# Science and policy for the energy and climate transition

## Keynote Address to the 1st Energy & Environment Clustering Event on "Energy, environment and us: Circular economy and the role of citizens," Durham University, UK, September 23-24 2019


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*Professor of Energy Policy*

*Professor of Business & Social Sciences*

*Director of the Sussex Energy Group*

*Director of the Center for Energy Technologies*

# 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?

**Table 1**
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] |

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.

# Conceptualizing energy transitions

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

**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.

# Conceptualizing energy transitions

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*Original Article*

Science, Technology, & Human Values
1-32

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**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

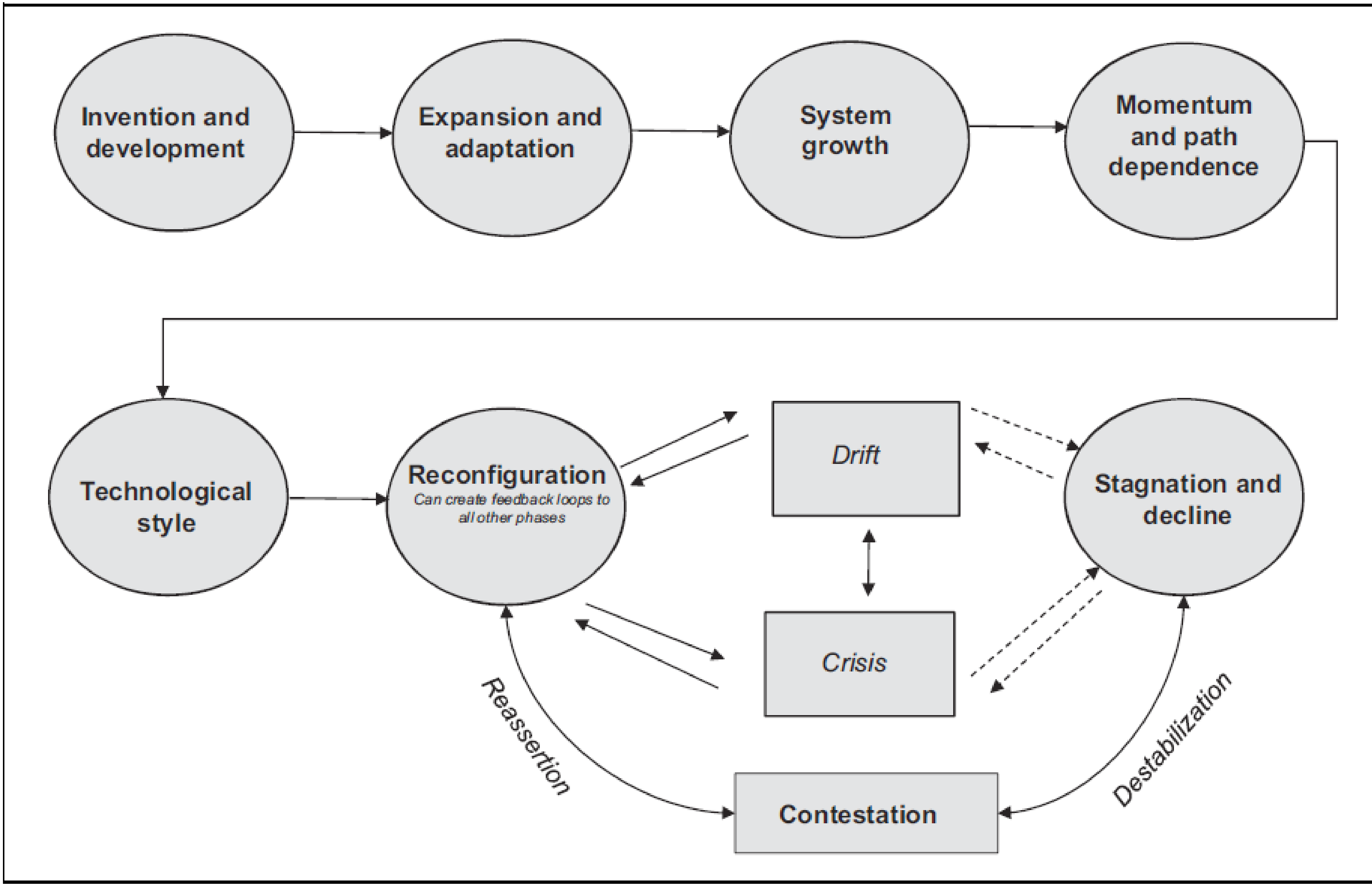


**Figure 2.** Eight conceptual phases of large technical systems. Source: Authors.

# Conceptualizing energy transitions

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**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

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*Original Article*

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Social Studies of Science
1–48

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## Ordering theories: Typologies and conceptual frameworks for sociotechnical change

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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

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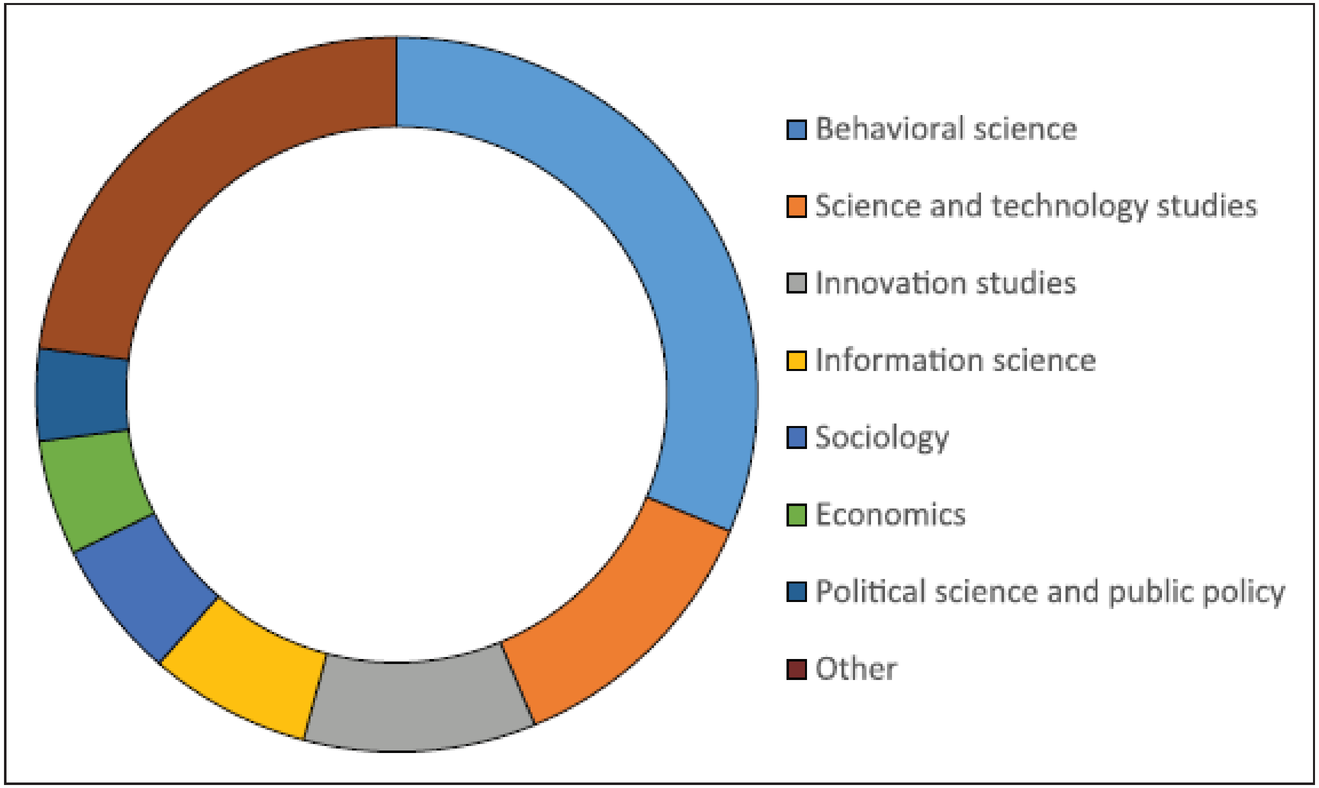


**Figure 2.** Academic discipline for selected theories (n = 96). 'Other' disciplines include history, organization studies, political ecology and geography, transport studies, business studies, communication studies, conflict resolution, consumption studies, development studies, energy studies, ethics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

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**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 |

