Delivering the Energy Transition

In theory and practice ..

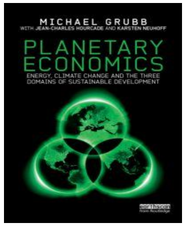
Michael Grubb

Prof. International Energy and Climate Change Policy, UCL

Chair, UK government Panel of Technical Experts on Energy Market Reform
Editor-in-Chief, *Climate Policy* journal

Australia National University
6 December 2016

- Broadening our economic frameworks
- Emerging transition in practice
- Innovation and cost reductions
- Integrating policies
- Some international implications



The Energy Trilemma

Energy policy needs to address:

- **Security**
  - *System resilience, over-concentration, geopolitical risk*
- **Affordability & competitiveness**
  - *Fuel poverty, the disconnected, 'industrial energy prices'*
- **Environment and sustainability**
  - *Air quality, climate change, mining and water*

Prioritising one too much over the others generates instability

Focus here particularly on electricity, increasingly important in other sectors (transport, buildings)

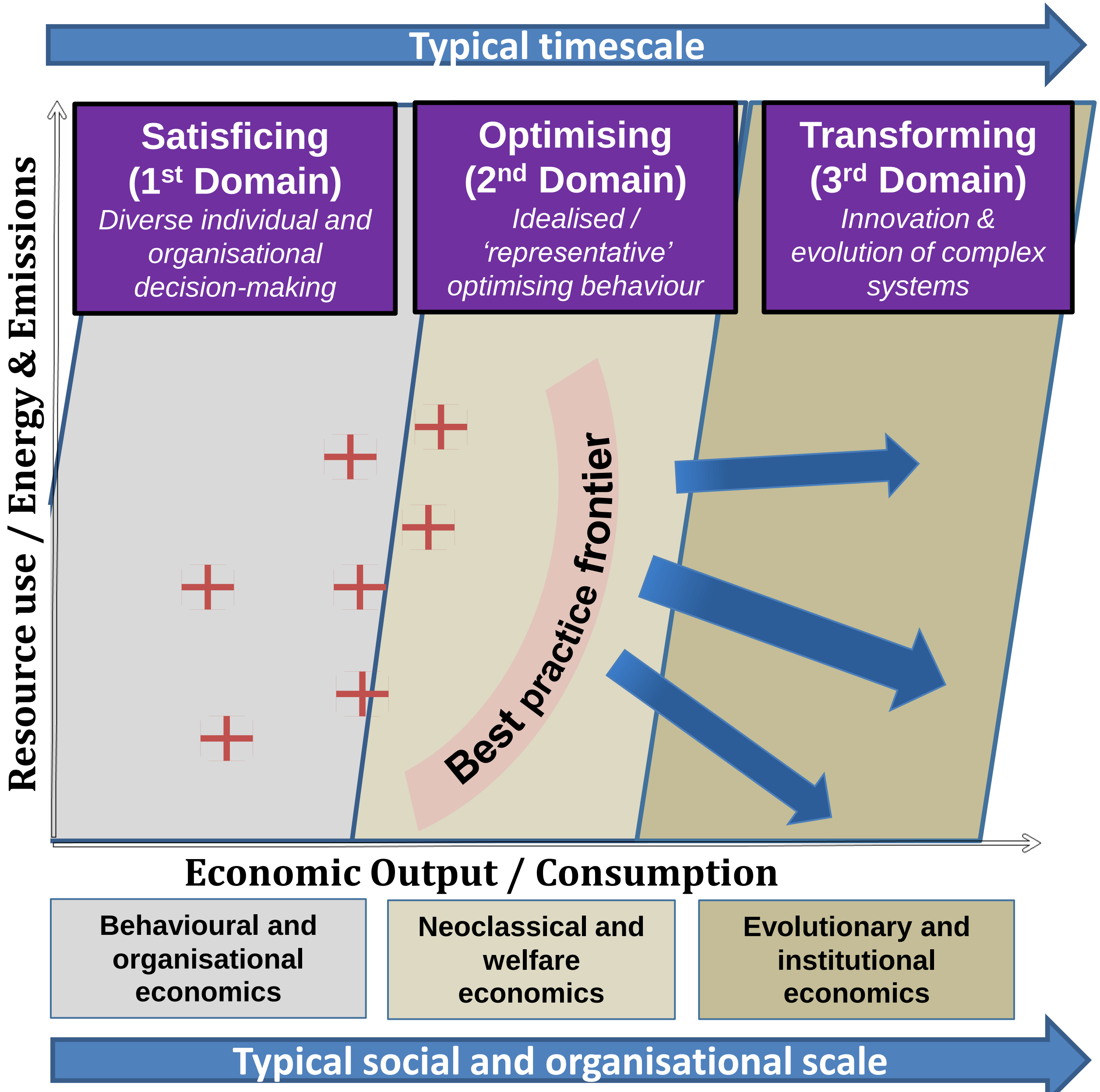
A *systems* issue .. and a challenge to theories

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



Ideal policy comprises a package which matches the best instrument to the respective domain of decision-making

Policy pillars

Domain	1 Standards & Enabling	2 Markets & Prices	3 Strategic Investment	
Satisfice	H	L/M	L	Smarter choices
Optimise	M	H	M	Cleaner products & processes
Transform	L	L/M	H	Innovation & infrastructure

- H Highest relevance
- M Medium relevance
- L Lowest relevance

Affordability – and energy prices

In the long run, *countries with higher energy prices do not spend more of their income on energy*

- Higher efficiency and innovation policies compensate
- *Indeed countries that subsidised energy to keep it cheap have ended up spending more*

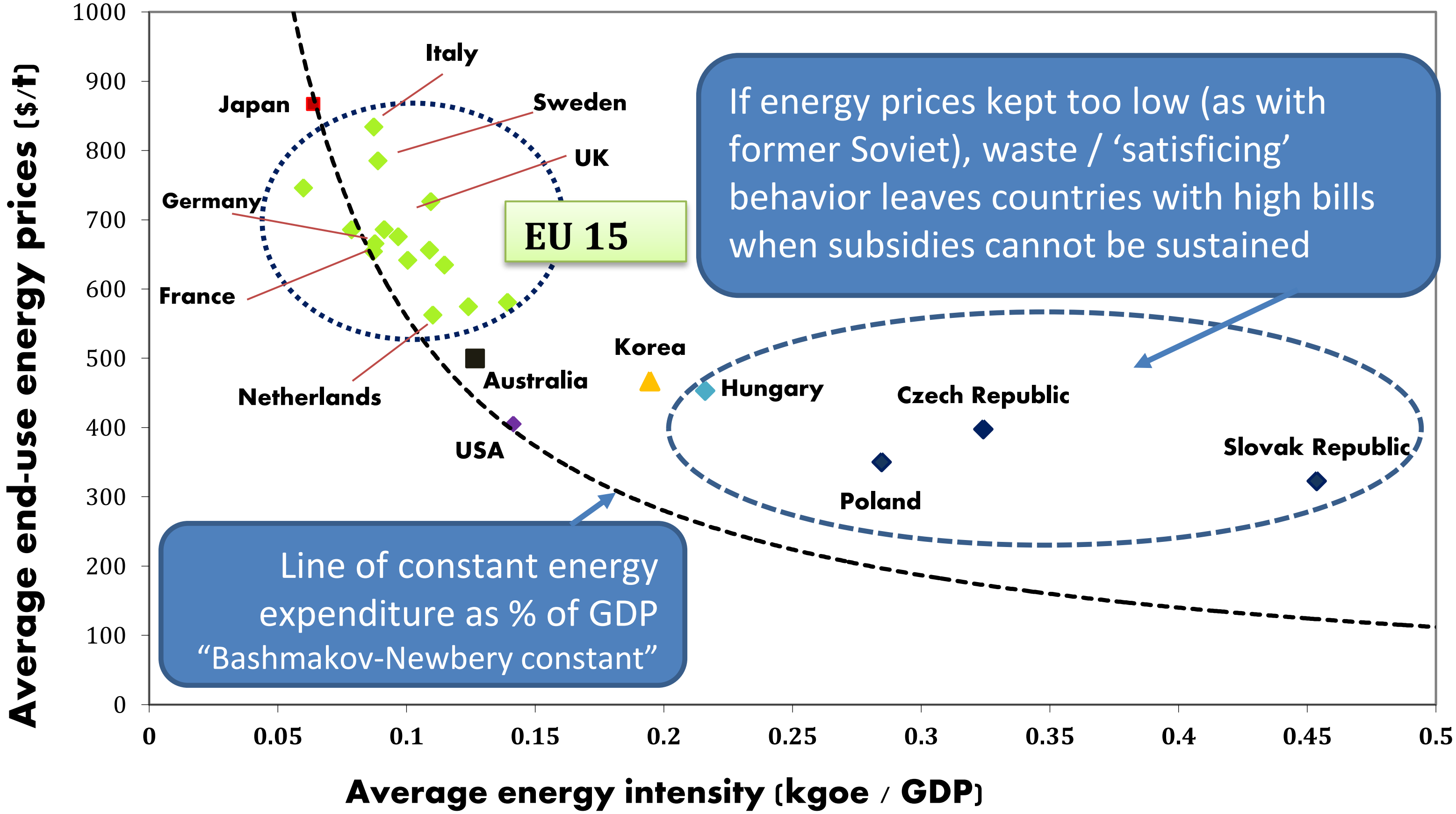


Figure 6-1 The most important diagram in energy economics

Note: The graph plots average energy intensity against average energy prices (1990-2005) for a range of prices. The dotted line shows the line of constant energy expenditure (intensity x price) per unit GDP over the period. *Source: After Newbery (2003), with updated data from International Energy Agency and EU KLEMS*

The “Bashmakov-Newbery Constant” of energy expenditure

- The proportion of national income spent on energy has remained surprisingly constant, *given sufficient time to adjust*
  - for more than a century
  - for most countries
- *Despite* huge variations in energy prices (Bashmakov)

- Cannot be explained through the classical measures of in-country consumer price response (elasticities) but needs also to invoke:
  - **Energy efficiency** regulation and related policy responses
  - **Innovation** throughout energy supply and product chains

Challenge is to accelerate efficiency & decarb-innovation for several decades *without politically untenable policy-driven price shocks*

- **From carbon prices, or eg. renewables support costs**

http://www.climatestrategies.org/projects/planetary-economics/
for information and register of related events.

