ACCELERATING ENERGY AND LOW-CARBON TRANSITIONS

KEYNOTE ADDRESS TO THE RUTGERS CLIMATE SYMPOSIUM "IN SEARCH OF SOLUTIONS," NEW BRUNSWICK, NEW JERSEY, NOVEMBER 15, 2023

Benjamin K. Sovacool, Ph.D
Professor of Earth and Environment, Boston University

DEFINING ENERGY TRANSITIONS

What is an energy transition?

- Change in fuel supply?
- Shift in technologies that exploit fuel, e.g. prime movers end use devices?
- Switch from an economic or regulatory system (e.g. Cuba)?
- Time taken for socio-technical diffusion?
- At what scale?

Source: Sovacool, BK. "How Long Will it Take? Conceptualizing the Temporal Dynamics of Energy Transitions," *Energy Research & Social Science* 13 (March, 2016), pp. 202-215.

Five definitions of energy transitions.

Definition	Source
A change in fuels (e.g., from wood to coal or coal to oil) and their associated technologies (e.g., from steam engines to internal combustion engines)	Hirsh and Jones [22]
Shifts in the fuel source for energy production and the technologies used to exploit that fuel	Miller et al. [23]
A particularly significant set of changes to the patterns of energy use in a society, potentially affecting resources, carriers, converters, and services	O'Connor [24]
The switch from an economic system dependent on one or a series of energy sources and technologies to another	Fouquet and Pearson [25]
The time that elapses between the introduction of a new primary energy source, or prime mover, and its rise to claiming a substantial share of the overall market	Smil [26]

CONCEPTUALIZING ENERGY TRANSITIONS

Grubler and Wilson: Experimentation and learning, unit scaling, industry scaling, standardization, market saturation (from core to periphery)

Source: Sovacool, BK. "How Long Will it Take? Conceptualizing the Temporal Dynamics of Energy Transitions," *Energy Research & Social Science* 13 (March, 2016), pp. 202-215.

Table 2
The differences in timing and speed of energy transitions in Europe.

Phase-out traditional renewables phase-in coal:		Diffusion midpoint	Diffusion speed
Core	England	1736	160
Rim	Germany	1857	102
	France	1870	107
	Netherlands	1873	105
Periphery	Spain	1919	111
	Sweden	1922	96
	Italy	1919	98
	Portugal	1949	135
Phase-out coal phase-in oil/gas/electricity:			
Core	Portugal	1966	47
	Italy	1960	65
	Sweden	1963	67
Rim	Spain	1975	69
	Netherlands	1962	62
	France	1972	65
Periphery	Germany	1984	50
	England	1979	67

CONCEPTUALIZING ENERGY TRANSITIONS

Original Article

Science, Technology, & Human Values
1-32

DOI: 10.1177/0162243918768074
journals.sagepub.com/home/sth
SAGE

Reconfiguration, Contestation, and Decline: Conceptualizing Mature Large Technical Systems

Benjamin K. Sovacool[1,2], Katherine Lovell[2], and Marie Blanche Ting[2]

- Thomas Hughes and the emergence of electricity networks:
  - System = seamless web of economic, educational, legal, administrative, and technical elements
  - Momentum = mass and velocity, path dependence
- Phases: Invention and development, technology transfer, growth, momentum, and style

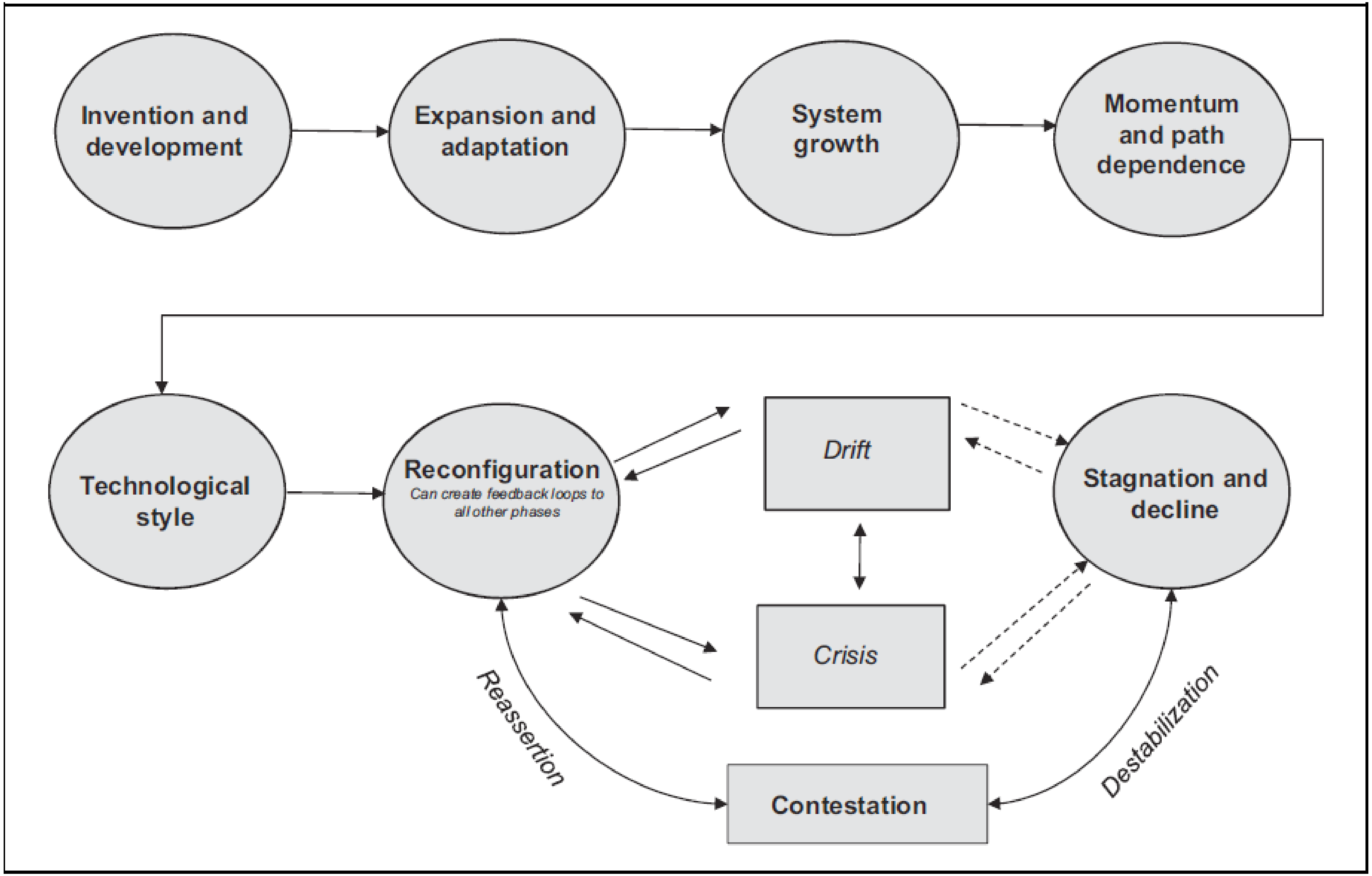


Figure 2. Eight conceptual phases of large technical systems. Source: Authors.

CONCEPTUALIZING ENERGY TRANSITIONS

Table 2. Phases, Mechanisms, and Empirical Cases for Reconfiguration, Contestation, and Decline.

Phase/Description	Mechanism(s)	Case(s)
Reconfiguration: system adapts to challenges; control over system is mostly stable	Interconnection and crosslinking	Railways, electricity grids, and telecommunications networks
	Selectivity	Electricity grids, telecommunications networks, and gas pipelines
	Repositioning	Sewer systems, ocean freight and marine transport, land transport, industrial manufacturing, and natural gas systems
Contestation: system is in limbo; control over system is challenged	Drift	South African electricity, shale gas in Eastern Europe, and telecommunications in the United States and United Kingdom
	Crisis	American flood control, British railways
Stagnation and decline: system growth declines or erodes; quality of service or volume deteriorates; control over system is lost	Substitution and transformation	French railways, electric streetcars (trolleys) in the United States, and coal in the United Kingdom

CONCEPTUALIZING ENERGY TRANSITIONS

Original Article

S|S|S

Social Studies of Science
1–48

DOI: 10.1177/0306312717709363
journals.sagepub.com/home/sss
SAGE

Ordering theories: Typologies and conceptual frameworks for sociotechnical change

Benjamin K Sovacool
Department of Business Development and Technology, Aarhus University, Herning, Denmark; Science Policy Research Unit, University of Sussex, Brighton, UK

