Navigating turbulent times

An integrating approach to energy-climate security and policy

Drawing on the book *Pla*

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Presentation to BIEE, 25 June 2014
An integrated approach to Energy Transition

- Nature of the energy-climate challenge
- The Three Domains and Three Pillars of Policy
  - System key components
  - Pillar I: Standards and Engagement
  - Pillar II: Markets and Pricing
  - Pillar III: Strategic investment
  - Growth theory and macroeconomic linkages
  - Policy Integration
  - A digression / illustration: electricity transitions and Capacity Mechanisms
- Joint Benefits
- The Economics of Changing Course
Turbulent times..

- Security
- “Affordability”
- Resources & climate

ie. The “Trilemma”

Define boundaries more than trade-offs?
Climate change economics 101:
Severity & CBA debates have been largely about the *discounting, scope & risk aversion* in impacts analysis (Weitzman’s Dismal Theorem)

<table>
<thead>
<tr>
<th>What kinds of climate changes?</th>
<th>Which kind of impacts?</th>
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</thead>
<tbody>
<tr>
<td>Projection (trend)</td>
<td>Market</td>
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<tr>
<td></td>
<td>Coastal protection;</td>
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<td></td>
<td>Dryland loss;</td>
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<td>Energy (heating and</td>
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<td></td>
<td>cooling)</td>
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<td></td>
<td>Non-market</td>
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<td>Heat stress;</td>
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<td>Wetland loss;</td>
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<td>Ocean acidification;</td>
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<td>Ecosystem migration/</td>
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<td></td>
<td>termination</td>
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<td></td>
<td>Multiple stresses and</td>
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<td></td>
<td>socially contingent</td>
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<tr>
<td>Climate variability &amp;</td>
<td>Displacement from</td>
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<tr>
<td>(bounded) extremes</td>
<td>coastal zones;</td>
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<td></td>
<td>Regional systemic</td>
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<tr>
<td></td>
<td>impacts</td>
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<tr>
<td>System changes &amp;</td>
<td>Agriculture;</td>
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<tr>
<td>surprises</td>
<td>Water;</td>
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<td></td>
<td>Storms</td>
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<td></td>
<td>Loss of life;</td>
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<td></td>
<td>Biodiversity;</td>
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<td></td>
<td>Environmental services</td>
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<td></td>
<td>Cascading social</td>
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<tr>
<td></td>
<td>effects;</td>
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<tr>
<td></td>
<td>Environmental</td>
</tr>
<tr>
<td></td>
<td>migration</td>
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<tr>
<td></td>
<td>Regional collapse;</td>
</tr>
<tr>
<td></td>
<td>Famine;</td>
</tr>
<tr>
<td></td>
<td>War</td>
</tr>
</tbody>
</table>

*Figure 1.8 The risk matrix: an assessment framework for evaluating the social cost of climate change*


*Note: ‘Socially contingent’ costs may be understood as those that may be amplified by the inability of society to respond to impacts effectively, such as failures of governance, inability to act collectively, or the frictions associated with migration or deeper disturbances*
Climate change – context

- A mega-problem of risk management under deep uncertainty
  - Not the primary science but the consequences
  - .. And how to value them, act, and coordinate response
- “The biggest market failure in history” (Stern)
- “The perfect moral storm”
- A “Super-Wicked” problem

And we have not been doing very well globally ...

- “Current trends are at the high end of levels that had been projected … growing on average at 2.2%/yr since 2000” [IPCC 2014]
- Energy debate in Europe dominated by bills and competitiveness
- Frontier energy investments concentrated on finding more Carbon …
- Developing countries largely following the existing model
Figure 6-6 Stylised benefits and costs of cutting emissions: implications for ‘tax or cap’?
Evidence of strong *long run* adjustment of costs...
National energy intensity approx inversely proportional to long-run prices
- across countries the % of GDP spent on energy is remarkably constant

**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*
Scope for adjustment in long term enables a security-oriented, goal driven approach to safe boundaries (ii) in the long term, fix a safe quantity

Damage costs are highly uncertain but risks rise steeply with cumulative emissions

Mitigation costs are uncertain, but far more scope for deep reductions in long term ("flatter")

Long Term Outlook

Long term: target safe quantity
The energy challenge of decarbonisation

Historic average: 1.3%/yr

Global emissions reduction below 1990 level

20% by 2030

50% by 2050

Historical Decarbonisation/Energy...