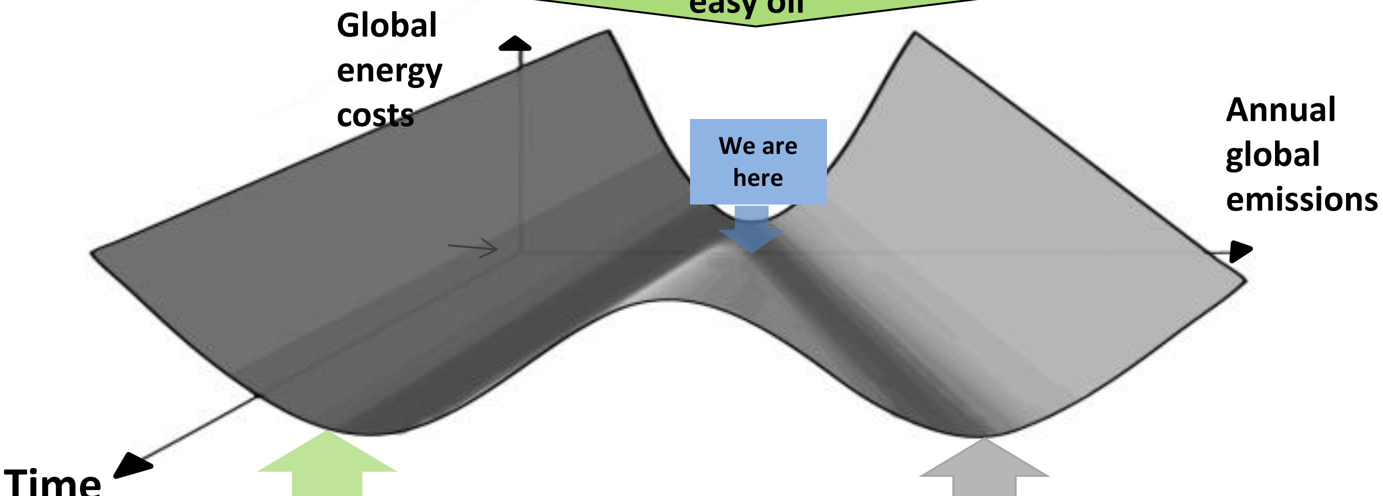
The Three Domains link to wider debates about macroeconomic growth

- Economic research points to two key areas of economic growth in addition to resource accumulation:
  - Improving efficiency of many economic actors and structures
  - Education, infrastructure and innovation
- *ie.* First and Third domain processes are recognised as important for macroeconomic growth. Yet these remain
  - largely absent in global (or national) modelling
  - poorly charted in policy
- Energy is a particularly strong candidate because
  - Multiple product characteristics => structural inefficiencies
  - Historic instability of fossil fuel markets
  - Exceptionally low rates of innovation particularly electricity & construction
  - Pervasive input to numerous production sectors

A sense of direction ….

Need to steer not marginal+ but structural and systemic change

Clustering of 'low cost' energy futures around higher and lower emissions, rather than in the middle, reflects divergent responses to depletion of 'easy oil'



'Green' futures

- Integrated high-innovation system
- Biomass and electricity in transport
- Low-carbon, 'smart electricity'
- High capital costs….
- ……but low operating costs

'Brown' futures

- Continued dependence on fossil fuels
- Unconventional and synthetic oil in transport
- Low capital costs…
- …but high operating costs and a host of environmental issues beyond carbon

"No wind is favourable to those who don't know where they are going"

- Lucius Annaeus Seneca

Figure 10-6: Two kinds of energy future – the carbon divide
Source: Upper panel: Gritsevskyi and Nakićenović (2000); lower panel: authors

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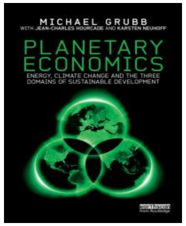
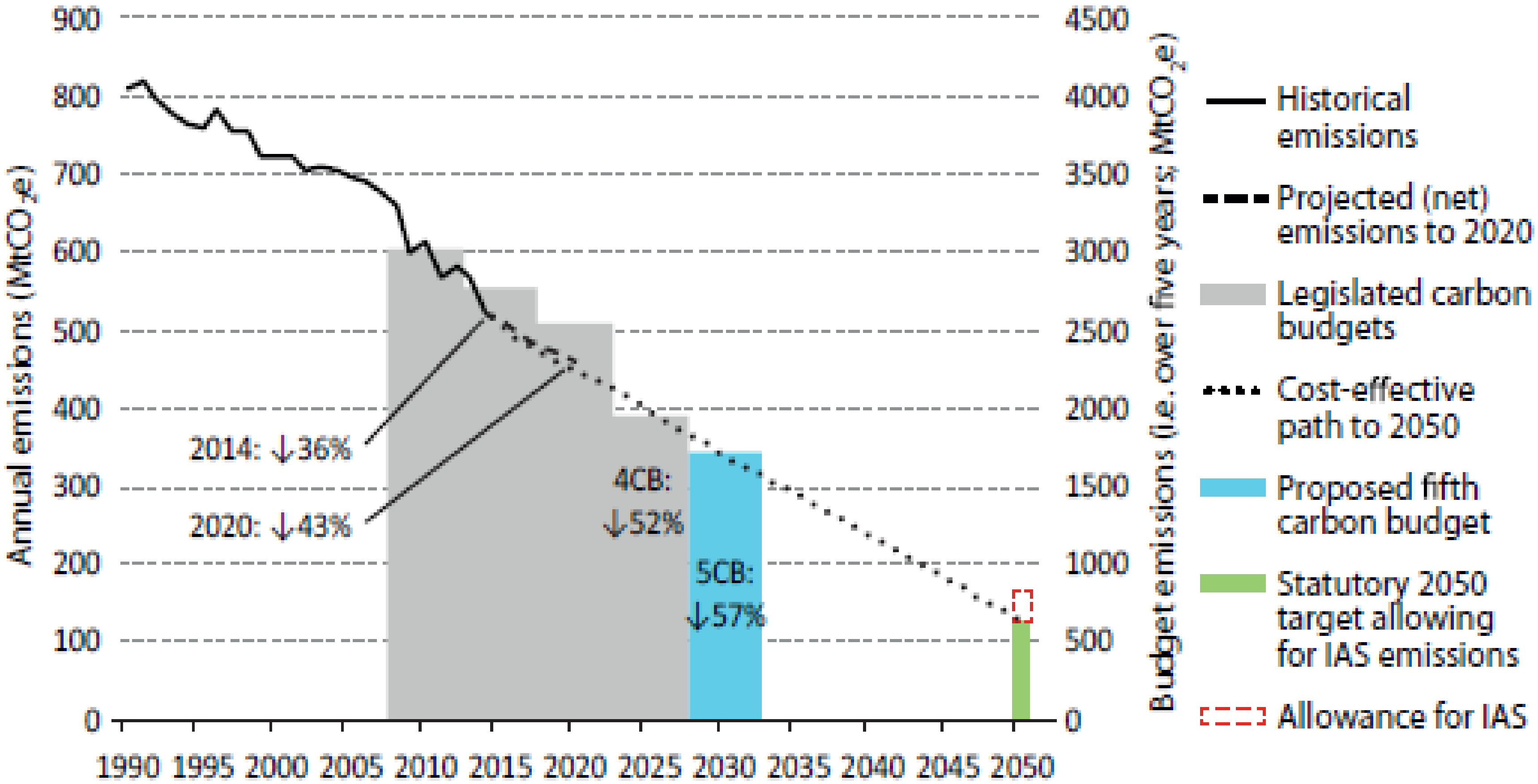
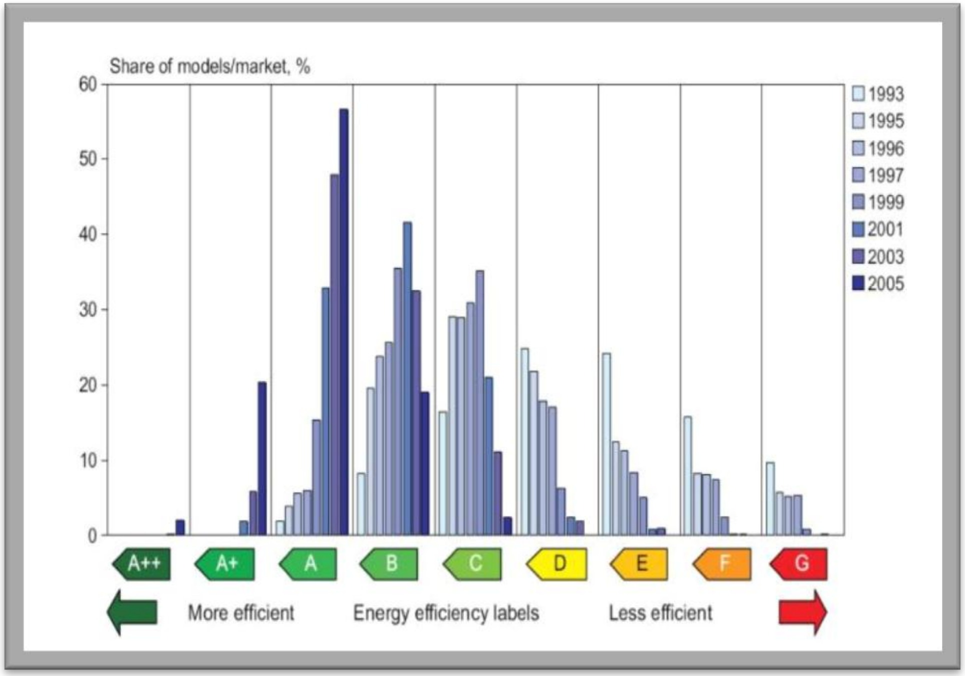