David J Hess
Department of Sociology, Vanderbilt University, Nashville, TN, USA

THEORIES OF SOCIO-TECHNICAL TRANSITIONS: THE LONG-LIST

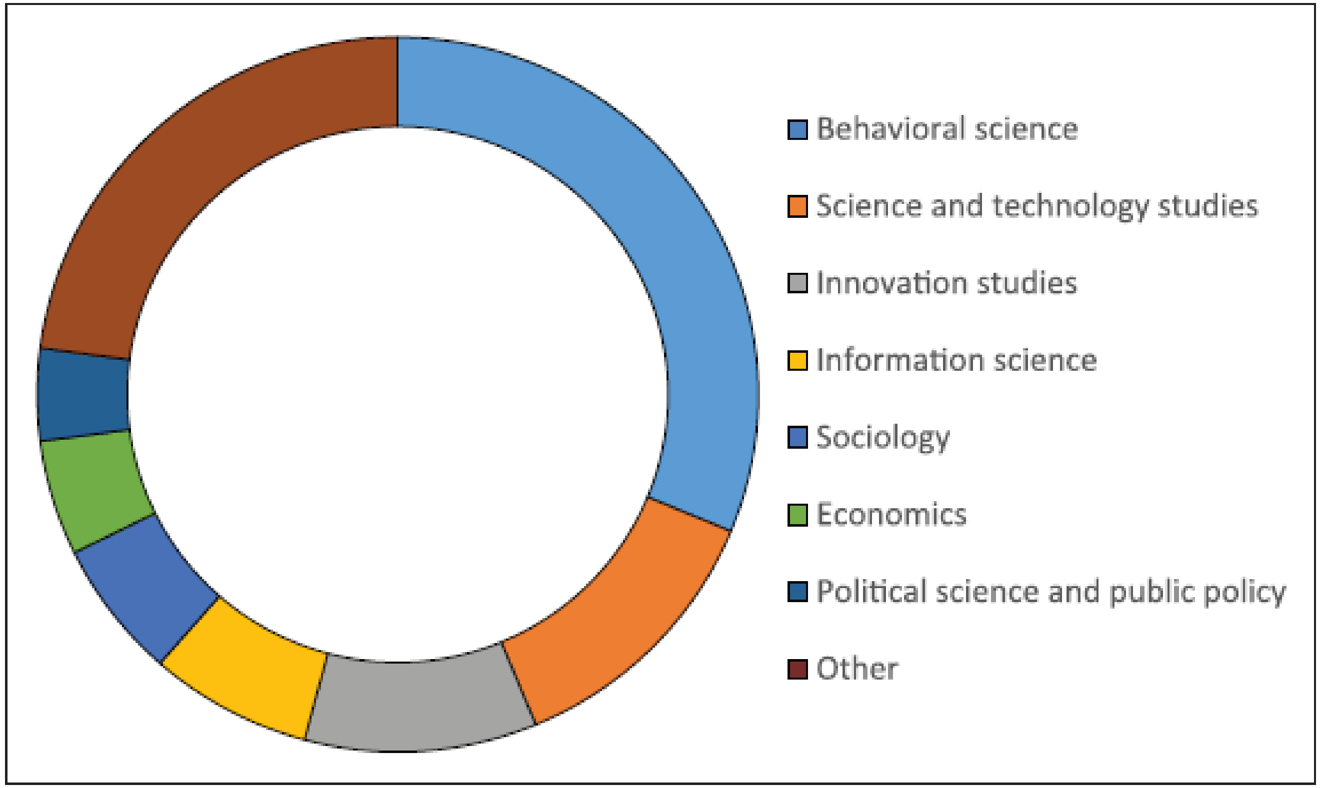


Figure 2. Academic discipline for selected theories (n = 96). 'Other' disciplines include history, organization studies, political ecology and geography, transport studies, business studies, communication studies, conflict resolution, consumption studies, development studies, energy studies, ethics and moral studies, legal studies and jurisprudence, linguistics and semiotics, marketing, and mathematics.

ORDERING THEORIES: THE LONG-LIST

No.	Discipline	Name	Key author(s)	Application to sociotechnical diffusion and acceptance
1	Behavioral science	Attitude-Behavior-Context (ABC) Theory	Paul C. Stern, Stuart Oskamp	A kind of field theory for behavior intended to be environmentally sustainable, inclusive of accepting environmentally friendly technologies. Behavior (B) is an interactive product of 'internal' attitudinal variables (A) and 'external' contextual factors (C).
2	Behavioral science	Attribution Theory	Kelvin Lancaster, F. Heider	Attempts to explain why ordinary people explain events as they do, including the adoption of new technology, and it suggests that the two most influential factors are internal attribution to characteristics of the individual or external attribution to a situation or event outside of personal control
3	Behavioral science	Comprehensive Technology Acceptance Framework	N.M.A. Huijts, Linda Steg	Proposes a complex model of technological diffusion predicated on experience and knowledge which are then mediated by trust, issues of procedural and distributive fairness, social norms, attitudes, and perceived behavioral control
4	Behavioral science	Cognitive Dissonance Theory	Leon Festinger	Argues that people in general are motivated to avoid internally inconsistent (dissonant) beliefs, attitudes and values, including when they adopt new technologies or practices

ORDERING THEORIES: THE SHORT-LIST

Table 1. Most frequently mentioned theoretical approaches (respondents = 35).

No.	Name	Frequency mentioned by respondents (n)	Frequency mentioned (%)
1	Sociotechnical Transitions	15	43
2	Social Practice Theory	14	40
3	Discourse Theory	10	29
4	Domestication Theory	9	26
5	Large Technical Systems	9	26
6	Social Construction of Technology	9	26
7	Sociotechnical Imaginaries	7	20
8	Actor-Network Theory	7	20
9	Social Justice Theory	7	20
10	Sociology of Expectations	6	17
11	Sustainable Development	6	17
12	Values Beliefs Norms Theory	5	14
13	Lifestyle Theory	4	11
14	Universal Theory of Acceptance and Use of Technology	4	11

MOVING AWAY FROM THIS CONCEPTUAL QUAGMIRE OR MINEFIELD, WHAT ABOUT THE *EMPIRICAL* DYNAMICS OF TRANSITIONS?

TEMPORALITY AND ENERGY TRANSITIONS

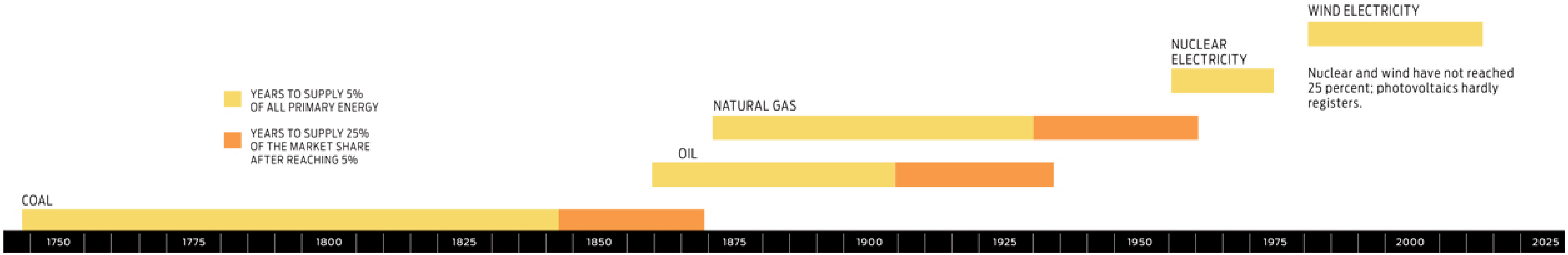
"Energy transitions have been, and will continue to be, inherently prolonged affairs, particularly so in large nations whose high levels of per capita energy use and whose massive and expensive infrastructures make it impossible to greatly accelerate their progress even if we were to resort to some highly effective interventions …"

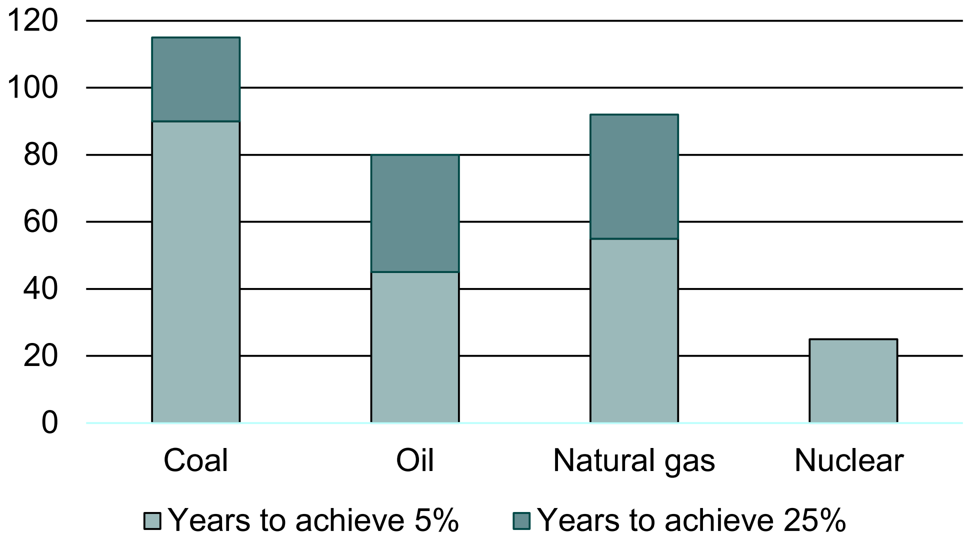
Table 2
The differences in timing and speed of energy transitions in Europe.