Combination needed for percentage emissions reduction

Possible future paths

Global energy efficiency
Carbon & energy intensity has fallen but countries remain at widely varying levels

Figure 1.6 Trends in carbon intensity, by region and globally from 1980-2008

Source: Authors. Data from IEA (2010) and World Bank (2011)
… Over last few decades, largely stable per-capita emissions (recent declines) in industrialised countries with little sign of convergence.

Figure 1.7 Per-capita CO2 emission trends vs income - trends of major countries
Source: Authors. Data from World Bank (2011) and IEA (2010)
An integrating approach to climate policy

Three Domains
and the
Three Pillars of Sustainable Development

- Nature of the challenge
- The Three Domains and Three Pillars of Policy
- System key components
- Pillar I: Standards and Engagement
- Pillar II: Markets and Pricing
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- The Economics of Changing course
## Prelude: three levels of risk conception ..

<table>
<thead>
<tr>
<th>Risk Conception</th>
<th>Basic Belief</th>
<th>Typical Strategy</th>
<th>Societal process</th>
<th>Time-scale of climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indifferent or disempowered</td>
<td>Not proven, or “What you don’t know can’t hurt you”</td>
<td>“Ignorance is bliss”</td>
<td>NGO campaigns vs resistance lobbying</td>
<td>First few decades of climate change</td>
</tr>
<tr>
<td>Tangible and attributed costs</td>
<td>Weigh up costs and benefits</td>
<td>Act at costs up to level of marginal benefits</td>
<td>Technocratic valuation and politics of pricing</td>
<td>As impacts rise above the noise – next few decades</td>
</tr>
<tr>
<td>Disruption and securitization</td>
<td>Personal or collective security at risk climate change as a “threat multiplier”</td>
<td>“Containment and defence”</td>
<td>Mitigate as much as practical and adapt to the rest</td>
<td>Ultimately, for all (systemic and global risk) <strong>Most vulnerable</strong>, sooner, with international spillover</td>
</tr>
</tbody>
</table>
The “Bashmakov-Newbery Constant”

- The proportion of national income spent on energy has remained surprisingly constant
  - for more than a century
  - for most countries

- *Despite* huge variations in energy prices (Bashmakov)

- This 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
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

2. Innovation & evolution of complex systems

3. Innovation & evolution of complex systems

Economic Output / Consumption

Resource Use / Energy & Emissions

“Business as usual” innovation

Accelerated low carbon innovation

Purely carbon-price-driven innovation

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

The Three Domains rest on different fields of theory that apply at different scales.

- **Behavioural and organisational**
- **Neoclassical and welfare**
- **Evolutionary and institutional**

Three realms of abatement opportunities..

- [ Global estimates for 2030 highlight first two .. ]

Estimates of Global Mitigation Costs and Potential by 2030


Solutions need to harness corresponding policy pillars based on the three domains, to transform energy systems.

**Domain**
- Satisfice
- Optimise
- Transform

**Policy pillars**
1. Standards & Engagement
2. Markets & Prices
3. Strategic Investment

**To deliver**
- Smarter choices
- Cleaner products & processes
- Innovation & infrastructure

**Domains & Relevance**
- Satisfice: Standards & Engagement (H), Markets & Prices (H), Strategic Investment (L)
- Optimise: Standards & Engagement (M), Markets & Prices (M), Strategic Investment (M)
- Transform: Standards & Engagement (L), Markets & Prices (L), Strategic Investment (H)

An integrating approach to climate policy

Three Domains and the First Pillar of Sustainable Development

- Nature of the challenge
- The Three Domains and Three Pillars of Policy
- System key components
  - Pillar I: Standards and Engagement
  - Pillar II: Markets and Pricing
  - Pillar III: Strategic investment
  - Policy Integration
  - Joint Benefits
  - The Economics of Changing course
Energy and emission flows within the fossil fuel system

Note: The lower panel gives the numeric breakdown at each stage illustrated in the upper panel. Numbers at each step in the Chart (fuel, channel, end-use) independently add to 100%.

