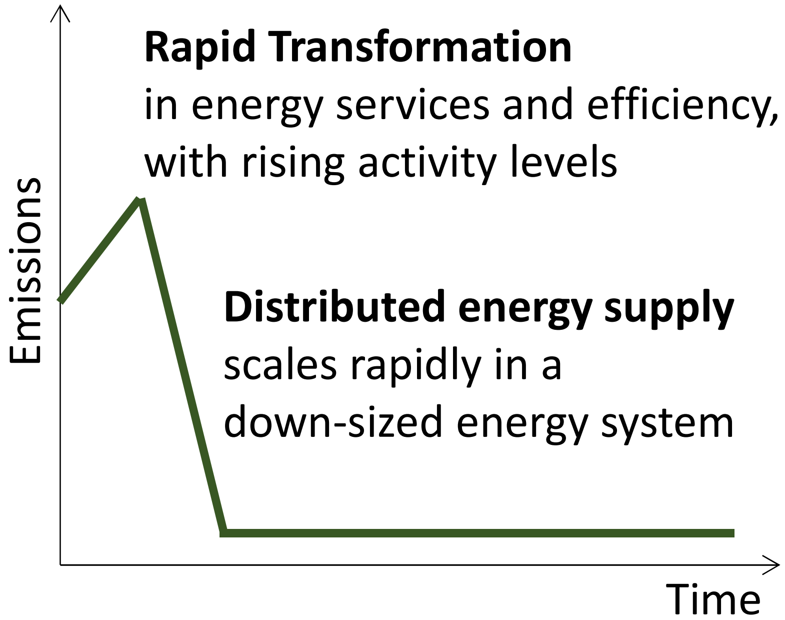
- **'Low Energy Demand' (LED) scenario**
- Explores rapid transformation in **energy services** through social, organisational, *and* technological innovation
- Allows for rising activity levels to meet **decent living standards**
- Downsizing energy use enables **feasible supply-side decarbonisation**

Is the conventional wisdom for meeting the 1.5°C target right?





Low Energy Demand (LED) scenario:
disruptive consumer innovation, granularity, energy-service transformation + *standards*



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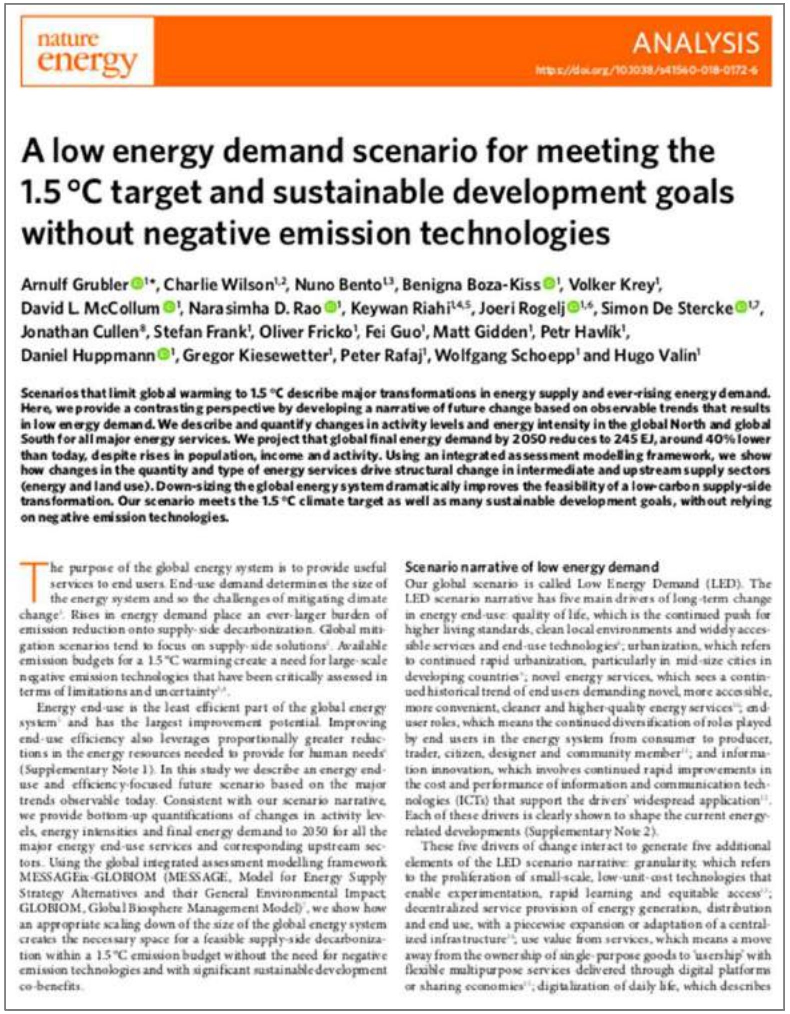


nature energy

ANALYSIS

https://doi.org/10.1038/s41560-018-0172-6

A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies

Arnulf Grubler[1*], Charlie Wilson[1,2], Nuno Bento[1,3], Benigna Boza-Kiss[1], Volker Krey[1], David L. McCollum[1], Narasimha D. Rao[1], Keywan Riahi[1,4,5], Joeri Rogelj[1,6], Simon De Stercke[1,7], Jonathan Cullen[8], Stefan Frank[1], Oliver Fricko[1], Fei Guo[1], Matt Gidden[1], Petr Havlík[1], Daniel Huppmann[1], Gregor Kiesewetter[1], Peter Rafaj[1], Wolfgang Schoepp[1] and Hugo Valin[1]

Scenarios that limit global warming to 1.5 °C describe major transformations in energy supply and ever-rising energy demand. Here, we provide a contrasting perspective by developing a narrative of future change based on observable trends that results in low energy demand. We describe and quantify changes in activity levels and energy intensity in the global North and global South for all major energy services. We project that global final energy demand by 2050 reduces to 245 EJ, around 40% lower than today, despite rises in population, income and activity. Using an integrated assessment modelling framework, we show how changes in the quantity and type of energy services drive structural change in intermediate and upstream supply sectors (energy and land use). Down-sizing the global energy system dramatically improves the feasibility of a low-carbon supply-side transformation. Our scenario meets the 1.5 °C climate target as well as many sustainable development goals, without relying on negative emission technologies.

