Submission to **Competition and Markets Authority**
Energy Market Investigation

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On the distinguishing features of energy systems and innovation
- how these affect the nature of competition, its potential impact and the role of complementary measures

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This submission is divided into two parts as follows.

Part 1: Analytic framework and evidence sets out an analytic framework that may be relevant to CMA concerning in particular the following aspects of the 'theories of harm':

- "(1) market rules and regulatory framework … lead to inefficiencies in wholesale electricity markets ..
- (4) weak incentives to compete … in retail markets, due in particular to inactive customers, supplier behaviour and/or regulatory interventions ..
- (5) broader regulatory framework …. Acts as a barrier to pro-competitive innovation and change …."

Drawing on its analytic framework, Part 1 of this submission summarises some aspects of underpinning evidence concerning ways in which the energy sector appears to differ from most other sectors, which may affect potential judgements relating to the Theories of Harm.

Part 2: Policy implications relating to investment and capacity explains some implications particular with reference to the CMA working paper on Capacity, and in particular its concerns about technology competition and distortions between different technologies. This aims to illustrates the need for a clear understanding of these underlying characteristics of energy systems, to avoid unrealistic expectations of what any energy market on its own can deliver.

The underlying motivation of this submission is the importance of the CMA fully understanding the nature of energy systems, and specifically the ways in which they differ from most markets. A failure to understand these characteristics could risk prescriptions that are ineffective – with major effort and potentially new uncertainties added to little positive effect - and potentially even counterproductive.

*

Please note that although I advise Ofgem I am making this submission in my academic capacity, separate from Ofgem, drawing on my long-standing involvement in energy economics and innovation.[1]

[1] I have held Professorships at Imperial College and now UCL; between these positions I was at Cambridge University, Faculty of Economics alongside a position as Chief Economist at the Carbon Trust, and was then at Cambridge Centre for Climate Change Mitigation Research before taking up my current academic role, which is half time alongside my advisory position with Ofgem.

Part 1. An analytic framework with outline evidence relevant to CMA 'updated theories of harm.'

On economic frameworks

Economics is largely concerned with efficient resource allocation and tradeoffs. To clarify terminology for the rest of this submission, the left panel of Figure 1 shows the simplest possible case of resource tradeoffs, determined by a line often called the 'possibilities frontier', but probably appropriately the 'best practice frontier' – the best readily available way to produce output (horizontal axis) for a given use of a key physical resource (the vertical axis). The frontier defines the trade-off between this resource and others in a state of equilibrium. Much of welfare economics is, fundamentally, about how systems can be designed to optimise the tradeoffs defined by such curves across the enormous range of resources available. Markets, through relative prices, offer the prime mechanism for transmitting information about the scarcity and value of the different inputs available. The defining behavioural assumption is one of conscious optimisation based on current, or rational expectations about, relative prices, and exogenous technology costs and preferences.