In UK – once an ‘island of coal in a sea of oil and gas’ - orientation set by Climate Change Act, with statutory 80%-below-1990 mid-Century



UK Pillar 1: Energy Efficiency



- ***Labelling and standards*** (mostly driven from EU): effective in appliances, significant in buildings but implementation challenges major improvements in vehicles
- ***Supplier obligations*** *("white certificates")* delivered 1-2% reductions in electricity & gas demand, 2008-13, from domestics – pressure to switch focus from '*cheap*' to '*deep*' to '*vulnerable*'
- Substantial impact (but also controversy) over ***'Carbon reduction commitment'*** system for less energy intensive business (retail, etc)
- Much-hyped '***Green Deal***' – loans for energy efficiency tied to properties – an unmitigated embarrassment

UK Pillar II in power sector: trends..

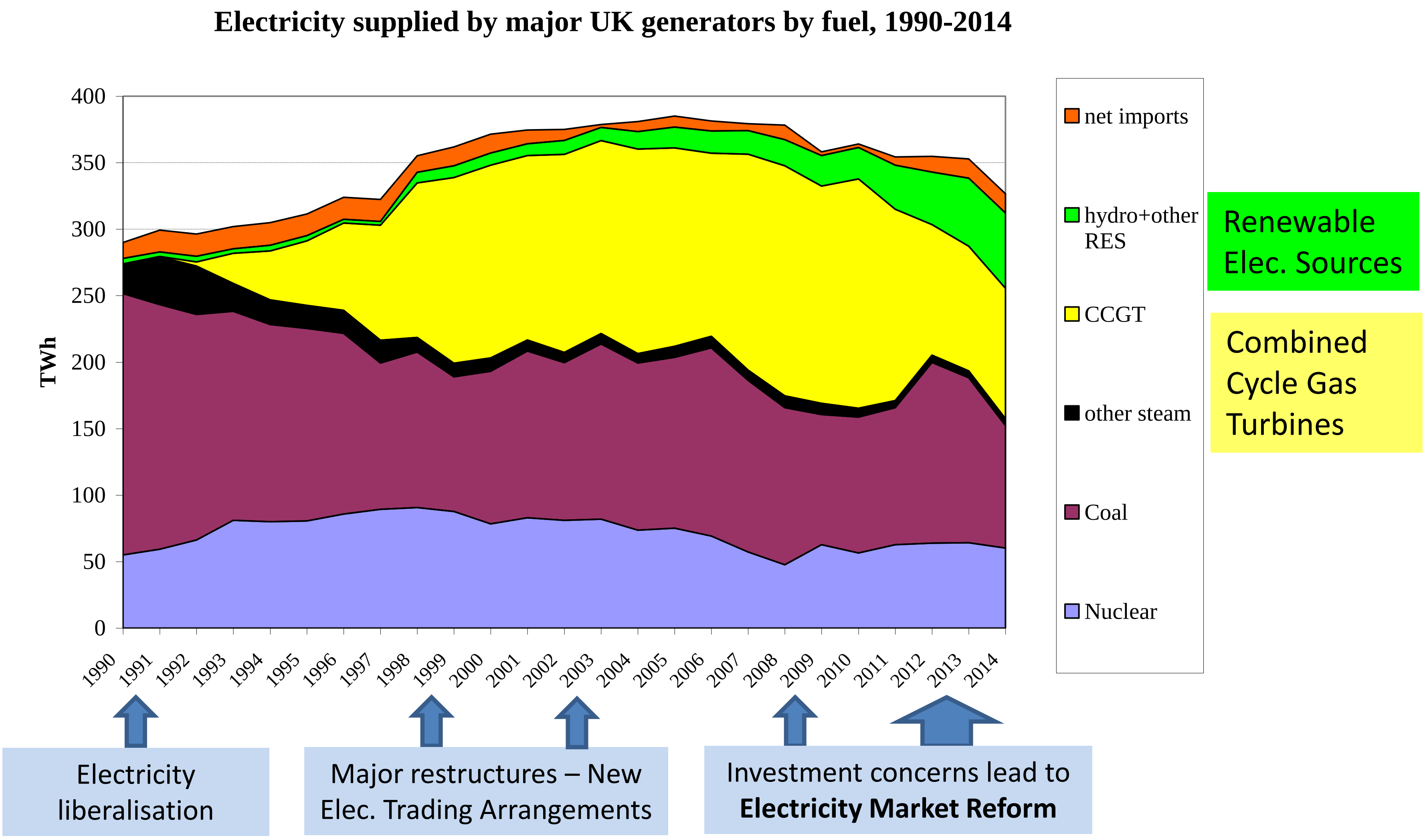
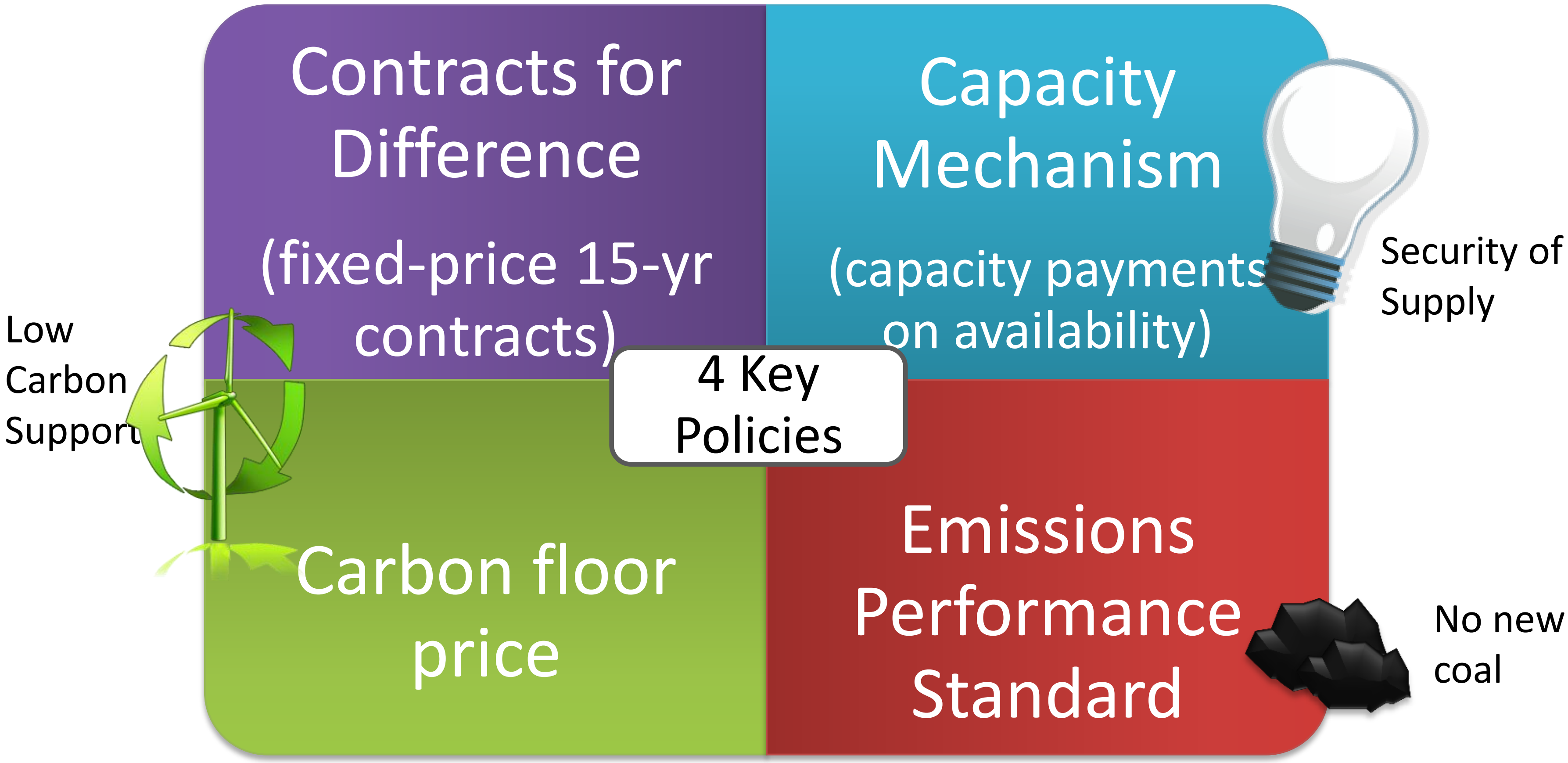