All data from the International Energy Agency, accessed through ESDS.
In transforming energy systems globally, all three domains are

• ... approximately *equally important*
  – Cost curve data
  – Difference between in-country and international elasticities
  – Observed policies of the most successful countries
  – Suggestive evidence from economic Growth Accounting & individual pillar ‘bottom up’ evidence

• .. *and interdependent*
  – *The pillars are complementary, not competing*
  – “Any pillar on its own will fail”

But the relative importance of different measures varies across sectors and nature of co-benefits are diverse
A key to Planetary Economics – and politics – lies in the potential to align different levels of risk conception with the different pillars of response

<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>Ignore / Satisfice</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>Compensate / Optimise</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>Secure / Transform</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>
</tbody>
</table>

Figure 2-6 Alignments within each domain
An integrating approach to climate policy

Three Domains
and the
First Pillar of Sustainable Development

- Nature of the challenge
- The Three Domains and Three Pillars of Policy
- System key components
- **Pillar I: Standards and Engagement for Smarter Choices**
  - Pillar II: Markets and Pricing
  - Pillar III: Strategic investment
  - Policy Integration
  - Joint Benefits
- The Economics of Changing course
Evidence confirms potential exists across individuals and organisations and many sectors, and endless scope to argue about how ‘big and real’ it is ...

Annual abatement in 2030 GtCO2e

Cost $USD/tonne of CO2e

-80 -70 -60 -50 -40 -30 -20 -10 0 10

A. ECONOMIC SCEPTICISM

B. BUILDINGS EXPERTS

C. CO-BENEFITS

D. REBOUND

Hidden & Implementation costs

Warmer homes, more driving with lower energy costs

Health, energy subsidies, environmental benefits

Economic benefits

Default (inefficient) baselines & holistic solutions

Hidden & Implementation costs

Source: Authors, with data from McKinsey Pathways to a Low Carbon Economy (2009)
But in both buildings & vehicles, balance is moving towards embodied energy

![Bar chart showing Embodied vs Use energy for 2000, 2010, Best practice, and Future? with a trend towards improving efficiencies in use.](chart)

Figure 5-11 Embodied energy in buildings

Source: Allwood and Cullen (2012)
Taking energy / resource efficiency much further is likely to require digging into dimensions of use and embodied energy.

### Consumer-driven energy & emissions

<table>
<thead>
<tr>
<th>Efficiency of Stock</th>
<th>Use</th>
<th>Embodied</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Buildings</strong></td>
<td></td>
<td><strong>Construction materials</strong></td>
</tr>
<tr>
<td>• Insulation</td>
<td>• Closing windows while heating or cooling system is operating</td>
<td>• Construction and transport</td>
</tr>
<tr>
<td>• Integrated heating and</td>
<td></td>
<td>• Surrounding infrastructure</td>
</tr>
<tr>
<td>cooling system.</td>
<td></td>
<td><strong>Industry</strong></td>
</tr>
<tr>
<td>• Efficient appliances</td>
<td>• Avoid dripping taps or</td>
<td><strong>Transport</strong></td>
</tr>
<tr>
<td><strong>Industry</strong></td>
<td></td>
<td>• Raw materials used:</td>
</tr>
<tr>
<td>• Efficiency of machinery</td>
<td></td>
<td>extraction, transport and processing</td>
</tr>
<tr>
<td>used</td>
<td></td>
<td>• Leakage from mines,</td>
</tr>
<tr>
<td>• Modes of transporting</td>
<td></td>
<td>• Raw materials in vehicle construction</td>
</tr>
<tr>
<td>goods incorporated</td>
<td></td>
<td>• Vehicle disposal</td>
</tr>
<tr>
<td><strong>Transport</strong></td>
<td></td>
<td><strong>Note that these categorisations of the consumers’ part are not entirely independent of one another. For example the emissions from the industrial process make up the embodied emissions of consumer goods and services.</strong></td>
</tr>
<tr>
<td>• Vehicle efficiency</td>
<td></td>
<td><strong>Source: Authors</strong></td>
</tr>
<tr>
<td>• Mode of transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Tyre pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Maintenance</td>
<td></td>
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</tbody>
</table>

**Figure 5-10** The scope of consumer-driven emissions

*Note that these categorisations of the consumers’ part are not entirely independent of one another. For example the emissions from the industrial process make up the embodied emissions of consumer goods and services.*

*Source: Authors*
An integrating approach to climate policy

Three Domains
and the
Second Pillar of Sustainable Development

- Nature of the challenge
- The Three Domains and Three Pillars of Policy
- System key components
- Pillar I: Standards and Engagement
- Pillar II: Markets and Pricing for cleaner products and processes
- Pillar III: Strategic investment
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Price stabilisation mechanisms are essential for credibility – and also for linkages to other domains.