# Temporality and energy transitions

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- *"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 |
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| Core | England | 1736 | 160 |
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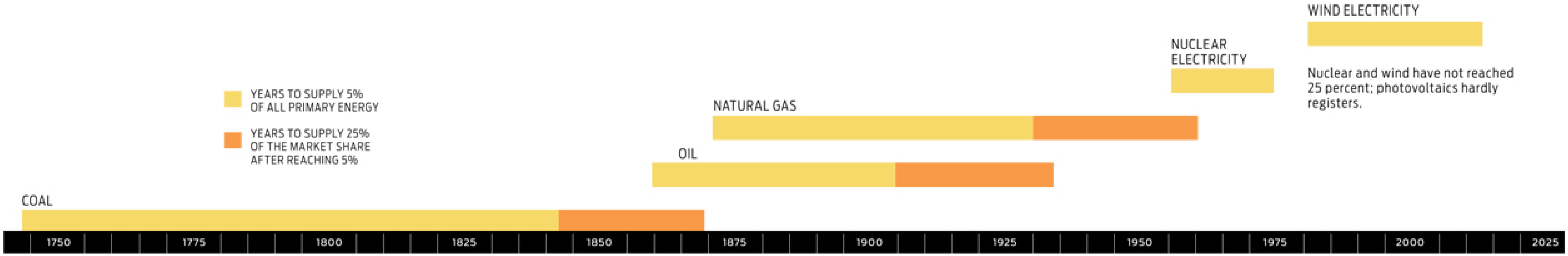
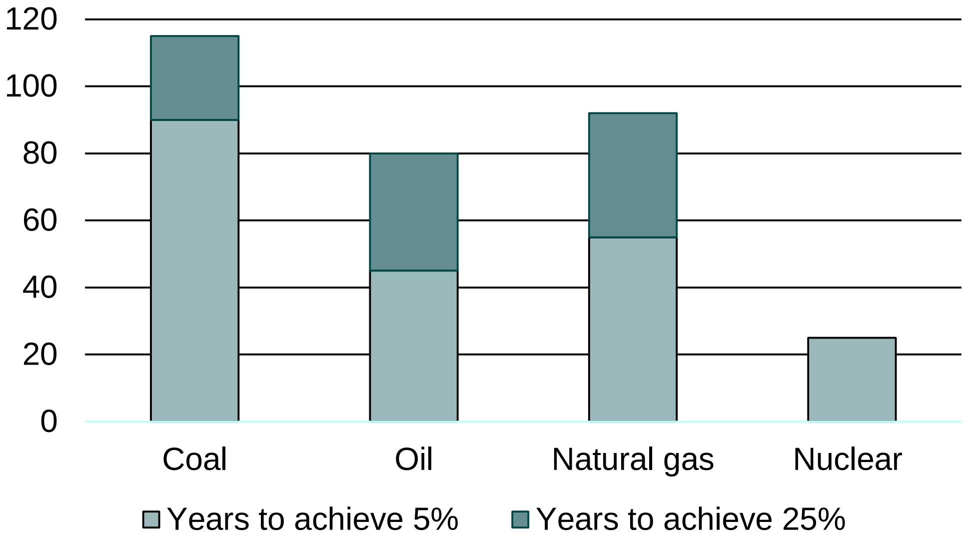
# Temporality and energy transitions



# Temporality and energy transitions

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

Contents lists available at ScienceDirect

Energy Research & Social Science

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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

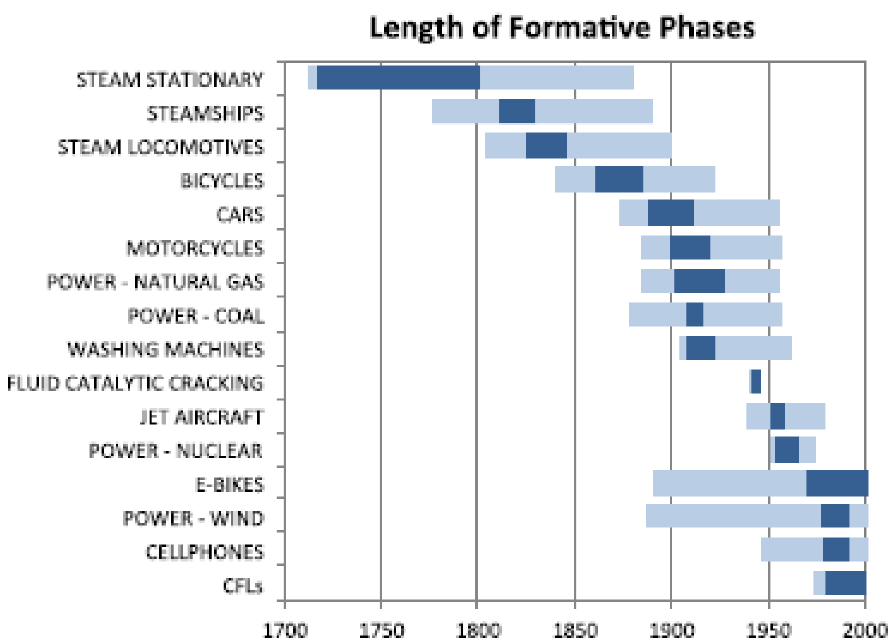



**Fig. 1.** Durations of formative phases for energy technologies are at a decadal scale [4]. Note: Ranges refer to alternative definitions for the start and end points of formative phases, and so capture measurement uncertainties.

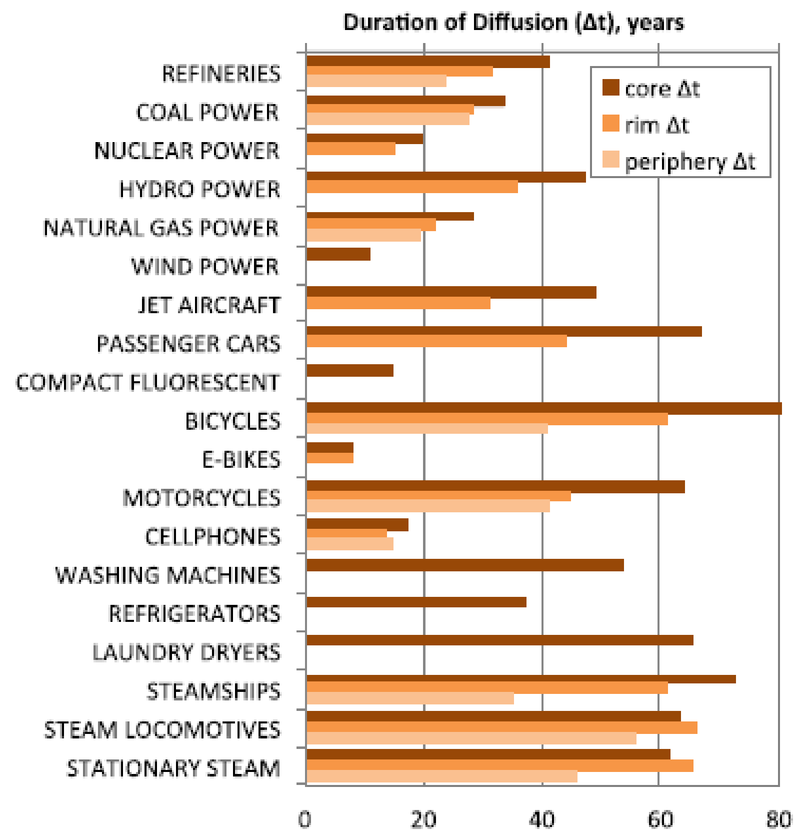
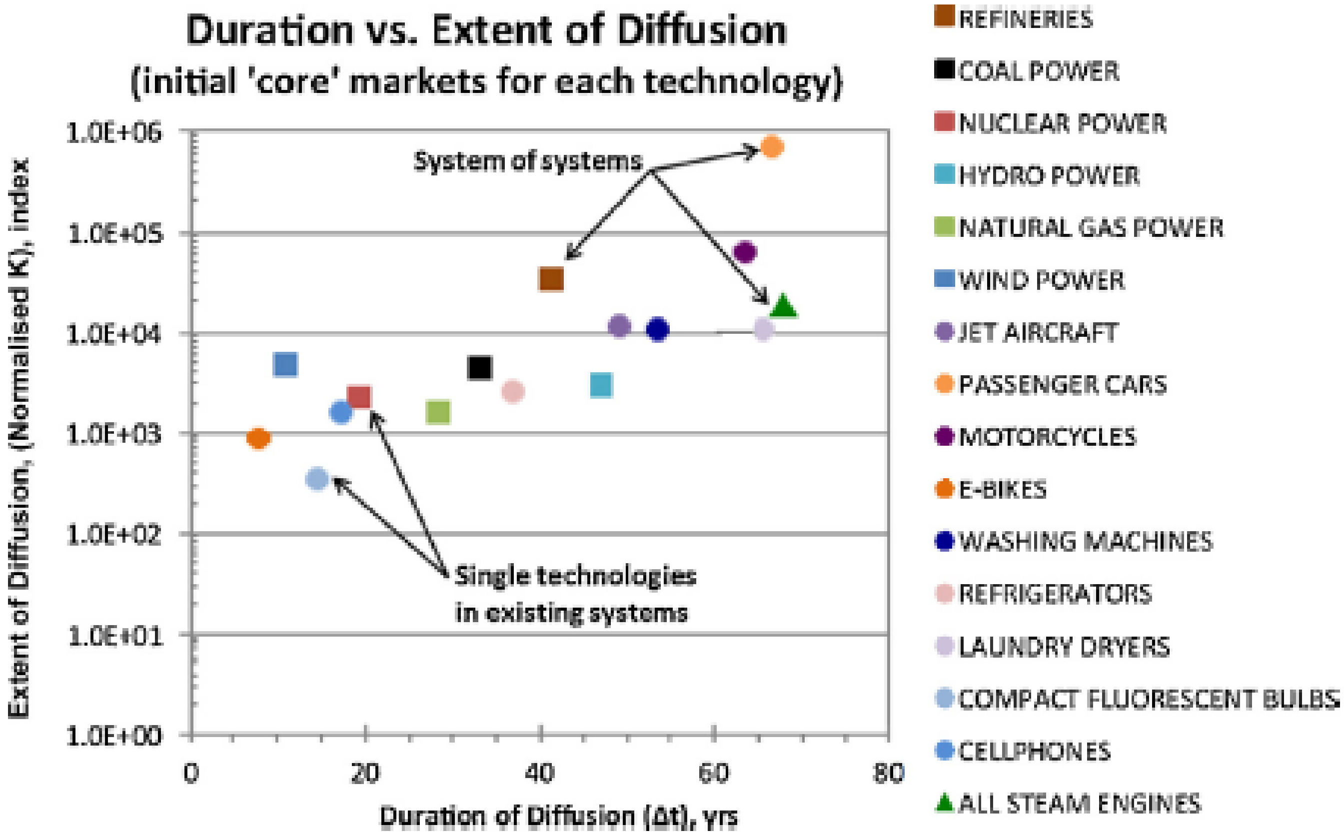