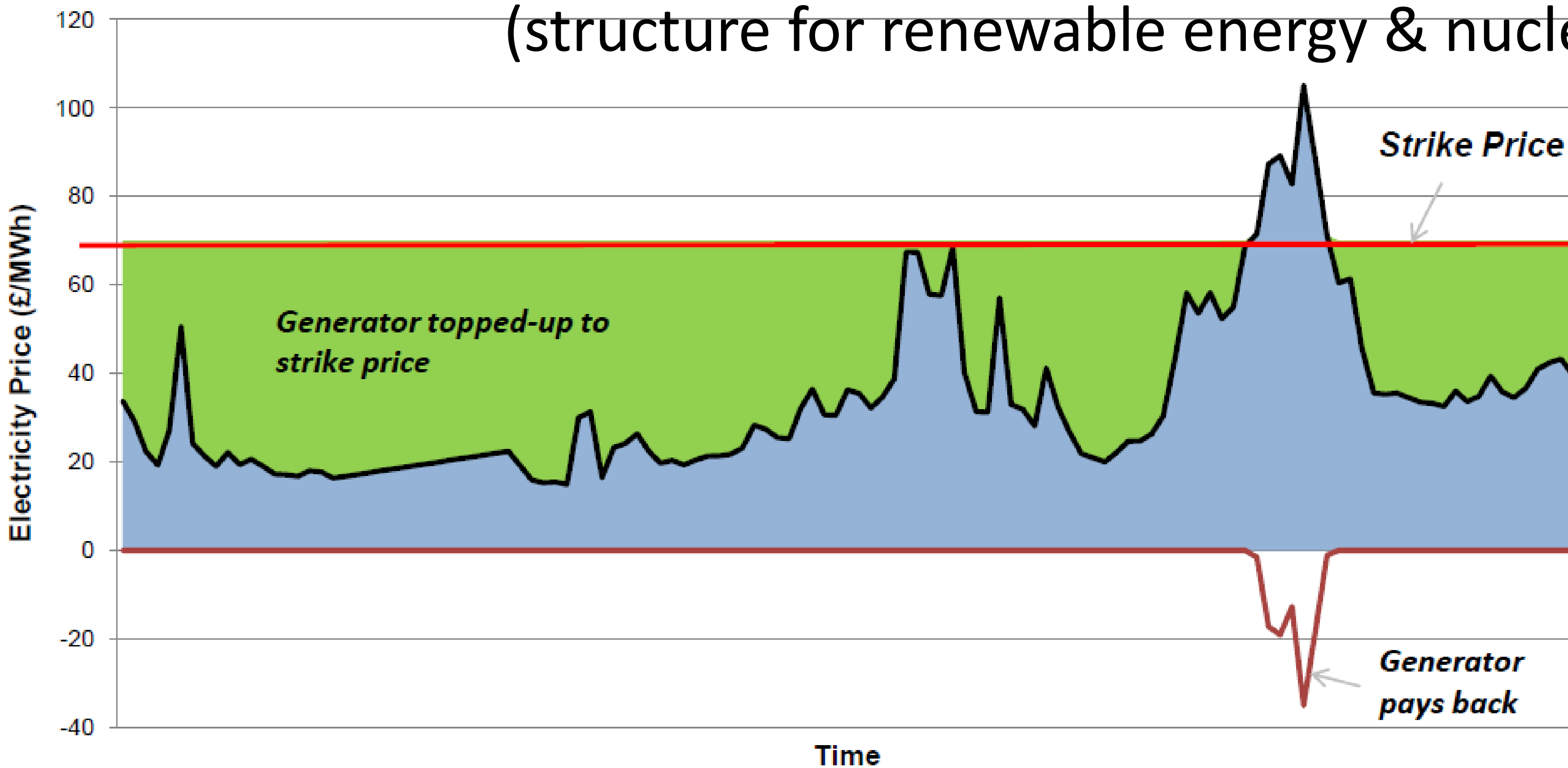
Figure 1 The dash for gas, the decline of coal, a competitive market & Elec Market Reform
Source (data): Digest of UK Energy Statistics, various years

Four elements of UK *Energy Market Reform*



Major changes to UK electricity market, implemented during 2011-15

Contracts for Difference (CfDs)
(structure for renewable energy & nuclear)



- Energy price topped up (or reimbursed) to a **"strike price"**
- **Initial contracts** awarded by government; moving to
- **Competitive auction** held by National Grid, sophisticated design

Yielding big cost savings

… *when combined with competitive auctions*

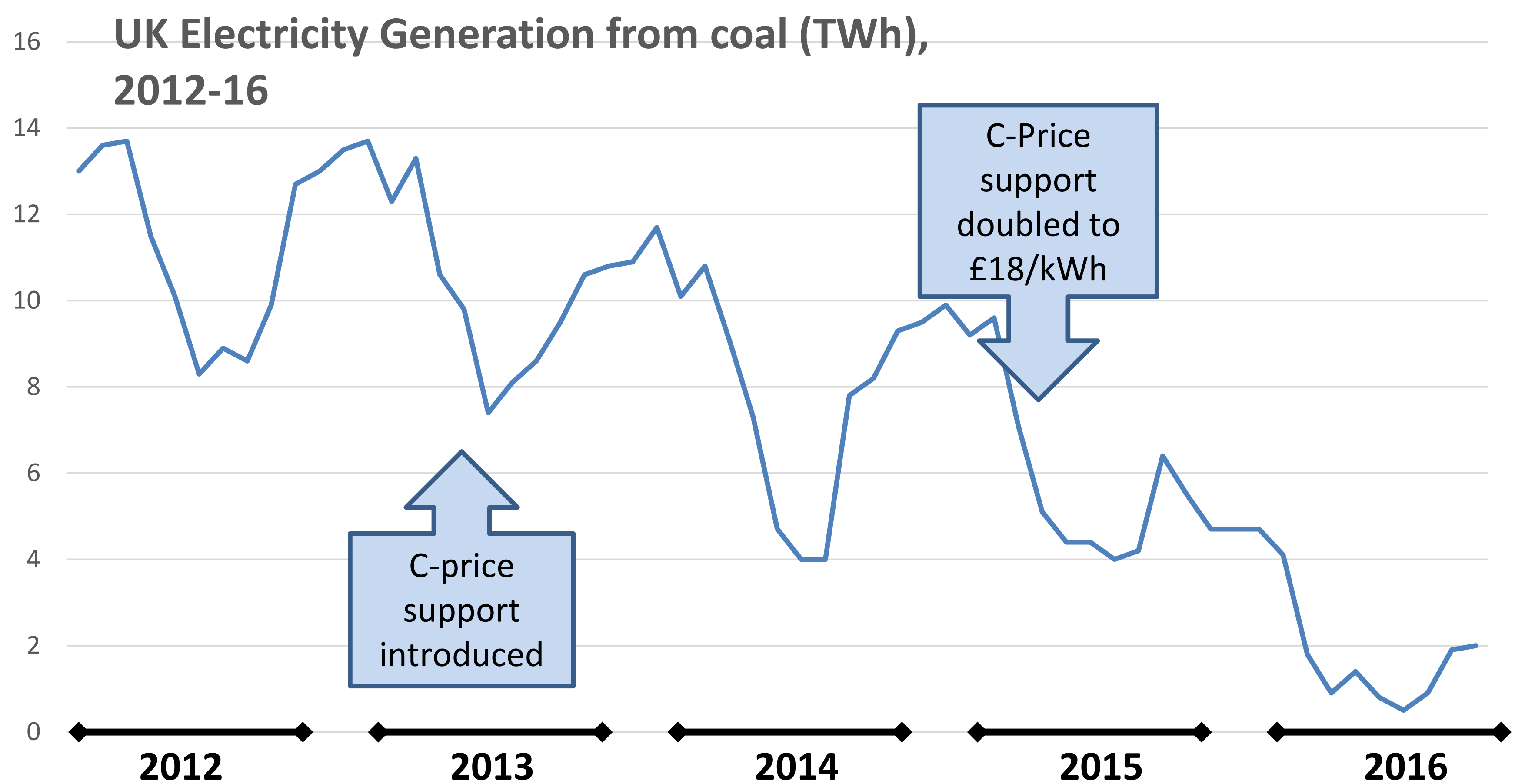
- Administered prices, May 2014 followed by competitive auction, Jan 2015
- Over £315m/yr new contracts offered to five renewable technology classes
- Over 2GW of new capacity with saving £110m/yr cf administered price in 2014
- Estimate cost of capital reduction by 3 percentage points – saving £bns.