Phase-out traditional renewables phase-in coal:		Diffusion midpoint	Diffusion speed
Core	England	1736	160
Rim	Germany	1857	102
	France	1870	107
	Netherlands	1873	105
Periphery	Spain	1919	111
	Sweden	1922	96
	Italy	1919	98
	Portugal	1949	135
Phase-out coal phase-in oil/gas/electricity:			
Core	Portugal	1966	47
	Italy	1960	65
	Sweden	1963	67
Rim	Spain	1975	69
	Netherlands	1962	62
	France	1972	65
Periphery	Germany	1984	50
	England	1979	67

Source: Sovacool, BK. "How Long Will it Take? Conceptualizing the Temporal Dynamics of Energy Transitions," *Energy Research & Social Science* 13 (March, 2016), pp. 202-215.

TEMPORALITY AND ENERGY TRANSITIONS





TEMPORALITY AND ENERGY TRANSITIONS

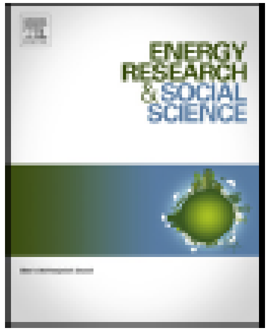
Energy Research & Social Science 22 (2016) 18–25

ELSEVIER

Contents lists available at ScienceDirect

Energy Research & Social Science

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



Short communication

Apples, oranges, and consistent comparisons of the temporal dynamics of energy transitions

Arnulf Grubler[a,b,*], Charlie Wilson[a,c], Gregory Nemet[d]

TEMPORALITY AND ENERGY TRANSITIONS

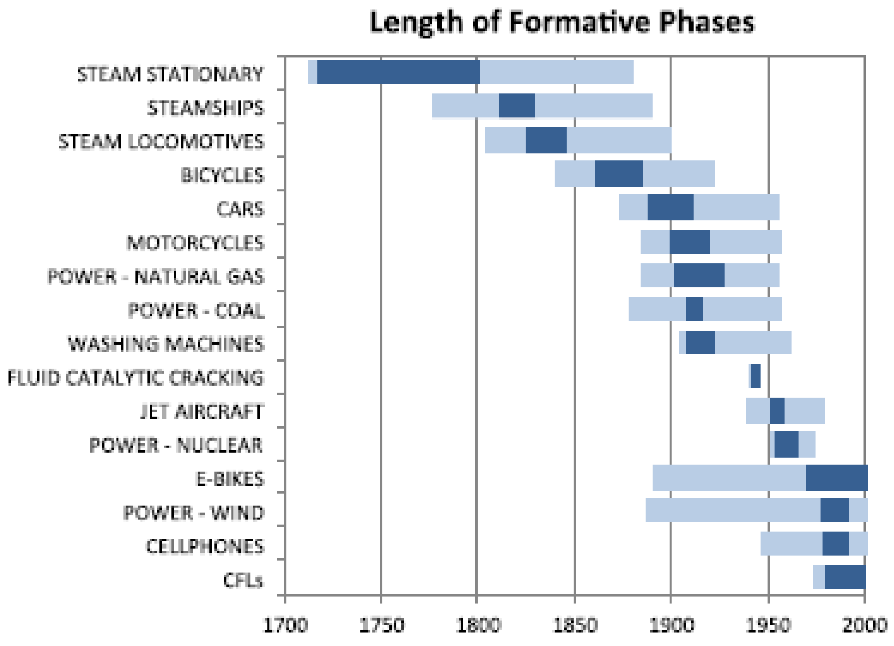


Fig. 1. Durations of formative phases for energy technologies are at a decadal scale [4]. Note: Ranges refer to alternative definitions for the start and end points of formative phases, and so capture measurement uncertainties.

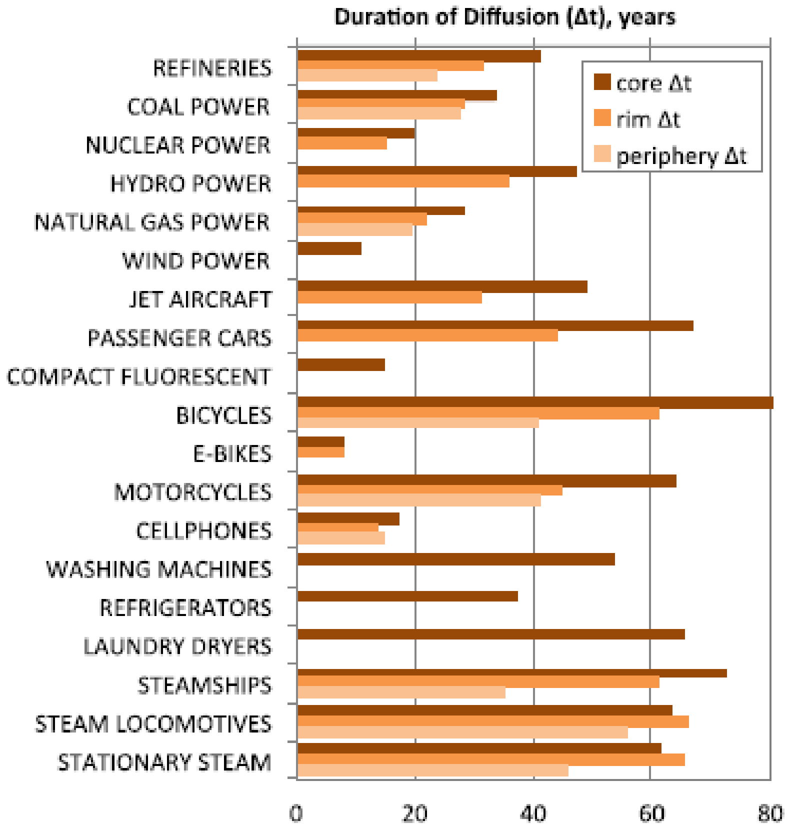
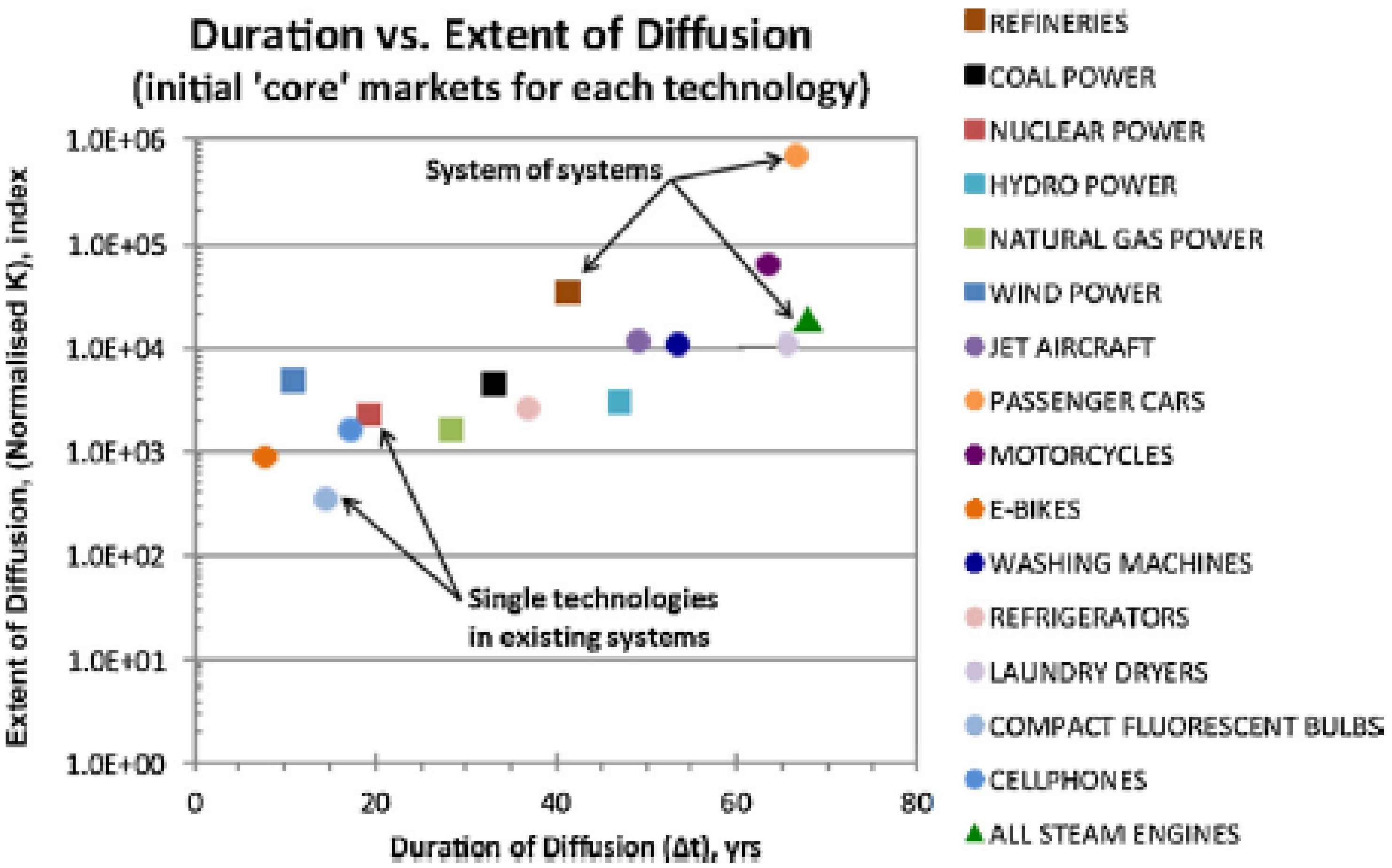


Fig. 2. Diffusion speeds accelerate as technologies diffuse spatially. Notes: Bars show durations of diffusion measured by cumulative total capacity installed, with historical data fitted via a logistic growth curve and the diffusion duration expressed as Δ t in years. 'Core' is typically within the OECD; 'Rim' is typically Asian countries; 'Periphery' is typically other world regions. For details and data, see: [42,3].