**Fig. 2.** Diffusion speeds accelerate as technologies diffuse spatially. Notes: Bars show durations of diffusion measured by cumulative total capacity installed, with historical data fitted via a logistic growth curve and the diffusion duration expressed as $\Delta t$ in years. 'Core' is typically 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

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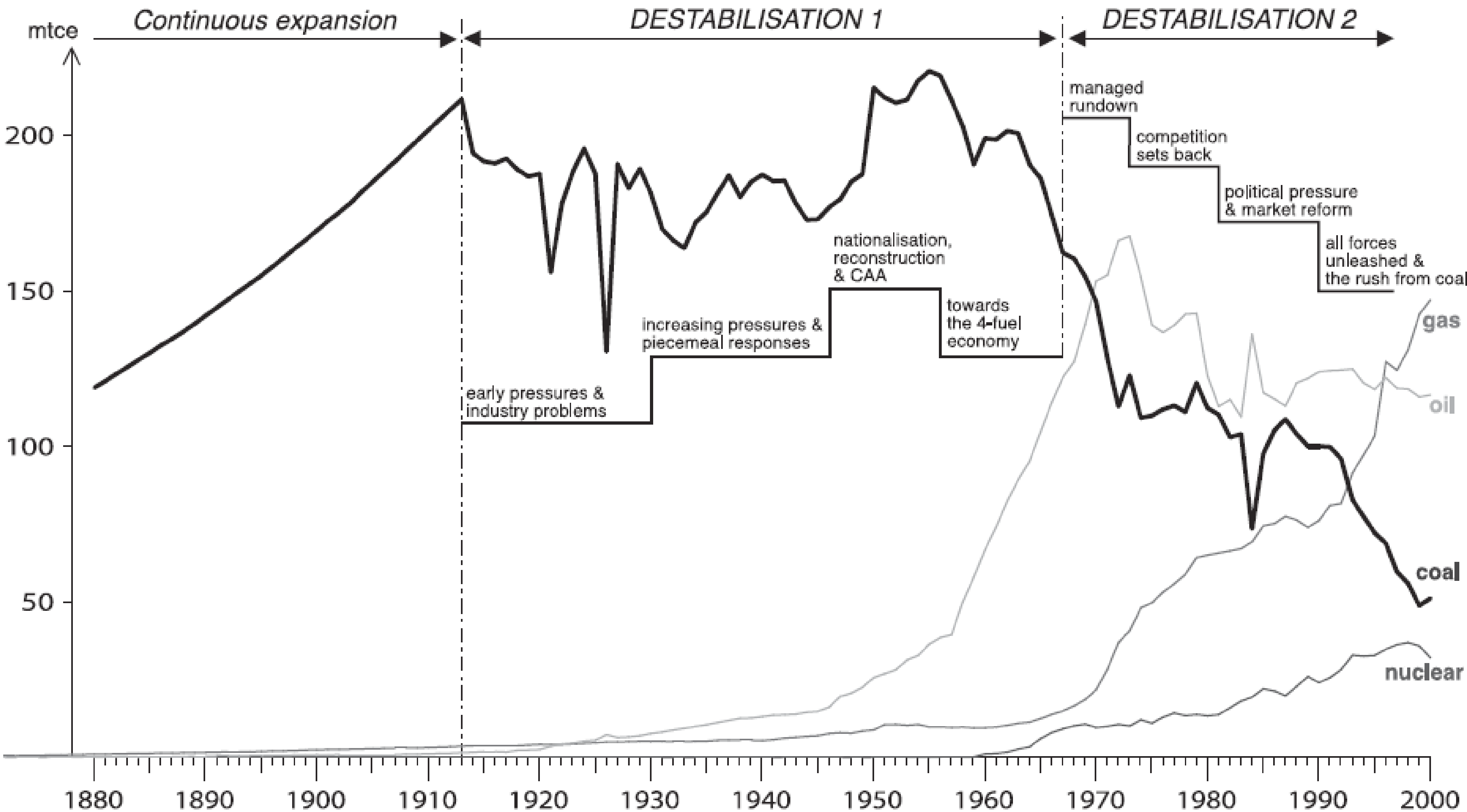
ENERGY POLICY

## 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)?

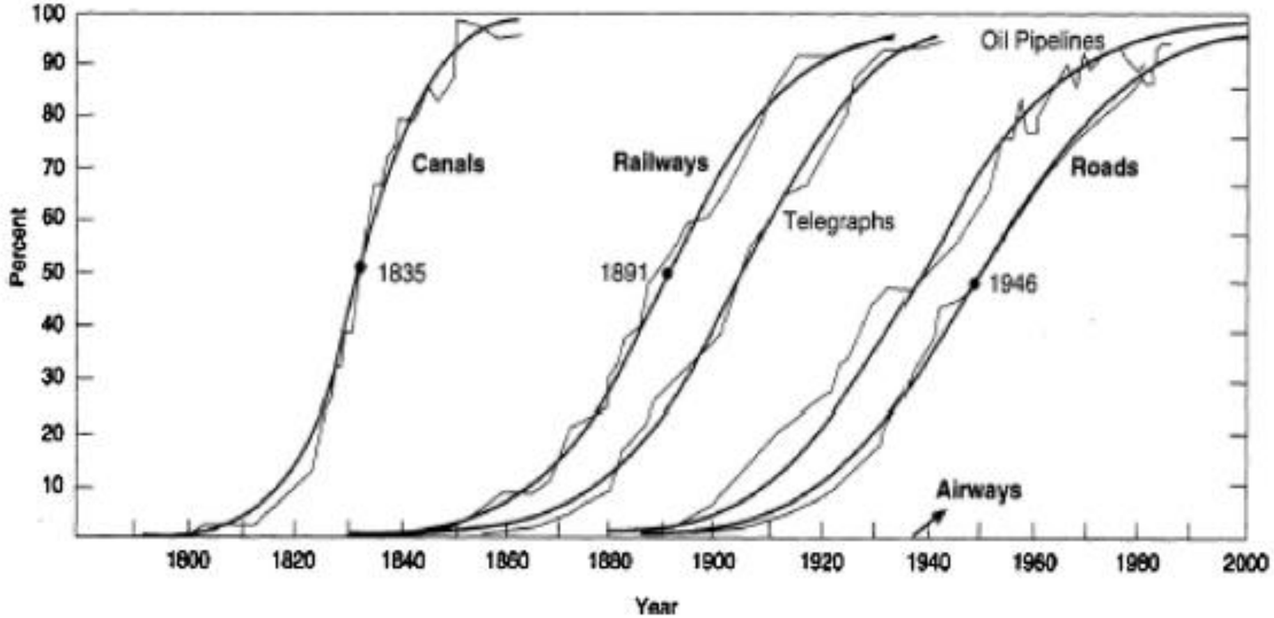



**Fig. 1.** Growth of Infrastructures in the United States as a Percentage of their Maximum Network Size.

- *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?

