Energy, Europe and the Economics of Innovation

Michael Grubb

Professor of Energy and Climate Change

University College London (UCL),

Institute for Sustainable Resources

Inaugural Lecture,
UCL
Monday 26th February, 2018

Energy, Europe and the Economics of Innovation

Four topics

- What Am I?

  and how did I get here, and ..?
- Economics: the Science and the Art

  and how lessons from the history of energy & science might inform

  a 'Planetary Economics' broad enough to help tackle climate change
- Innovation and energy: from micro to systems

  the role of markets and government
- What does that imply for policy?

  on a few modest topics like energy & climate change, industrial policy, & Europe

Economics: the Science and the Art

Energy, Europe and the Economics of Innovation

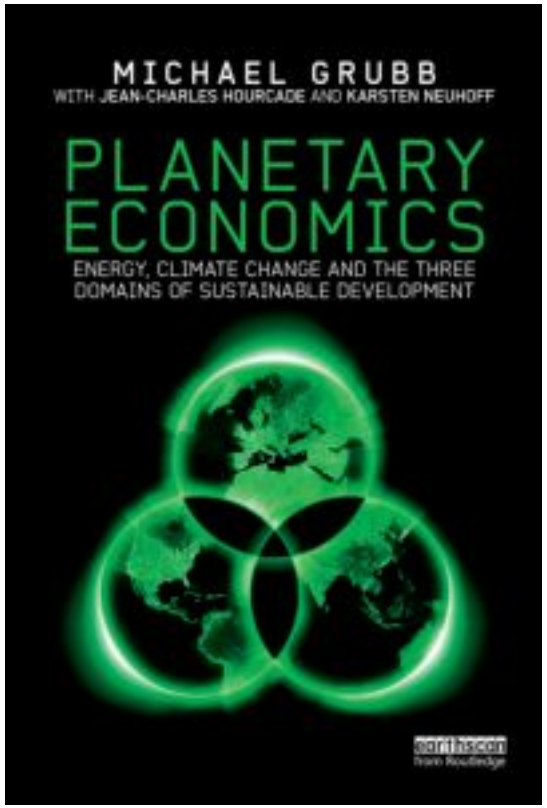
Michael Grubb

Professor of Energy and Climate Change

University College London (UCL),

Institute of Sustainable Resources

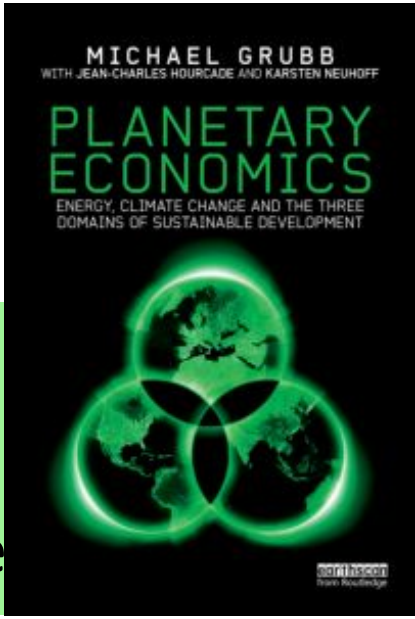
Inaugural Lecture,
UCL
Monday 26th February, 2018



Energy, Climate Change and the Three Domains of Sustainable Development

Energy, Europe and the Economics of Innovation

Four topics



- What Am I?

  and how did I get here?

- Economics: the Science and the Art

  and how lessons from the history of energy & science might inform

  a 'Planetary Economics' broad enough to help tackle climate change

- Innovation and energy: from micro to systems

  the role of markets and government

- What does that imply for policy?

  on a few modest topics like energy & climate change, industrial policy, & Europe

Economics: the Science and the Art

Oxford English Dictionary:

Economics: 'the science of political economy'

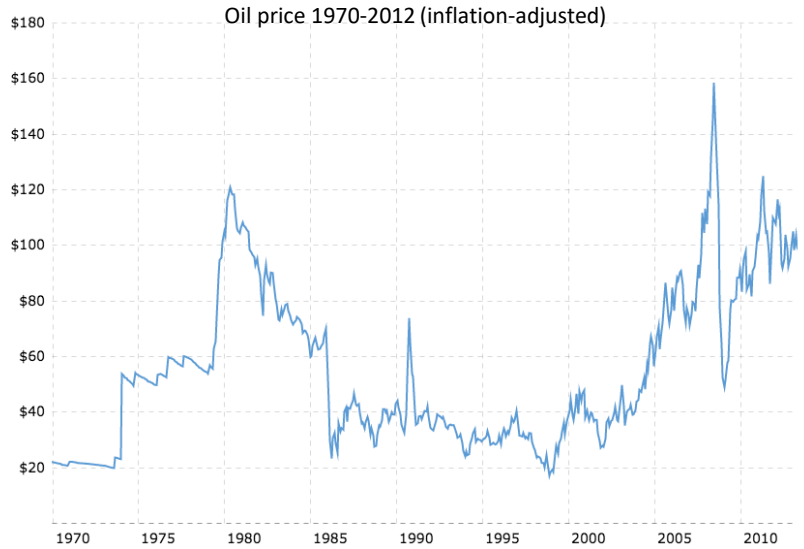
Political economy: 'the art of managing the resources of a people and its government'

The people: everyone, today and future generations
The resources: energy, minerals, the planet – atmosphere, oceans …
The government …. ???

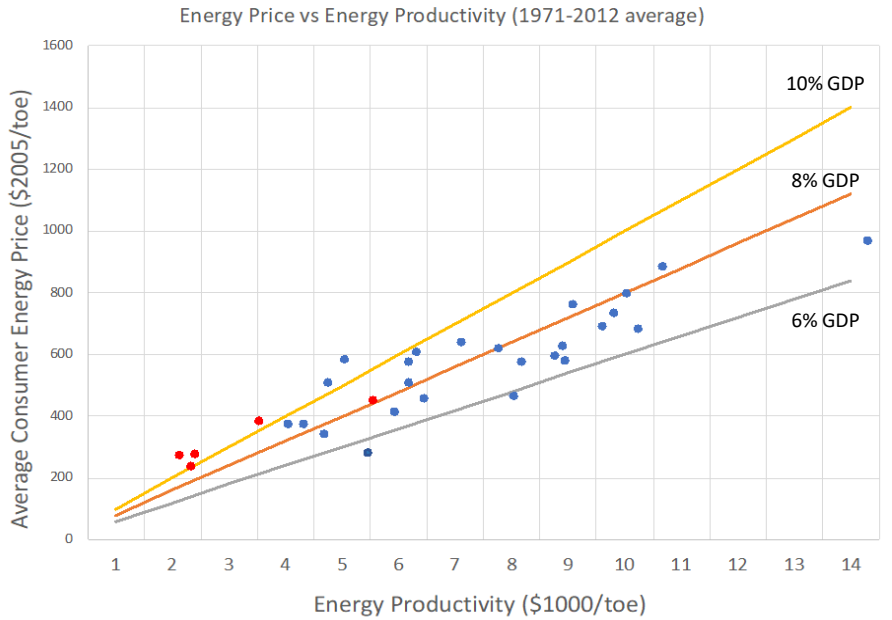
"The biggest market failure in history" (Stern, 2005)
"The perfect moral storm" (S. Gardiner, 2011)
A "Super-Wicked" problem (K. Levin et al, 2012)

Energy economics - Forty-five years of evidence …

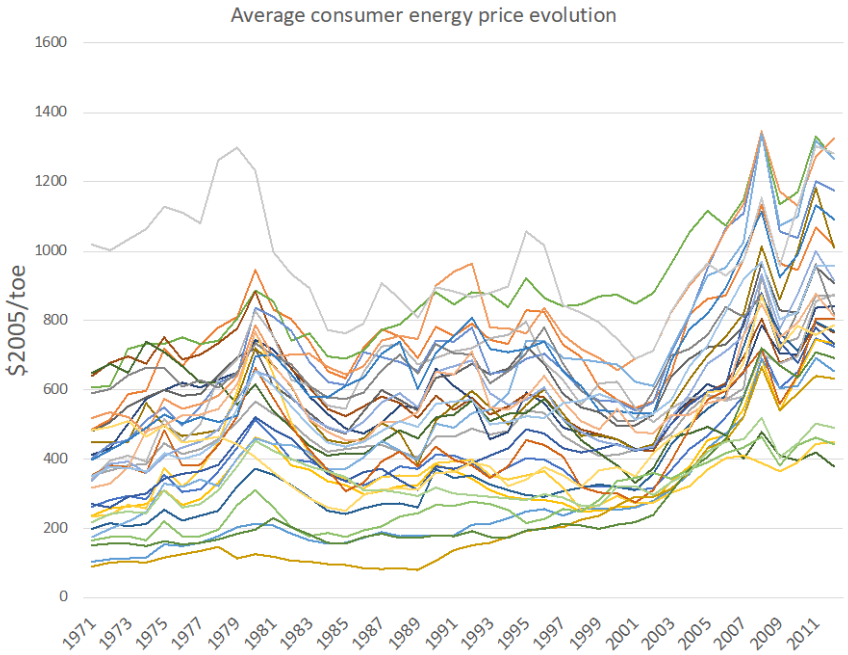
Oil prices volatile – shocks to system, big responses on supply ….



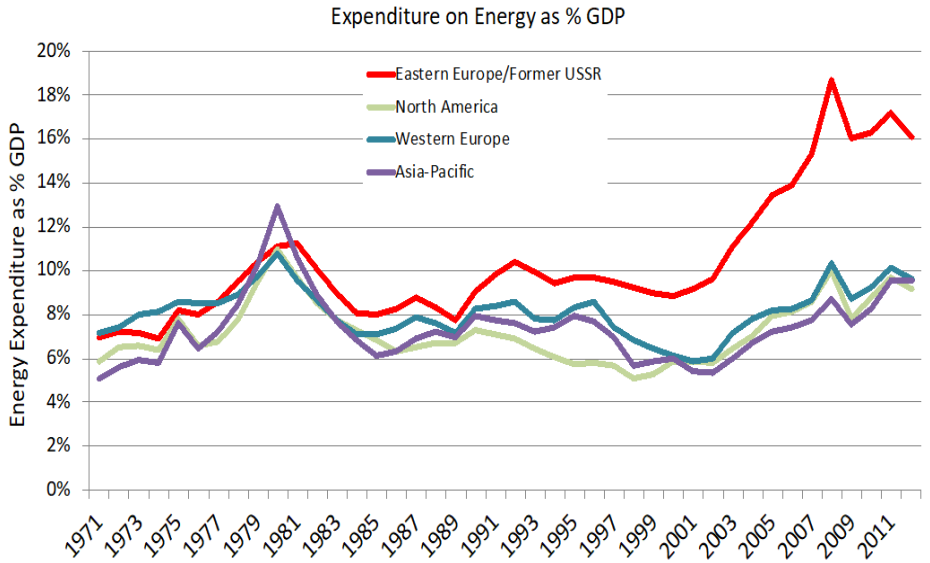
Higher avg price matched by higher efficiency - Surprising constancy of *energy cost share*



Responses varied across industrialised world, inc end-use average energy prices



Adjustment, slow (30-40yrs) …. & painful



Source: Grubb, Bashmakov, Drummond et al (2018)

