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HIGHLIGHTS FROM

Planetary Economics:

Energy, Climate Change and the Three Domains of Sustainable Development

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Introduction

Climate change transcends the normal boundaries of human affairs. It is 25 years since scientific warnings were officially accepted by governments, yet that quarter century has seen global CO_2 emissions rise by 50%. *Planetary Economics* offers a new approach. Reviewing the development of economic thought and policy on global warming, the book argues that an important reason for inadequate progress lies fundamentally in the lack of integration between different schools of thought and policy prescriptions.

The leading US economist Martin Weitzman recently stated that climate change is "a hellish problem that is pushing the bounds of economics". Attempts to cost the problem have been stymied by its global and intergenerational nature, and the scale of uncertainties and risks. Governments have agreed to limit warming to 2ºC, based on scientific assessment of risks that to many practical decision-makers seem distant and eclipsed by more pressing concerns. Yet the goal – indeed, any move to stabilise the atmosphere – implies the deep transformation of energy systems.

The traditional tools of economics generally focus on trade-offs rather than transformation; and consider the costs of constraints rather than the opportunities created by change. This in turn feeds a mind-set that international negotiations are about sharing burdens – creating a distributional struggle that is insoluble with 200 countries, whilst precluding the idea of smaller groups pursuing greater ambitions.

In reality, energy systems are constantly evolving and deep decarbonisation involves radically improved efficiency and extensive innovation. The challenge of climate change can thus be recast as a question: whether it is easier to adapt our societies to an ever changing climate, or to adapt our energy systems to decarbonise whilst also addressing more immediately tangible needs?

Tapping energy efficiency and innovation involves human behaviour and expanding technological possibilities, as well as economic incentives. This raises two important questions: how one can develop an integrated approach to these multiple forces; and the possible corresponding implications for policy.

Planetary Economics argues that economics can only help guide solutions if the conventional horizons of economics are expanded to include psychological and organisational sciences to explain wasteful behaviours, and evolutionary and systems sciences to illuminate processes of innovation and transformation. Together these form 3 distinct domains of socio-economic processes, each of which involves different scales, modes of decision-making and decision makers.

The 3 domains in turn point to different pillars of policy. Each pillar can be aligned with corresponding concerns, motivations and opportunities, and the key to tackling climate change lies in integrating all three. *Planetary Economics* covers more than 500 pages and 1000 references; this Highlight sets out the main themes.

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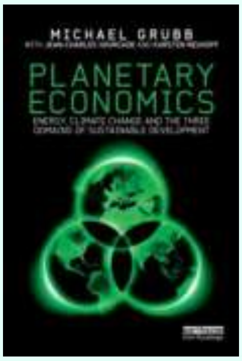
Michael Grubb, Professor of International Energy and Climate Change Policy, UCL
Editor-in-Chief, Climate Policy journal, with Professors **Jean-Charles Hourcade and Karsten Neuhoff**

'The book is compulsory reading for policymakers and academics for understanding the broader challenges of environmental change.' Professor Marcel Fratzscher, President, Institute for Economic Research (DIW Berlin)

'A seminal book that challenges conventional wisdom about growth, innovation and climate policy.' Laurence Tubiana, Ambassador and Special Envoy for Climate Change and COP21 Presidency, Government of France

'This is an important read for anyone looking for a sensible and comprehensive way forward.' Billy Pizer, Associate Professor of Public Policy at Duke University and former Deputy Assistant Secretary for Environment and Energy, US Treasury