Figure 7-8 Steadying mechanisms for emissions trading systems

Note: The Figure illustrates mechanisms to help emissions cap-and-trade systems deal with deep uncertainties, so as to maintain a reasonable balance of price and quantity objectives. The mechanisms are most simply illustrated with respect to price floors and ceilings, in which case the shaded area indicates the likely region of price and quantity for a system with substantial surplus allowances. However the same principle could apply to other ‘threshold’ triggers, for example based on the level of cumulative surplus.

Source: Authors
41% of EU ‘value added’ (GDP) in manufacturing industry + utilities

Most of manufacturing emissions are from c. 2 % ‘value added’ of EU GDP

- The Big Six
- Lime
- Cement
- Coke
- Oven
- Fertilisers and Nitrogen
- Refined petroleum
- Basic Iron and Steel
- Alumium Production
- Paper
- Other inorganic basic chemicals
- Other manufacturing (0.09%)
- Motor vehicles (0.6)
- Construction (0.01%)
- Mining and Quarrying (0.02%)

But must address distributional concerns
- Of both industry ...
- c. half a dozen primary commodity sectors

Figure 8-4 Impact of carbon pricing on EU industry sectors and their share of the EU economy

Data source: Eurostat and EU Commission
.. And domestic consumers. downstream the *direct* impacts are ‘all losers’ and regressive: ‘Bills constancy’ hinges on the other Pillars

**Figure 8-7 Household expenditure on energy UK 2008**

Pillar II Conclusions

• Too much ‘looking under the lamppost’
• The economics of carbon pricing are as much about design and strategic credibility than level
• The politics of carbon pricing are driven by distributional impacts and the lack of clearly articulated positive narrative for either industry or consumers
• Links to the other two domains are central to any ‘tangible’ positive narrative, drawing on ‘Bashmakov’s Constant of Energy Expenditure’
An integrating approach to climate policy

Three Domains and the Third Pillar of Sustainable Development

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- Pillar III: Strategic investment for Innovation and Infrastructure
- Policy Integration
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From II to III: Clean tech innovation and benefits

Fig. 9.1 Immediate costs and future benefits of low carbon technology
We are seeking radical innovation in some of the least innovative sectors of our economies.

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

Technologies have to traverse a long, expensive and risky chain of innovation to get from idea to market.

**Fig. 9.5 The Innovation Chain**

*Source: Author*
Highly innovating, close connection consumers and innovators
- 1st & 3rd Domains -
R&D intensity 5-15% (eg. IT, drugs)

Moderate innovation, mostly business to business connection
- 2nd & 3rd Domains -
R&D intensity 1-5% (eg. industrial & product engineering)

Low innovation, little connection between innovators and markets
R&D intensity < 1% (eg. energy & construction)

Figure 9.7. Innovation intensity and the broken chain
Source: Authors
Energy & related sectors are ‘complex sociotechnical systems’, with big evolutionary & lock-in characteristics

- Progress in clean energy industries impressive, but heavily dependent on public policy
- .. and so far outweighed by ‘carbon entanglement’
- Consider response to oil price rises
- .. and study the policy implications of evolutionary economics:
  - Niche accumulation
  - Hybridisation strategies
- Industrial strategy is unavoidable
- … with the potential positive side being macroeconomic version of “Porter’s kick”
Macro modelling: Global GDP in mid Century has little or nothing to do with global mitigation ...

Figure 11.4 Gross World Product in 2050 (excluding environmental benefits) from a wide range of models

20 GtCO2 = halving of global CO2 emissions by mid Century

Planetary Economics

An integrating approach to climate policy

- Nature of the challenge
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By mid-century, there is a huge range of possible emissions, all with similar level of global economic development.