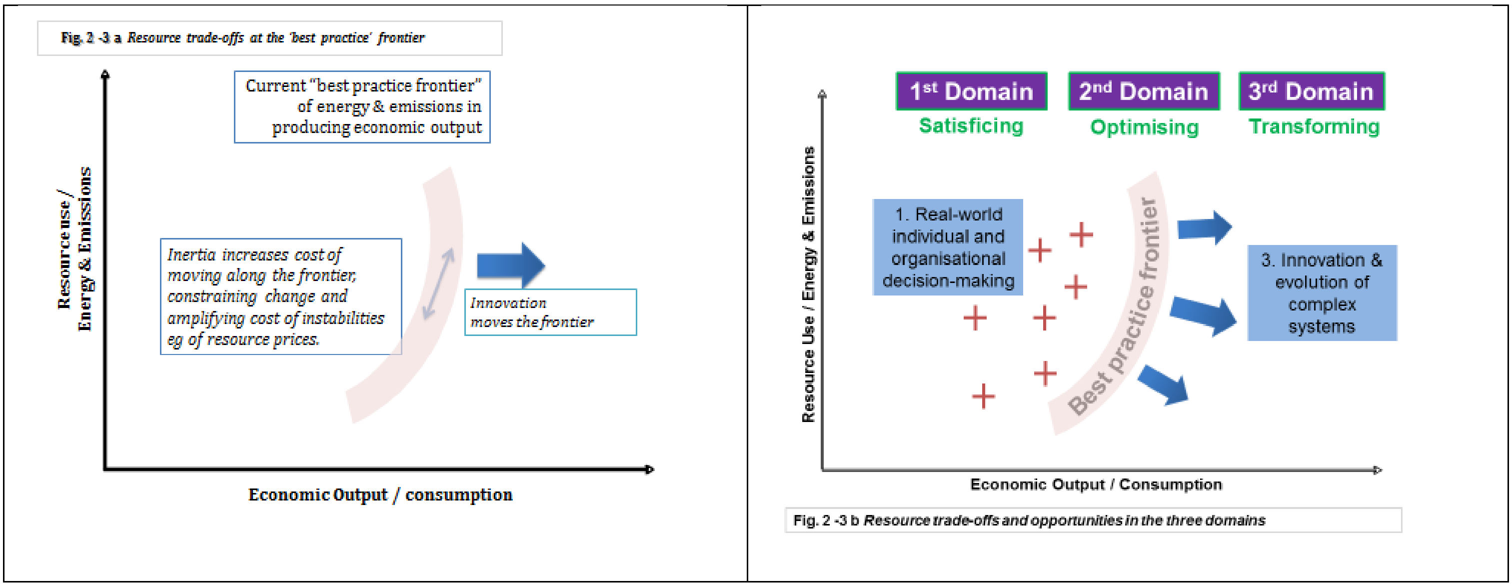

Figure 1: Resources and economic outputs, illustrating different domains of economic processes

In practice, in energy systems most entities operate some way short of the curve. One illustration of this is the CMA observation that many people appear not to switch to cheaper suppliers, despite potential savings in the region of £150-200/yr. Another illustration is reflected in what is widely known as the 'energy efficiency gap' – the abundant evidence that people tend to consume substantially more energy than would be pareto-optimal give the technologies available, creating large apparent potential for greater energy efficiency. Whilst often ascribed to 'hidden costs', in practice the literature shows that this involves a diverse mix of contractual and market failures (such as the tenant-landlord split of incentives) together with more intrinsic personal and behavioural traits, in consumers and organisations (such as internal principal-agent and related problems).

This indicates that most entities are actually some way to the left of the 'best practice frontier', as illustrated by the right-hand panel in Figure 1. Mainstream economics observed this general fact many decades ago, and Simon (1955, 1959) introduced the term 'Satisficing' behaviour – in which entities appear to be 'satisfied' with behaviour that appears to be sub-optimal. This launched the literature on 'bounded rationality' in economics, which is one dimension of a far wider set of reasons why most people, organisations, and governments, most of the time, fall well short of the neoclassical ideal. It is principally the experimental evidence underpinning behavioural and managerial economics which has revealed and explained this as a systematic feature of human psychology and organisation, rather than an anomaly that people or organisations could be expected to spontaneously deal with given information (overview in Khaneman 2014).

On the other side of the line, the frontier defined by available technologies and systems moves over time: technologies, systems and institutional structures improve to allow more output with the same input of resources. Time thus enters through movement of the curve itself – technical change, which increases the output available from use of a given resource, for example. Indeed, innovation is widely acknowledged as a prime driver of economic growth. The classical simplifying assumption is that this process is either autonomous – it occurs like manna from heaven – or optimising – the product of economic agents maximising their benefits from innovations. In practice as I explain later, reality is far more complex. Technical and institutional innovation, along with infrastructure and cultural changes, can influence the whole direction in which the systems evolve and thus may fundamentally reshape the 'best practice' frontier.

Again there are many branches of analysis and corresponding literatures and terminology associated with this. In economics these include endogenous growth theories, various strands of development economics, endogenous technological change, evolutionary and institutional economics, complexity theory, and systems innovation theories, to name a few, as well as earlier antecedents in Schumpeterian theories of creative destruction and dimensions of development economics.

To provide a simple language with which to categorise these myriad dimensions and theories, it is useful to refer to the three parts of Figure 1(b) as different domains – respectively 'satisficing', 'optimising', and 'transforming' domains. Figure 2 summarises some key characteristics of these different domains of economic processes and the theoretical foundations on which they rest.