The Three Domains

The Logic of neoclassical equilibrium construction

"The prescription .. is simple: price carbon … and get out of the way. It's simple. It works."
- Gernot Wagner, Harvard University and Environmental Defense Fund

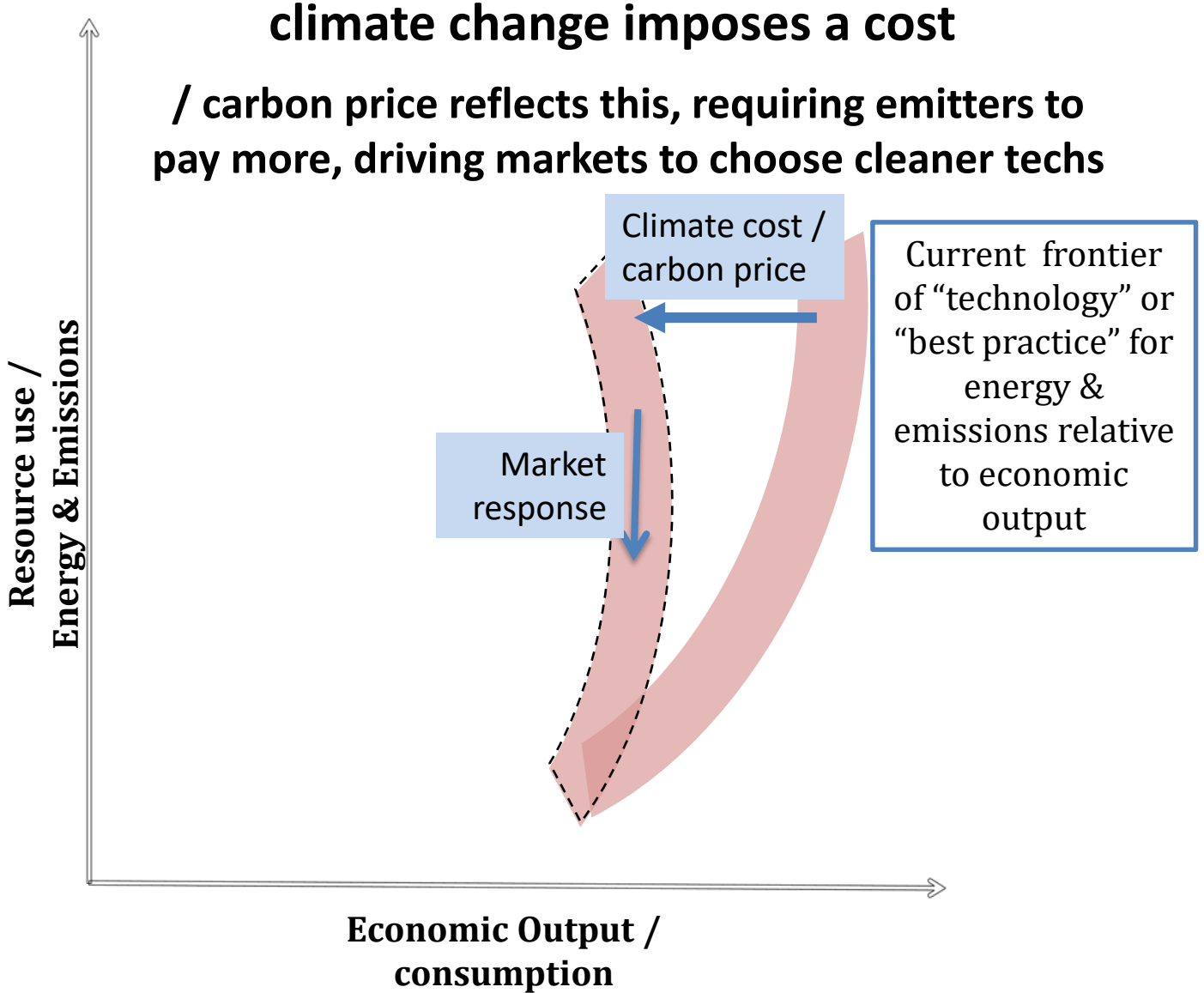
"Widely agreed that Carbon price is the most efficient and cost-effective tool …
- Business Leaders for Climate

"The EU should focus on reducing greenhouse gases as the unique climate objective after 2020, and allow the market to identify the most cost efficient way to deliver this target.–
Former Shell upstream executive director, Malcolm Brinded.

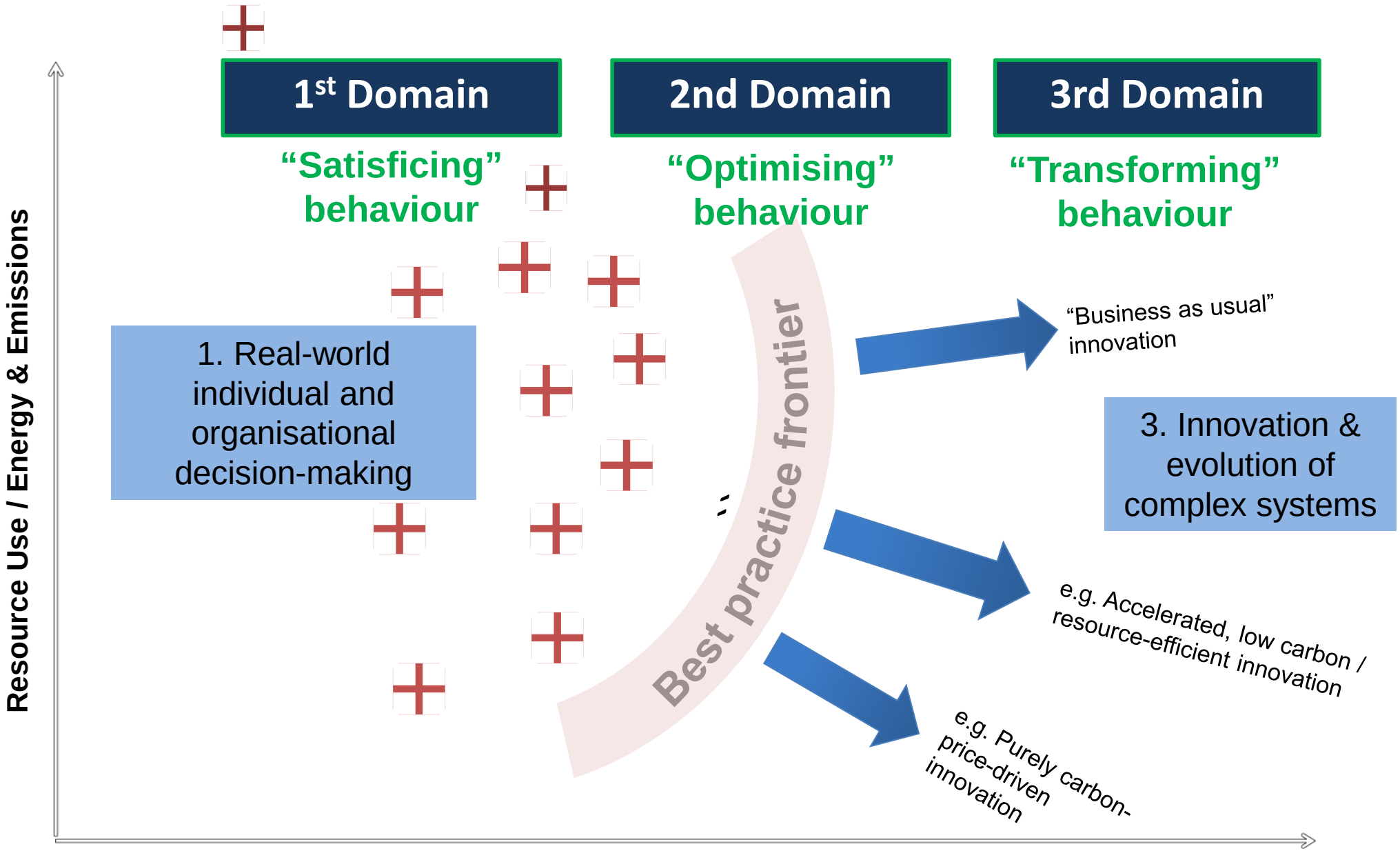
Resources ⇨ welfare via technology

climate change imposes a cost

/ carbon price reflects this, requiring emitters to pay more, driving markets to choose cleaner techs



Beyond ‘optimal equilibrium’: the Three Domains



PE Fig. 2 -3 b Resource trade-offs with the other two domains

The Art: to see Three Domains of decision-processes…

with different characteristics and theoretical foundations, operate at different scales

TIME HORIZON

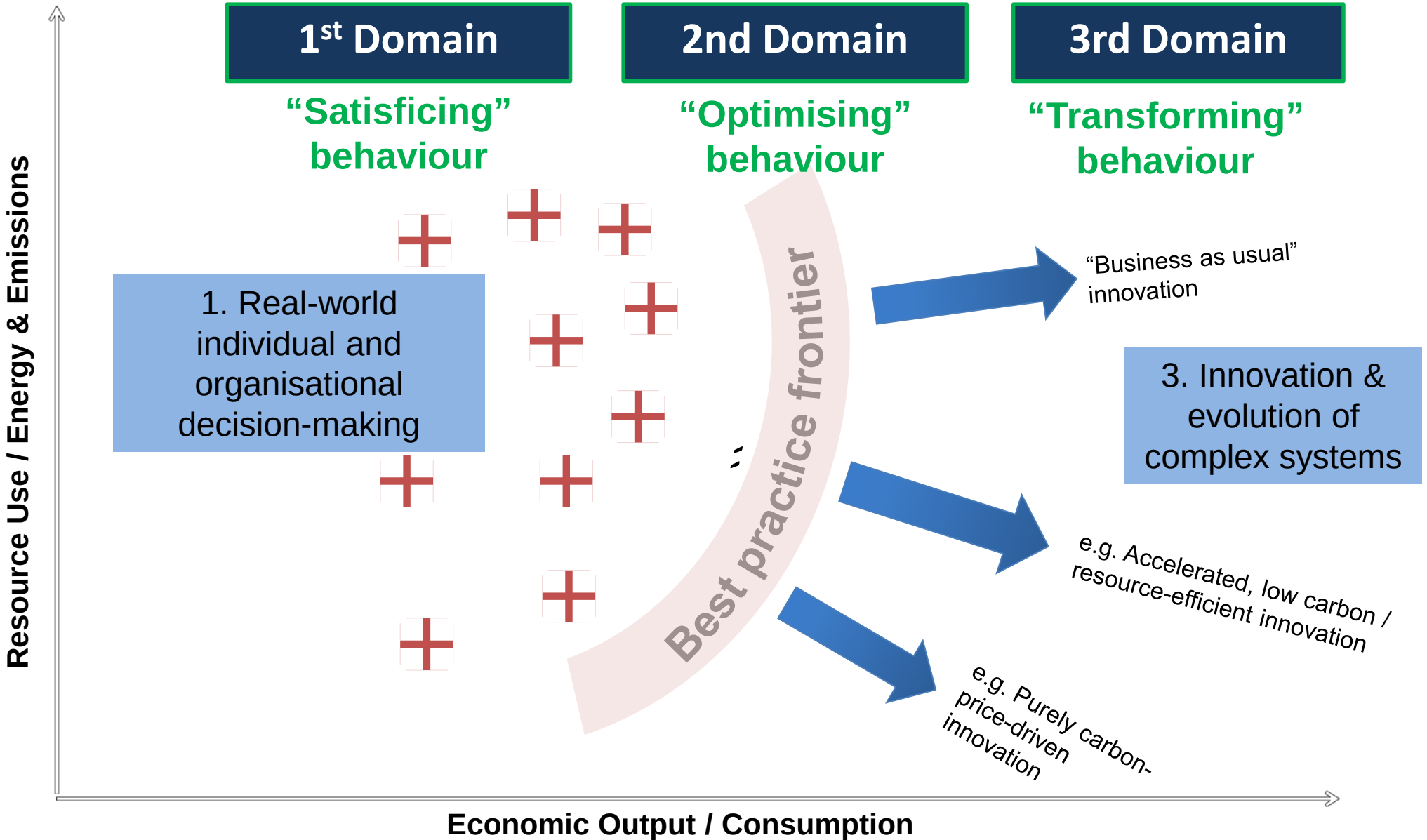
DOMAIN	Characteristics	Theoretical foundations
1. Satisficing	Habits, risk aversion to change or new investment, myopia, inattention to incidental / intangible costs; endemic 'contractual failures', principal-agent failures,	**Behavioural and organisational economics**
2. Optimising	Economic optimisation based on relative prices, 'representative agents' with 'rational expectations', stable preferences and tech trends	**Neoclassical and welfare economics**
3. Transform-ing	Technology, structure, institutional and behavioural change, typically from innovation, scale economies, infrastructure, supply chain development & social awareness	**Evolutionary and institutional economics**