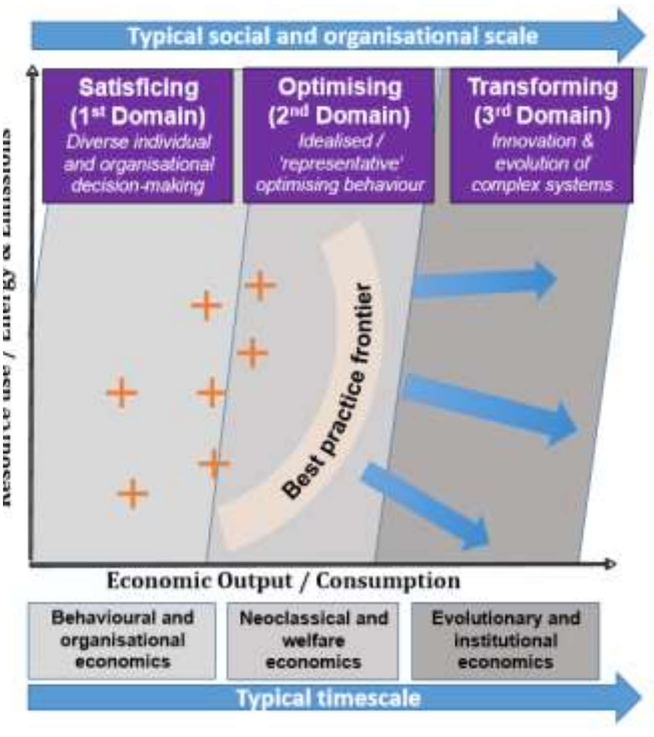
'A book of extraordinary scope and ambition that will challenge readers to think more clearly and carefully about some of the biggest issues this planet and its people face.' Michael Levi, Senior Fellow for Energy and the Environment, US Council on Foreign Relations



The Three Domains

Much of economics concerns resource allocation and trade-offs. Implicitly this assumes a certain 'technology frontier', which defines the maximum economic output or welfare available from a given amount of a key physical resource. Using less comes at a cost of lost economic output, at least in the short term, because other factors (e.g. more capital, labour or other resources) must be used instead. The frontier defines the trade-off. The band in the middle of Figure 1 illustrates this. The vertical axis represents energy or the safe capacity of the atmosphere to absorb emissions, and the horizontal axis represents economic output.

Figure 1. Resources and economic outputs in the three domains



'Neoclassical' economics primarily concerns the optimisation of trade-offs defined by such curves across the enormous range of resources available. Markets typically deliver this best, through relative prices which reflect the scarcity and value of the different resources available, assuming *conscious optimisation* based on *current,* or *rational expectations about* prices and the 'technology frontier'.

In practice however, most entities are not on the frontier; economists once called this 'satisficing' which falls short of the 'best'. In energy, there is a corresponding 'efficiency gap' – people often consume far more energy, at a higher cost, than appears necessary given the technologies available. At present we sit to the left of the line in Figure 1, for many reasons (see Page 3). Since these reflect observed real-world behaviour, this can be termed the '***First Domain***' of socio-economic processes.

Traditional neoclassical economic assumptions of conscious optimisation with fixed and rational expectations can thus be termed '***Second Domain***' economics. In practice, this has become widely equated with economics itself. It assumes that self-interested individuals and organisations, given the freedom and a lack of market distortions, will gradually move to the frontier of the 'best' available options – best for themselves, and (under certain neoclassical assumptions and ignoring distributional effects) also best for society.

On the other side of the band, the frontier defined by available technologies, infrastructures and so on moves over time: technologies, systems and institutional structures improve to allow more output given the same input of resources. Time, innovation, infrastructure and other forces thus move and reshape the frontier. These process reflect a complex mix of public and private forces; the corresponding theories encompass endogenous growth, innovation and network economics, evolutionary and institutional economics, with additional insights from complexity and systems research and earlier ideas of 'creative destruction.' Collectively these form a '***Third Domain***' of socio-economic processes – those which affect the pace and direction of innovation, and the related infrastructural and institutional changes, and hence shape the evolution of what is possible. Third Domain economics is concerned with the question of *how* and *why* the frontier moves in ways that enhance productivity, intensity and the choice of different resource uses over time. In essence, complex systems can innovate and evolve in many different directions – ultimately, transforming what is possible.

Much of economics tends to either ignore First and Third Domain processes, or characterises these as 'failures' of Second Domain markets. Yet as indicated, each domain is backed by extensive theory and evidence, and is associated with different time and social scales, involving different actors and modes of decision-making.