	Capacity	Admin Strike price 2014 (£/MWh)	Lowest auction clearing price Jan 2015	Maximum % saving
Solar PV	72	120	**79**	**34%**
Onshore Wind	1162	95	**79**	**17%**
Energy from Waste CHP	95	80	**80**	**0%**
Offshore Wind	750	140	**114**	**18%**
Advanced Conversion Technologies	62	140	**114**	**18%**

- Other European auctions in 2016 with further cost reductions
- Next UK auction announced, expected even offshore wind << £100/MWh
- Now well within the ‘BNC’ range of affordability, *if & as system evolves*

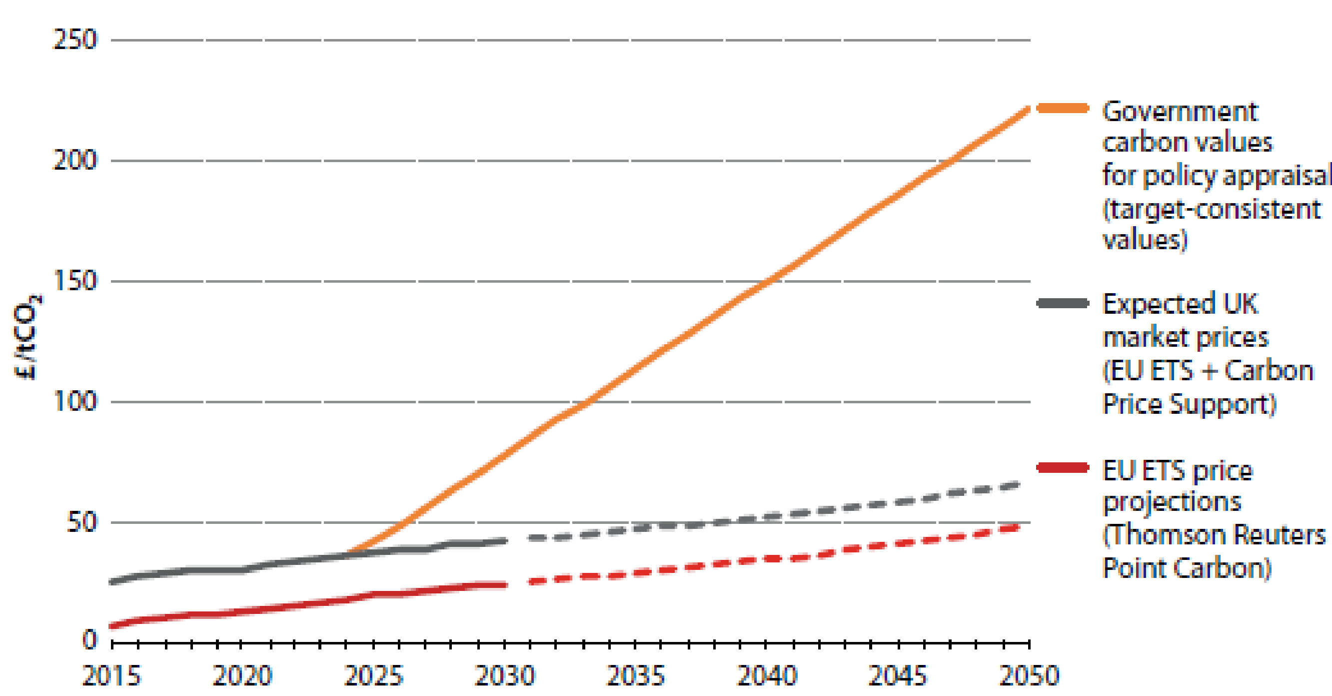
+ Carbon floor price impacts coal

Dramatic (80%) fall since 2012: first hours without coal power for over a Century
Driven as declining gas price meets rising carbon price, and renewables
Falls 2012-15 offset by rising renewables; increased gas in 2016



Target consistent carbon values

Figure B3.7: Target-consistent carbon values and market prices (2015-2050)



- Scenarios include measures available at lower cost than Government carbon values
- And reflect need to ensure that measures required to meet 2050 target are available to be deployed when needed

UCL Institute for Sustainable Resources

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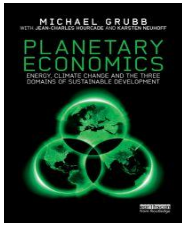


We are seeking radical innovation *in some of the least innovative sectors of our economies*

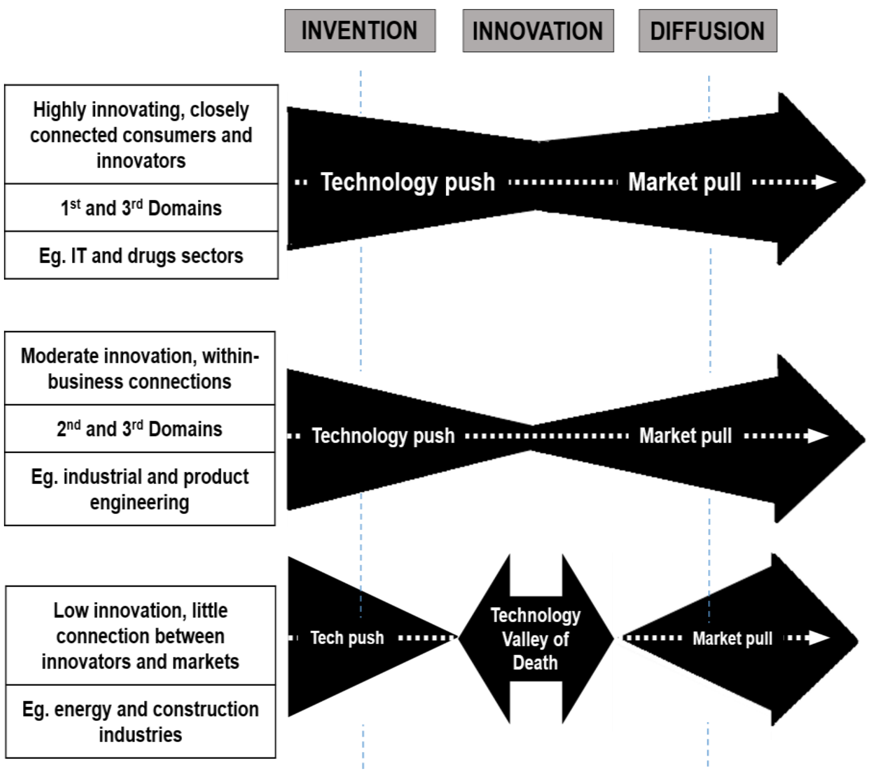


Fig.9.7

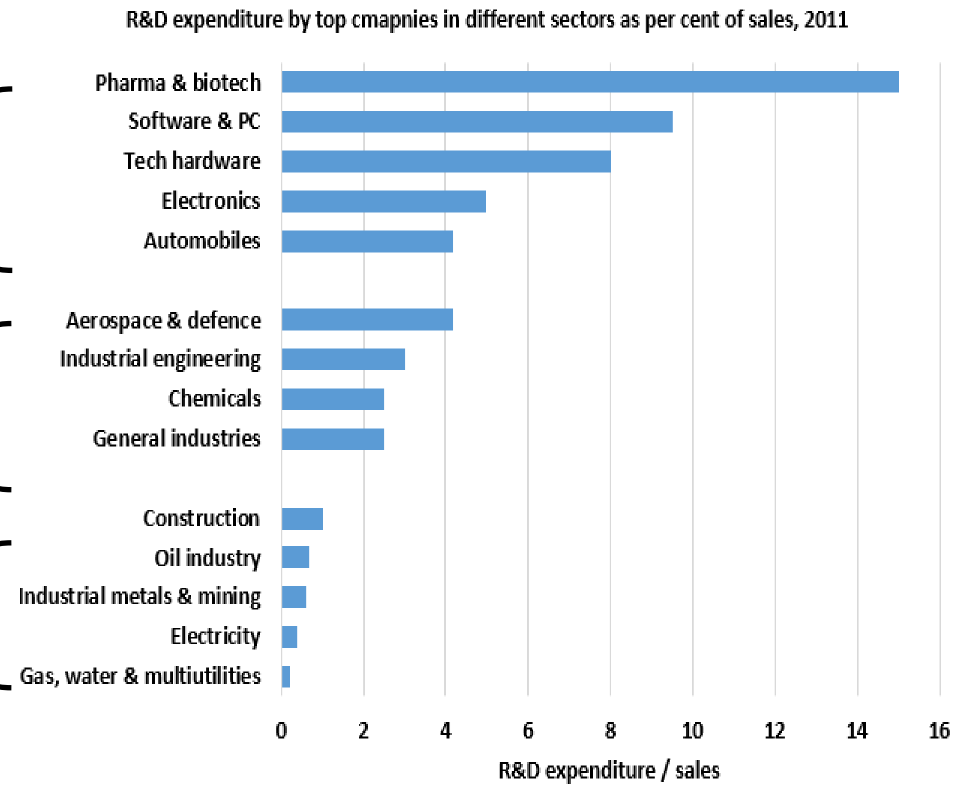


Fig.9.3 R&D expenditure by top companies in different sectors as % of sales, 2011