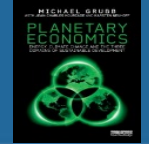
SOCIAL SCALE

Potential for improved efficiency, services & lower bills

Potential for new technology waves

The Three Domains form a *dynamic system*





The 'Dark Matter of macroeconomic growth'

- Macro-economic research points to two key areas of economic growth in addition to resource & capital accumulation:
  - Improving efficiency of many economic actors and structures throughout the economic system
  - Infrastructure, innovation and education
- *ie.* First and Third Domain processes are recognised as important for macroeconomic development. Yet these remain
  - largely absent in global (or national) modelling
  - poorly charted in policy
- Optimality is *so much easier, and so much more elegant*
  - *Just like Newtonian Mechanics*

Reality

Is not
A Market Failure

Markets – more specifically *competitive forces* – play a crucial *evolutionary* role: they *select* innovations, *connect* them to users, and *in the right conditions* will fund the growth of successful innovations

[Eric Beinhocker, *The Origins of Wealth*]

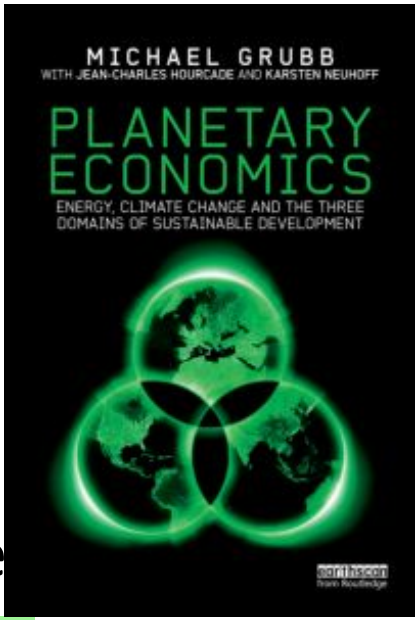
The competitive and evolutionary characteristics of markets can also be quite destructive – *The **Blind** Watchmaker.* The role of the State is not just to police markets, but to help manage their consequences, to steer their evolution – and to open up whole new vistas

A (big-picture) interlude:

The Marketisation
Of the European Union

Energy, Europe and the Economics of Innovation

Four topics



- What Am I?

  and how did I get here?

- Economics: the Science and the Art

  and how lessons from the history of energy & science might inform

  a 'Planetary Economics' broad enough to help tackle climate change

- Innovation and energy: from micro to systems

  the role of markets and government

- What does that imply for policy?

  on a few modest topics like energy & climate change, industrial policy, & Europe

Q: What two things do the following energy technologies have in common?

- Offshore oil extraction
- Shale gas
- Combined cycle gas turbines
- Solar PV
- Wind energy
- High efficiency lighting (LED lights)

[1] They all turned out to be ***much cheaper*** than anyone expected

[2] They all involved government action at scale over many years

- On both technology/resource development, and demand/price

Solar revolution – driven largely by the German *Energiewende*

Basic R&D → Technology RD&D → Demonstration → Commerciali-zation → Market accumulation → Wide diffusion

"Solar power is by far the most expensive way of reducing carbon emissions

- *The Economist,* **2014.**

'[deploying current renewables] is not only blinkered, but also incredibly expensive'

— Dieter Helm

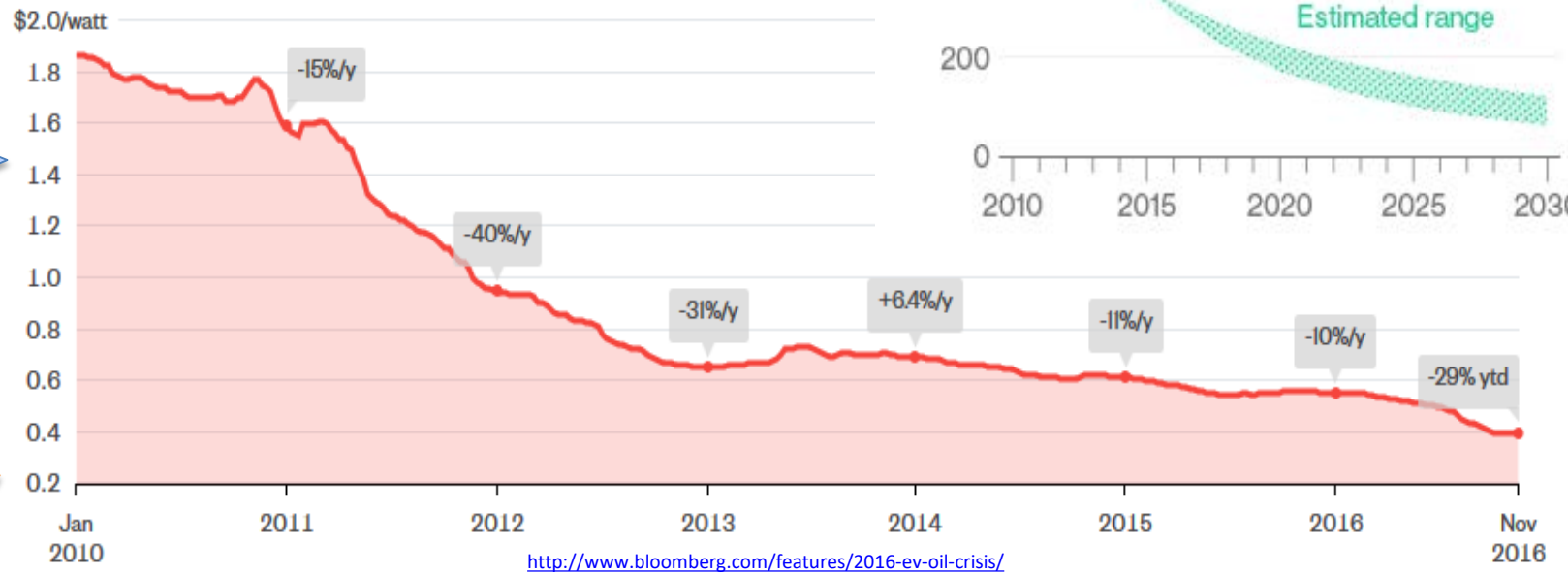
Solar power in Germany "makes as much sense as growing pineapples in Alaska."

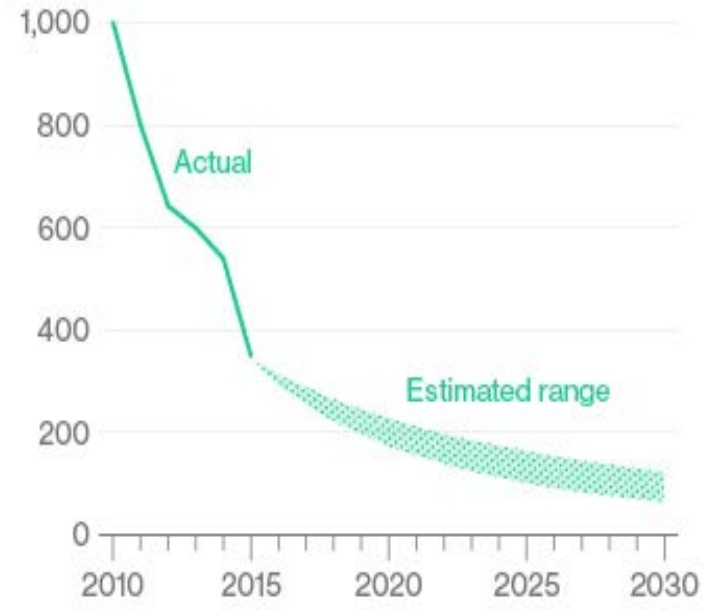
- J. Grossmann, then CEO of RWE AG in 2012

PV: New record installed power prices

Chile	= $30/MWh
Masdar	= $25/MWh
Abu Dhabi	= $24/MWh

Module costs: -29% in 2016 to $0.39/Watt





http://www.bloomberg.com/features/2016-ev-oil-crisis/
http://www.bloomberg.com/news/articles/2016-07-27/elon-musk-says-it-s-pencils-down-for-tesla-s-model-3

http://reneweconomy.com.au/how-the-jaw-dropping-fall-in-solar-prices-will-change-energy-markets-55160/