The purpose of the global energy system is to provide useful services to end users. End-use demand determines the size of the energy system and so the challenges of mitigating climate change[1]. Rises in energy demand place an ever-larger burden of emission reduction onto supply-side decarbonization. Global mitigation scenarios tend to focus on supply-side solutions[2]. Available emission budgets for a 1.5 °C warming create a need for large-scale negative emission technologies that have been critically assessed in terms of limitations and uncertainty[3,4].

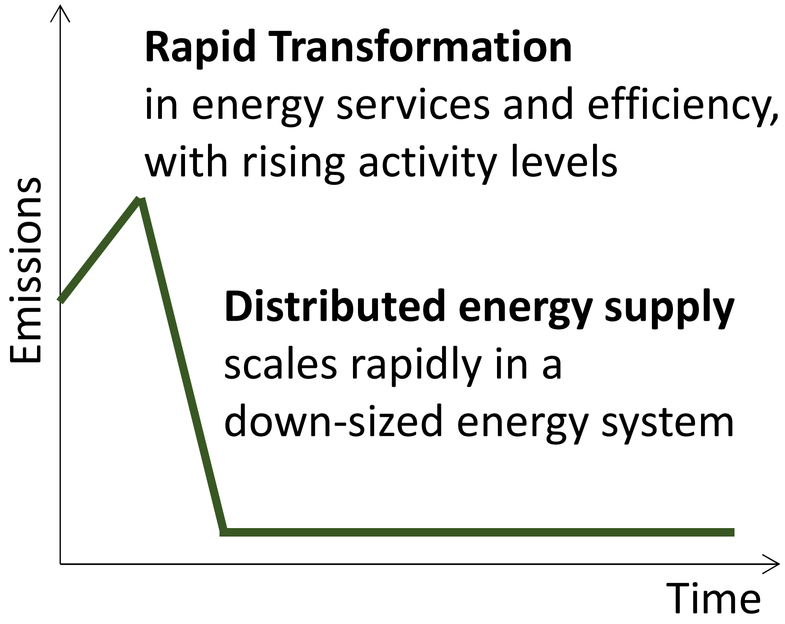
Energy end-use is the least efficient part of the global energy system[5] and has the largest improvement potential. Improving end-use efficiency also leverages proportionally greater reductions in the energy resources needed to provide for human needs[6] (Supplementary Note 1). In this study we describe an energy end-use and efficiency-focused future scenario based on the major trends observable today. Consistent with our scenario narrative, we provide bottom-up quantifications of changes in activity levels, energy intensities and final energy demand to 2050 for all the major energy end-use services and corresponding upstream sectors. Using the global integrated assessment modelling framework MESSAGEix-GLOBIOM (MESSAGE, Model for Energy Supply Strategy Alternatives and their General Environmental Impact; GLOBIOM, Global Biosphere Management Model)[7], we show how an appropriate scaling down of the size of the global energy system creates the necessary space for a feasible supply-side decarbonization within a 1.5 °C emission budget without the need for negative emission technologies and with significant sustainable development co-benefits.

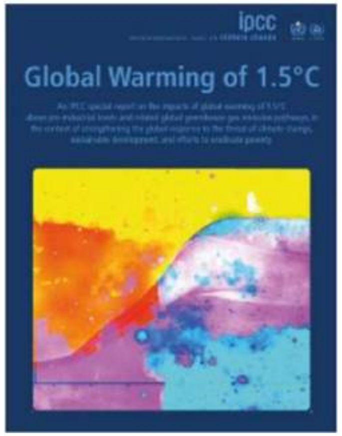
Scenario narrative of low energy demand

Our global scenario is called Low Energy Demand (LED). The LED scenario narrative has five main drivers of long-term change in energy end-use: quality of life, which is the continued push for higher living standards, clean local environments and widely accessible services and end-use technologies[8]; urbanization, which refers to continued rapid urbanization, particularly in mid-size cities in developing countries[9]; novel energy services, which sees a continued historical trend of end users demanding novel, more accessible, more convenient, cleaner and higher-quality energy services[10]; end-user roles, which means the continued diversification of roles played by end users in the energy system from consumer to producer, trader, citizen, designer and community member[11]; and information innovation, which involves continued rapid improvements in the cost and performance of information and communication technologies (ICTs) that support the drivers' widespread application[12]. Each of these drivers is clearly shown to shape the current energy-related developments (Supplementary Note 2).

These five drivers of change interact to generate five additional elements of the LED scenario narrative: granularity, which refers to the proliferation of small-scale, low-unit-cost technologies that enable experimentation, rapid learning and equitable access[13]; decentralized service provision of energy generation, distribution and end use, with a piecewise expansion or adaptation of a centralized infrastructure[14]; use value from services, which means a move away from the ownership of single-purpose goods to 'usership' with flexible multipurpose services delivered through digital platforms or sharing economies[15]; digitalization of daily life, which describes

[doi 10.1038/s41560-018-0172-6]

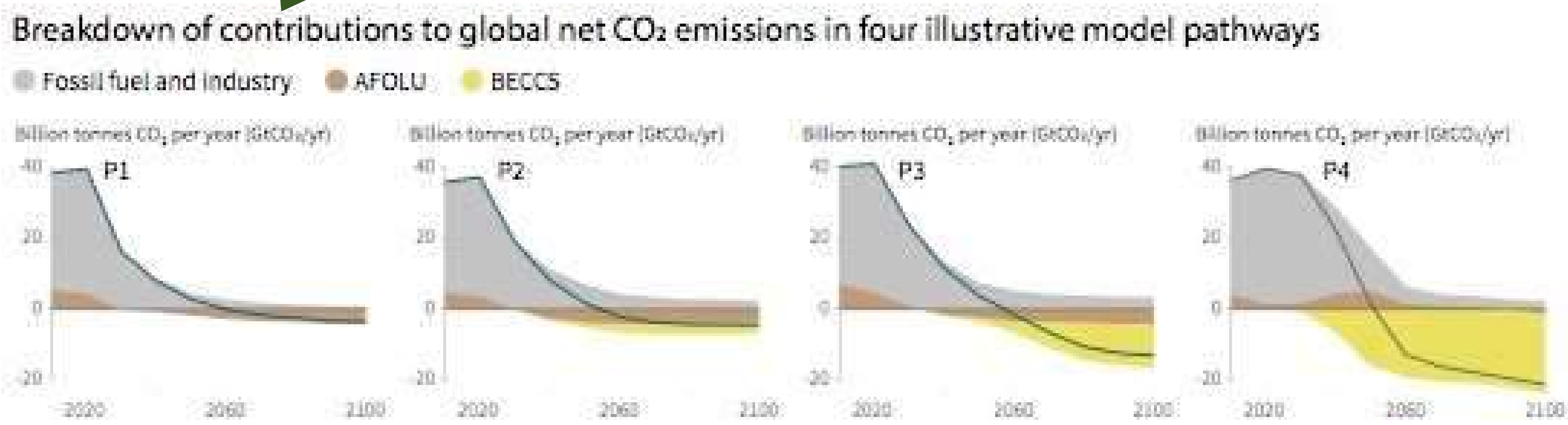




Low Energy Demand (LED) scenario:

disruptive consumer innovation, granularity, energy-service transformation + *standards*

conventional wisdom



LED scenario is based off SSP2 assumptions

Source: IPCC (2018) Special Report on Global Warming of 1.5°C. Figure SPM 3b.

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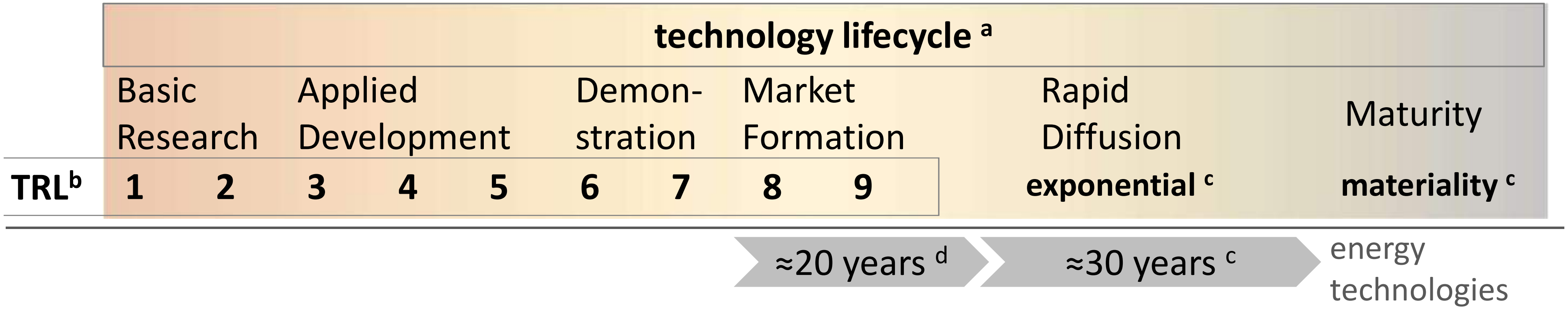
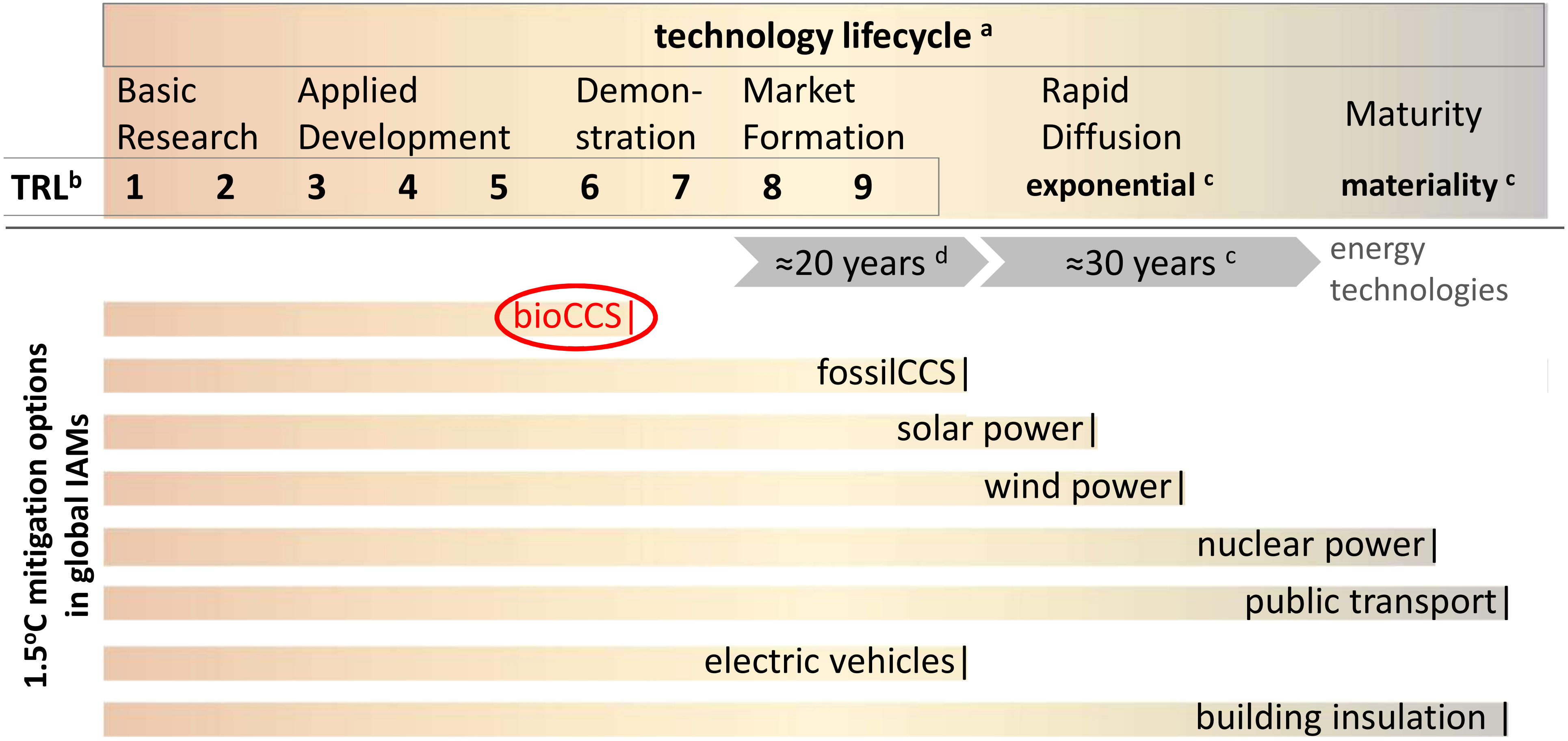


emergence of novelty?

energy-service transformation?