Planetary Economics notes that climate change spans from the individual energy choices of seven billion people, through to the transformation of some complex systems on the planet. The corresponding evidence suggests that each of the three Domains are of roughly equal importance. Consequently, the three Domains need to be understood on their own terms. The associated literature provides a shorthand terminology of the (1) *Satisficing*, (2) *Optimising*, and (3) *Transforming* domains and crucially, each points to a different pillar of policy.

Pillar I: Standards and engagement for smarter choices

The cheapest and most compelling opportunities lie in increasing the efficiency of energy use. Despite major improvements in recent decades, overall we still consume about ten times as much energy as is physically necessary for the activities we enjoy. Numerous technologies and other options for improving efficiency are demonstrably cost-effective today: many measures would pay back, in terms of energy savings, within a few years. The scope for 'smarter choices' is not confined to end-use energy efficiency: expanding horizons reveal important opportunities for 'smarter systems' overall (*Planetary Economics,* Chapter 3).

Developments in behavioural and organisational studies help explain this wasteful pattern of energy usage – a pattern which reflects a tension between habits, intentions, and the options practically available to individuals as constrained by their infrastructure, and their organisational and technological environment. Structural barriers may impede more efficient energy choices, particularly when energy characteristics are embodied within far larger choices such as property, where occupiers typically pay the bills but (especially when renting) can do little to improve thermal performance. However, such barriers are hugely amplified by the intrinsic First Domain characteristics of decision-making in relation to recurring, incidental costs: habits, inertia, inattention, myopia and rules-of-thumb tend to dominate (Chapter 4).

Organisational decision-making shows surprisingly similar patterns of inefficient energy use. Public bodies often restrict investment opportunities; many corporations do not take full advantage of possible energy efficiencies, and/or demand payback rates far higher than for their core business (e.g. Figure 2).

Almost four decades of policies to enhance energy efficiency have yielded considerable benefits, and per-capita energy demand has fallen in several rich countries. The global spread of such policies has reduced exposure to international energy price fluctuations more cheaply than equivalent investment in new supplies, and has the added benefit of avoiding the external impacts associated with most supply options (Chapter 5).

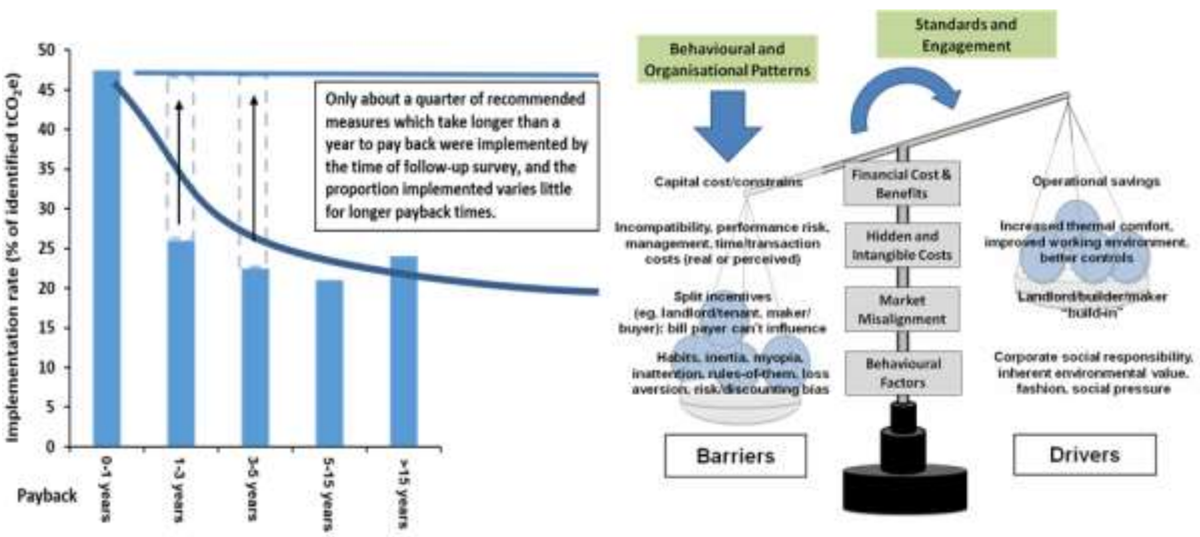
There is a huge remaining practical potential for improvement, and tapping this potential is central to sustainable energy futures. Buildings in particular, which account for over a third of global energy consumption (and more, through their indirect use of energy in concrete and steel), represent the biggest single sector of opportunity.