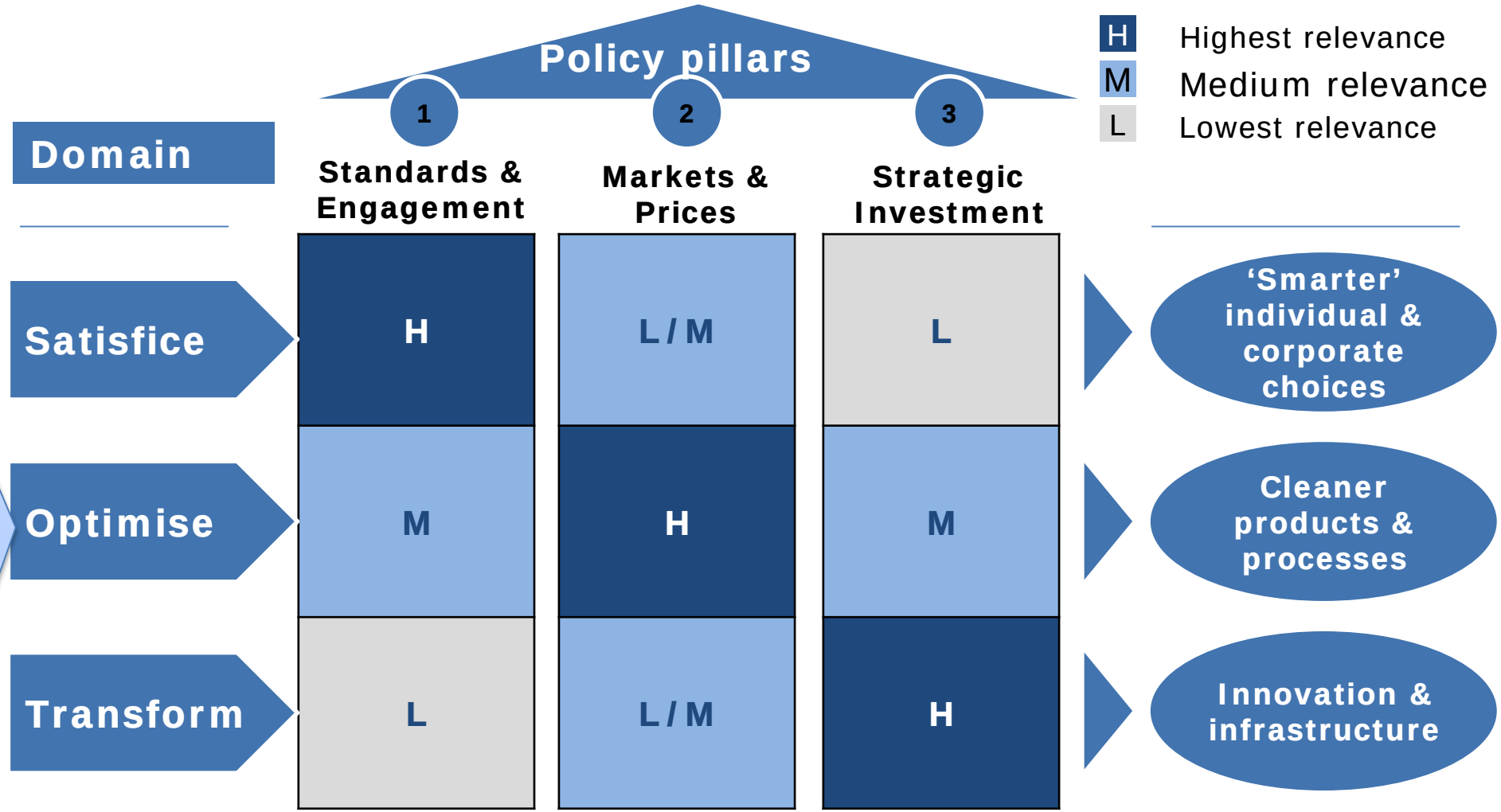
Ideal policy comprises a package …

"Other policies such as feed-in tariffs, industry regulation and subsidies, are far less economically preferable than carbon pricing to reduce emissions… " (OECD, 2013)

"The EU 3-targets approach is madness.. "

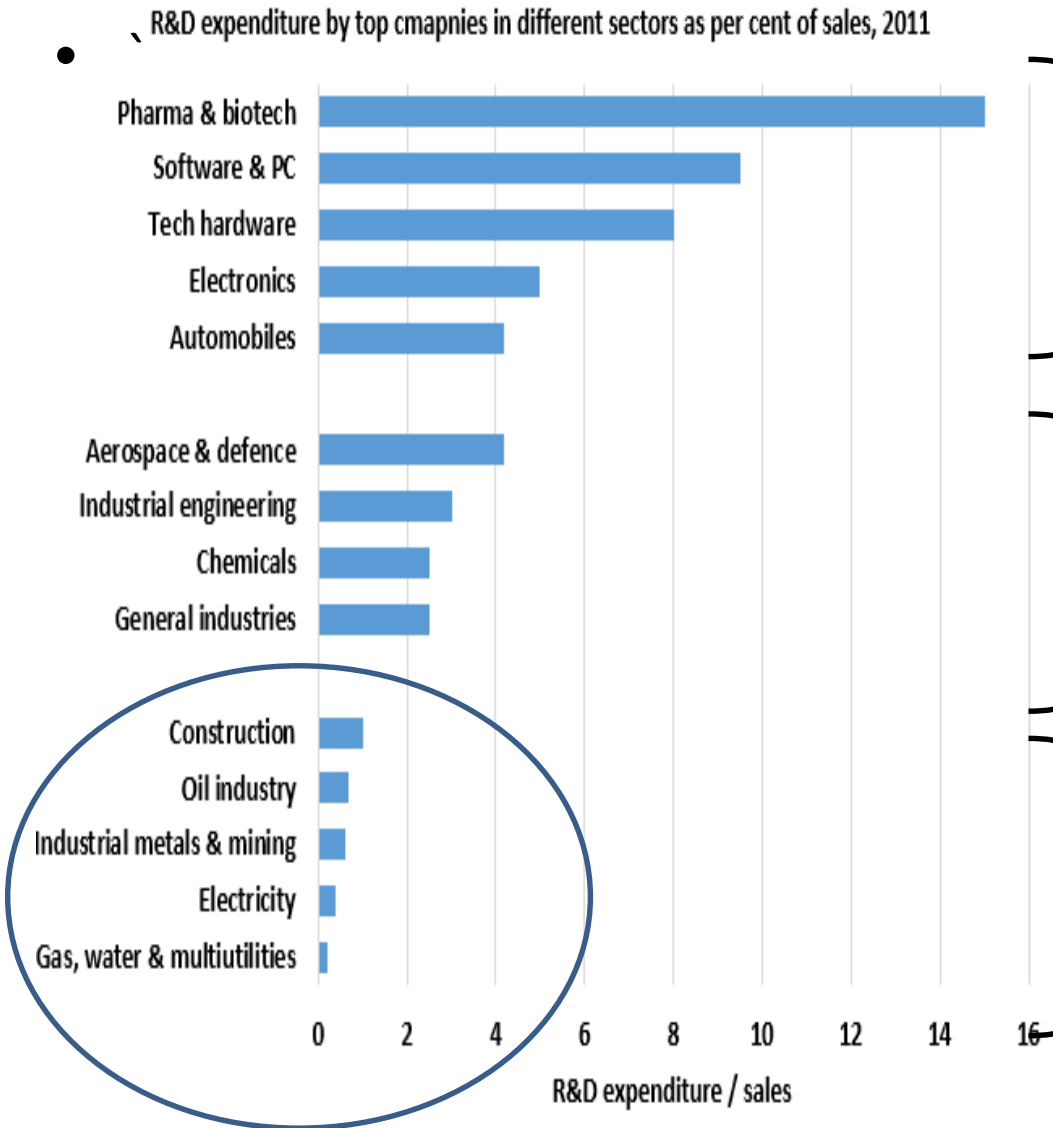
I beg to differ …

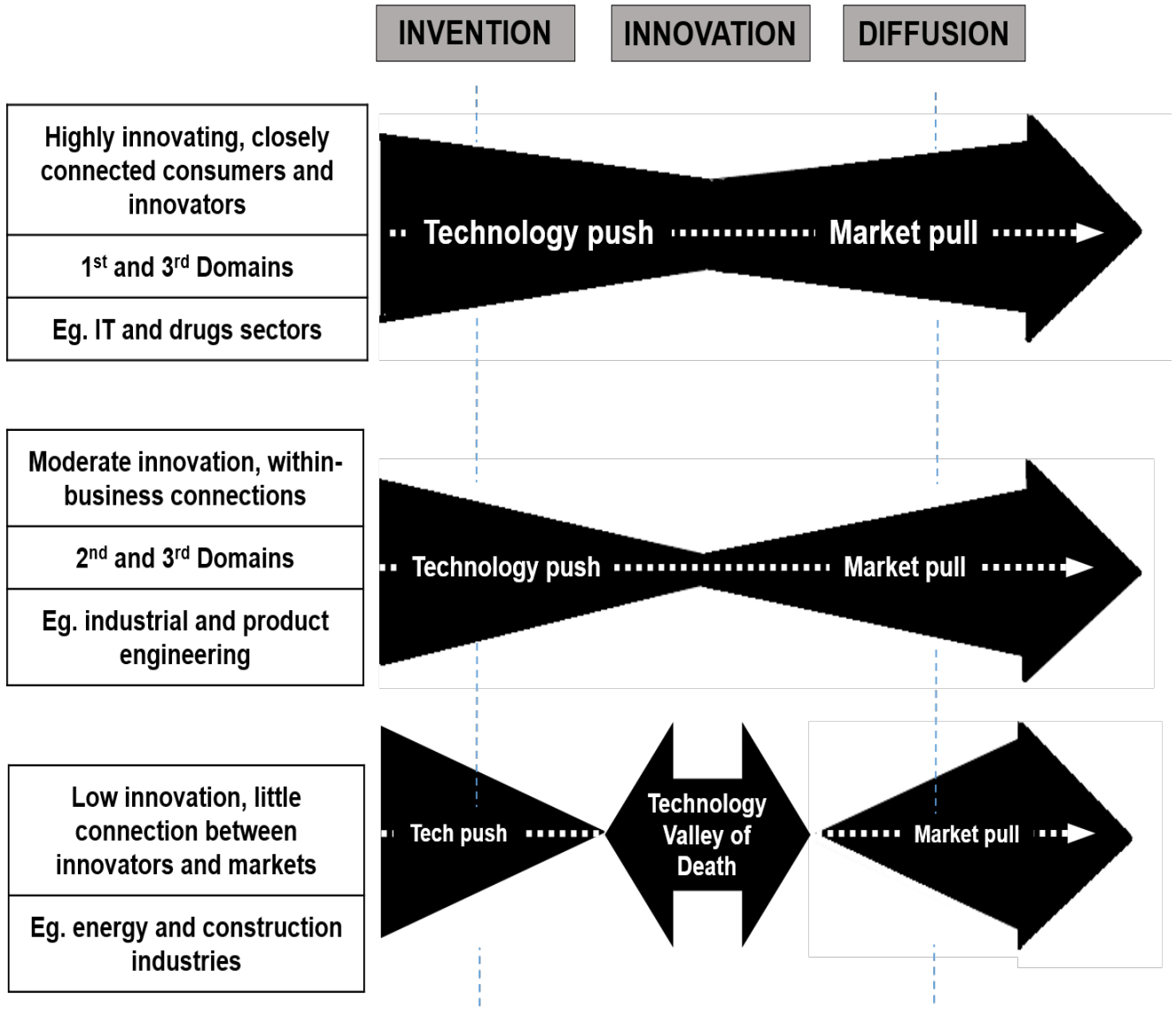
Key is to match the best instrument to the respective domain of decision-making