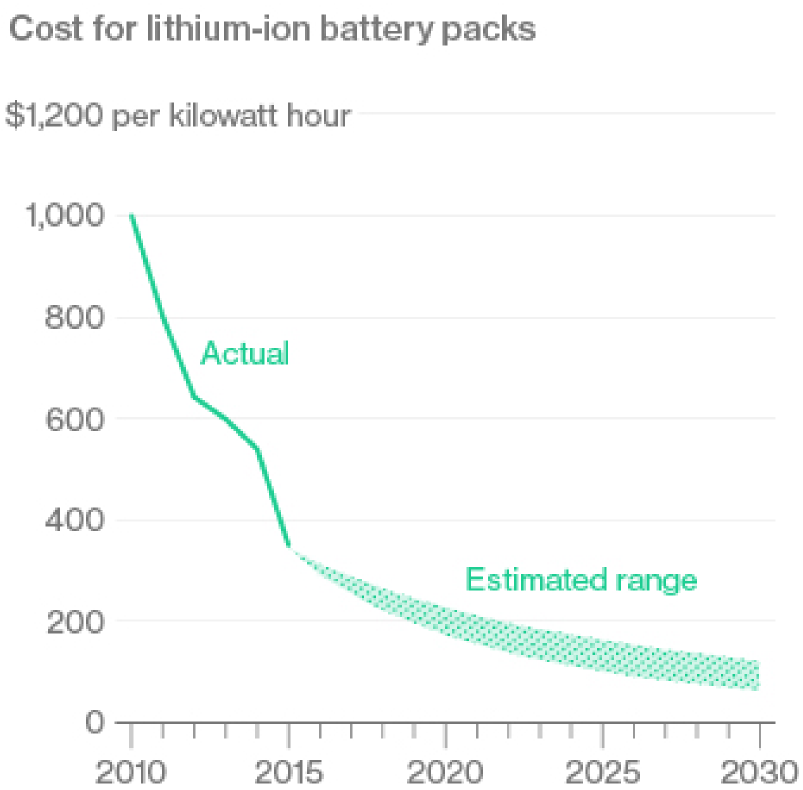
The 'technology valley of death' caused by

high up-front innovation costs & long lead times => large risks

weak demand-pull and large market risks in innovating for policy-dependent value

Mix of strategic investments in both technology push and demand pull needed to overcome numerous obstacles

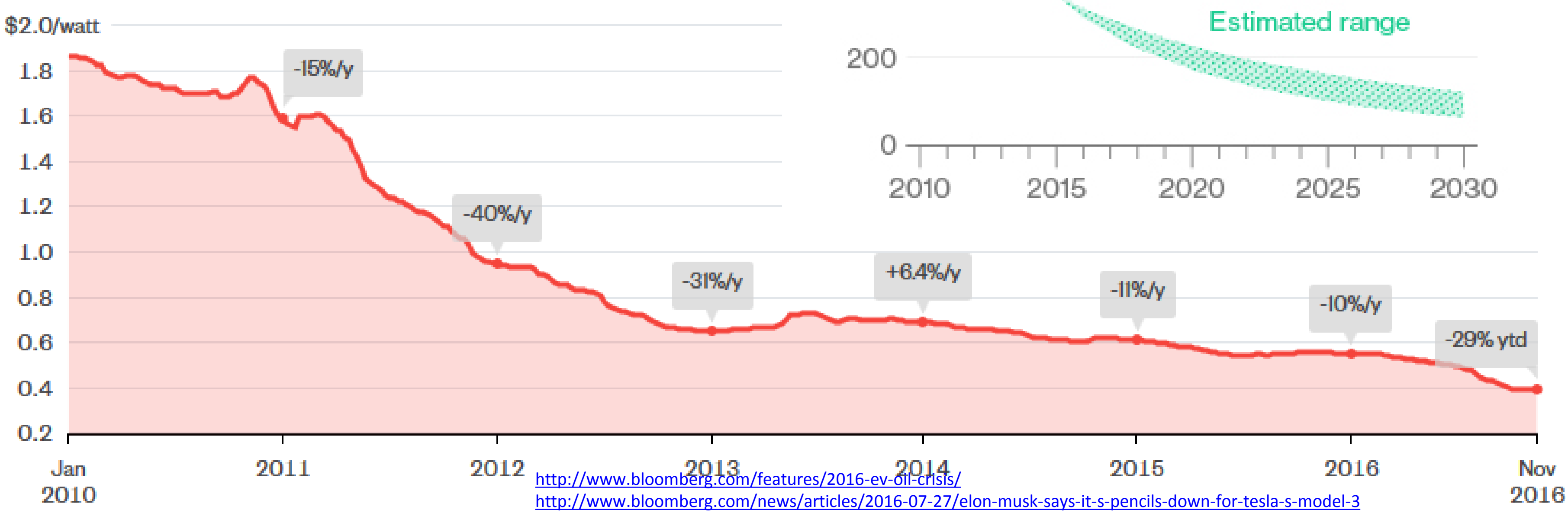
Driven mainly by public policy, big reductions in PV and battery costs



PV: New record installed power prices

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

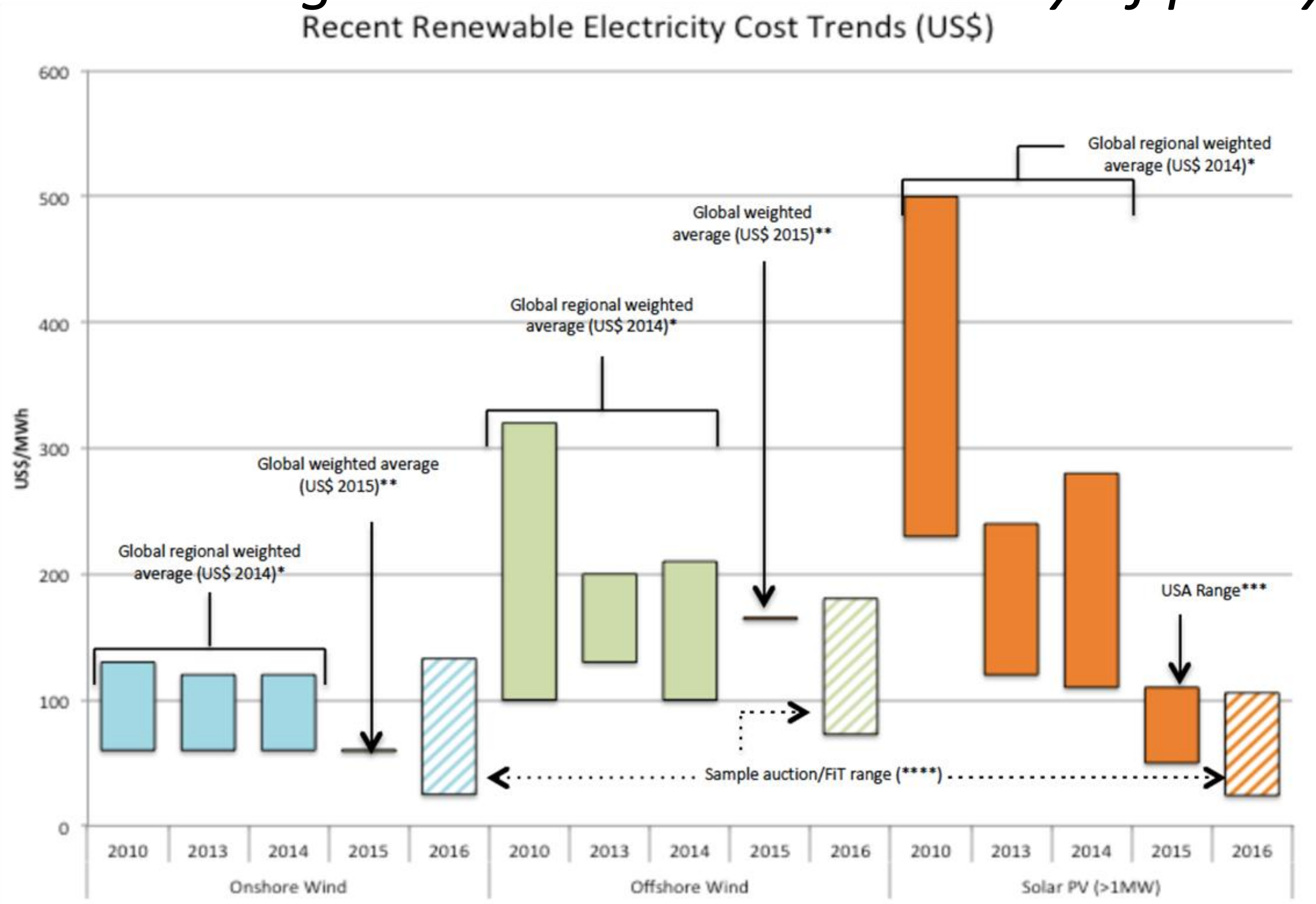
Module costs: -29% in 2016 to $0.39/Watt