Sources:
[a] Wilson & Grubler (2014)
[b] EC (2017)
[c] Kramer & Haigh (2009)
[d] Bento & Wilson (2016)



emergence of novelty?

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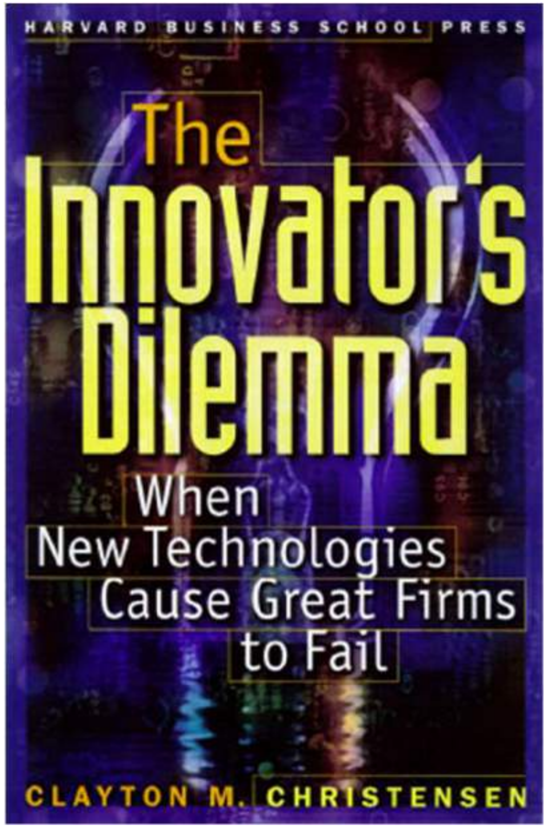
Sources:
[a] Wilson & Grubler (2014)
[b] EC (2017)
[c] Kramer & Haigh (2009)
[d] Bento & Wilson (2016)

Disruptive innovations offer novel attributes to end users ... and can rapidly change markets

***Sustaining* innovations** -> improve currently valued attributes

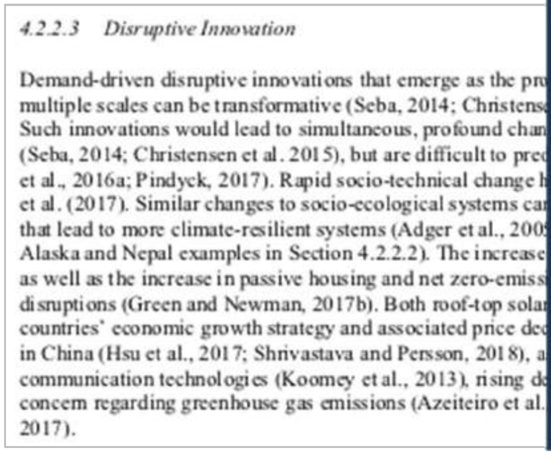
power -
speed -
storage -
low cost per MB -

portability -
versatility -
accessibility (coding) -
low cost per unit -

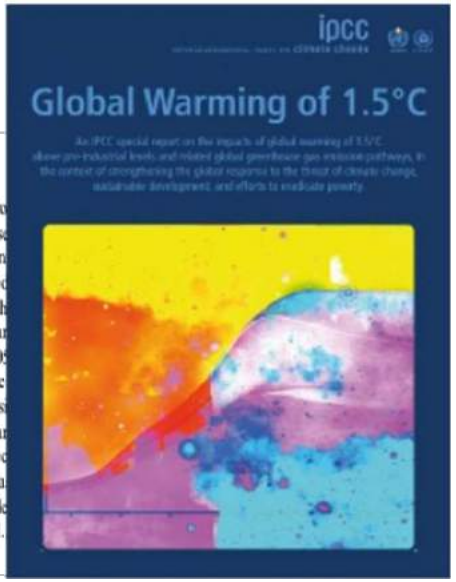


***Disruptive* innovations** -> offer novel attributes, create new value *energy X digital X users*

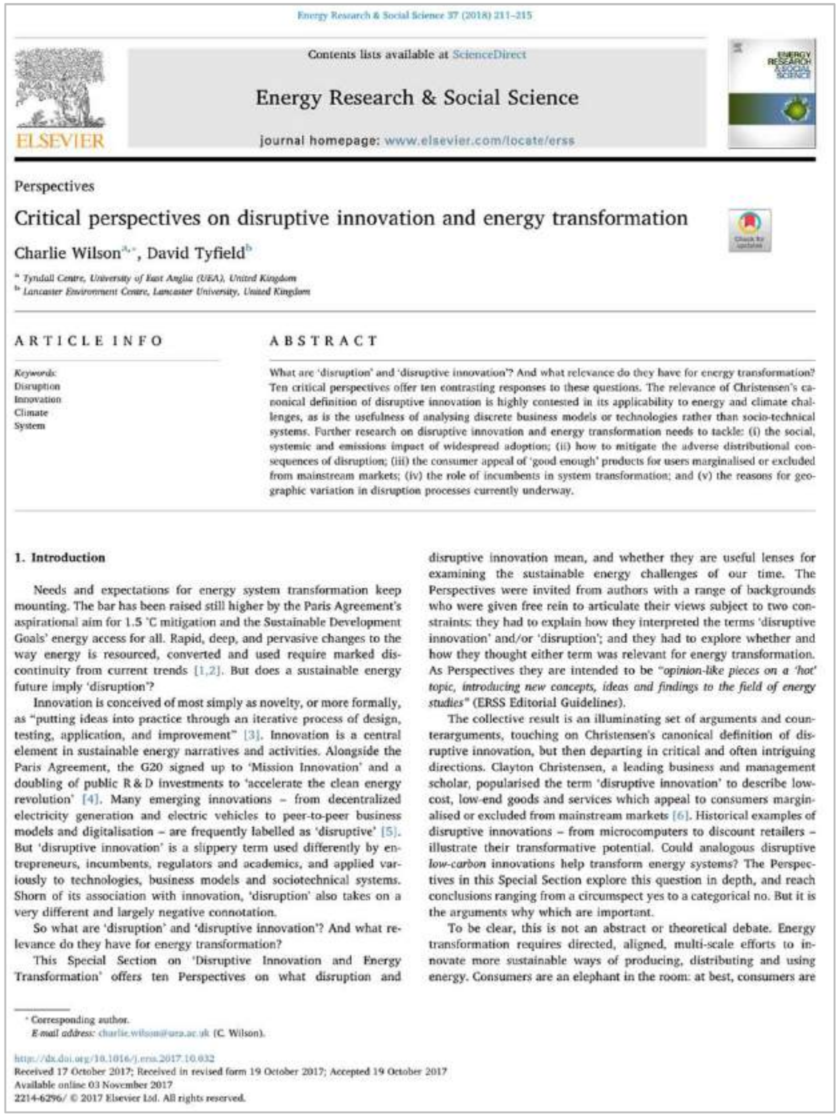
Is disruptive innovation relevant for low-carbon transitions?