Increased incomes and building floor areas over the next few decades could add 50% to global buildings-related energy consumption by mid-Century; conversely, strong policies could halve thermal energy consumption, and substantially curtail electricity growth (Chapters 3, 4, 5).

Pillar I policies could be expanded further with net benefits by going beyond the historic focus mainly on the technical energy performance of products. Important areas for future attention include tackling habits of energy use aided by IT (such as smart meters), and extending the lessons of energy efficiency policies to address the broader energy and carbon footprint of construction and consumption (Chapter 5).

However historically the overall scale of the impact of improved energy efficiency has also been less than hoped for, often with slow uptake even of highly cost-effective options, and with a significant part of the gains 'taken back' by a combination of rebound effects and the growing overall scale of consuming activities. To achieve their full potential – sustaining global energy efficiency improvements at 2%/yr or more over the coming decades – Pillar 1 policies ultimately have to be combined with the other two pillars.

Figure 2. The efficiency gap and payback periods experienced in UK business, and causal First Domain characteristics



Source: PE, adapted from Figure 4.3 [p136] and Figure 4.4 [p138]

Pillar II: Markets and prices for cleaner products and processes

Markets connect; prices inform. Energy prices should in principle convey the real costs of both producing and consuming energy, including the resulting environmental damages.

However, many developing countries subsidise energy consumption and many industrialised countries subsidise fossil fuel production. Removing such subsidies is usually advantageous for both economies and the environment, as it encourages efficiency, deters damaging activities, and rewards cleaner investment and innovation. However the process of adjustment to higher prices can be slow, painful, and complex, and involves all three Domains.

Energy price impacts can disproportionately affect the poor; many countries implement rebates or other targeted supports, but the most enduring response is to strengthen energy efficiency policies that can help to contain the impact of price rises on actual bills. There is powerful evidence to suggest that countries with higher energy prices do not *end up* spending more on energy, due to greater energy efficiency (Figure 3).

Pricing CO_2 is an obvious way to reduce emissions efficiently, and there can be significant co-benefits associated with dispersing revenues and reducing other environmental impacts as well as dependence on international fuel markets (Chapter 6).

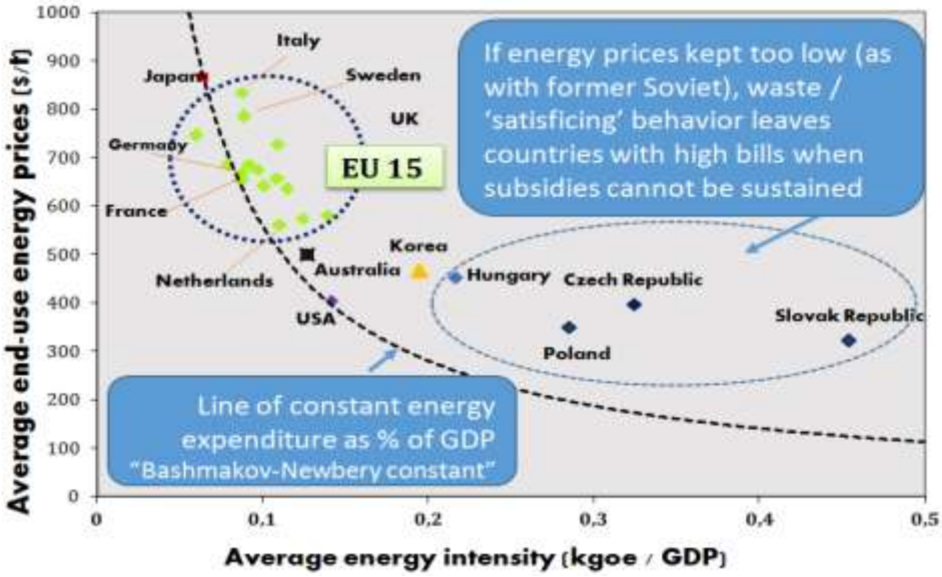
CO_2 emissions can be priced either through taxation or by capping emissions with allowances that can then be traded. Designing carbon markets to provide more robust support to investment requires a hybrid mix of quantity with price-based/stabilisation elements. Economically, appropriate and feasible carbon pricing will vary with national conditions; the world does and will have to cope with CO_2 prices that vary widely, are implemented through a diversity of systems (Chapters 7, 8) and consequently have unequal impacts.