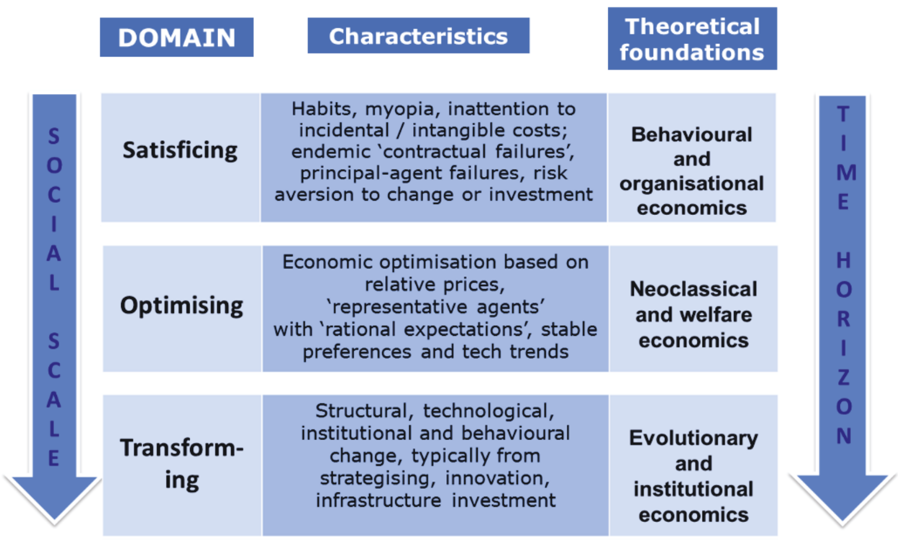

Figure 2: Characteristics of the Three Domains

Given the complexity of the issues, there is surprising little overlap between the different domains: as suggested by the Figure they largely concern different timescales, processes, and decision makers, a point developed more fully in Grubb et al (2014). The underlying ideas have often been cast as alternate explanations for the same phenomena, spawning debate about which is "right". Recognising the different decision processes, and social and temporal scales, associated with the different Domains underlines why this is often unnecessary and inappropriate. The most useful debate is not about which is right, but for what types of decisions and at what social, spatial and temporal scales different processes may be significant, what their complementary contributions may be, and how this may affect policy choices.

Is Energy Special (1)? Energy consumers and consumption

A key reason why this may be of interest to the present CMA enquiry is evidence that in energy, First and Third Domain processes appear to be particularly important. This raises questions about the extent to which a competitive energy market *on its own* will deliver various objectives. A major focus of my research has included reviewing the evidence and explanations for why energy seems to have exceptional characteristics regarding the first ('satisficing') and third ('transforming') domains.

Key areas of underpinning evidence for the significance of 'satisficing' behaviours include:

- Limited switching despite significant economics savings, a topic already substantially explored in the CMA papers
- Large potential for cost-effective energy efficiency improvements; in addition to consistent engineering assessments of cost-effective potentials, many government efficiency programmes and standards have delivered savings that the retail market did not, with a strongly positive benefit-cost ratio to these policies.

In support of its energy efficiency programmes, DECC has provided extensive analysis of the economics of energy efficiency and the cost-effectiveness of efficiency programmes, which is widely supported by academic analysis. I offer a review of international evidence, covering c. 70 references, in Grubb *et al* (2014), Chapter 5.

At least four characteristics in combination can help to explain these facts.

(a) No (physical) product differentiation.

All electrons are substantively the same; so are all methane molecules. Apart from price, there may be some potential to differentiate in terms of customer service, but the physical product is undifferentiated.

(b) No substitutes.

For the vast majority of uses there are no reasonable substitutes to electrons or methane.

(c) Incidental not deliberative consumption

Energy demand is rarely a conscious choice; energy consumption is implicit in other decisions, and its cost is usually invisible (and often trivial) at point of use in relation to other factors of attention

(d) Continuous.

There is no discrete point at which consumers need to "go and buy a new one"; consequently there is no natural point of conscious engagement with the need to take a decision. The essential nature of energy means makes it impractical to force this (eg. "choose or be disconnected") unlike many financial or insurance products with natural expiry terms.

Putting these together, this contrasts energy supply even with something like telecoms connection where though the physical asset is a data connection, 'supply' is typically bundled with different service product packages (and different line capacities), which can drive consumer interest and engagement.

The characteristics of energy being an undifferentiated, non-substitutable, incidental and continuous product has the consequence that First Domain (***'behavioural' / satisficing) characteristics are intrinsically likely to dominate*** in energy consumer markets. Consequently, ***a low level of engagement has been the natural state*** of electricity and gas systems, most of the time. One can debate as a separate issue the merits or not of any intervention, but it needs to start from this understanding.

Data on innovation, to which I now turn, underlines this further.