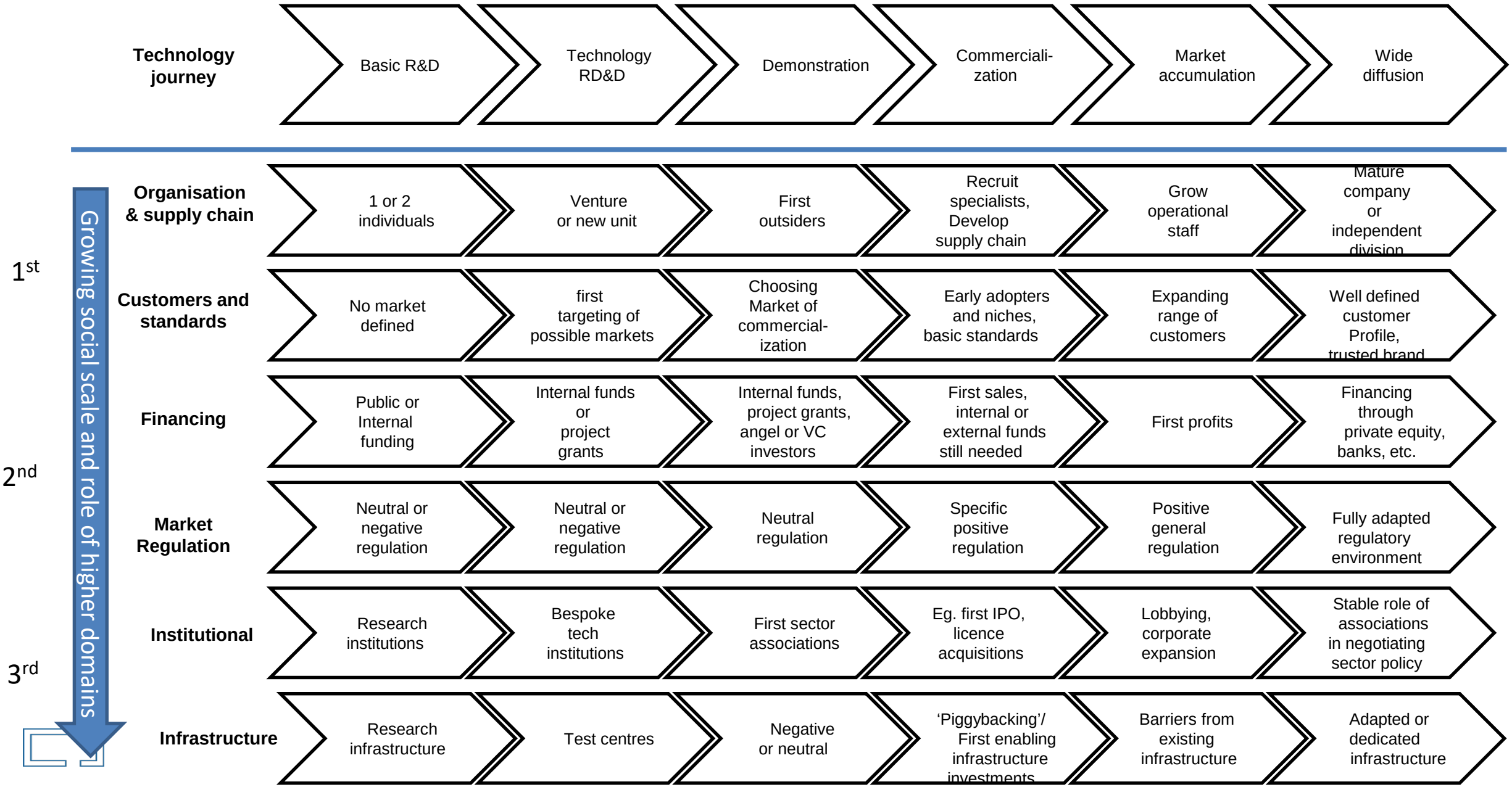
The energy-climate challenge – seek radical change in …

… some of the historically least innovative sectors of our economies

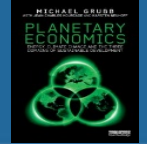




Successful innovation must span a complex multi-domain journey



Source: Grubb, McDowell and Drummond (2017), On order and complexity in innovations systems, Energy Research & Social Science; derived from Fig.9.8 in Grubb et al (2014) *Planetary Economics*



Exacerbated by financialisation …. ?

of a sector in which three-pillar policy particularly important because

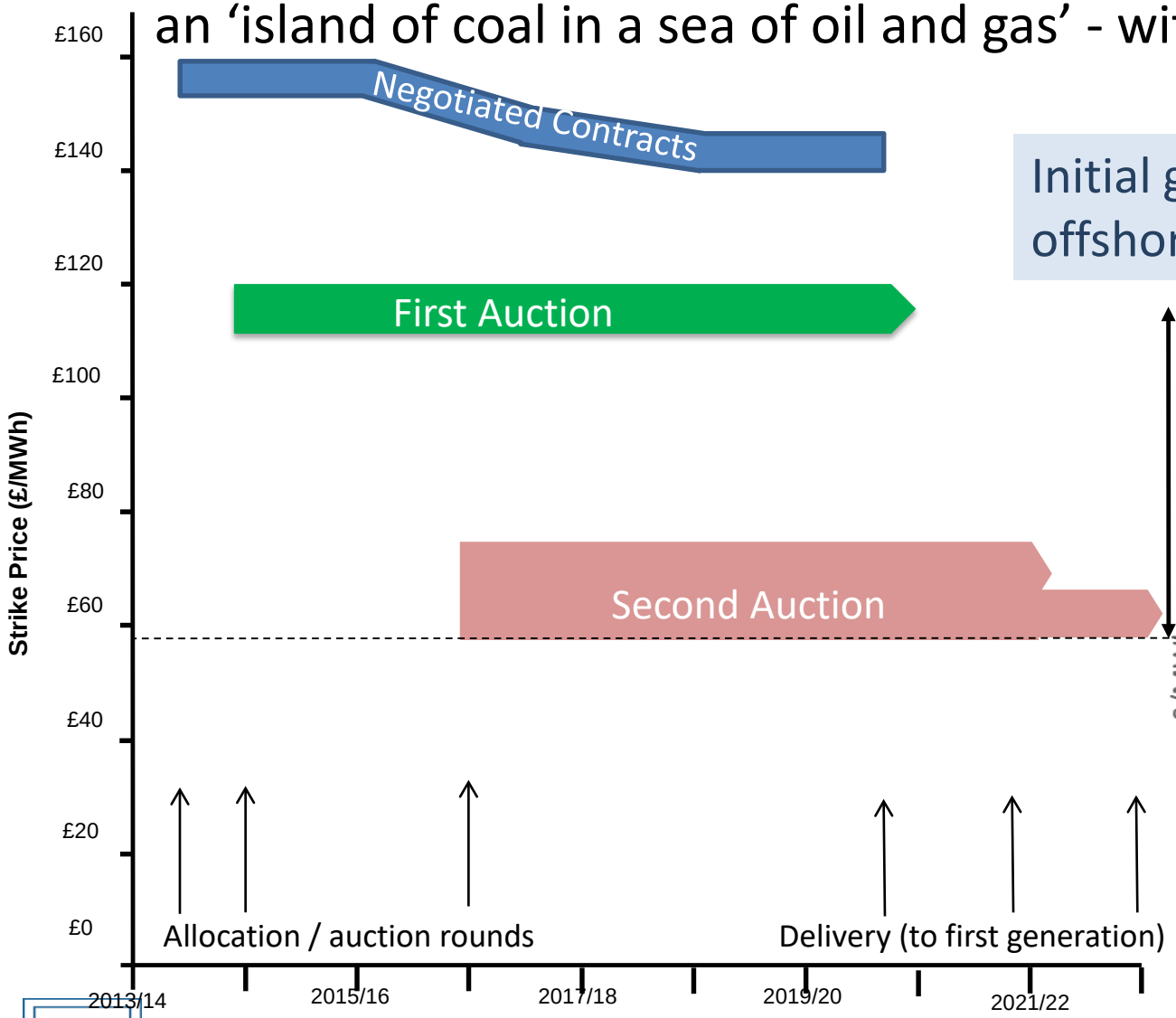
- An essential good
- Deep structural impediments – 'energy efficiency gap', little or no product differentiation, natural monopolies etc
- Exceptionally low rates of private sector innovation
- Historic instability of fossil fuel markets – business cycles on politicised steroids
- Pervasive input to numerous production sectors
- Large, global and very long timescale 'externalities'

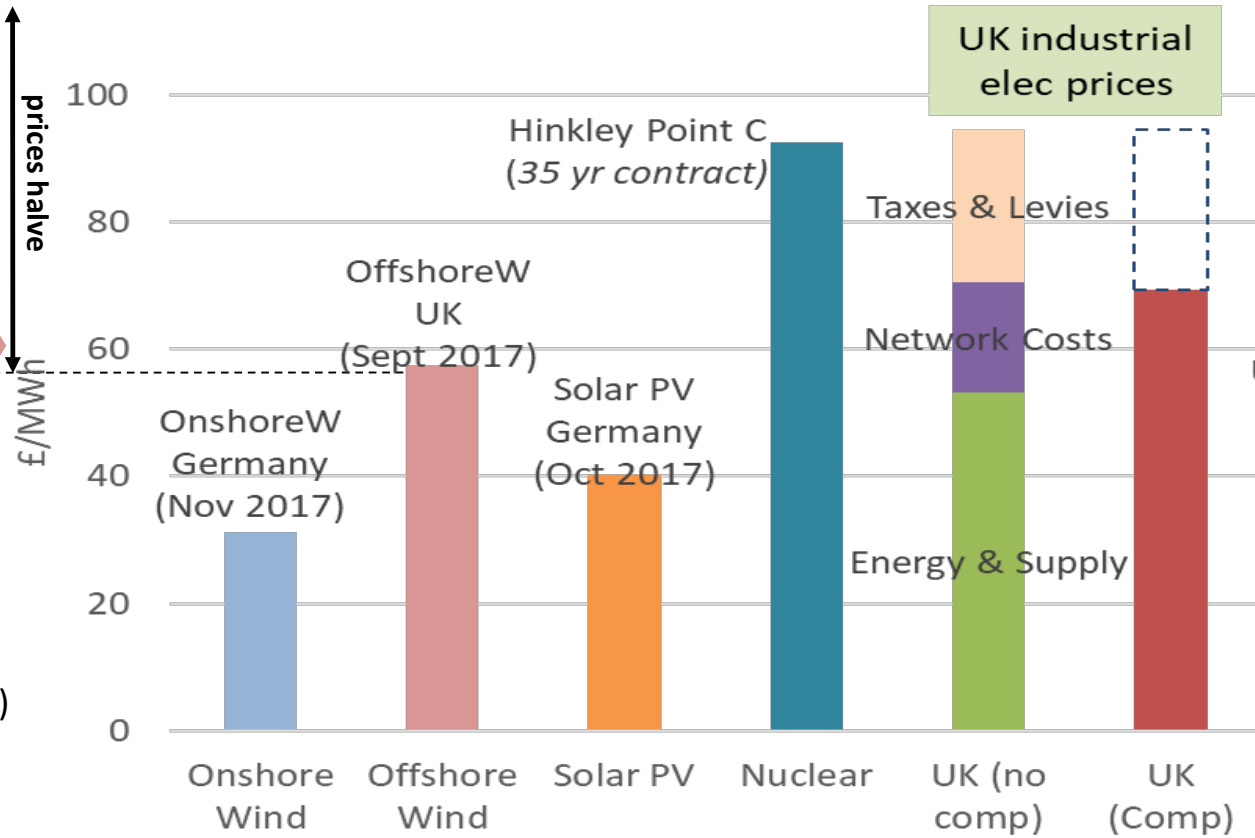
German *Energiewende* wasn't growing solar pineapples in Alaska:
it was planting them in the most fertile soil, of a country with the industrial capacity, financial structures, and political determination, to fund and forge a new industrial revolution

With benefits and lessons for UK Offshore wind

That the UK has been able to draw on to engineer our own dramatic transformation for an 'island of coal in a sea of oil and gas' - with maybe more efficient and balanced policy

Initial gain from auctions followed by huge progress in offshore wind, reducing costs towards wholesale price