4.2.2.3 Disruptive Innovation

Demand-driven disruptive innovations that emerge as the pro
multiple scales can be transformative (Seba, 2014; Christens
Such innovations would lead to simultaneous, profound chan
(Seba, 2014; Christensen et al. 2015), but are difficult to pred
et al., 2016a; Pindyck, 2017). Rapid socio-technical change h
et al. (2017). Similar changes to socio-ecological systems ca
that lead to more climate-resilient systems (Adger et al., 200
Alaska and Nepal examples in Section 4.2.2.2). The increase
as well as the increase in passive housing and net zero-emiss
disruptions (Green and Newman, 2017b). Both roof-top sola
countries' economic growth strategy and associated price de
in China (Hsu et al., 2017; Shrivastava and Persson, 2018), a
communication technologies (Koomey et al., 2013), rising d
concern regarding greenhouse gas emissions (Azeiteiro et al.
2017).



Dedicated section in:
IPCC (2018) Special Report on Global Warming of 1.5oC Chapter 4: Strengthening & implementing the global response


Energy Research & Social Science 37 (2018) 211–215

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Perspectives

Critical perspectives on disruptive innovation and energy transformation

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ARTICLE INFO

Keywords:
Disruption
Innovation
Climate
System

ABSTRACT

What are 'disruption' and 'disruptive innovation'? And what relevance do they have for energy transformation? Ten critical perspectives offer ten contrasting responses to these questions. The relevance of Christensen's canonical definition of disruptive innovation is highly contested in its applicability to energy and climate challenges, as is the usefulness of analysing discrete business models or technologies rather than socio-technical systems. Further research on disruptive innovation and energy transformation needs to tackle: (i) the social, systemic and emissions impact of widespread adoption; (ii) how to mitigate the adverse distributional consequences of disruption; (iii) the consumer appeal of 'good enough' products for users marginalised or excluded from mainstream markets; (iv) the role of incumbents in system transformation; and (v) the reasons for geographic variation in disruption processes currently underway.

1. Introduction

Needs and expectations for energy system transformation keep mounting. The bar has been raised still higher by the Paris Agreement's aspirational aim for 1.5 °C mitigation and the Sustainable Development Goals' energy access for all. Rapid, deep, and pervasive changes to the way energy is resourced, converted and used require marked discontinuity from current trends [1,2]. But does a sustainable energy future imply 'disruption'?

Innovation is conceived of most simply as novelty, or more formally, as "putting ideas into practice through an iterative process of design, testing, application, and improvement" [3]. Innovation is a central element in sustainable energy narratives and activities. Alongside the Paris Agreement, the G20 signed up to 'Mission Innovation' and a doubling of public R & D investments to 'accelerate the clean energy revolution' [4]. Many emerging innovations – from decentralized electricity generation and electric vehicles to peer-to-peer business models and digitalisation – are frequently labelled as 'disruptive' [5]. But 'disruptive innovation' is a slippery term used differently by entrepreneurs, incumbents, regulators and academics, and applied variously to technologies, business models and sociotechnical systems. Shorn of its association with innovation, 'disruption' also takes on a very different and largely negative connotation.

So what are 'disruption' and 'disruptive innovation'? And what relevance do they have for energy transformation?

This Special Section on 'Disruptive Innovation and Energy Transformation' offers ten Perspectives on what disruption and disruptive innovation mean, and whether they are useful lenses for examining the sustainable energy challenges of our time. The Perspectives were invited from authors with a range of backgrounds who were given free rein to articulate their views subject to two constraints: they had to explain how they interpreted the terms 'disruptive innovation' and/or 'disruption'; and they had to explore whether and how they thought either term was relevant for energy transformation. As Perspectives they are intended to be "*opinion-like pieces on a 'hot' topic, introducing new concepts, ideas and findings to the field of energy studies*" (ERSS Editorial Guidelines).

The collective result is an illuminating set of arguments and counterarguments, touching on Christensen's canonical definition of disruptive innovation, but then departing in critical and often intriguing directions. Clayton Christensen, a leading business and management scholar, popularised the term 'disruptive innovation' to describe low-cost, low-end goods and services which appeal to consumers marginalised or excluded from mainstream markets [6]. Historical examples of disruptive innovations – from microcomputers to discount retailers – illustrate their transformative potential. Could analogous disruptive *low-carbon* innovations help transform energy systems? The Perspectives in this Special Section explore this question in depth, and reach conclusions ranging from a circumspect yes to a categorical no. But it is the arguments why which are important.

To be clear, this is not an abstract or theoretical debate. Energy transformation requires directed, aligned, multi-scale efforts to innovate more sustainable ways of producing, distributing and using energy. Consumers are an elephant in the room: at best, consumers are

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http://dx.doi.org/10.1016/j.erss.2017.10.032
Received 17 October 2017; Received in revised form 19 October 2017; Accepted 19 October 2017
Available online 03 November 2017