TEMPORALITY AND ENERGY TRANSITIONS



Diffusion durations scale with market size. Notes: X-axis shows duration of diffusion (t) measured in time to grow from 10%to 90%of cumulative total capacity; y-axis shows extent of diffusion normalized for growth in system size. All data are for 'core' innovator markets. Round symbols denote end-use technologies; square technologies denote energy supply technologies; triangular symbol denotes general purpose technologies (steam engines). Arrows show illustrative examples of system of systems (refineries describing the rise of multiple oil uses across all sectors, cars describing the concurrent growth of passenger cars, roads, and suburbs, and steam engines are a proxy of the growth of all coal-related technologies in the 19th century). Arrows also highlight examples of single technologies diffusing into existing systems substituting existing technologies (nuclear power, compact fluorescent light bulbs).

TEMPORALITY AND ENERGY TRANSITIONS

ELSEVIER

Contents lists available at SciVerse ScienceDirect

Energy Policy

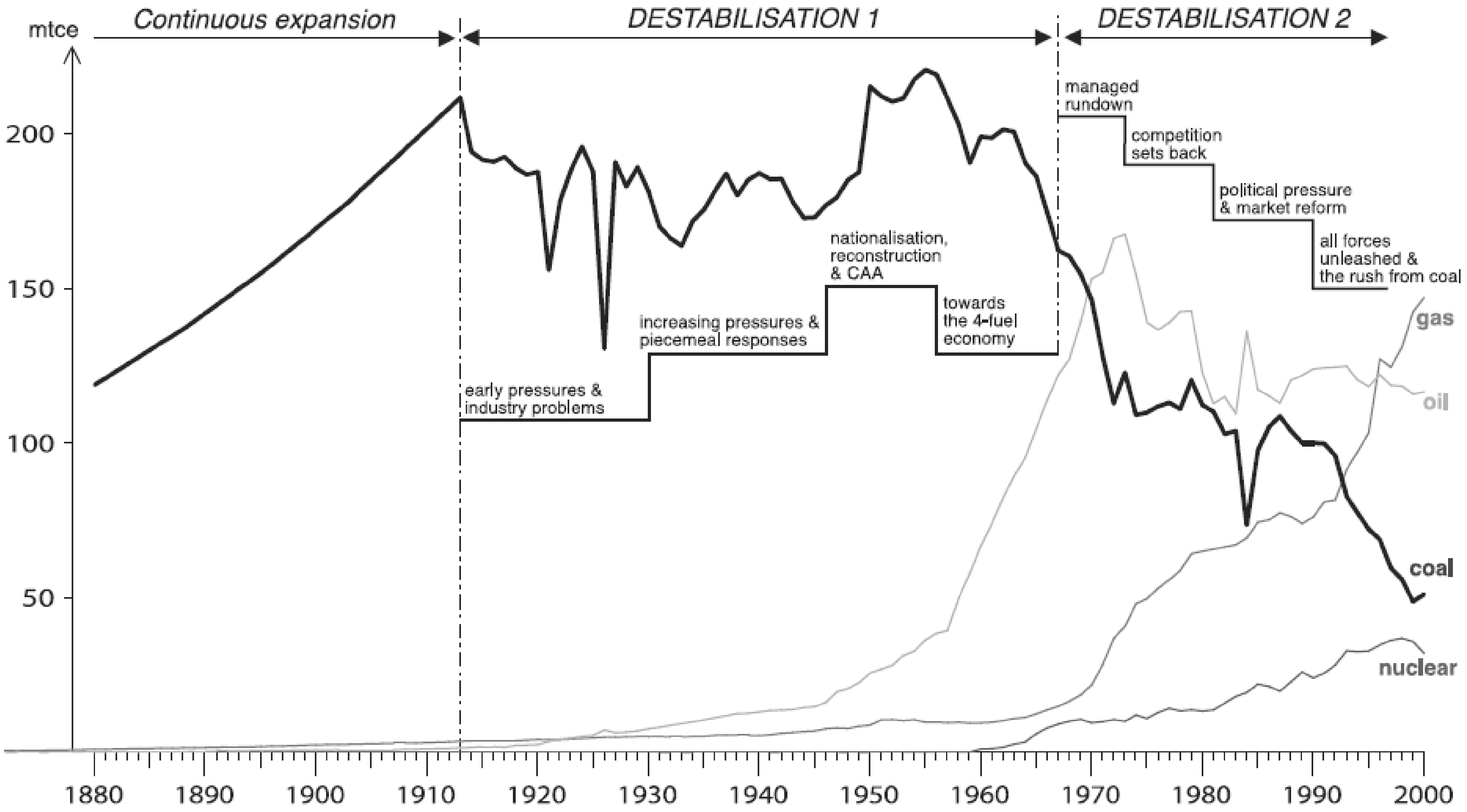
journal homepage: www.elsevier.com/locate/enpol

ENERGY POLICY

Regime destabilisation as the flipside of energy transitions: Lessons from the history of the British coal industry (1913–1997)

Bruno Turnheim*, Frank W. Geels

TEMPORALITY AND ENERGY TRANSITIONS



SOME PECULIARITIES

- *Diffusion thresholds*: what % constitutes a transition (5%, 10%, 25%, 50%)?
- *Co-evolution*: one isolated technology or the seamless web (e.g. mimicry plus rail and telegraph, oil and roads)?

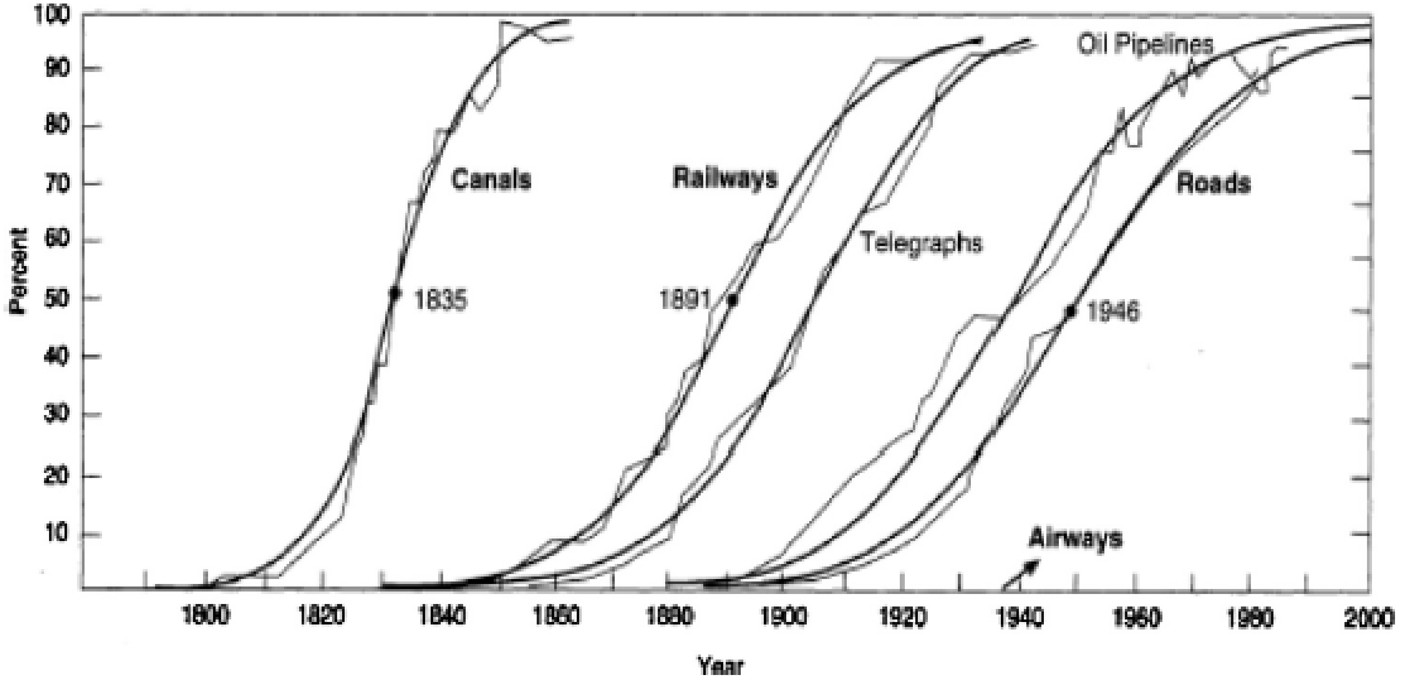


Fig. 1. Growth of Infrastructures in the United States as a Percentage of their Maximum Network Size.