The impacts of carbon pricing on industry are largest in six big sectors (Chapter 8). These sectors have the potential to make either large profits or large losses from CO_2 pricing, depending on how it is applied. Potential costs induce the fear and risk of 'carbon leakage' — production moving abroad to escape paying for pollution. Three options exist to address this leakage: 'levelling down' the price, by exemption or free allocation; 'levelling up' by establishing the same price on all such production globally; or levelling at the border or at the point of entering consumption. The first is not an enduring solution, the second is a mirage and the third is untested.

Ultimately, CO_2 taxes and cap-and-trade must address four basic challenges: (i) making the gains to citizens more tangible than the costs to them as consumers — including by funding programmes to help the 'fuel poor'; (ii) reconciling the political and strategic advantages of cap-and-trade with the realities of uncertain energy projections and investor needs; (iii) maintaining incentives for emission reductions on the most carbon-intensive emitters without inducing 'carbon leakage'; and (iv) forging mutually reinforcing links between CO_2 pricing and the other policy pillars.

Politically, proper pricing is the most difficult of the three pillars of policy yet it must play a central role, especially in market-based economies: pricing 'bads' is good. In reality pricing is likely to be an evolutionary process. There will be many differences among regions, tensions, and occasional breakthroughs. The common key will be to make systems more robust and to entrench their credibility, effectiveness and political feasibility through establishing links both internationally, and with the other pillars of policy.

Figure 3. Relationship between national average prices and national energy intensity.



Note that its high efficiency meant that Japan spent the same %GDP on energy as the US despite end-user prices being more than twice as high; so did France and Germany.
Source: PE, Figure 6.1 [p209]

Pillar III: Strategic investment for innovation and infrastructure

Providing energy for the 21st Century will cost trillions of dollars every decade. Innovation and investment in infrastructure are central to determining the long-run costs and impacts. However, energy-related sectors spend only a small fraction of their income on innovation for clear structural reasons (Figure 4). Moreover, industries invest principally in technologies to extend their established positions: fossil fuel industries invest far more in oil-related technologies than in clean energy solutions. Accelerating innovation in low carbon technologies is likely to be economically beneficial, but thus requires public intervention: policies have to support the degree of confidence and financing required for large corporations to make long-term bets that coincide with the public interest (Chapter 9).

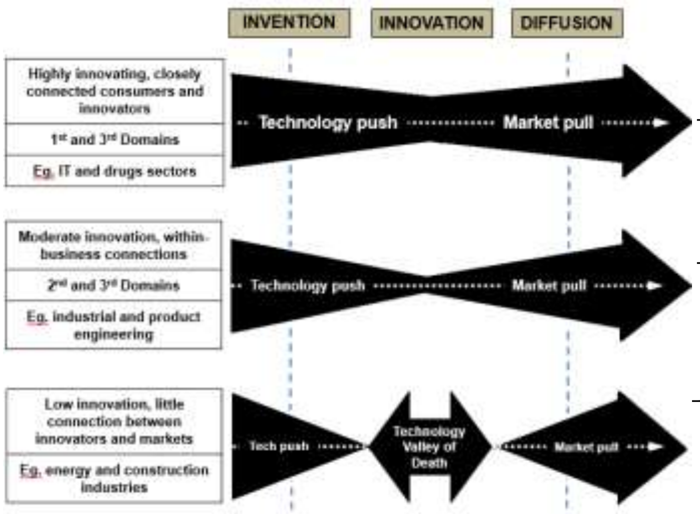
Technological transitions also involve transformation of infrastructure and institutions. This makes them highly 'path dependent', thus prone to 'lock-in' – interrelated sets of technology, infrastructure and institutions which have huge inertia tend to perpetuate the established interests. Present systems of fossil fuel dependence display all these characteristics: the dominant trajectory is towards accessing ever more difficult and remote carbon resources, and thus also in ways to pollute the atmosphere more cheaply.