Ten contrasting perspectives in:
Energy Research & Social Science (2018) 37: 211-274

potentially *disruptive* consumer innovations

e-bikes

'taxi-bus'

ride-share

car-share

bike-share

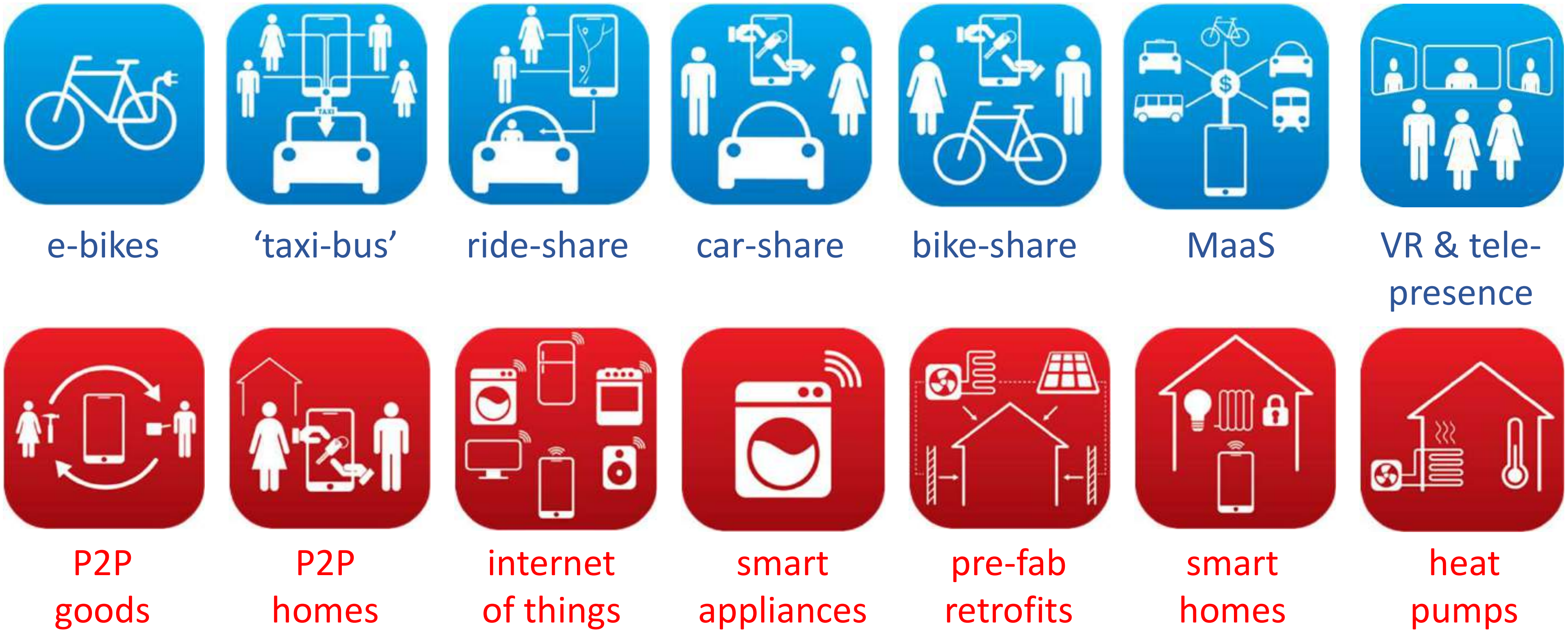
MaaS

VR & tele-presence

SILCI project: silci.org

Wilson et al. (2018). "The potential contribution of disruptive low-carbon innovations to 1.5 °C climate mitigation." *Energy Efficiency.*

potentially *disruptive* consumer innovations



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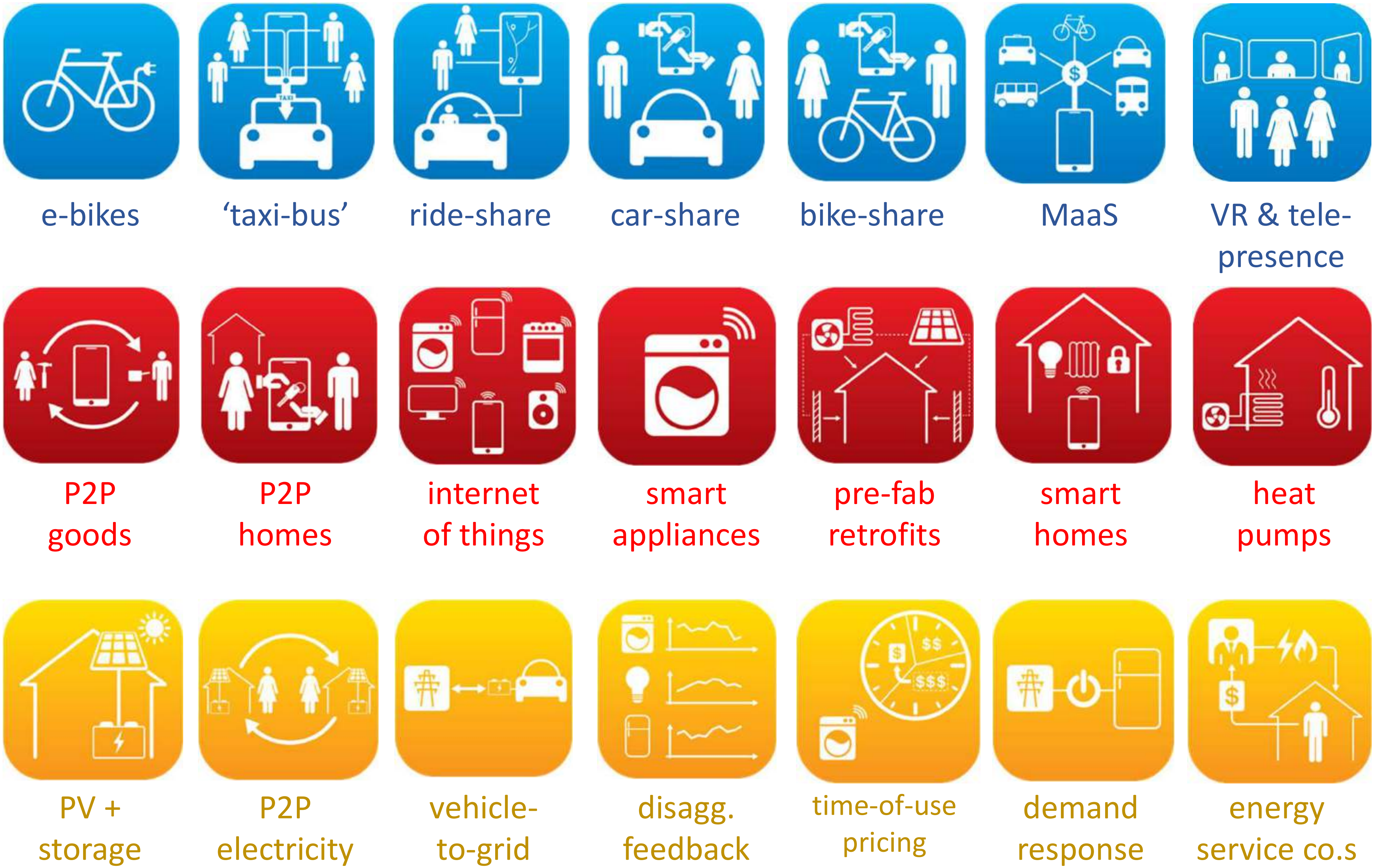
potentially *disruptive* consumer innovations



