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Part 1: Fundamentals:
The Triads of Energy Policy

- The Energy ‘Trilemma’
- Three Domains and Three Pillars of Policy
- Outline evidence & macro implications

Part 2: Electricity technology trends and UK experience
Part 3: Policy integration, valuing and conclusions
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, minerals extraction and water

Prioritising one too much over the others generates instability.

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

A systems issue ... Laurence Tubiana’s Question
Three Domains – an Economic Interpretation

1st Domain
“Satisficing” behaviour

2nd Domain
“Optimising” behaviour

3rd Domain
“Transforming” behaviour

1. Real-world individual and organisational decision-making

Best practice frontier

“Business as usual” innovation

e.g. Accelerated low carbon innovation

e.g. Purely carbon-price-driven innovation

3. Innovation & evolution of complex systems

Resource Use / Energy & Emissions

Economic Output / Consumption
Three domains of decision-processes, with different characteristics and theoretical foundations, operate at different scales.

<table>
<thead>
<tr>
<th>Domain</th>
<th>Characteristics</th>
<th>Theoretical foundations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisficing</td>
<td>Habits, risk aversion to change or new investment, myopia, inattention to incidental / intangible costs; endemic ‘contractual failures’, principal-agent failures,</td>
<td>Behavioural and organisational economics</td>
</tr>
<tr>
<td>Optimising</td>
<td>Economic optimisation based on relative prices, ‘representative agents’ with ‘rational expectations’, stable preferences and tech trends</td>
<td>Neoclassical and welfare economics</td>
</tr>
<tr>
<td>Transforming</td>
<td>Technology, structure, institutional and behavioural change, typically from strategising, innovation, infrastructure investment</td>
<td>Evolutionary and institutional economics</td>
</tr>
</tbody>
</table>
Ideal policy comprises a package which matches the best instrument to the respective domain of decision-making.

**Policy pillars**

1. Standards & Enabling
   - Satisfice: H
   - Optimise: M
   - Transform: L

2. Markets & Prices
   - Satisfice: L/M
   - Optimise: H
   - Transform: L/M

3. Strategic Investment
   - Satisfice: L
   - Optimise: M
   - Transform: H

**Domain**

- Satisfice
- Optimise
- Transform

**Relevance**

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

**Policy outcomes**

- Smarter choices
- Cleaner products & processes
- Innovation & infrastructure
Pillar 1: Large possibilities remain to enhance efficiency, even in business: complex structure of ‘barriers and drivers’

Only about a quarter of recommended measures which take longer than a year to pay back were implemented by the time of follow-up survey, and the proportion implemented varies little for longer payback times.

Data Source: Carbon Trust

PE Chapter 4, “Why so wasteful?”, Figures 4-3 and 4-4
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

PE 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
We are seeking radical innovation ... in some of the historically least innovative sectors of our economies

Pillar 3: Mix of strategic investments in both technology push and demand pull needed to accelerate innovation and new entrants

‘Technology valley of death’ caused by high up-front costs, long lead times => large risks + weak demand-pull and large market uncertainties in innovating for policy-dependent value

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

PE Chapter 9, “Pushing further, pulling deeper”: Figure 9.7

Technology push  Market pull
Highly innovating, closely connected consumers and innovators
1st and 2nd Domains
Eg. IT and drugs sectors

Technology push  Market pull
Moderate innovation, within-business connections
2nd and 3rd Domains
Eg. industrial and product engineering

Technology push  Valley of Death  Market pull
Low innovation, little connection between innovators and markets
Eg. energy and construction industries

R&D expenditure / sales

Pharma & biotech
Software & PC
Tech hardware
Electronics
Automobiles
Aerospace & defence
Industrial engineering
Chemicals
General industries
Construction
Oil industry
Industrial metals & mining
Electricity
Gas, water & multiutilities
Some core points about innovation / evolutionary ("Third Domain") economics

- Neither pace nor direction of energy innovation is self-optimising
  - (least of all in presence of a public bad – eg. Acemoglu, Aghion et al 2012 & 2013)
- Accelerating innovation in such sectors can generate an economic surplus
  - which can be shared between private and public / cooperative
- Innovation is not synonymous with R&D but must span the full innovation chain (see Part II)
  - the economic gains emerge as industry gets closer to market and supply chains mature
  - The deployment phase also starts to forestall fossil lock-in costs – the challenge is systemically to generate positive not negative lock-in
- ‘Carbon leakage’ (-ve) is increasingly offset by ‘clean tech diffusion’ (+ve)
  - The latter grows over time
- ...which also amplifies the economic gains to the earlier emergent industrial capabilities
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

Source: Planetary Economics, Chapter 11 “The Dark Matter of Economic Growth”
A key to Planetary Economics – and politics – lies in the potential to align different levels of risk conception with the different pillars of response - A strategic risk issue like climate change aligns particularly with transformation.

<table>
<thead>
<tr>
<th>Risk conception / Domain</th>
<th>Dominant scale</th>
<th>Decision framework</th>
<th>Field of theory</th>
<th>Mitigation economic process</th>
<th>Realm of opportunity</th>
<th>Pillar of policy/response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ignore / Satisfice</strong></td>
<td>Short term / local</td>
<td>Indifferent or disempowered</td>
<td>Behavioural &amp; Organisational</td>
<td>Move closer to the ‘best practice frontier’</td>
<td>‘Smarter choices’</td>
<td>Standards and engagement (Pillar I)</td>
</tr>
<tr>
<td><strong>Compensate/ Optimise</strong></td>
<td>Medium term / regional</td>
<td>Costs / impacts are tangible and significant</td>
<td>Neoclassical &amp; welfare economics</td>
<td>Make best trade-offs along the frontier</td>
<td>Substitute cleaner production &amp; products</td>
<td>Markets and pricing (Pillar II)</td>
</tr>
<tr>
<td><strong>Secure/ Transform</strong></td>
<td>Long term / global</td>
<td>Transformatio nal risks and opportunities</td>
<td>Evolutionary &amp; Institutional</td>
<td>Evolve the frontier</td>
<td>Innovation &amp; infrastructure</td>
<td>Strategic investment (Pillar III)</td>
</tr>
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</table>
A sense of direction ....

“No wind favours those who don't know where they are going”

- Lucius Annaeus Seneca

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

Global energy costs

Annual global emissions

Time

‘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

Need to steer not marginal+ but structural and systemic change

Planetary Economics Chapter 10, “Transforming systems”, Figure 10-6: Two kinds of energy future – the carbon divide
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
Conclusion: 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
Conclusions: Theory

• The answer to Laurence’s question is that economics helps when it respects the boundaries of a given theory, but can 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 ..
Planetary Economics: Energy, Climate Change and the Three Domains of Sustainable Development

1. Introduction: Trapped?
2. The Three Domains

Pillar I
• 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