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

https://www.bloomberg.com/gadfly/articles/2016-11-23/solar-industry-makes-feast-of-price-famine http://reneweconomy.com.au/how-the-jaw-dropping-fall-in-solar-prices-will-change-energy-markets-55160/

Prices trends of the big renewables, sharp declines – *but ranges also show the centrality of policy risk*



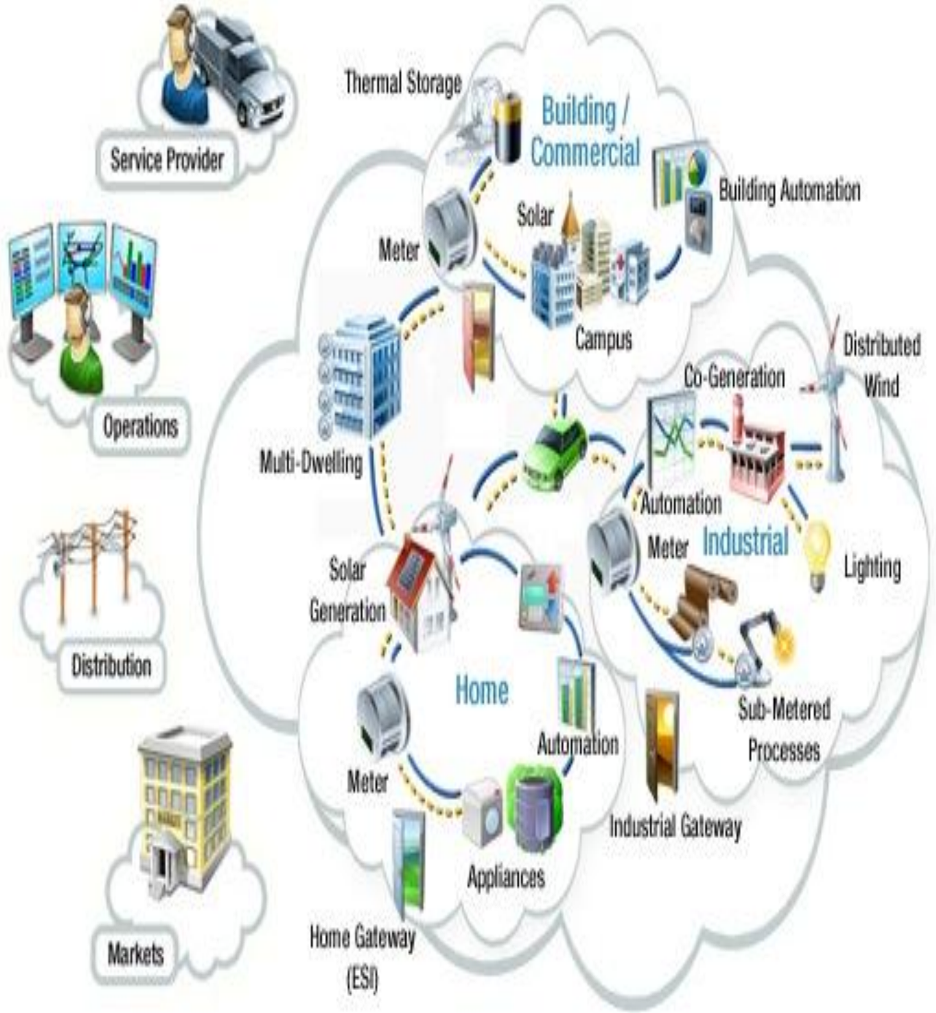
Recent trends in international costs and contracted prices for wind and solar (source: UCL Submission)

A transition *at all scales*..

Distributed Service Providers

Combined with

Big generation developments, such as North Sea wind



TenneT CEO Mel Kroon commented: *'In Germany and more recently in the Netherlands, TenneT has the role of developer and operator of the offshore grid. From this responsibility we have taken the initiative to establish a realistic and achievable plan for further development of the North Sea. The success of the energy transition depends largely on the extent to which we mount a coordinated joint effort in Europe. Cooperation between national governments, regulators, the offshore wind industry, national grid administrators and nature and environmental organisations is a precondition for achieving Europe's environmental targets. The vision we have presented shows the relevance of cooperation in the North Sea.'*

North Sea Infrastructure: the vision

Solar and wind energy will be necessary on a large scale because attainment of Europe's targets for reducing CO_2 emissions depends largely on the production of renewable electricity. Moreover, wind and solar energy are

Source: Prof Jun Dong, North China University of Electric Power

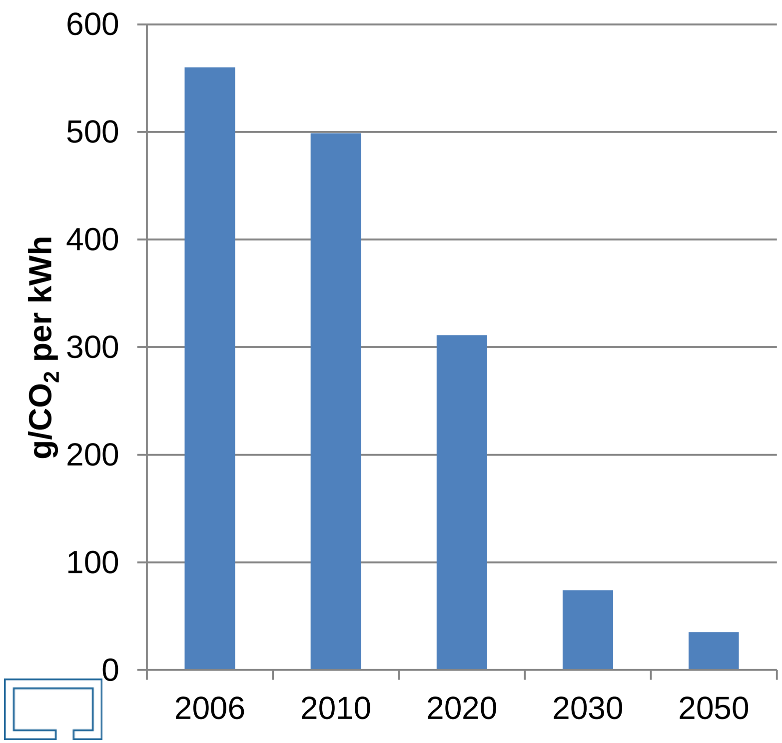
Source: TenneT

Decarbonising power contributes into other sectors

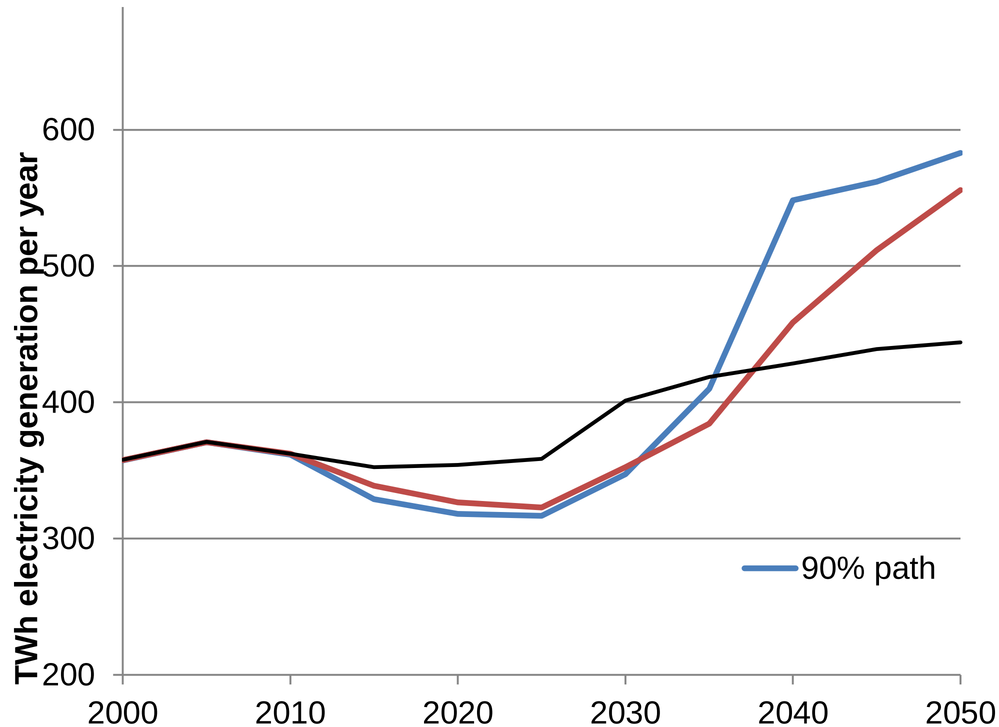
Renewables (Wind, solar, tidal and marine, biomass), nuclear, CCS

Application of power to transport and heat

Electricity emissions intensity to 2050



Electricity demand to 2050



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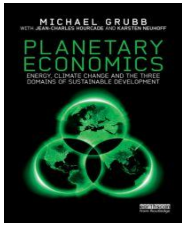