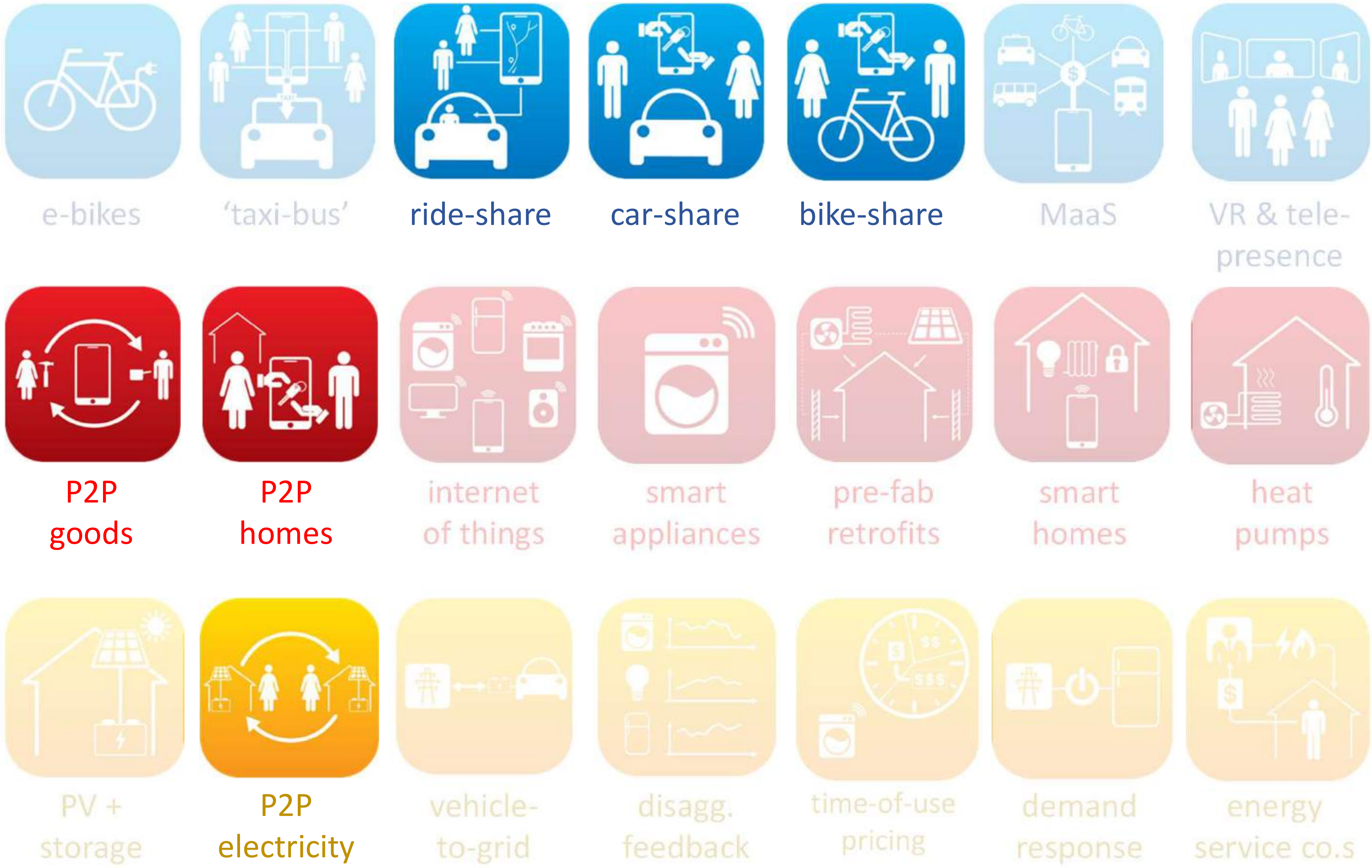
‘mega-trend’ (1) from ownership to *usership*