‘Business-as-usual’ frontier in 2050

Efficiency and low carbon innovation frontier in 2050

Projected economic growth without climate damages
(Frontiers not to scale)

Figure 12-1 Global trends: default and potential trajectories
Different pillars have different structures of returns, and involve different actors in economies and society.

**Pillar I**
- Smarter choices

**Pillar II**
- Cleaner products and processes

**Pillar III**
- Innovation and infrastructure

1. Private returns >> public returns but not realised
   => Standards and engagement

3. Public returns (including innovation, security & environment) >> private returns
   => Strategic investment

**Fig. 12.3 Public and private returns in the 3 domains**
Experience and theoretical reasoning on each pillar shows ...

- There are multiple lines of evidence that in context of transforming the global energy system over a few decades, **all three domains are of comparable importance**
- Only approaches that integrate across all three domains have potential to generate ‘Green Growth’
- The dominant neoclassical ‘Second Domain’ theories emphasise instrument (pricing) that maximises political opposition unless it is nested in the complementary triad
- First and Third pillar policies can (and have) delivered multiple benefits, but ....
But 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
Changing course requires a sustained package - the key is to integrate and synergise across all three domains.
An integrated approach to Energy Transition

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Transformation involves not just technologies but sectors – is possible, but complex

Three key “case studies”

- Transport in the Americas
- Electricity in Europe
- Urbanisation in Asia

The systems themselves also become more integrated
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 energy system
- Biomass and electricity in transport
- Low-carbon 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

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

Not marginal+ but structural and systemic change
Integrated view of elec system ‘Mechanisms’

- Instruments for Capital Intensive – eg. CfD-FiTs
- ? Instruments for (grid) infrastructure *including interconnectors* ?

- Balancing & capacity adequacy
  - Energy efficiency may be forestalling need for new plant – see latest UK & European elec data
  - The Capacity challenge may be increasingly:
    - *Keeping the better existing plant (potentially for lower load factors) available*
    - *Economically & environmentally efficient dispatch & short-run balancing*
    - *Rewarding DSR and storage, including household level storage through rising electric vehicle use, as available Capacity?*
The underpinning evidence and theory of Planetary Economics suggests several routes to ‘co-benefits’. 

Figure 12-4 Potential joint benefits in energy and climate policy

Economic modelling is proving a double-edged sword

- Economic models are mostly based on “Second Domain” assumptions and assume a cost function in relation to the degree of abatement from ‘reference projection’ at time t, ie.
  - have no history eg. DICE equations
  - assume separability
  - have no finance sector, so missing crucial practical issues

**In contrast,**

- Most First Pillar gains do not reverse and deliver on multiple objectives through regulatory or behavioural innovation
- Most Third Pillar gains do not reverse: infrastructure endures and innovation generally also delivers multiple benefits
- Issues of finance, risk and policy uncertainty are at the heart of the issues

An Annex to book explores modelling with transitional costs but enduring benefits; can generate very different profiles
Key implications of numerical & macro analysis

• The value of measures which *adjust the pathway* is *several times* that of measures which just save CO2
• Useful to think of a ’base’ carbon price as that which can be implemented today to reflect the assumed damage of CO2 emissions
• Measures in the First and Third Domains may well justify a “cost of carbon” well above this base carbon price
• A rising base carbon price can also enhance in particular strategic investments & leverage *long term institutional finance*
Extending Instruments – some concluding questions

• Pillar 1: Energy efficiency and …
  – Standards – towards “embodied carbon”?  
  – Engagement – is Green Deal a dead end or an important precursor .. ?

• Pillar 2: Carbon pricing and ...
  – Credibility – is the ‘Stabilisation mechanism’ salvation, sclerosis, or a window of opportunity for development?  
  – Can we talk about revenues, please?

• Pillar 3: Infrastructure, Innovation and ..
  – Governance for interconnection and cost-sharing in Eurosceptic times?  
  – Closing the loop by bringing in consumers - can we get energy to look more like IT?
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

**Seminar: The policy implications & EU 2030**
*British Institute of Energy Economics, London, 25th June 2014*