- *Unit of analysis*: big oil or smaller changes in ICEs, steam engines on ships, oil lamps, oil heating boilers and furnaces?

RETHINKING TRANSITIONS: TOWARDS ACCELERATION?

- We have seen at least five fast transitions in terms of energy end-use and prime movers
- Examples of many rapid national-scale transitions in energy supply also populate

Table 4
Overview of rapid energy transitions.

Country	Technology/fuel	Market or sector	Period of transition	Number of years from 1 to 25% market share	Approximate size (population affected in millions of people)
Sweden	Energy-efficient ballasts	Commercial buildings	1991–2000	7	2.3
China	Improved cookstoves	Rural households	1983–1998	8	592
Indonesia	Liquefied petroleum gas stoves	Urban and rural households	2007–2010	3	216
Brazil	Flex-fuel vehicles	New automobile sales	2004–2009	1	2
United States	Air conditioning	Urban and rural households	1947–1970	16	52.8
Kuwait	Crude oil and electricity	National energy supply	1946–1955	2	0.28
Netherlands	Natural gas	National energy supply	1959–1971	10	11.5
France	Nuclear electricity	Electricity	1974–1982	11	72.8
Denmark	Combined heat and power	Electricity and heating	1976–1981	3	5.1
Canada (Ontario)[a]	Coal	Electricity	2003–2014	11	13

[a] The Ontario case study is the inverse, showing how quickly a province went from 25% coal supply to zero.

RETHINKING TRANSITIONS: TOWARDS ACCELERATION?

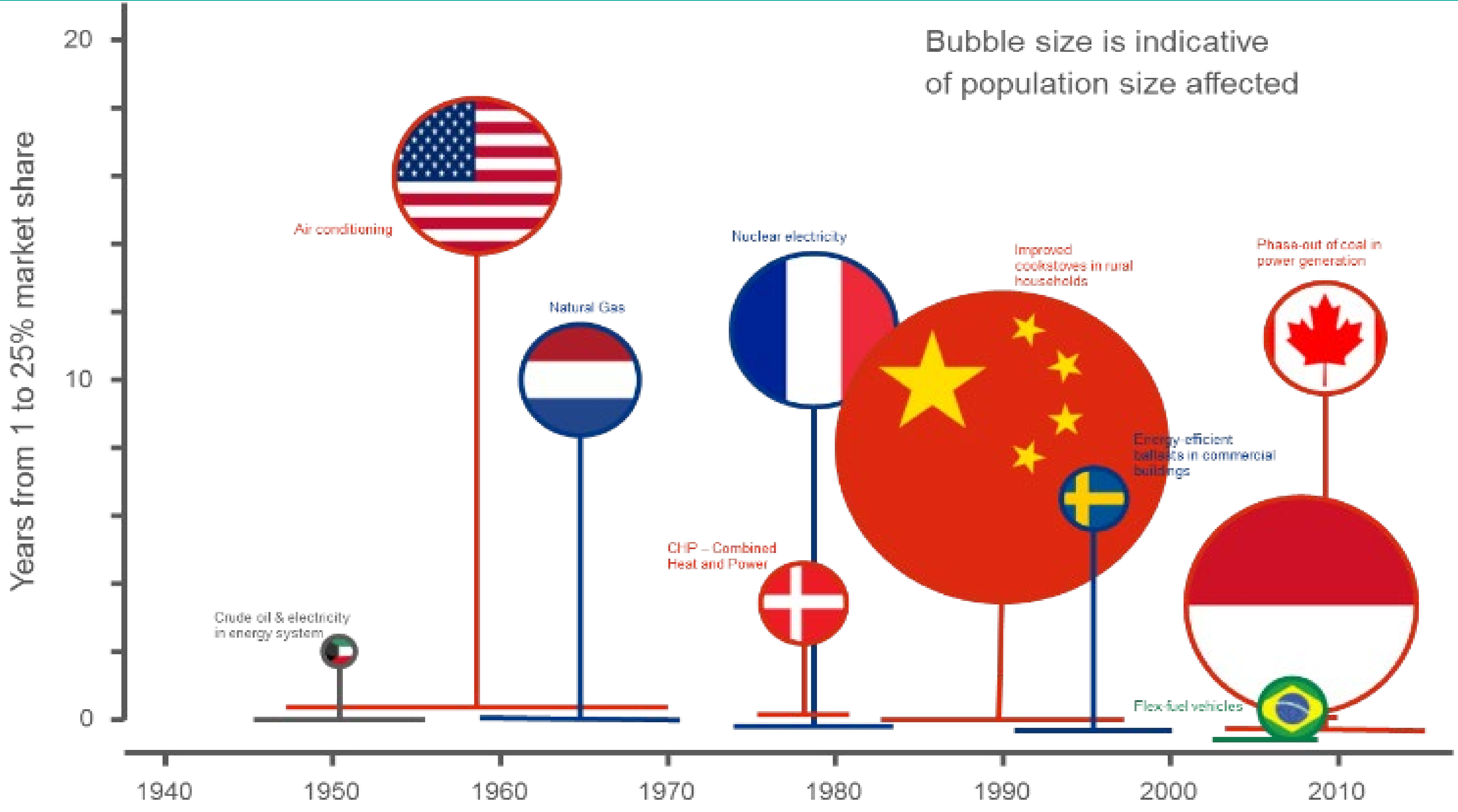


Figure designed by Gert Jan Kramer, used with permission

RETHINKING TRANSITIONS: TOWARDS ACCELERATION?

Energy Policy 139 (2020) 111330

Contents lists available at ScienceDirect

Energy Policy

journal homepage: http://www.elsevier.com/locate/enpol

ELSEVIER

ENERGY POLICY

Check for updates

Hot transformations: Governing rapid and deep household heating transitions in China, Denmark, Finland and the United Kingdom

Benjamin K. Sovacool [a,b,*], Mari Martiskainen [a]

[a] *Science Policy Research Unit (SPRU), School of Business, Management, and Economics, University of Sussex, United Kingdom*
[b] *Center for Energy Technologies, Department of Business Development and Technology, Aarhus University, Denmark*

- Other heating transitions that were (fairly) *rapid*, taking 18–35 years
- And *deep*, involving diffusion that collectively reached more than 100 million households and more than 310 million people

RETHINKING TRANSITIONS: TOWARDS ACCELERATION?

Summary of four rapid household heating transitions.

Country	Years	Technology	Diffusion across national population	Polycentric component	Description
China	1995–2015	Solar thermal hot water and space heating	19.2% (approximately 263.5 million people)[a]	Stimulated industrial research with strong municipal and national targets and policies	Household use of solar heating grows from a few thousand units in the 1990s to 1 million units being manufactured each year by 2015, corresponding to 70 million square meters of collectively installed solar collection; some urban areas saw adoption rates surpass 95% of homes; China held 76% of worldwide capacity by 2015 and the total number of installed units nationally surpassed 85 million; solar thermal systems displace an estimated 75.7 million tons of carbon dioxide per year in 2015
Denmark	1976–2011	District heating networks and combined heat and power	28.9% (approximately 1.61 million people)[b]	Blended small-scale decentralized community control with national standards and policies	Reversed Danish dependence on oil for heating in five years; converted 800,000 heating systems and installed 45,000 km of heat pipes; provided 80% of household heating needs in 2011; reduced national carbon dioxide emissions by 20%
Finland	2000–2018	Heat pumps	33.9% (approximately 1.87 million people)[c]	Harnessed user and peer-to-peer learning and innovation alongside national and European policies and incentives	Diffusion grew 613-fold from approximately 1500 heat pumps in 2000 to 930,000 in 2018. The majority of heat pumps have been installed in detached and semi-detached houses; 70% of new homes choose a heat pump
United Kingdom	1960–1977	Natural gas central heating	77.2% (approximately 43.4 million people)[d]	Coordinated a nationalized Gas Council and Area Boards with industry groups, appliance manufacturers, installers and marketing campaigns	Converted 40 million appliances and 14 million homes (almost half of *all* homes at that time) to run on natural gas from the North Sea, rather than town gas; a majority of these conversions happen in just 10 years' time; Corresponding fuel consumption went from almost entirely town gas in 1966 (110,000 GWh), to almost entirely natural gas (443,000 GWh) by 1977; 92% of the population of the UK has a gas grid connection

Sovacool, BK and M Martiskainen. "Hot transformations: Governing rapid and deep household heating transitions in China, Denmark, Finland and the United Kingdom," *Energy Policy* 139 (April, 2020), 111330, pp. 1-16.