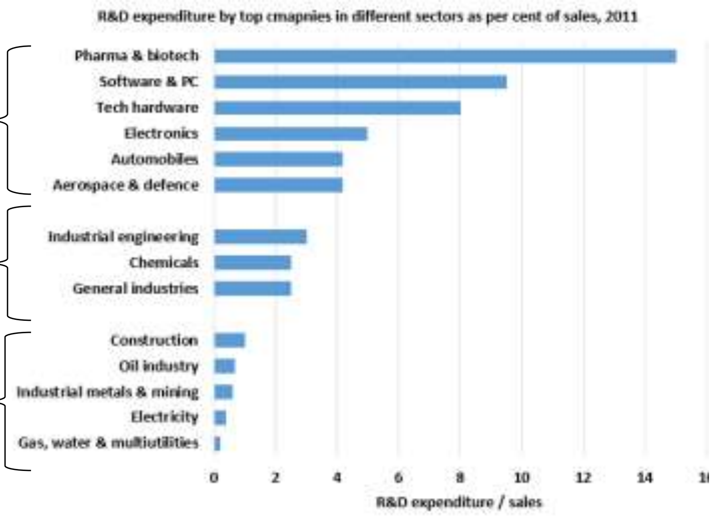
Meeting global energy needs over the next twenty years is likely to require around $50trn investment. Turning the supertanker away from fossil fuel dependence requires several $trillion more, offset against higher efficiency and reduced fuel dependence. Reorientation towards low carbon development will depend not just on efficiency and credible carbon pricing, but also on smart strategies to enable new entrants. For instance 'hybridisation' enables low carbon technologies (e.g. hybrid vehicles) to use existing infrastructure. The transition offers clear potential strategic benefits in key sectors (e.g. vehicles, electricity, buildings), but realising them requires up-front investment of both political and financial capital (Chapter 10).

However, there is no compelling evidence that low carbon trajectories need ultimately be more expensive, even without taking into account the climatic and security benefits. Given the obvious inherent risks associated with the current trajectory, its continuation may indeed reflect a condition of individual short-term rationality but collective failure reminiscent of the factors which led to the global financial crisis. Breaking out of this trap requires effort and innovation. Smart government-led policies, motivated actions by citizens and companies and greater up-front investment can shape efficiency, innovation and infrastructure in ways compatible with energy and climate security without compromising economic development (Chapter 11).

Depressed economies may, ironically, be best able to harness such investment as they have both large unutilised resources (labour) and historically low interest rates. Presently, a lack of confidence deters investment in energy infrastructure. However, the physical constraints of a finite atmosphere imply a solid science-based value in saving carbon, which should rise over time. Policy to translate that fact into clear and robust incentives thus has the potential to spur renewed investment, innovation, and clean growth.

Figure 4a. [below left] The Innovation chain and 'technology valley of death'; 4(b) [below right] R&D expenditure by top companies in different sectors as per cent of sales, 2011



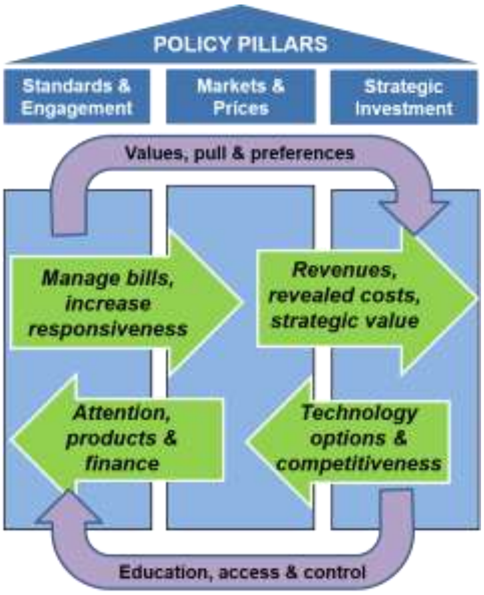


Source: PE, Figures 9.7 [p328] and 9.4 [p321]