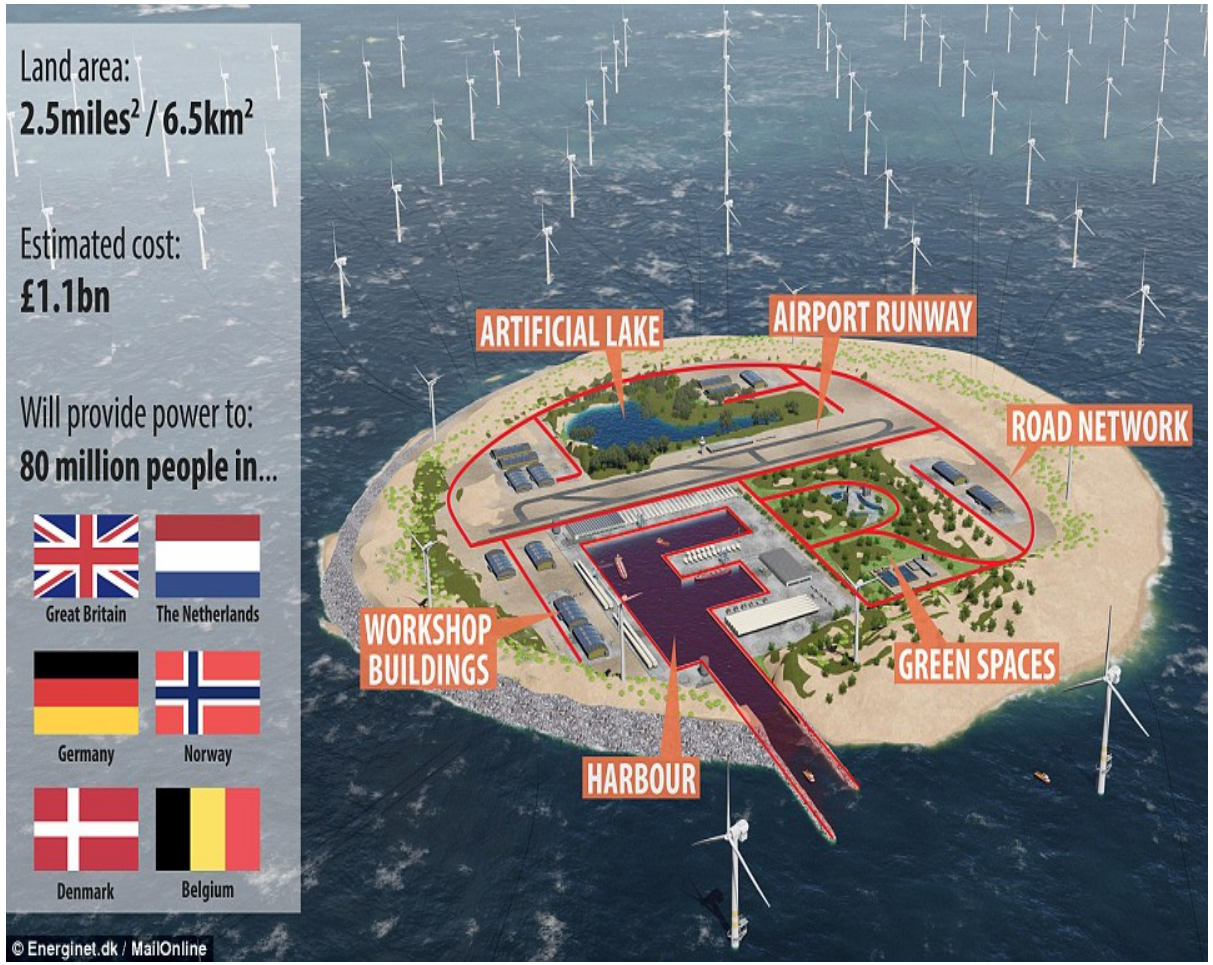




Sources: M.Grubb and D.Newbery (2018), 'UK Electricity Market Reform and the Energy Transition: Emerging Lessons', MIT-CEEPR working paper; Grubb & Drummond (2018), UK Industrial Elec Prices

The Prize: a new North Sea Energy Renaissance

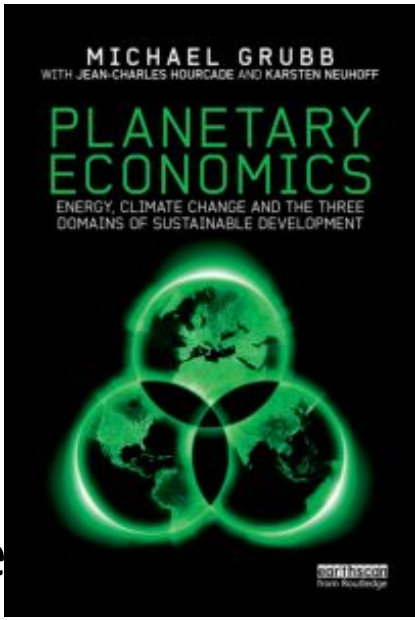
… with proposal for offshore wind based around island in Dogger Bank
- a scale, value & strategic significance on a par with North Sea gas



Source: Guardian/Tennet

Energy, Europe and the Economics of Innovation

Four topics



- What Am I?

  and how did I get here?

- Economics: the Science and the Art

  and how lessons from the history of energy & science might inform

  a 'Planetary Economics' broad enough to help tackle climate change

- Innovation and energy: from micro to systems

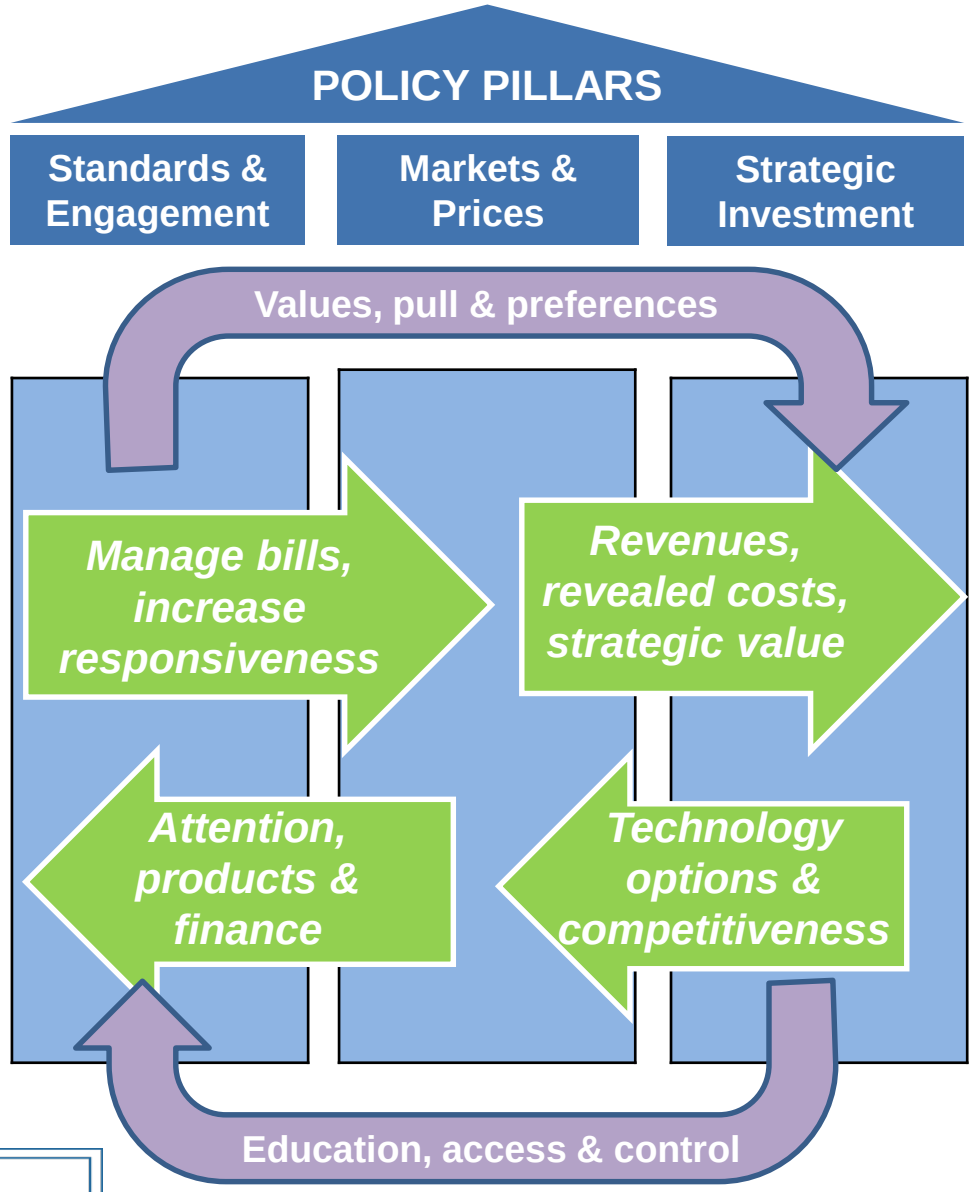
  the role of markets and government

- What does that imply for policy?

  on a few modest topics like energy & climate change, industrial policy, & Europe

- This cannot happen from pure markets and pricing
  - (Nor did North Sea oil, which enjoyed £10bn/yr investment for a decade)
- There would be vast gains to European collaboration
  - Investment scale (learn from Hinckley Point)
  - Complementary skills
  - Transmission efficiency
  - Managing the variability, dispersion and backup to maximum benefit
- Have we become so much market societies that we can no longer think in such terms?
- Will European relations become so difficult that we can no longer find common cause to develop a resource of strategic importance to the entirety of northern Europe?