RETHINKING TRANSITIONS: TOWARDS ACCELERATION?

Energy Research & Social Science 22 (2016) 13–17

Contents lists available at ScienceDirect

Energy Research & Social Science

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

Short communication

The pace of governed energy transitions: Agency, international dynamics and the global Paris agreement accelerating decarbonisation processes?

Florian Kern[a,*], Karoline S. Rogge[a,b]

- Historic energy transitions have not been consciously governed, whereas today a wide variety of actors is engaged in active attempts to govern the transition towards low carbon energy systems
- International innovation dynamics can work in favor of speeding up the global low-carbon transition.
- The 2015 Paris agreement demonstrates a global commitment to move towards a low carbon economy for the first time

RETHINKING TRANSITIONS: TOWARDS ACCELERATION?

Accelerating low-carbon innovation: the role for phase-out policies

Policy Briefing 05

March 2017

About the authors:

Dr Florian Kern is a Senior Lecturer at the Science Policy Research Unit, University of Sussex and a Senior Researcher for the Centre on Innovation and Energy Demand. He is also Co-Director of the Sussex Energy Group. Contact: F.Kern@sussex.ac.uk

Dr Karoline Rogge is Lecturer in Energy Policy Sustainability at the Science Policy Research Unit, University of Sussex and Senior Research Fellow for the Centre on Innovation and Energy Demand. Contact: K.Rogge@sussex.ac.uk

Dr Paula Kivimaa is a Senior Research Fellow at the Science Policy Research Unit, University of Sussex and the Centre on Innovation and Energy Demand. Contact: P.Kivimaa@sussex.ac.uk

About this briefing:

This briefing is based on work carried out on behalf of the Centre on Innovation and Energy Demand (CIED), an RCUK-funded End Use Energy Demand Centre. Contact: CIED@sussex.ac.uk

Phase-out policies include:

- **Control policies** that reduce emissions from specific technologies or sectors.
- **Changing market rules** that address decarbonisation of a whole market, sector or system.
- **Reduced support** (such as tax breaks or subsidies) for high-carbon technologies.
- **Policies to ensure a balanced debate** that considers both new entrants and incumbents (such as the creation of new committees or networks).

RETHINKING TRANSITIONS: TOWARDS ACCELERATION?

comment

Designing car bans for sustainable transportation

Car bans could contribute to both climate change and air-quality goals. However, most car bans announced to date lack enforcement mechanisms and are therefore not bans at all. Here, we provide recommendations to design car bans as a more-effective policy tool for sustainability.

Patrick Plötz, Jonn Axsen, Simon A. Funke and Till Gnann

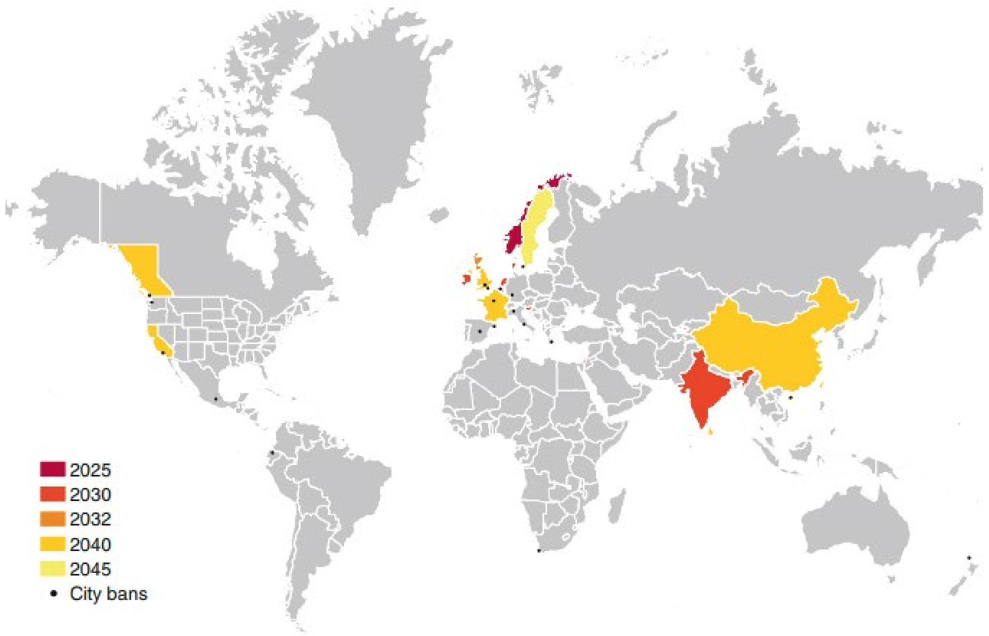


Table 1 | Overview of announced ICE car bans worldwide

Coverage	Start year	Ban of diesel vehicles	Ban of gasoline vehicles	Ban of hybrid vehicles	Limit	Status
National						
Norway	2025	Yes	Yes	Yes	New sales	Target
Israel	2030	Yes	Yes	-	Car import	Planned
Slovenia	2030	Yes	Yes	Yes	New registrations	Planned
Ireland	2030	Yes	Yes	-	New sales	Planned
India	2030	Yes	Yes	-	New sales	Target
Denmark	2030	Yes	Yes	-	New sales	
Netherlands	2030	Yes	Yes	-	?	Planned
UK	2040	Yes	Yes	-	?	Planned
Taiwan	2040	Yes	Yes	?	New sales	Planned
France	2040	Yes	Yes	-	New sales	Proposed law
Sri Lanka	2040	Yes	Yes	-	Driving	Target
Sweden	2045	Yes	Yes	-	Driving	Target
China	TBD	Yes	Yes	?	New sales	Planned
Regional						
Balearic Islands	2025	Yes	-	-	-	-
Scotland	2032	Yes	Yes	-	?	Planned
California	2040	Yes	Yes	-	New sales	Proposed law
British Columbia	2040	Yes	Yes	Yes	New sales	Law
Citywide						
Paris, Mexico City, Athens, Madrid, and Rome.	2025	Yes	-	-	?	Target
Auckland, London, Barcelona, Cape Town, Milan, Seattle, Oxford, Quito, Vancouver, Copenhagen, Los Angeles, Hainan, and Heidelberg.	2030	Yes	Yes	Yes	Driving	Target
Brussels	2030	Yes	Yes	-	-	Target
Beijing	Exists	-	-	-	Cap for new registrations, fossil lottery	Existing law
Part of city						
Central Oslo	2019	Yes	Yes	Yes	Parking	Planned

TBD, to be decided, with 2040 as the most likely year. The 'fossil lottery' refers to the system in Beijing where one has to win a lottery to obtain a license plate for a combustion engine vehicle, whereas electric vehicle license plates are obtained directly.

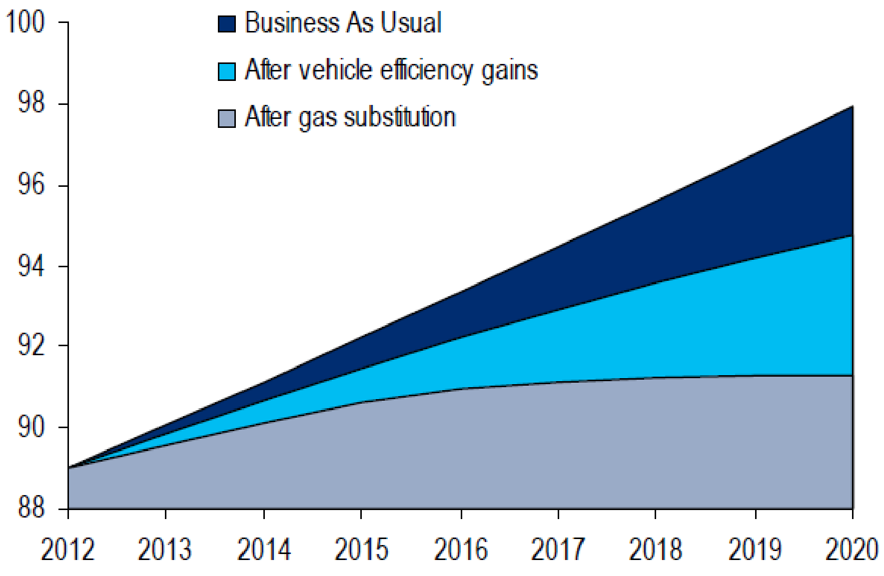
RETHINKING TRANSITIONS: CHANGES IN DEMAND PREFERENCES, DEMAND “PEAKS?”