e-bikes
‘taxi-bus’
ride-share
car-share
bike-share
MaaS
VR & tele-presence

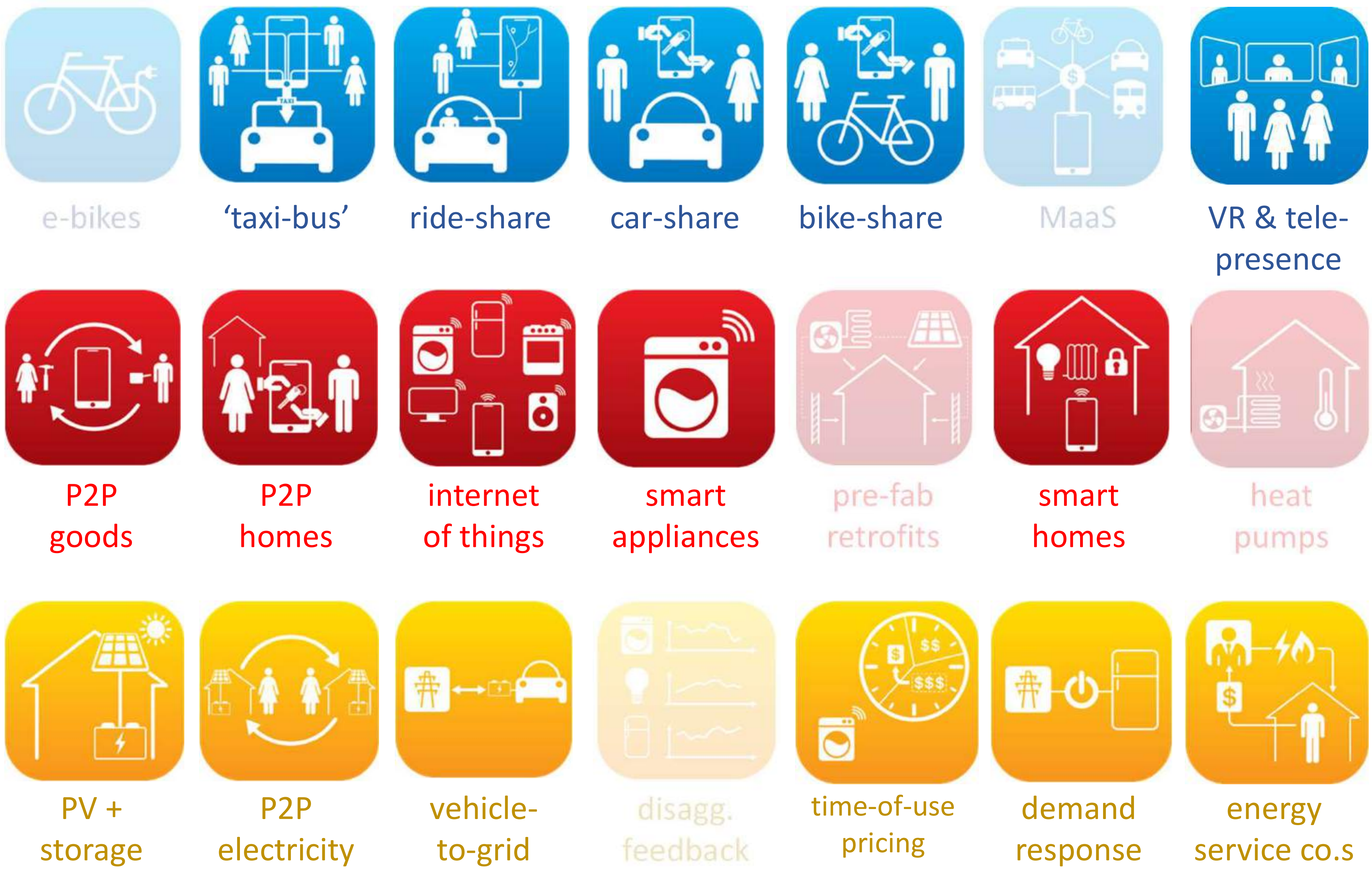
P2P goods
P2P homes
internet of things
smart appliances
pre-fab retrofits
smart homes
heat pumps

PV + storage
P2P electricity
vehicle-to-grid
disagg. feedback
time-of-use pricing
demand response
energy service co.s

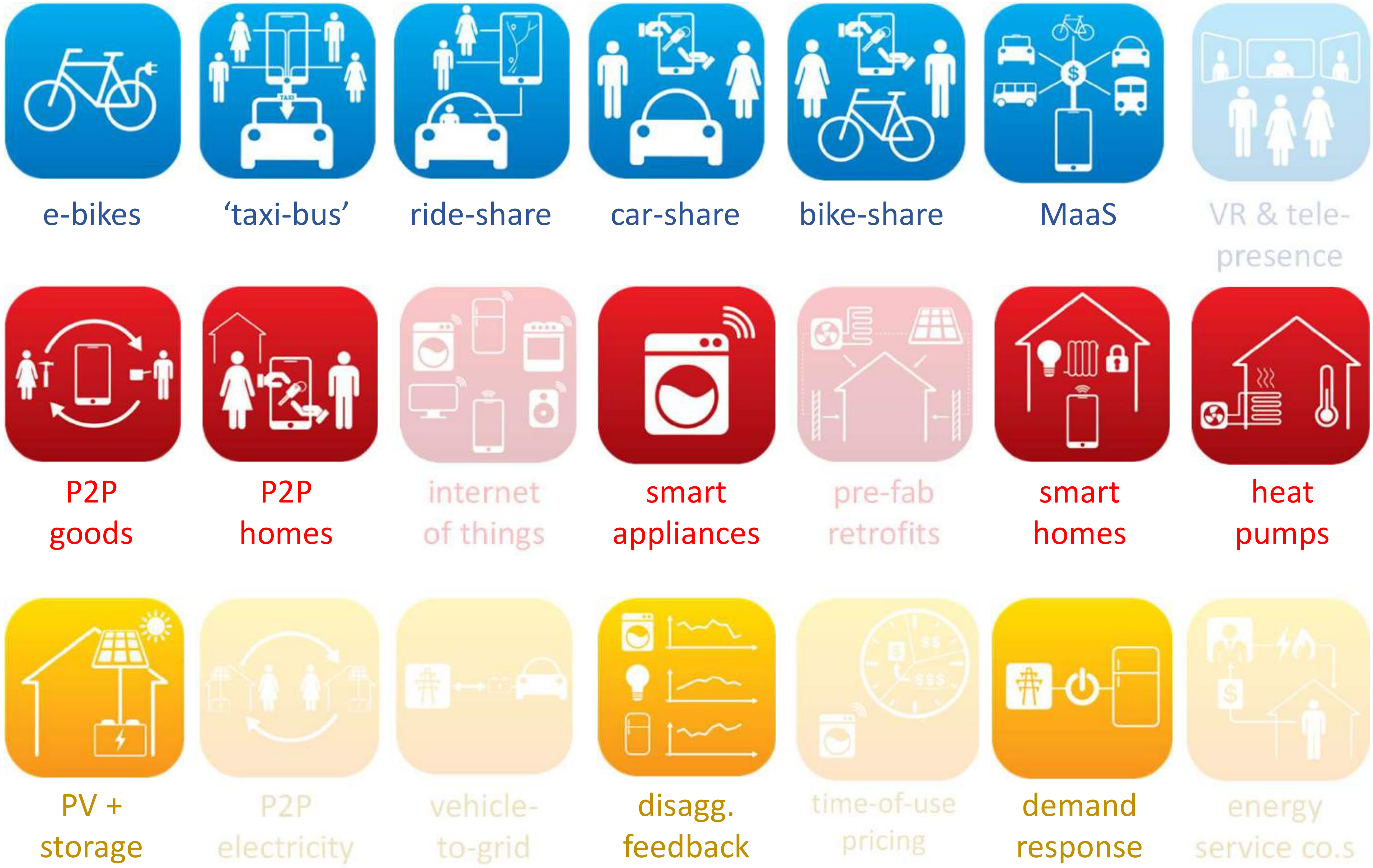
‘mega-trend’ (2) *sharing economy,* including P2P



‘mega-trend’ (3) from atomised to *connected*



currently *commercial*, niche, but growing rapidly



factored into *LED scenario* (1st order estimates)