“Only Connect”



- .. When the Three Domains & associated Pillars of Policy designed as a mutually reinforcing package
- 21st Century energy systems will be radically different from 20th Century
- Transition is already under way, so far driven far more by the non-pure-market policies
- We need the full and balanced package – including fresh consideration of carbon pricing:
  - Stability and direction?
  - Use of revenues for energy infrastructure?
  - Direct consumer access to zero-carbon energy
- Clear policy direction can shift risk, lower finance costs, and increase the gains to innovation and infrastructure

Europe needs a pan-European Energy Union – and so do we

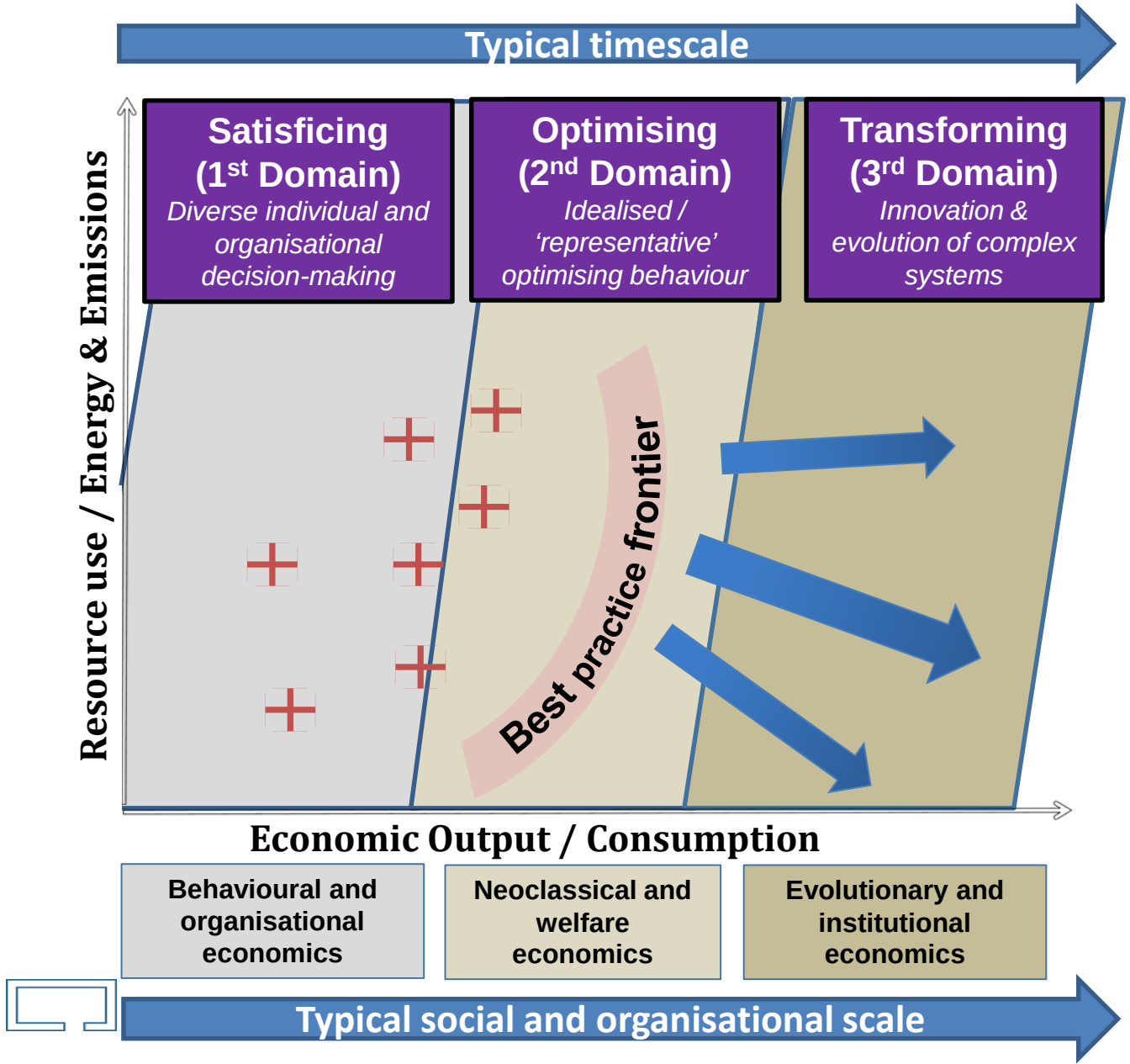
- We don't necessarily need to be part of the Internal Energy Market
  - *It might help, but regional energy trade will continue, just with a bit more friction (and dilemmas with the Irish Single Elec Market)*
- But whatever outcome of current political debate
  - *Customs Union is totally irrelevant to electricity and gas:*
    - *No physical links outside the European area*
    - *No tariffs*
- The real challenges are governance, political will – and ideology

Interdisciplinary Economics

- The answer to Laurence Tubiana's question is that economics helps when it respects the boundaries of a given economic theory, but can hinder when it tramples across them
  - *The academic community needs to decide what it sees as the legitimate scope of economics*

- Fully understanding the Three Domains inevitably must draw also on other disciplines
  - ***Social and psychological*** *dimensions of risk perceptions and First Domain behaviours*
  - ***Engineering and physical determinants of*** *Third Domain innovations and infrastructure*
  - *The* ***regulatory and institutional*** *dimensions of both*

Pulling it together: Broadening economic horizons



For a problem which spans from

- the inattentive decision-making of seven billion energy consumers, to
- long-term transformation of vast and complex infrastructure-based techno-economic systems

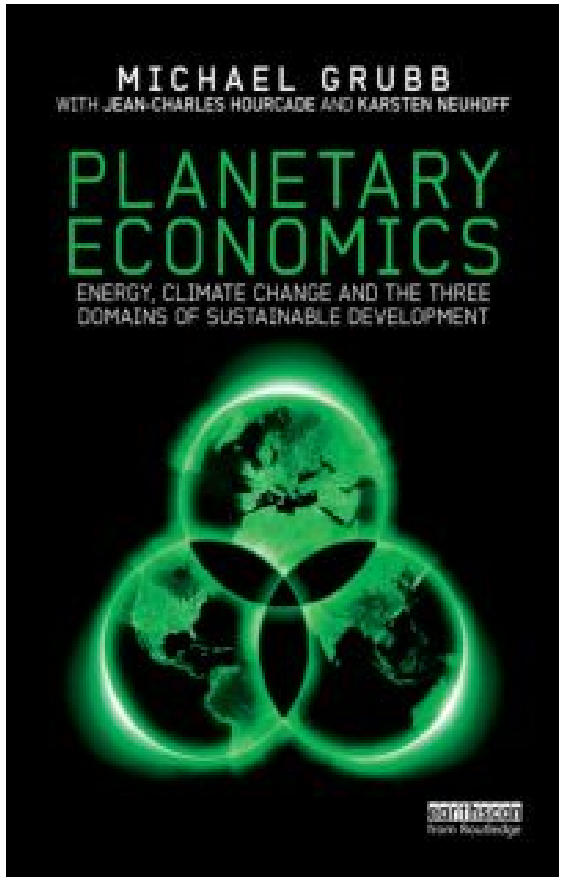
To date, more progress on energy efficiency and technology / renewables etc policy than carbon pricing

Time for full integration …

Questions?

Planetary Economics:

Energy, Climate Change and the Three Domains of Sustainable Development



1. **Introduction: Trapped?**
2. **The Three Domains**

Pillar 1

- **Standards and engagement *for* smarter choice**
- 3: Energy and Emissions – Technologies and Systems
- 4: Why so wasteful?
- 5: Tried and Tested – Four Decades of Energy Efficiency Policy

Pillar II

- **Markets and pricing *for* cleaner products and processes**
- 6: Pricing Pollution – of Truth and Taxes
- 7: Cap-and-trade & offsets: from idea to practice
- 8: Who's hit? Handling the distributional impacts of carbon pricing

Pillar III

- **Investment and incentives for innovation and infrastructure**
- 9: Pushing further, pulling deeper
- 10: Transforming systems
- 11: The dark matter of economic growth

12. **Conclusions: Changing Course**

Published Routledge 2014
6-page 'Highlights' paper available

http://climatestrategies.org/projects/planetary-economics/
for further information #planetaryeconomics

“This Changes Everything”

‘It’s not only blinkered, but also incredibly expensive’ — Dieter Helm

It results in an extremely expensive policy to achieve the carbon reductions - Dieter Helm at House of Lords hearing in 2017

…ost expensive way of reducing carbon emissions …. …rise to $185 a tonne ….” - *The Economist,* **2014. Err ……**

…elow wholesale

Chile = $30/MWh
Masdar = $25/MWh
Abu Dhabi = $24/MWh
Module costs: -29% in 2016 to $0.39/Watt

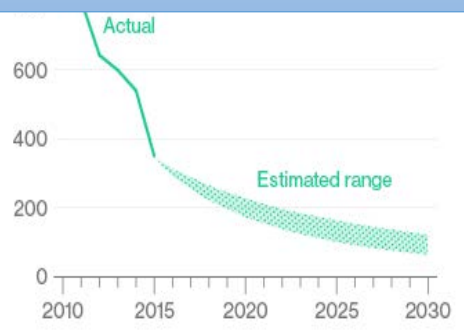
Even offshore wind energy: series of auctions across Europe have seen prices tumble to about half that of 5 years ago

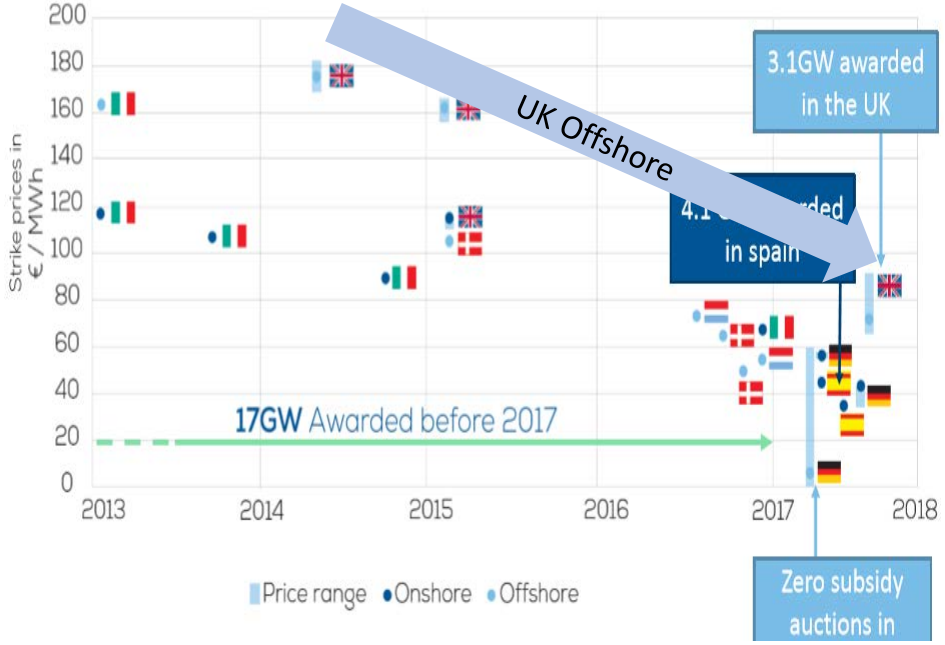
“Their costs are simply too high, even for OECD countries…” - Patrick Heren and John Constable

Batteries also …

“Other policies such as feed-in tariffs, industry regulation and subsidies, are far less economically preferable than carbon pricing to reduce emissions… and should be at the centre of government efforts to tackle climate change”- (OECD, 2013)

Solar power in Germany “makes as much sense as growing pineapples in Alaska.” Jürgen Grossmann, then the CEO of RWE AG in 2012





Solar power in Germany "makes as much sense as growing pineapples in Alaska."
- Jürgen Grossmann, Former CEO of RWE AG in 2013

"Germany is an example of how not to do green energy" - Bjorn Lomborg in a 2014 Financial Times article

'…Their costs are simply too high, even for OECD countries … the policy is collapsing as a consequence. .. the policy entails the premature mass deployment of renewables technologies so expensive that their subsidies will reduce the standard of living of the developed world and offer no benefits to the developing world." (Patrick Heren and John Constable, 2013)

'It's not only blinkered, but also incredibly expensive' — Dieter Helm in Spectator

"What is not well understood is that current renewables like wind turbines, rooftop solar and biomass stand no serious chance of making much difference to decarbonisation" - (Dieter Helm, 2012)

"..what are Britain and Europe's politicians doing? They are presiding over a dash for coal and channelling scarce customers' monies towards wind farms, solar panels and biofuels. It's not only blinkered, but also incredibly expensive."- (Dieter Helm, 2012)

The Big Themes

- A historically strategic approach to the energy sector (Germany, France)
- More integrated approach to renewables development (FiTs, network development, planning regs)
- …with more activist / differentiated approach to cost recovery (Germany, Italy)
- Greater interconnection and longer contracting, inc. cross-border industrial contracting

Prospects ?