Conclusions

The central conclusion of *Planetary Economics* is that getting to grips with problems on the scale of energy and climate change requires three quite distinct domains of socio-economic decision-making to be

Figure 5. An integrated package: interactions between the Three Pillars



Source: PE, Figure 12.3 [p466]

recognised, understood and connected. Each Domain has developed its own bodies of thought, evidence, analysis and constituencies, and implies different policy responses. No single one is either correct or incorrect, but rather describes different elements of the whole.

Energy consumption is driven by individual choices, ingrained habits and risk horizons of the global population, but the global challenges which arise involve systemic risks and imply changing some of the most complex systems humanity has ever developed, over the course of the century. Analysing all this through the assumptions of neoclassical economics is like trying to understand the Big Bang with the tools of Newtonian mechanics. No single approach offers an adequate explanation of all that matters, or in isolation offers a sufficient foundation for policy; conventional economic theory needs to be flanked by the other two domains. From this, and all the supporting evidence, flows five cross-cutting, generic implications:

- ***Energy systems have a large capacity to adapt, and this increases the long-term value of action***. The first and third domains in particular involve largely adaptive processes, which result in enduring changes to energy systems that are unlikely to reverse. The benefits of associated actions in terms of changing course may be far bigger than the value of their directly-attributed impact on energy and emissions.
- ***We need to broaden the tools of analysis, particularly relating to* Third Domain *processes***. Theoretical and computer models can illuminate and inform us about many of the future implications of today's decisions - and hesitations. They can also constrain and mislead by narrowing intellectual horizons, where the assumptions are inappropriate. Notably, few of the Third Domain processes of induced innovation, systems evolution, lock-in and path dependence are represented in the models used by most academic and government appraisals
- ***Joint benefits are pervasive and inseparable***. There are many ways in which actions on energy and climate change may be associated with other benefits (and vice versa). These arise particularly from the intrinsic characteristics of first and third domain processes, but are likely to be biggest for integrated strategies across all three pillars of policy. Both technically and politically, most real-world decisions involve multiple dimensions; smart policy on climate change has the potential to help to *motivate*, to *stabilise*, to *coordinate*, and to attract *finance* to actions which are economically and socially beneficial in other respects.
- ***Multiple instruments are required*** to reflect the different processes in each domain, the complementary contributions of each policy, the complexity of motivations and markets, and the different structure of private and public returns to investment under each pillar. Improved design of economic instruments may extend the useful role for markets but cannot supplant other pillars. The detailed choices and balance will vary by country and stage of economic development.
- ***Only integrated strategies across all three policy pillars are effective or stable***. Measures focused purely on First Domain efficiencies will eventually run dry and their impact will be offset by rebound effects. Relying purely on Second Domain pricing to 'internalise external impacts' is politically unsustainable without First Domain efficiencies and engagement, and the generation of new options to respond in the Third Domain. However, Third Domain innovations will be inhibited and unable to fulfil their potential without the drivers generated by the other Pillars of Policy.

In contrast, an integrated package to enhance efficiency, establish proper pricing, and invest strategically in innovation and infrastructure, can provide a mutually-reinforcing package (Figure 5), aligned to the risk horizons of associated decision-makers. Our energy systems can adapt to atmospheric constraints; the key to *Planetary Economics* thus lies in integrating all three domains, and exploiting the positive interactions between the corresponding pillars of policy.

Further information, presentations and graphics from the book Planetary Economics are available through: http://climatestrategies.org/publication/planetary-economics.
Journal articles based on the book so far include 'The Three Domains Structure of Energy-Climate Transitions', in Technology Forecasting and Social Change (2015), and (with Mejean) 'The "Dark Matter" in the Search for Sustainable Growth: Energy, Innovation and the Financially Paradoxical Role of Climate Confidence', in International Papers in Political Economy (2014). Papers on other elements of the book are in preparation.