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- 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 the historical record

**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?

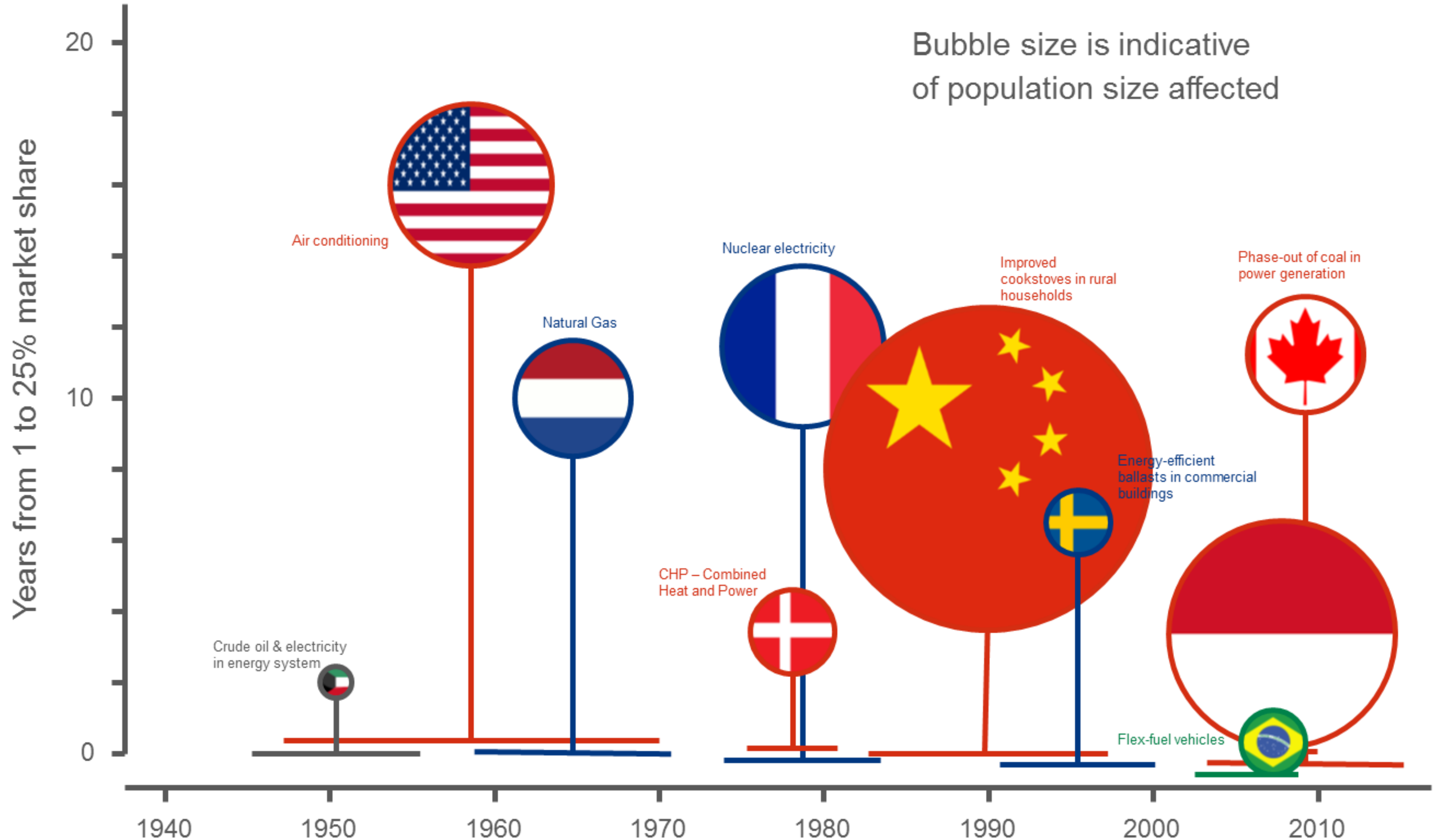


*Figure designed by Gert Jan Kramer, used with permission*

# Rethinking transitions: towards acceleration?

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

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Short communication

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

CrossMark

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**

### 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).


### About the authors:

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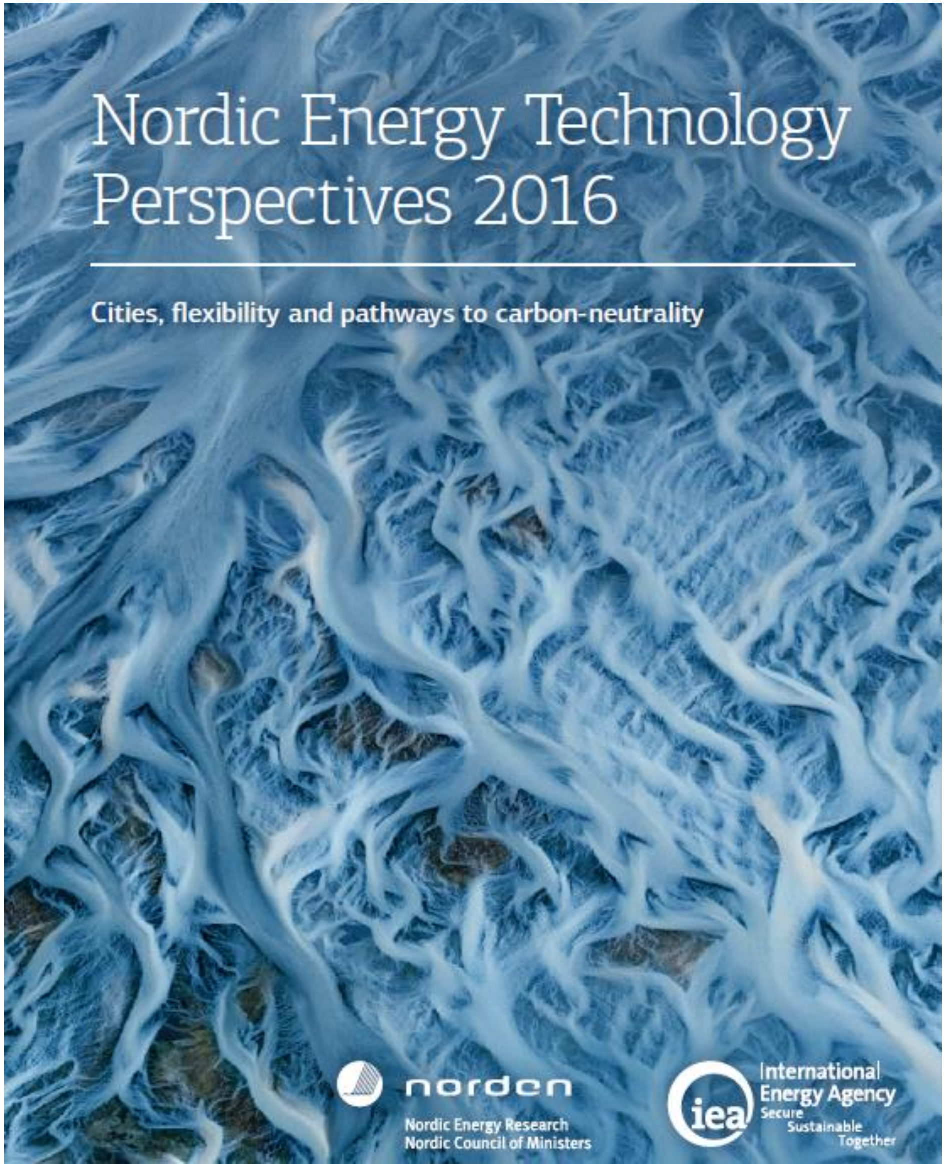
### About this briefing:


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

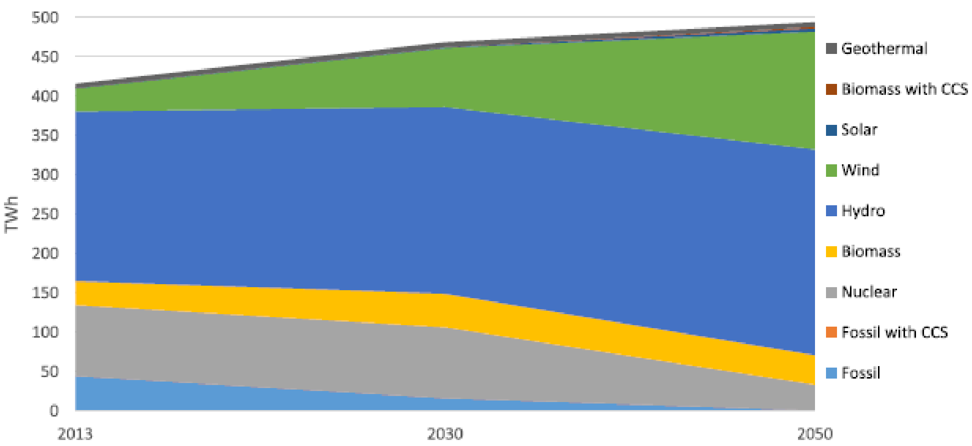
# Rethinking transitions

Centre on Innovation and Energy Demand

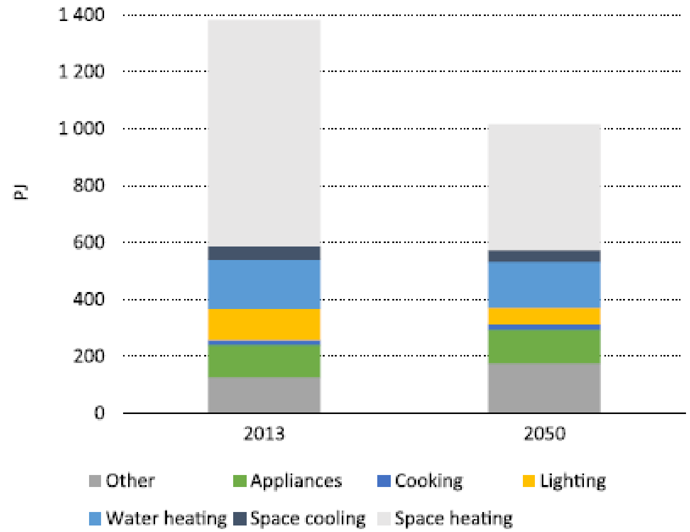


# Rethinking transitions: electricity, heat, and buildings

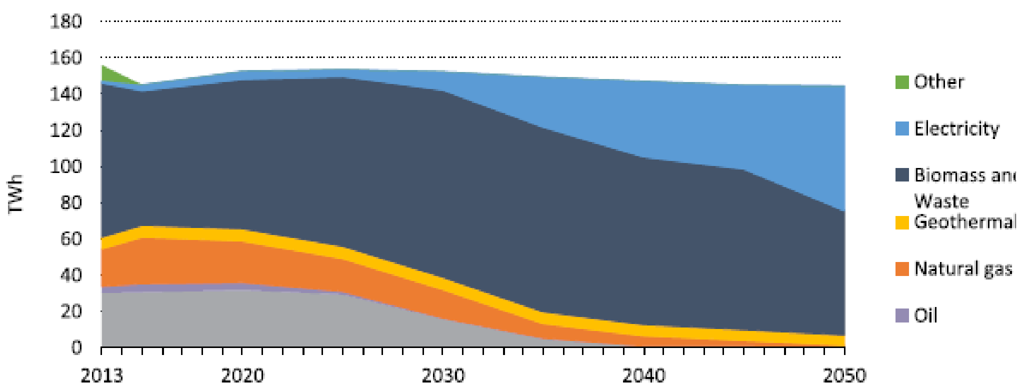
*a. Top panel: Electricity generation*



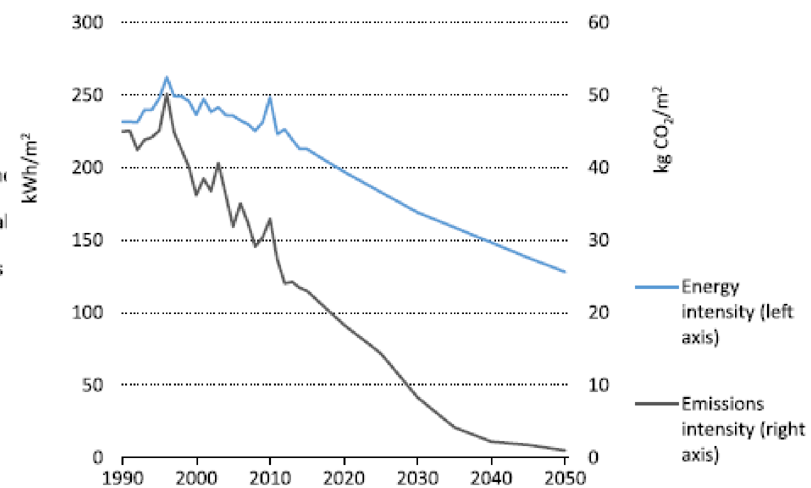

*a. Top panel: Buildings energy consumption, 2013 and 2050*




*b. Bottom panel: heat supply*

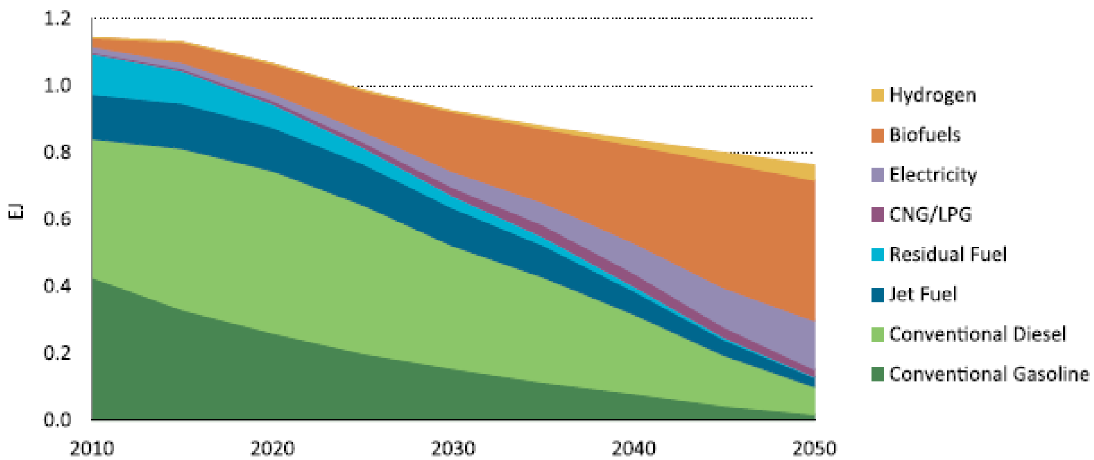



*b. Bottom panel: Energy intensity and emission intensity, 1990 to 2050*

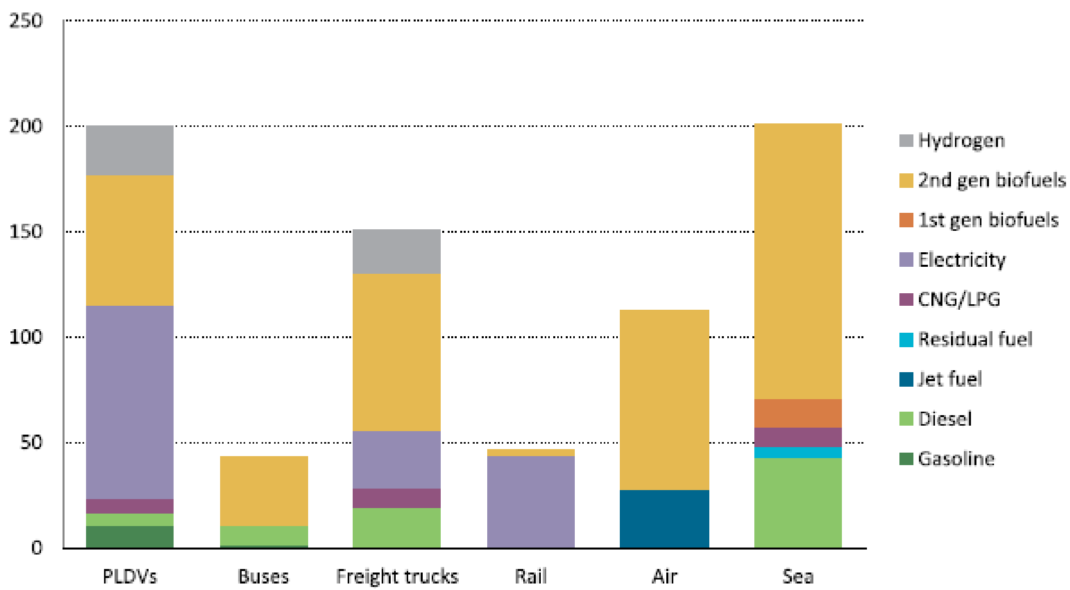


# Rethinking transitions: transport and mobility

*a. Top panel: by fuel source, 2010-2050*




*b. Bottom panel: by transportation mode, 2050*



# Rethinking transitions: affordability

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Contestation, contingency, and justice in the Nordic low-carbon energy transition

Benjamin K. Sovacool[a,b,*]

**Table 3**
Cumulative Nordic Investments for Decarbonization by Sector, 2016–2050.
Source: Modified from International Energy Agency and Nordic Energy Research, Nordic Energy Technology Perspectives 2016 (Paris: OECD, 2016). Assumes the Carbon Neutral Scenario.

| Sector | $ (USD Billion) |
|---|---|
| Energy-related investments in buildings | 326 |
| Industry | 103 |
| Transport: vehicles | 1,674 |
| Transport: infrastructure | 1,121 |
| Power: generation | 197 |
| Power: infrastructure | 151 |
| Total | 3,572 |

- The total cost of the Nordic transition is roughly $3.57 trillion
- It requires an additional investment of only $333 billion
- This is less than 1% of cumulative GDP over the period
- If you monetize air pollution and fuel savings, it tips the economic equation firmly in favour of the transition