Pressures on continental wholesale costs

ageing nuclear fleet (life extension / decommissioning; cost data in report)

emission regulations & rising carbon prices impact coal

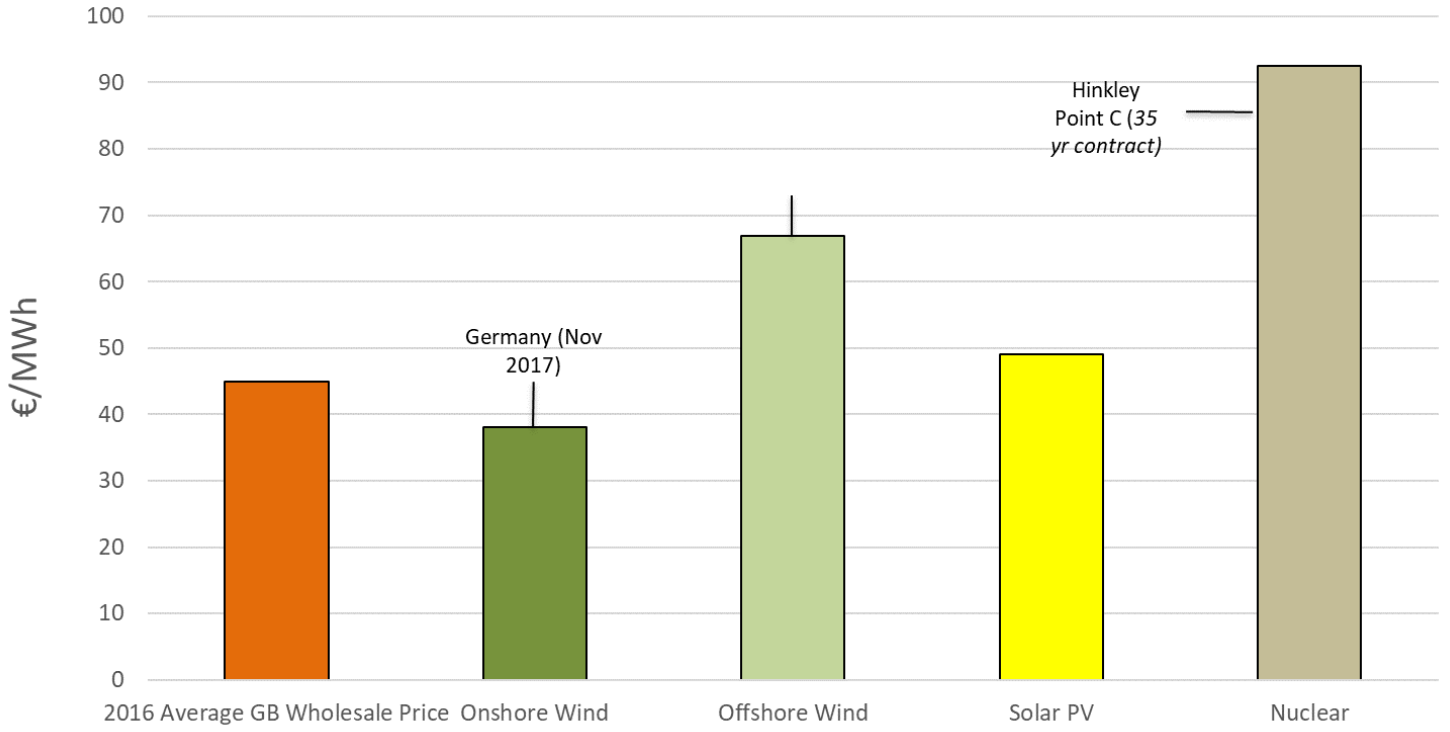
Some convergence of coal and gas prices ??

Impact of UK carbon price will decline as coal retires

.. While Renewables costs fallen sharply

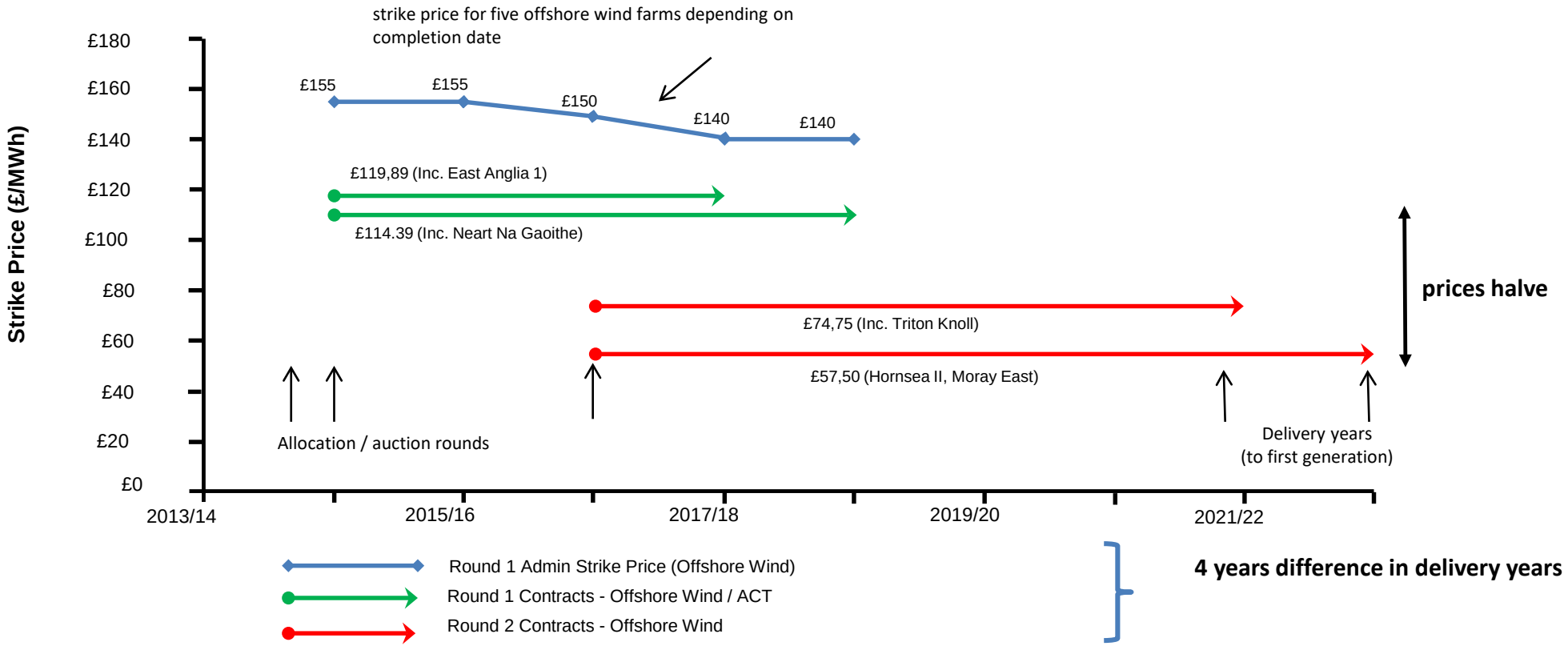
Both PV and wind, onshore and offshore … *along with batteries* and continuing progress in transmission, control and demand flexibility

to prices below UK industrial and even (onshore) wholesale



Huge cost reductions from auctioned contracts

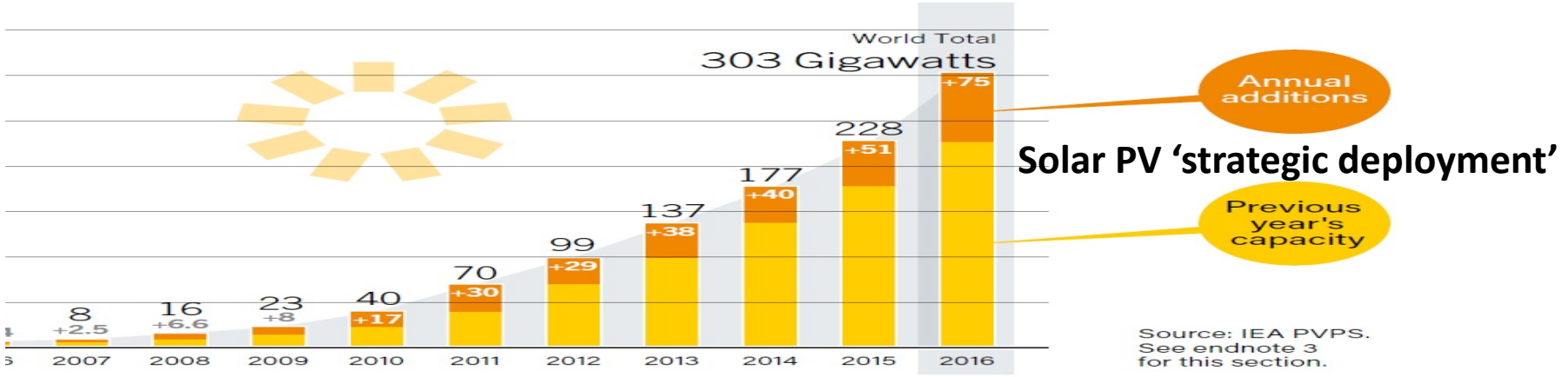
Initial gain from auctions followed by huge offshore wind cost reduction



Source: From M.Grubb and D.Newbery (2017), 'UK Electricity Market Reform and the Energy Transition: Emerging Lessons', MIT working paper (submitted)

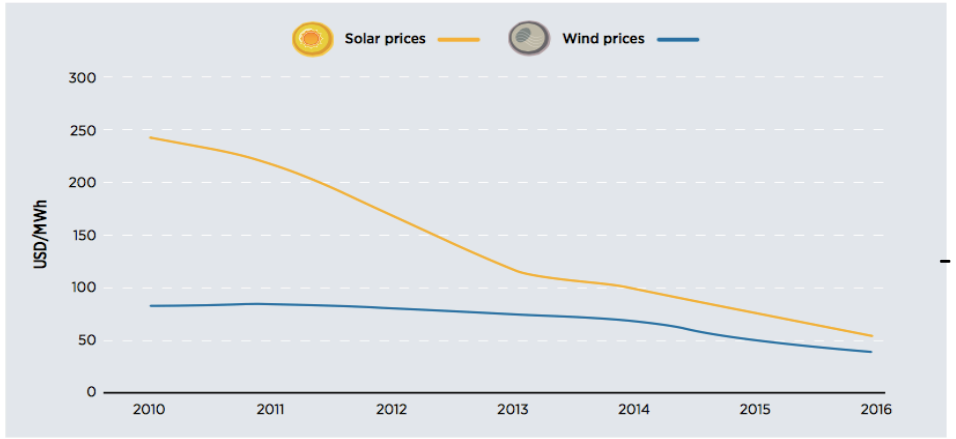
* 15-yr Contract prices

Huge market growth + cost reductions in renewables



Solar PV 'strategic deployment'

Figure 1 Average prices resulting from auctions, 2010-16



Source: IRENA, 2017.

.. accompanied by cost reductions, to 'learning curve' expectations
– growth over 2-3 decades

- .. documented across wide range of other supply and demand-side technologies including w.r.t. energy efficiency