No pillar on its own can credibly solve the problem

– nor offers a politically stable basis for policy

- Energy efficiency policy on its own limited by:
  - Scale of intervention required
  - Growing scale satisficing behaviour
  - …. Leading to large Rebound effects

- Pricing on its own limited by:
  - Blunt nature of impacts First and Third Domain impacts
  - Rising political resistance to rising fuel bills
  - .. and competiveness concerns

- Innovation on its own limited by:
  - Lack of demand pull incentives
  - Scale & risks of investment costs
  - Political failures in absence of rising market feedbacks

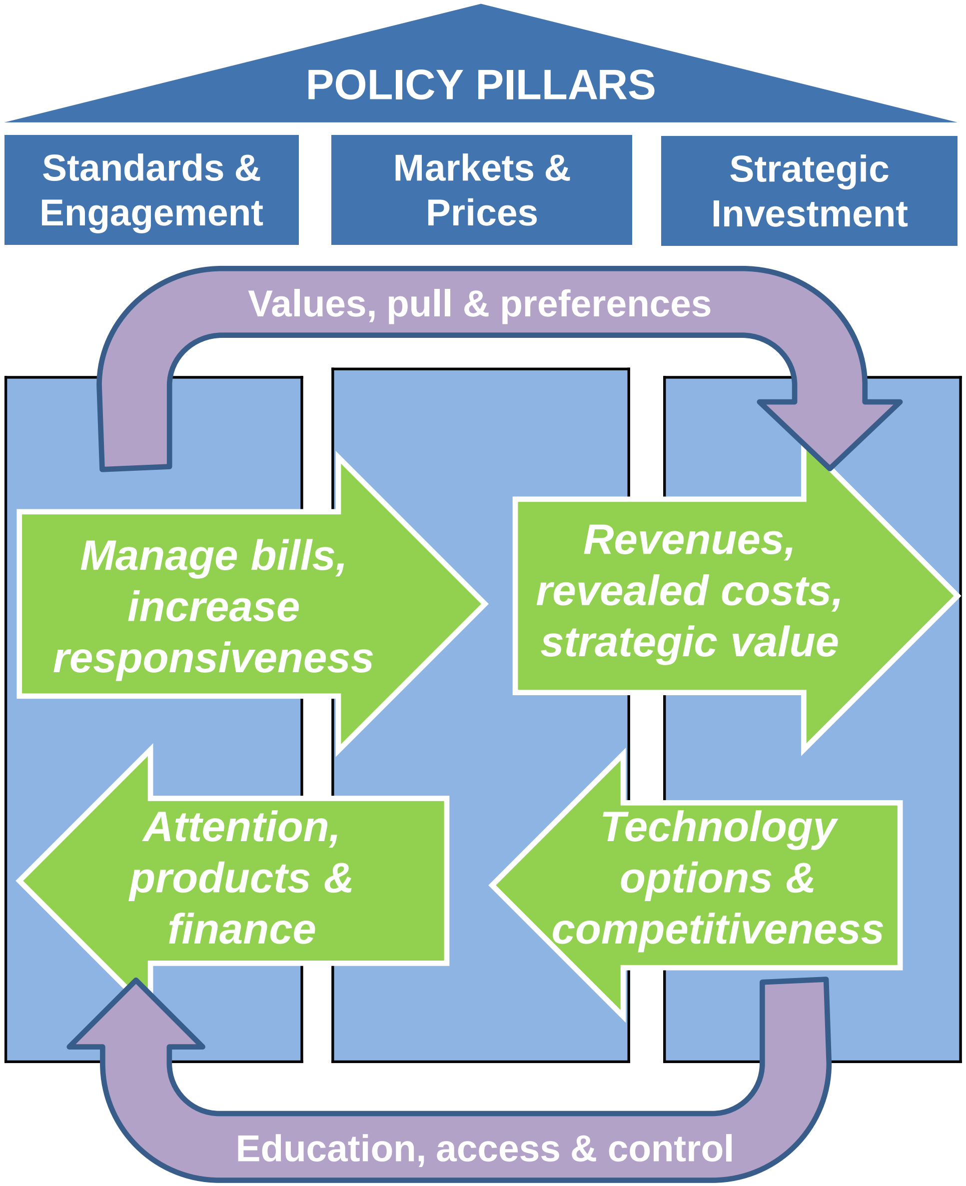
An *integrated package*

Need to integrate across all three pillars:

- Enhanced efficiency
- Cleaner products
- Innovation and infrastructure

And harness this for *social and industrial strategy*

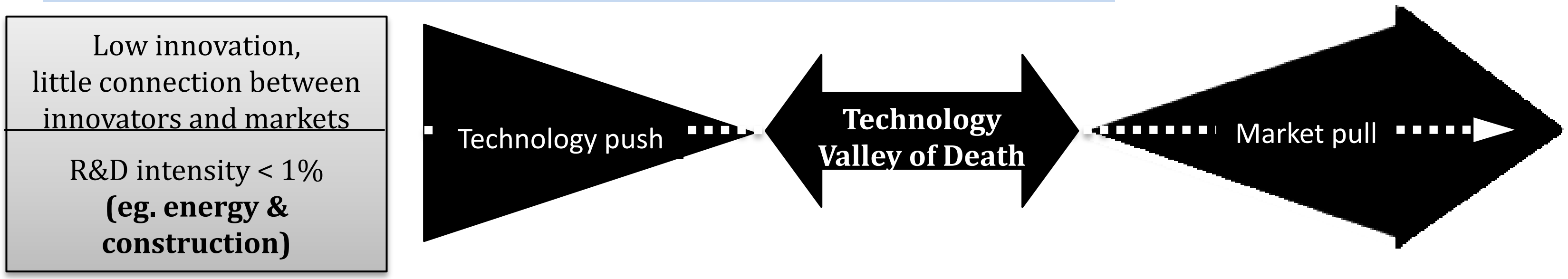
- Lower resource costs
- Consider carbon pricing including *materials consumption & low-C materials*
- Accelerate innovation for competitiveness



Spanning the innovation chain ..

Money ==========➔

At rising scale (Pillars II and III)



PE Figure 9.7. Innovation intensity & the broken chain

🡐 ======== Markets

Pillars I and II (strategically growing)

- We have gained extensive experience of policies to span innovation chain
- Need integration between public and private, & strategic investment and markets
- Infrastructure important as the technologies expand – need to overcome lock-in
- International technology cooperation can enlarge the market and amplify the benefits

The ‘narrative’ around carbon pricing …

Must change!

- Not an abstract (externality pricing) but an *instrumental* rationale
  - Investment as well as operational incentive
  - A source of funding for energy efficiency and innovation programmes
  - A political narrative based around stability of energy expenditure
- More tools in the toobox, including carbon-backed contracts, reference and internal carbon pricing
- Key design elements for market carbon pricing
  - A price corridor on emissions trading
  - Linked with technology strategy
  - Energy-intensive industry, carbon leakage concerns potentially addressed through trade linkages and/or carbon pricing on material consumption
  - ‘carbon leakage’ increasingly offset by ‘clean technology diffusion’

With a basis in international strategy / coalition implementation of PA

- A coalition of countries strengthening their NDC commitment in 2020?
- Coordination of price, technology investment and trade approaches?

Conclusions: Theory

- The answer to Laurence's question is that economics can help when it respects the boundaries of a given theory, but hinder when it tramples across them

- 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*

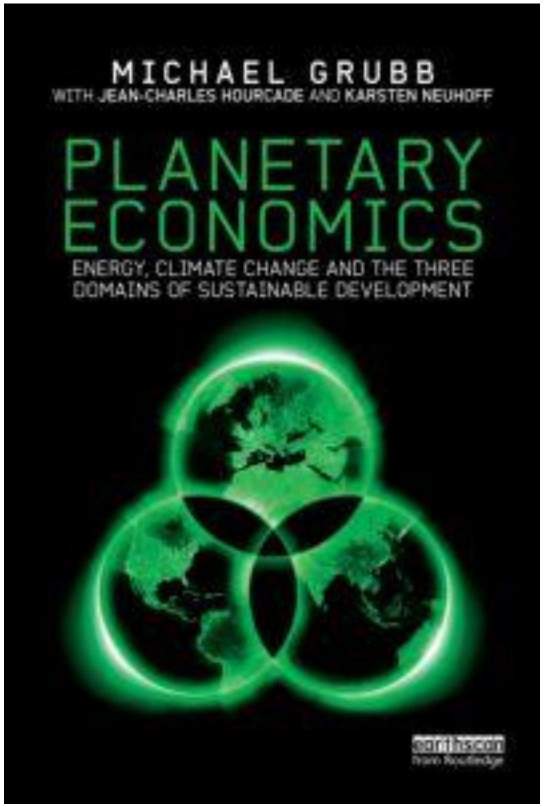
- And there is a wider analogy to be drawn ..

Conclusions: Practice

- 21st Century energy systems will be radically different from 20th Century
- Understanding transition on this scale means broadening economic horizons to all three domains and associated pillars of policy
- Transition is already under way, so far driven far more by the non-pure-market policies
- Aggregate cost impacts (eg. Germany) pushed to the limit of this approach, but resulting technology cost reductions place the transition within reach of global development and more balanced policy packages
- Clear policy direction can shift risk and lower finance costs
- … including new roles and narrative for carbon pricing

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