# Rethinking transitions: Changes in demand preferences, demand “peaks?”

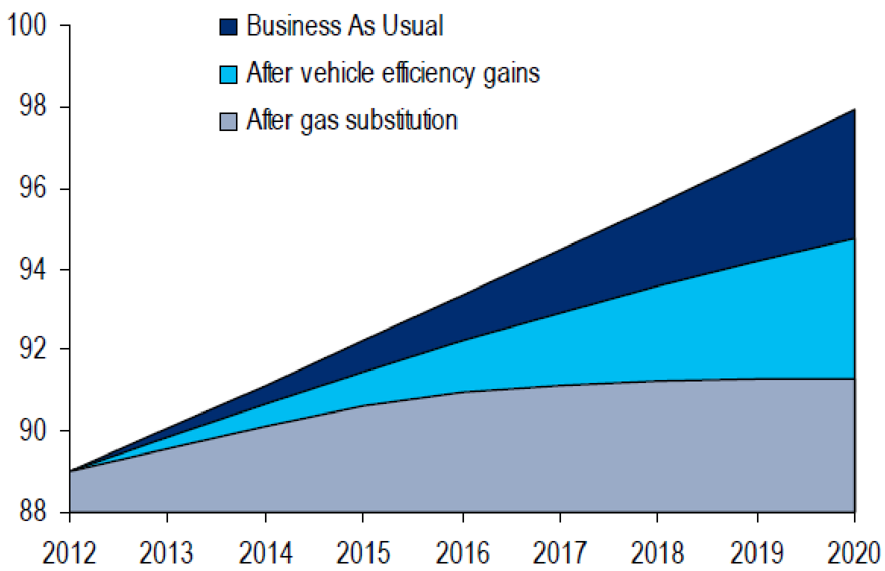
Centre on Innovation and Energy Demand

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

Citi Research

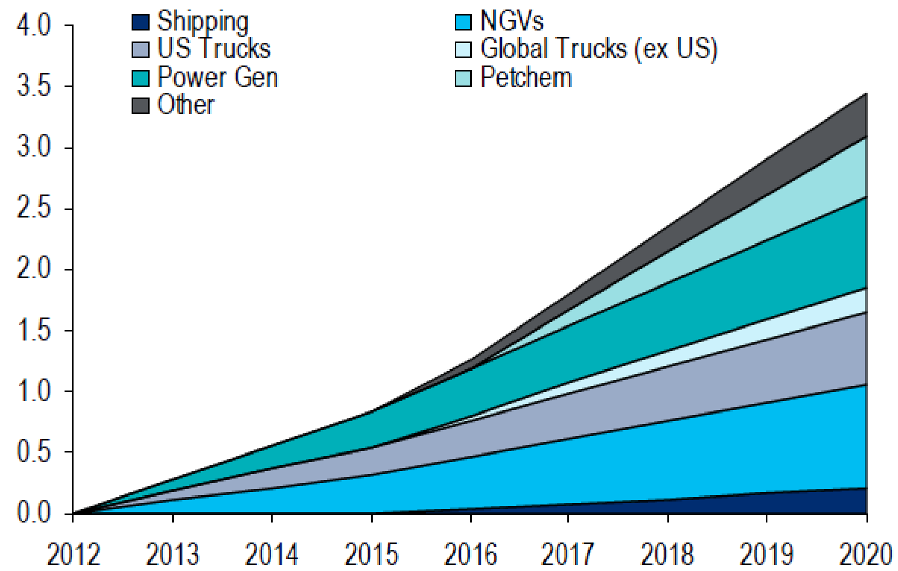
## Global Oil Demand Growth – The End Is Nigh

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?

| Disruptive Trend | Achieved: Pre-2015 | Anticipated: 2015 – 2030 – 2045 |
|---|---|---|
| Residential PV solar parity[1] | California 2012; New York 2013 | ERCOT 2018*; New England 2022*; PJM 2026 |
| *Annual sales (GW)* | *0.51*; *0.76* | *1.4*; *3.1*; *4.0* |
| PV plus battery grid defection[2] | Hawai'i Pre-2014 | Hawai'i 2022; New York 2025; California 2031; California 2037; Texas 2047 |
| Electric vehicle penetration[3,4] | **2014**: 100k units sold in yr | **2018**: 0.5m units sold in yr; **2025**: 0.7m units sold in yr (8% of 8.7m new car sales); **2040**: 1.1m units sold in yr (11% of 9.9m new car sales) |
| Gas-based distributed generation parity with retail[5] | MA, NY, PA & MD 2014 | |
| Net metering penetration[6,7] | In **2014**, only 6 states **without** net metering: TX, ID, SD, MS, AL, TN | In **2015**, 8 states **with virtual net metering***: CA, CO, CT, IL, ME, MD, MA, RI and VT; ?? net metering changes ?? |
| Smart Meter installation[8,9] | 7 million installed by **2007**; 50 million (43%) installed by **2014** | 132 million installed by **2020** |

[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

Residential

Commercial

# 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<br>• New solar PV technologies |
| Synergistic solutions increasing the value of renewables | • Solar PV + battery storage<br>• IT and storage for peak shaving |
| Data and internet of things increasing integration | • Sensors<br>• Predictive software<br>• Demand response automation |
| Innovative business models increasing customer bases | • Analytics and prediction<br>• Market assessment<br>• Value beyond energy |
| Innovative financing reducing cost of capital | • Third-party financing<br>• Green bonds<br>• YieldCos |

# 67 STARTUPS MAKING YOUR HOME SMARTER

## PET & BABY MONITOR
Petnet.io, iBaby, Petcube, nanit, sevenhugs, LULLY

## APPLIANCES & AUDIO DEVICES
hiku, INDEPENDA, innit, SONOS, SECTORQUBE, KITU SYSTEMS, MUSAIC

## LIGHTING
LUMETRIC LIGHTING, plum, switchmate, emberlight, LIFX

## MISCELLANEOUS
KAMARQ, notion

## SAFETY & SECURITY
leeo, BeONhome, SimpliSafe, roost, MY ALARM CENTER, myfox, august, Lockitron, canary, ring, LATCH, audio analytic, cocoon, Glue

## ENERGY & UTILITIES
Ecoisme, sense, thinkeco, rachio, ecobee, there., tado°


iStock.com/skypicsstudio

## DEVICE CONTROLLERS
SENTRI, Fluent, NINJA BLOCKS, muzzley, wigwag, ivee, peel, avi-on, iRule

## HEALTH & WELLNESS
evermind, beddit, hello, MedMinder

## GENERAL SMART HOME SOLUTIONS
ecovent, netatmo, KEEN home, vivint.SmartHome

## HOME ROBOTS
jibo, Rokid, 小鱼在家, robart, neato robotics

## GARDENING
grove, NIWA, EDYN

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 | | | | | | | |

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13 Appliances

33 Lighting

51 Energy gas & utilities

27 Entertainment

22 Health & wellness

4 Vehicles & drones

52 Safety & security

**267**

**Smart Home Technologies Available in the UK**

14 Home robots

5 Baby & pet monitors

3 Gardening

19 Integrated solutions

from **113** companies

9 Other

15 Clothes & Accessories

# Decarbonisation as an interdisciplinary challenge (policy mixes)

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comment

## Towards demand-side solutions for mitigating climate change

Research on climate change mitigation tends to focus on supply-side technology solutions. A better understanding of demand-side solutions is missing. We propose a transdisciplinary approach to identify demand-side climate solutions, investigate their mitigation potential, detail policy measures and assess their implications for well-being.

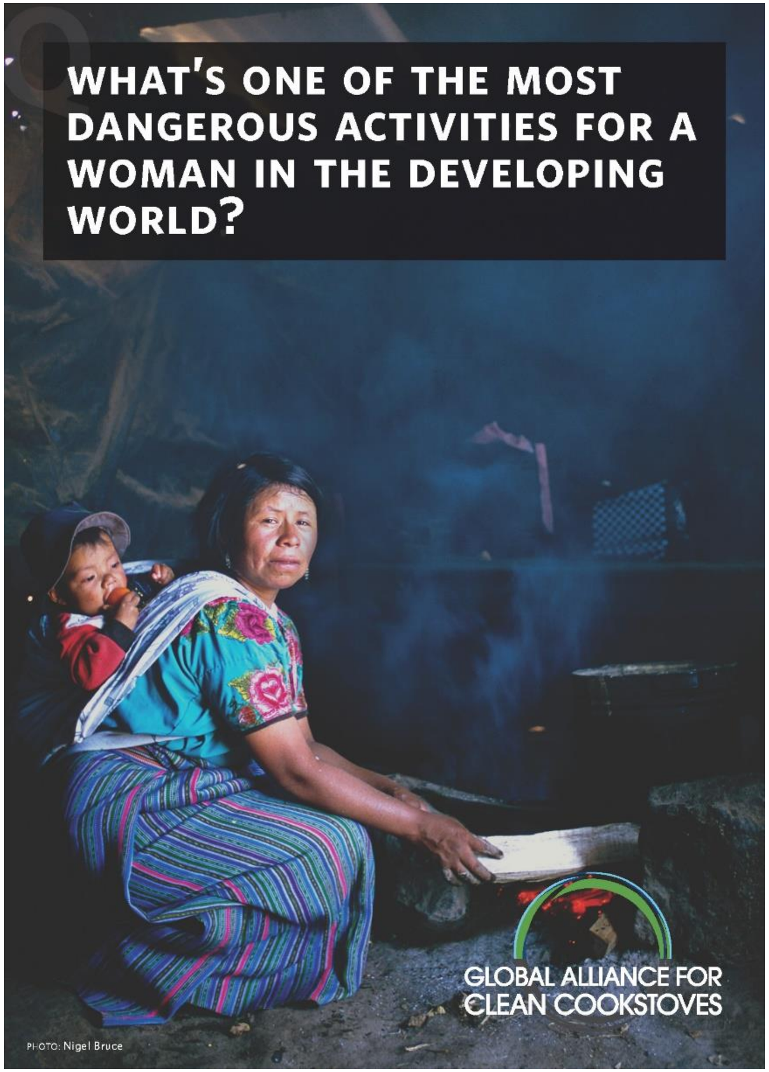
Felix Creutzig, Joyashree Roy, William F. Lamb, Inês M. L. Azevedo, Wändi Bruine de Bruin, Holger Dalkmann, Oreane Y. Edelenbosch, Frank W. Geels, Arnulf Grubler, Cameron Hepburn, Edgar G. Hertwich, Radhika Khosla, Linus Mattauch, Jan C. Minx, Anjali Ramakrishnan, Narasimha D. Rao, Julia K. Steinberger, Massimo Tavoni, Diana Ürge-Vorsatz and Elke U. Weber