Global Oil Demand Growth – The End Is Nigh
26 March 2013

Citi Research

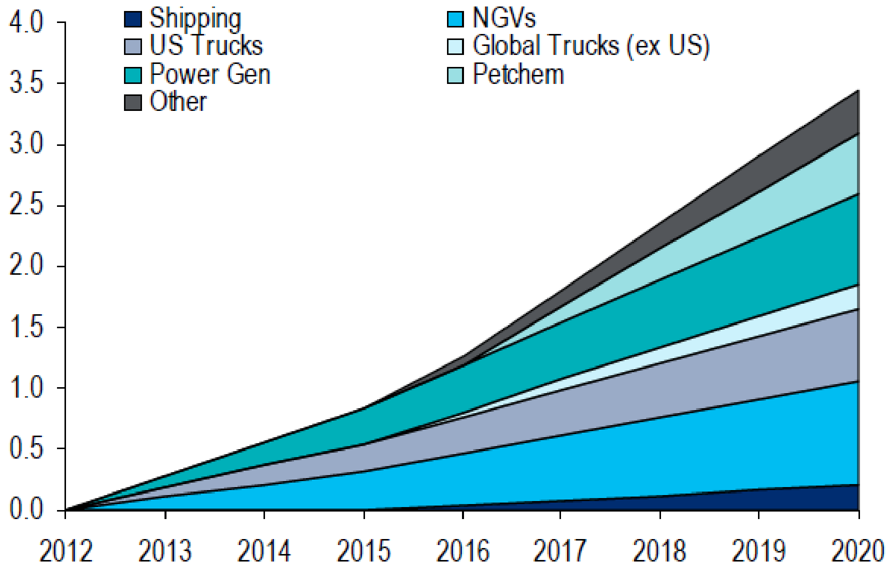
Global Oil Demand Growth – The End Is Nigh

Figure 1. Global Oil Demand Projections:-mb/d



Source: Citi Research

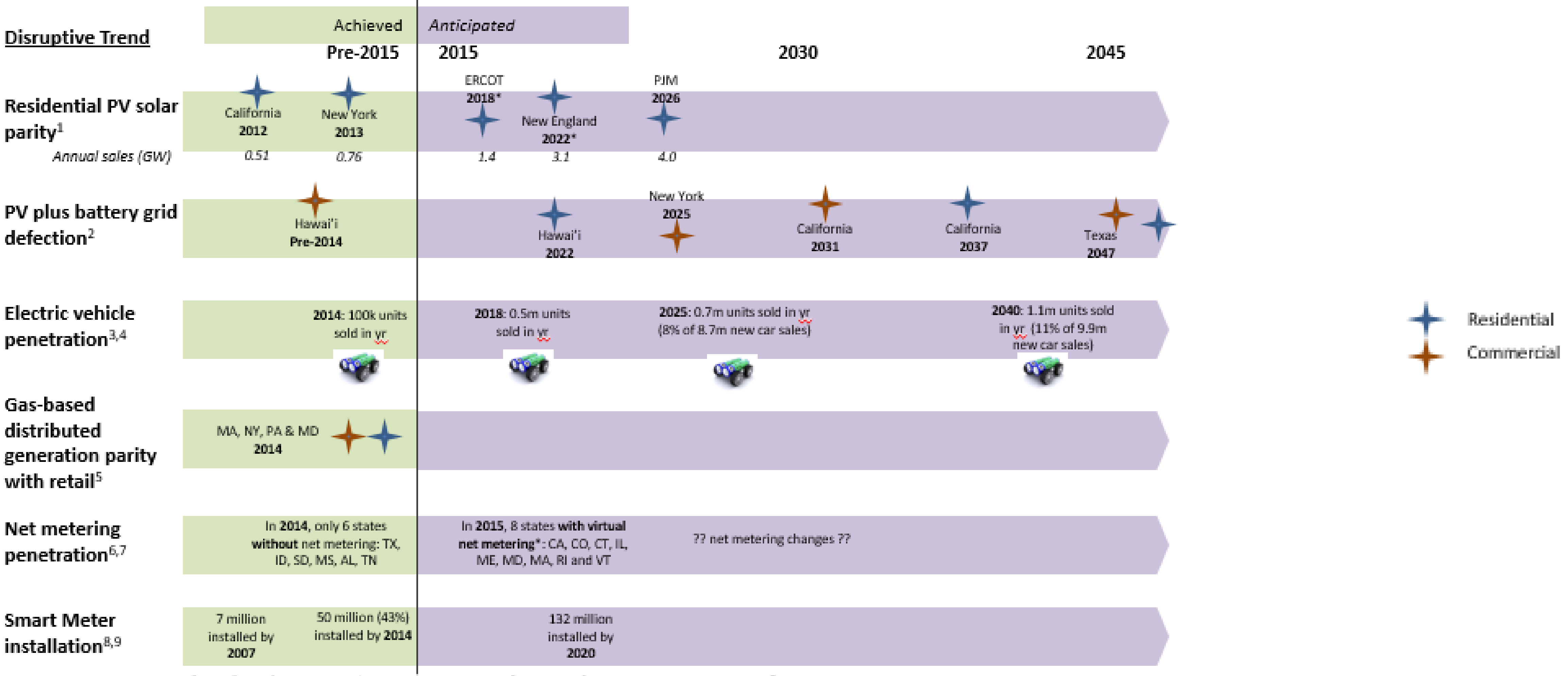
Figure 2. Potential Natural Gas Substitution For Oil:-mb/d



Source: Citi Research

RETHINKING TRANSITIONS: INCUMBENCY

THE ENERGY TRANSITION IS ALREADY HAPPENING?



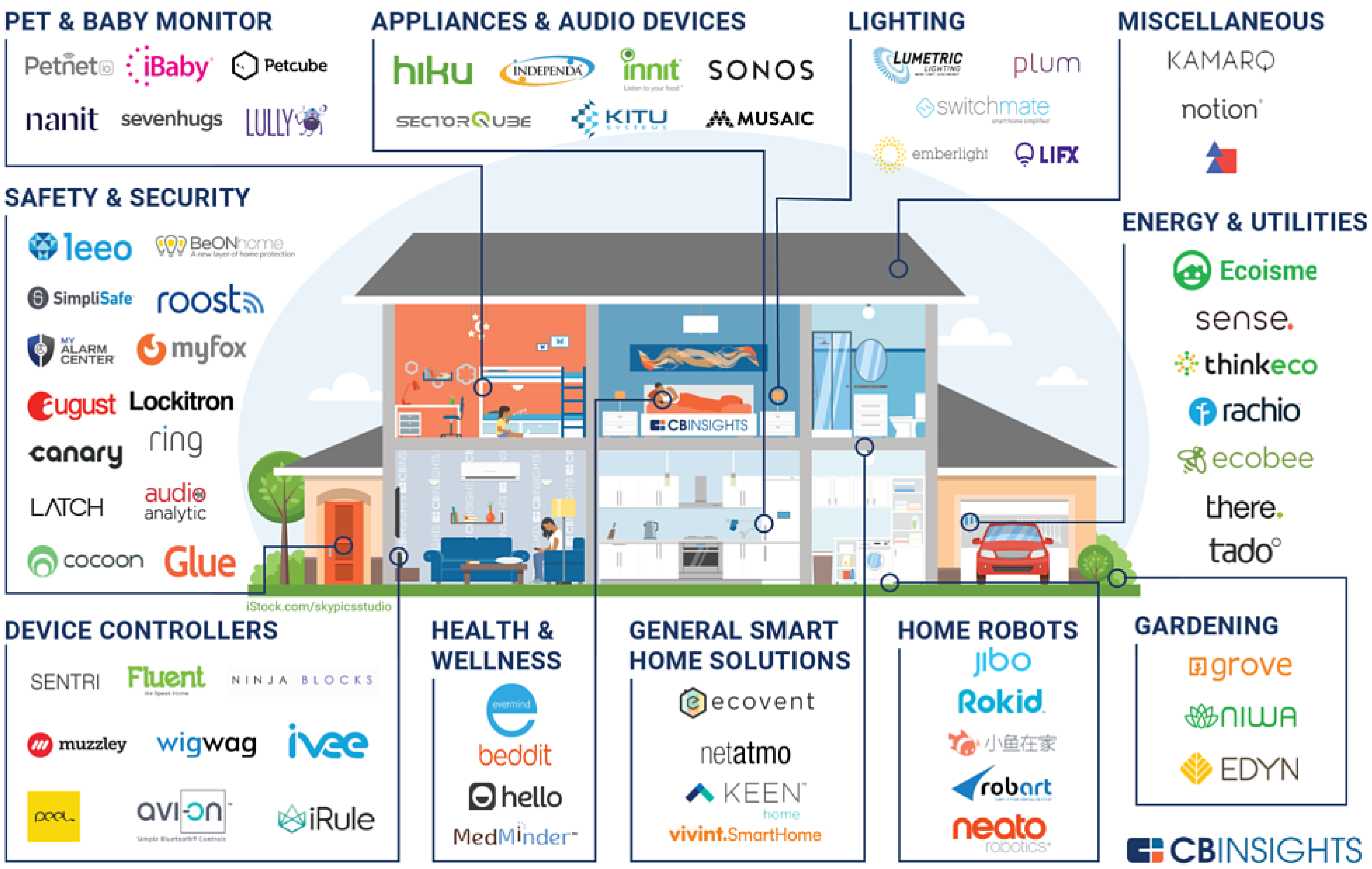
[1] Bloomberg New Energy Finance; [2] EPRI; [3] UBS; [4] U.S. Energy Information Administration; [5] GDF SUEZ; [6] Renewable Energy World.com; [7] Seia.org; [8] IIE; [9] Telefonica