Is Energy Special (2)? Innovation and investment

Key areas of underpinning evidence concerning problems with innovation in the energy sector include:

- The long-term dominance of incumbent technologies and lack of substantial new entrants in generation, transmission and distribution
- The exceptionally low intensity of R&D in the electricity and gas sectors (and the impact of liberalisation on innovation spend)
- The 'technology valley of death' and the pace of cost reductions driven by government investment and market development support programmes

Particularly because the CMA has introduced a new fifth Theory of Harm relating to 'pro-competitive innovation and change', I first present some data relating to this dimension. Figure 3 illustrates R&D intensities (R&D investment relative to sales) in different sectors, according to the EU's R&D scoreboard (EC JRI IRI 2013). Pharmaceuticals, IT and consumer hardware sectors typically spend 8-15% of their turnover on R&D. The corresponding figure for electricity is 0.6%,[2] and for gas, 0.33%. ***The industries covered by the CMA enquiry spend much less than a tenth as much on R&D, per unit turnover, compared to innovative sectors.***

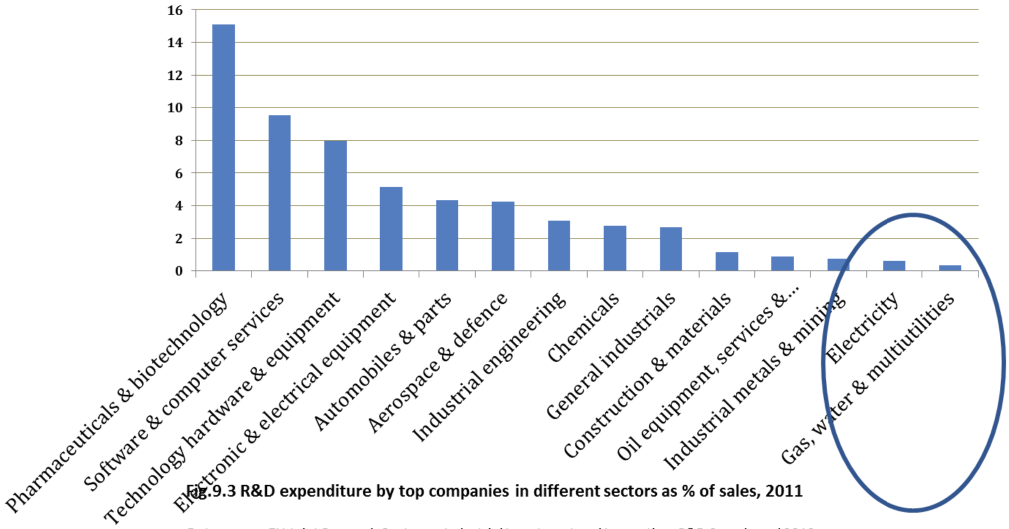

Fig.9.3 R&D expenditure by top companies in different sectors as % of sales, 2011

Data source: EU Joint Research Centre on Industrial Investment and Innovation, R&D Scoreboard 2012, http://iri.jrc.europa.eu/scoreboard12.html

Figure 3: R&D Intensities across different sectors

These data cover the EU. There is no reason to believe the UK is any better than the EU average, in fact the opposite is likely: the classic study of the impact of liberalisation on R&D found that a major 'unintended consequence' of UK energy liberalisation was a collapse of energy R&D investment (Dooley 1998).

A 1-page Annex summarises some general factors. Specific causes of low R&D in energy sector, particularly with respect to 'alternative' energy sources, include the following factors on the generating side:

- Energy generation, because it is handling a physical process at scale, has typically involved substantial long-lived capital-intensive assets ("infrastructure" to the finance industry): this implies *large capital commitment with long timescales of investment and returns*, all amplifying the risks;
- Current market structure yields short-run marginal cost pricing. Baseload / low carbon options with low marginal costs are hence *inframarginal in electricity markets and bear the risk of fossil fuel price volatility*. Hence the market left to itself is intrinsically tilted against clean energy generation, which (rather perversely) take the main risks associated with fossil fuel price variations;

[2] This electricity figure includes R&D expenditure by the nuclear company AREVA which is exceptionally high; taking out this single company reduces the electricity sector figure to 0.5%. Note there are many complexities in such data, including classification difficulties: energy obviously also may benefit from R&D in 'electrical equipment' and 'industrial engineering'.

- *Dependence on regulated networks* which injects an element of (actual or perceived) regulatory risk;
- *High externalities* (environment, security) which are hard or impossible for private actors to monetise themselves, and the value of which if fact in at all may be subject to large political uncertainty;
- *Almost-fixed market size.* Nothing that a company does – or even, companies collectively do - has a substantial impact on the size of the energy market, unlike for example the introduction of Broadband which, particularly combined with the internet, created a whole new industry and market.

The result is high merchant risks (investment, political and market), combined with modest potential rewards to innovation. The solution to inadequate R&D in the energy sector was once seen to be government R&D, but that too on its own proved unsatisfactory, generating a large literature on the 'technology valley of death' between government-funded R&D programmes and market take-up. Much industrial 'innovation' is to do with systems, learning-by-doing, economies of scale, and development of management & supply systems – and markets. Innovation and cost reduction is driven by investment, just as much as public R&D.