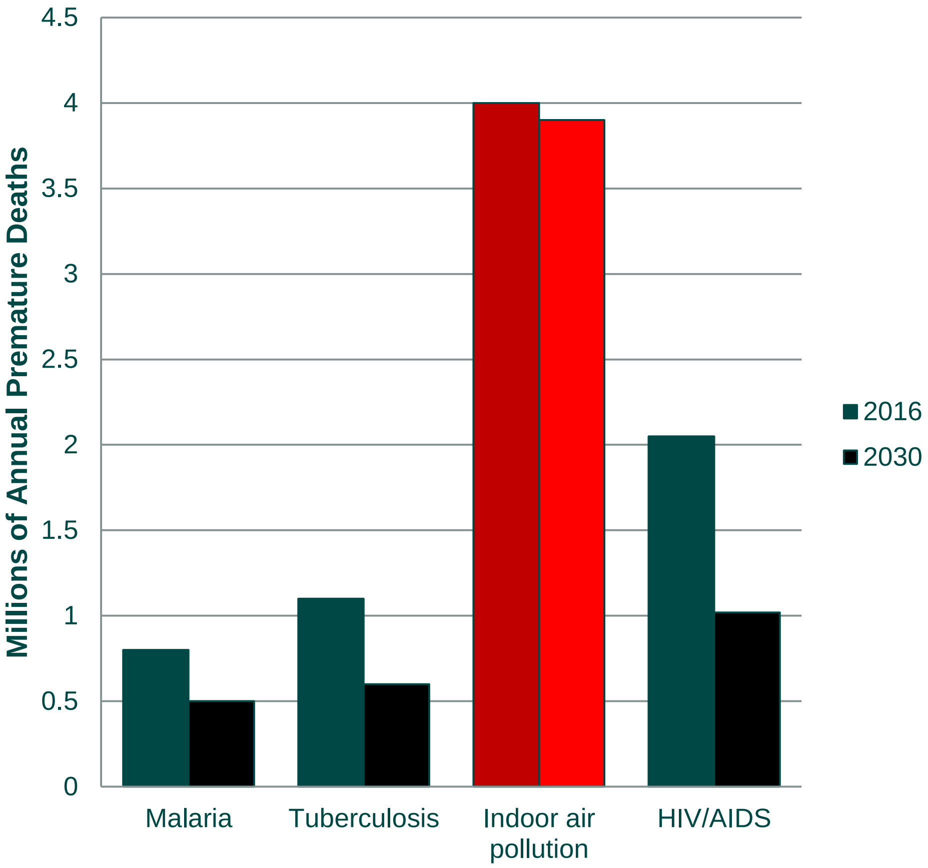
**Table 1 | Illustrative 'avoid-shift-improve' options in different sectors and services**

| | Service | Avoid | Shift | Improve |
|---|---|---|---|---|
| Transport | AccessibilityMobility | Integrate transport and land-use planningSmart logisticsTeleworkingCompact cities | Mode shift from car to cycling, walking, or public transit | Electric two-, three- and four-wheelersEco-drivingElectric vehiclesSmaller, light weight vehicles |
| Buildings | Shelter | Passive house or retrofit (avoiding demand for heating/cooling)Change temperature set-points | Heat pumps, district heating and coolingCombined heat and powerInvertor air conditioning | Condensing boilersIncremental insulation optionsEnergy-efficient appliances |
| Manufactured products and services | ClothingAppliances | Long-lasting fabric, appliances, sharing economyEco-industrial parks, circular economy | Shift to recycled materials, low-carbon materials for buildings and infrastructure | Use of low-carbon fabricsNew manufacturing processes and equipment use |
| Food | Nutrition | Calories in line with daily needsFood waste reduction | Shift from ruminant meat to other protein sources where appropriate | Reuse food wasteSmaller, efficient fridgesHealthy fresh food to replace processed food |

Many options, such as urban form and infrastructures, are systemic and influence several sectors simultaneously.

# Decarbonisation as an interdisciplinary challenge (gender and cooking)



# Decarbonisation as an interdisciplinary challenge (gender and cooking)

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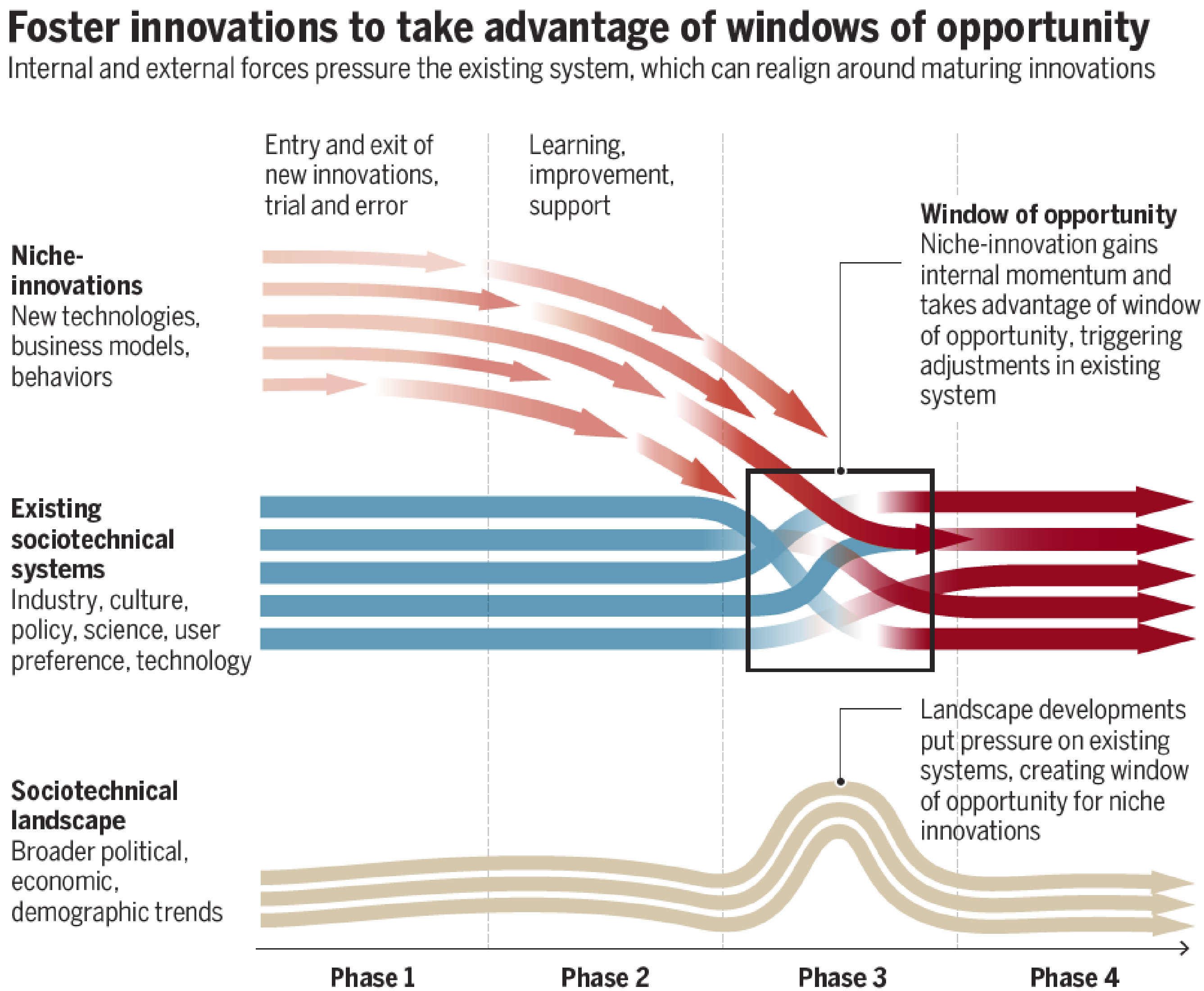
| Changing the source of pollution | Improving the living environment | Modifying user behavior |
|---|---|---|
| Improved cooking devices<br>• Improves stoves without flues<br>• Improves stoves with flues<br><br>Alternative fuel-cooker combinations<br>• Briquettes and pellets<br>• Kerosene<br>• Liquefied petroleum gas<br>• Biogas<br>• Natural gas, producer gas<br>• Solar cookers<br>• Modern biofuels (e.g. ethanol, plant oils)<br>• Electricity<br>Reduced need for fire<br>• Retained heat cooker (haybox)<br>• Efficient housing design and construction<br>• Solar water heating<br>• Pressure cooker | Improved ventilation<br>• Smoke hoods<br>• Eaves spaces<br>• Windows<br><br>Kitchen design and placement of stove<br>• Kitchen separate from house reduces exposure of family (less so for cook)<br>• Stove at waist height reduces direct exposure of the cook leaning over fire | Reduced exposure by changing cooking practices<br>• Fuel drying<br>• Pot lids to conserve heat<br>• Food preparation to reduce cooking time (e.g. soaking beans)<br>• Good maintenance of stoves, chimneys and other appliances<br><br>Reduced exposure by avoiding smoke<br>• Keeping children away from smoke (e.g. in another room if available and safe to do so) |

# Decarbonisation as an interdisciplinary challenge (multi-dimensionality)

- Transitions are a multi-scalar, polycentric process
- They are co-evolutionary and also temporally dynamic




Source: Geels, FW, BK Sovacool, T Schwanen, and S Sorrell. "Sociotechnical transitions for deep decarbonisation," *Science* 357 (6357) (September 22, 2017), pp. 1242-1244.