* Enables multiple homeowners to participate in the same metering system and share the output from a single facility that is not physically connected to their property or meter

SHIFTS IN BUSINESS MODELS AND VALUE CREATION ALONGSIDE TECHNOLOGY

Trends pushing down the cost of solar, other renewables and energy efficiency	Examples
Increasing technical innovation	• New battery chemistries • New solar PV technologies
Synergistic solutions increasing the value of renewables	• **Solar PV + battery storage** • **IT and storage for peak shaving**
Data and internet of things increasing integration	• Sensors • Predictive software • Demand response automation
Innovative business models increasing customer bases	• Analytics and prediction • Market assessment • Value beyond energy
Innovative financing reducing cost of capital	• Third-party financing • Green bonds • YieldCos

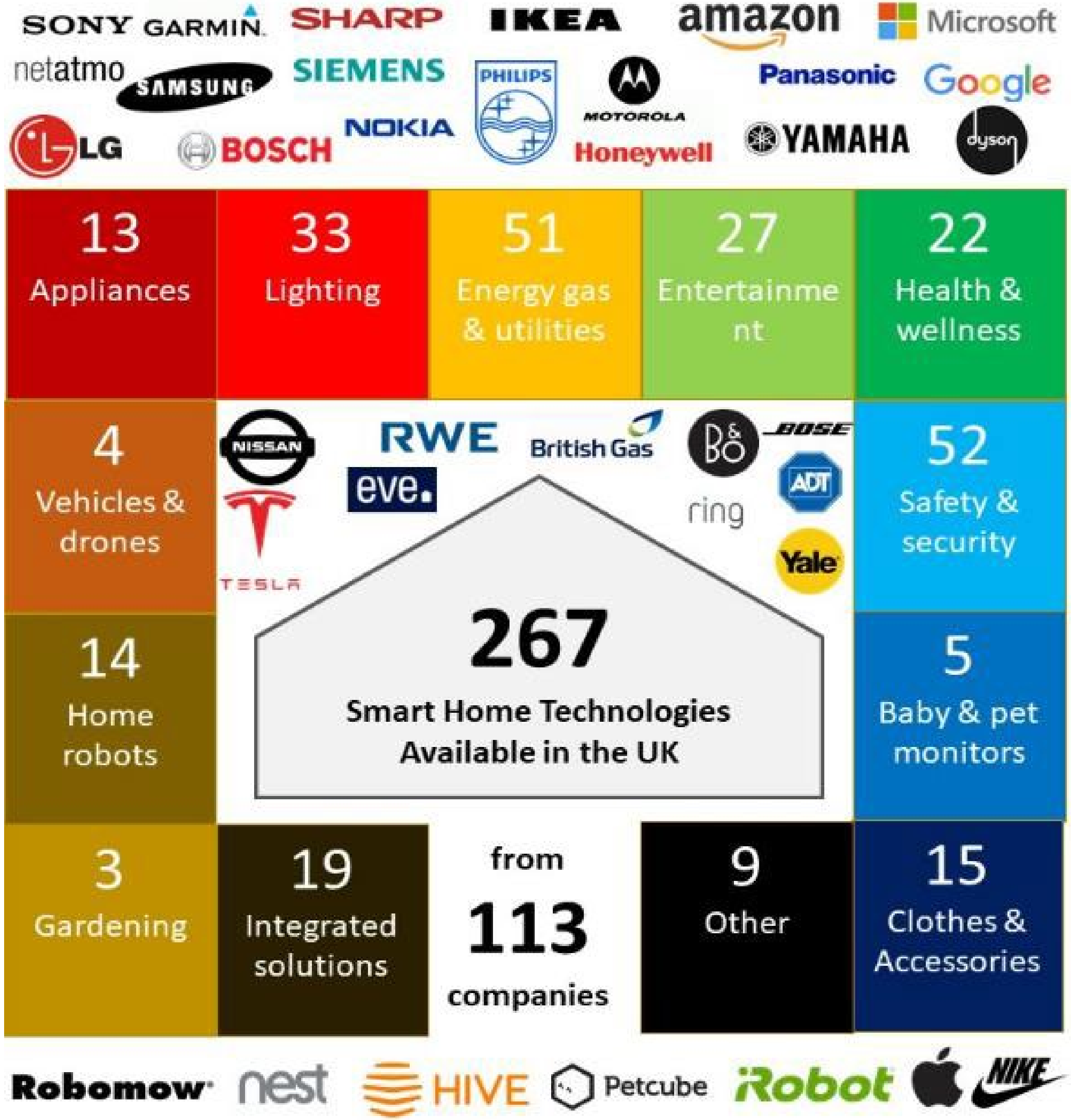
67 STARTUPS MAKING YOUR HOME SMARTER



CBINSIGHTS

Shop Visit	Appliances	Lighting	Energy, gas and utility	Entertainment	Health and wellness	Safety and security	Integrated solutions	Vehicles and drones	Home robots	Baby and pet monitors	Gardening	Clothes and accessories	Others
1		x											
2						x							
3	x	x	x	x	x	x	x		x			x	
4		x	x	x		x	x					x	
5	x	x	x	x	x	x	x					x	
6		x	x	x	x	x	x			x		x	
7		x	x										
8						x							
9						x							
10	x	x	x	x	x	x	x					x	
11		x	x	x	x	x	x	x	x		x	x	x
12				x								x	x
13		x	x	x	x	x	x			x		x	
14				x	x					x			
15	x	x	x	x		x	x					x	
16						x	x					x	x
17				x			x						
18		x	x	x	x	x	x	x	x		x	x	x
19	x	x	x	x	x	x	x		x			x	
20						x	x					x	x
21		x	x	x	x	x	x	x	x			x	x
22	x	x	x	x		x	x	x		x		x	
23						x							
24		x	x	x		x	x					x	
25				x			x					x	
26		x	x	x	x	x	x	x	x		x	x	x
27						x	x					x	x
28		x	x	x		x	x					x	
29		x	x	x		x	x					x	
30		x	x	x	x	x	x	x	x		x	x	x
31				x			x					x	
32		x	x	x	x	x	x		x	x		x	
33		x		x		x	x					x	
34							x					x	
35		x	x	x	x	x	x	x	x		x	x	x
36						x							
37						x							

Source: Sovacool, BK and DD Furszyfer Del Rio. “Smart home technologies in Europe: A critical review of concepts, benefits, risks and policies,” *Renewable & Sustainable Energy Reviews* 120 (March, 2020), 109663, pp. 1-20.


SONY
GARMIN
SHARP
IKEA
amazon
Microsoft
netatmo
SAMSUNG
SIEMENS
PHILIPS
MOTOROLA
Panasonic
Google
LG
BOSCH
NOKIA
Honeywell
YAMAHA
dyson
13
Appliances
33
Lighting
51
Energy gas & utilities
27
Entertainment
22
Health & wellness
4
Vehicles & drones
NISSAN
TESLA
RWE
eve.
British Gas
B&O
BOSE
ADT
ring
Yale
52
Safety & security
14
Home robots
267
Smart Home Technologies Available in the UK
5
Baby & pet monitors
3
Gardening
19
Integrated solutions
from
113
companies
9
Other
15
Clothes & Accessories
Robomow
nest
HIVE
Petcube
iRobot
NIKE

CONCLUDING REMARKS AND INSIGHTS

- Definitions abound: Whether an energy transition can occur quickly or slowly can depend in great deal about how it is defined, so always check sources, data, assumptions, thresholds, coupling/scale/unit of analysis, etc.
- The academy has no shortage of conceptual tools grappling with transitions, but in some ways this is its own quagmire
  - ✓ Implies none or few have strong resonance with scholars or puzzles?
  - ✓ Or, reflects the true breadth of intellectual scholarship?
  - ✓ All are useful, but all are also wrong?
  - ✓ MLP and social practice appear currently "hot"

CONCLUDING REMARKS AND INSIGHTS

- Causes are complex: WW2 (France and Kuwait), rural famine (China), 1970s oil crises (Denmark, Brazil), demand (AC in USA)
- Future transitions could be driven by active governance (phase-outs), scarcity, and demand pressures including pandemics (e.g., Covid-19), rather than supply, markets, or abundance
- The past need not be prologue; history can be instructive but not necessarily predictive

CONTACT INFORMATION

Benjamin K. Sovacool

Director, IGS

sovacool@bu.edu
/benjamin-sovacool-3b7b46
@BenjaminSovaco1