# Decarbonisation as an interdisciplinary challenge (energy justice)

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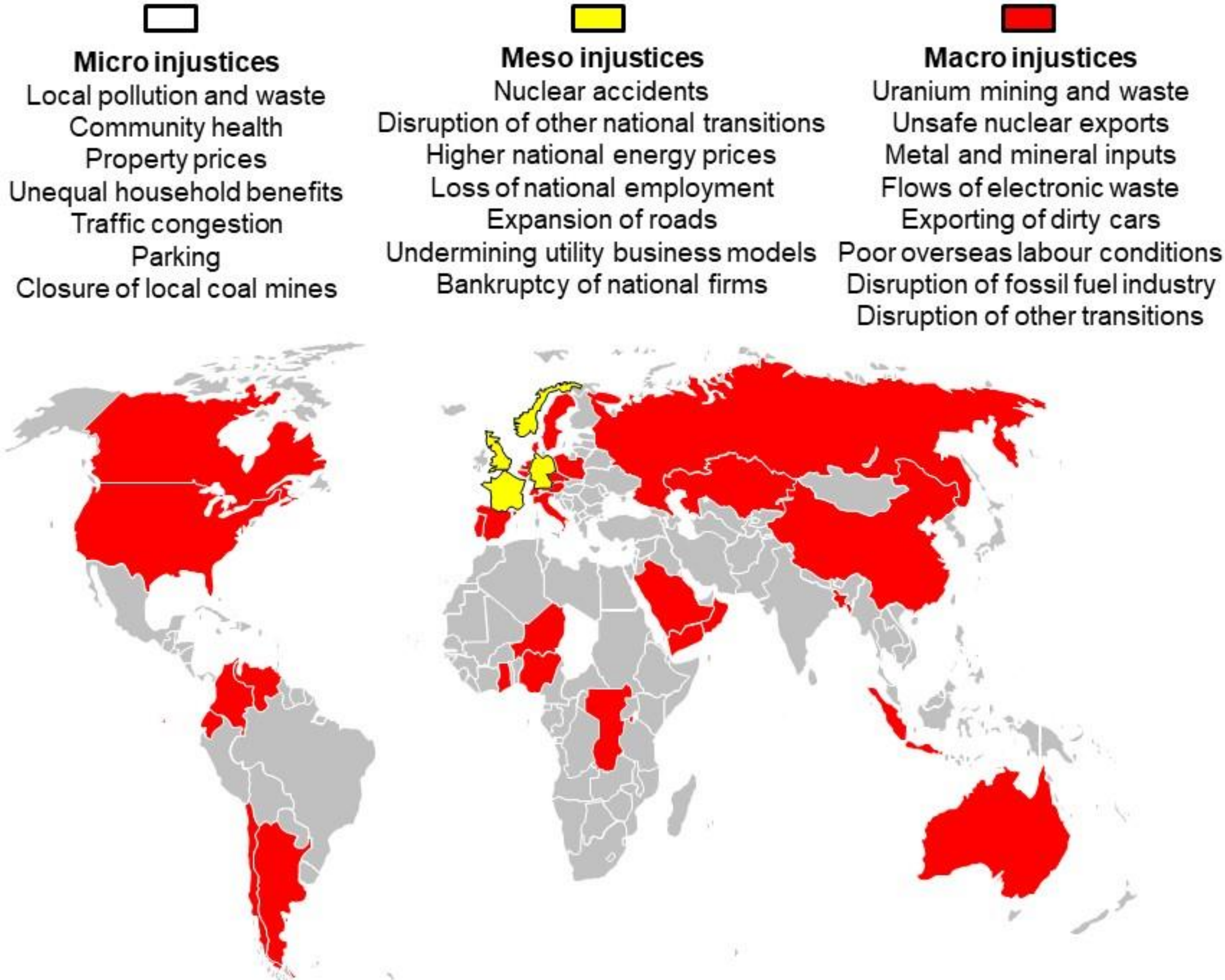
Micro injustices
Local pollution and waste
Community health
Property prices
Unequal household benefits
Traffic congestion
Parking
Closure of local coal mines
Meso injustices
Nuclear accidents
Disruption of other national transitions
Higher national energy prices
Loss of national employment
Expansion of roads
Undermining utility business models
Bankruptcy of national firms
Macro injustices
Uranium mining and waste
Unsafe nuclear exports
Metal and mineral inputs
Flows of electronic waste
Exporting of dirty cars
Poor overseas labour conditions
Disruption of fossil fuel industry
Disruption of other transitions

# Decarbonisation as an interdisciplinary challenge (energy justice)


Sovacool, BK, A Hook, M Martiskainen, and LH Baker, "Decarbonisation and its discontents: A critical energy justice perspective on four low-carbon transitions," *Climatic Change* (in press, 2019)

Sovacool, BK, A Hook, M Martiskainen, and LH Baker. "The whole systems energy injustice of four European low-carbon transitions," *Global Environmental Change* 58 (September, 2019), 101958, pp. 1-15.

# Interdisciplinary research nonetheless needs incentivized

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1. *If you like it, fund it:* **public and private organizations** should give a bigger slice of funding to social scientists ($1-35 bias, even worse for inter-d work)
2. *Collect social data*:  to reduce disciplinary bias, **energy ministries, statistical agencies and public utility commissions** should focus more on energy behaviour and demand, rather than just supply, and employ focus groups, interviews, surveys, etc. to create rich, complex narratives
3. *Focus on problems, not disciplines:* **University administrators** should make energy research more problem-oriented, including social perspectives, and tweak promotion guidelines to account for trans-disciplinary approaches
4. *Include others:* **researchers** should do more to accommodate expertise and data from laypersons, indigenous groups, community leaders and other non-conventional participants, and reach across disciplines, and beyond Europe and North America
5. *Incentivize social science methods and concepts*: **journal editors** can prioritize interdisciplinary, inclusive, comparative mixed-methods research in their aims and scope

Source: Sovacool, BK, SE Ryan, PC Stern, K Janda, G Rochlin, D Spreng, MJ Pasqualetti, H Wilhite, L Lutzenhiser, "Integrating Social Science in Energy Research," *Energy Research & Social Science* 6 (March, 2015), pp. 95-99

# Concluding remarks and insights

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- 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

- Transitions require truly interdisciplinary collaborations
  - By sector, e.g. avoid, shift, improve
  - By training/expertise, e.g. cooking and fuel science, buildings, behavior, gender studies
  - By dimension, e.g. technology but also culture, users, markets, discourses, power, etc.
  - By discipline, e.g. science and social science with the arts and humanities
- 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, rather than supply, markets, or abundance
- The past need not be prologue; history can be instructive but not necessarily predictive

# Contact Information

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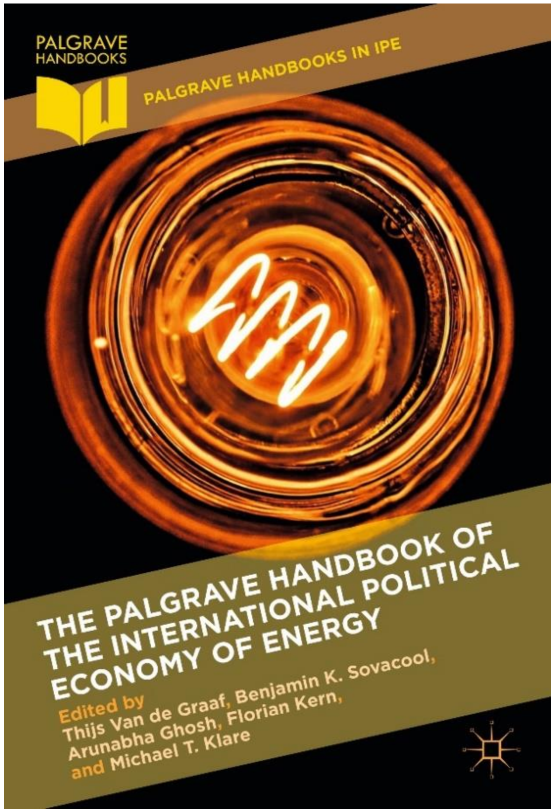


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