All this underlines the most fundamental problem for innovation in the energy system, as compared to many other sectors. As illustrated schematically in Figure 4, in sectors like IT and pharmaceuticals there is possibility for *relatively* rapid and cheap product development cycles, which push well beyond pure 'invention' well into the processes of market-oriented innovation, and these easily meet the demand pull incentives of huge value in the markets for new and exciting products: the 'push' and 'pull' are well connected.

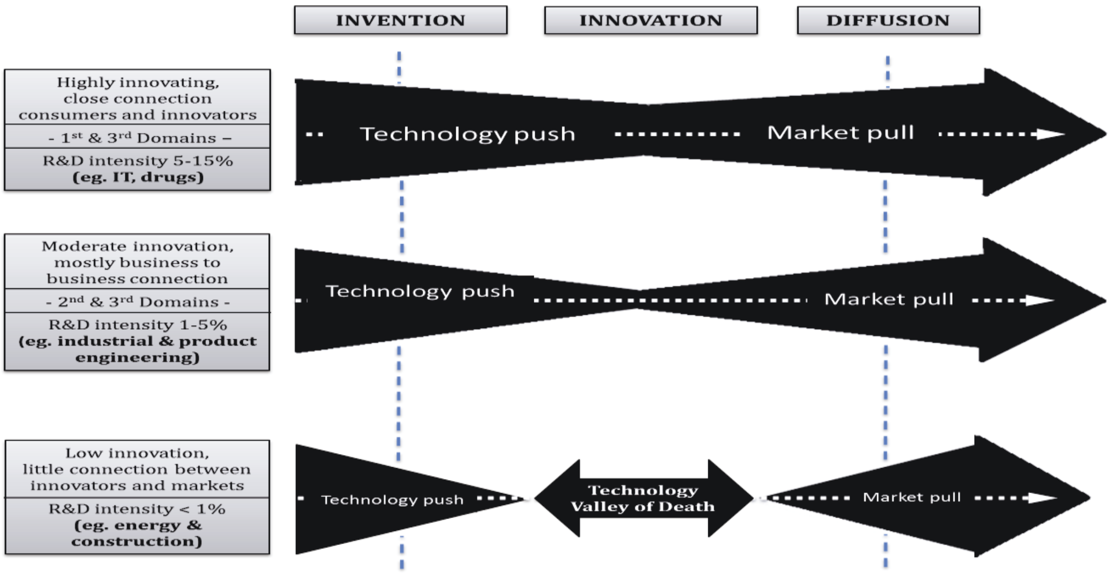

Figure 4 R&D intensity and the innovation chain
Source: ***Grubb et al (2014),*** **Figure 9.7.**

In energy, the situation is the opposite. The push is long, expensive and risky. And the process generates not a new exciting product with potential for huge margins in a new expanding market, but a somewhat different way of making exactly the same thing (electrons, or methane), in ways that have to undercut incumbent technologies with a century of development - and then sell to largely disengaged consumers. As illustrated in Figure 4, weak forces for 'Third Domain' innovation meet the multiple 'First Domain' impediments.

Hence the result for the last century has been a sector inherently dominated by incumbent companies, mostly honing (at best) long-established ways of generating power. Whereas competition is normally associated with greater innovation, in energy there is a clear risk of the opposite as suggested by the R&D data, and by the impact of liberalisation on R&D spend already noted. Competition alone cannot fix a broken innovation chain.

Part 2: Policy implications, illustrated with reference to the working paper on Capacity

In the CMA's updated Issues paper, concern as to whether the "broader regulatory framework …. acts as a barrier to pro-competitive innovation and change" is considered to be "sufficiently important and far-reaching to warrant consideration under a separate theory of harm." The main emphasis is upon the industry Codes system. This submission steps back to consider wider issues concerning the relationship of the energy market to innovation and investment, particularly in light of the CMA's paper on Capacity.

Reasons for concern

Concerns over innovation and investment are important for many reasons, including the generally positive role of these factors in relation to economic performance overall. In addition, at the heart of energy policy is the need to address the 'Trilemma' of security, environmental sustainability, and affordability:

- Ofgem's Project Discovery (2010) articulated concern that insufficient investment was putting the security of GB energy supplies at risk
- Warnings about the risks of climate change in particular - termed by Lord Stern as 'the greatest market failure in history' - have become increasingly strident through successive reports of the Intergovernmental Panel on Climate Change, and 2014 was the hottest year in recorded human history.[3]
- Affordability of energy particularly for vulnerable households has become increasingly salient as the economic crisis combined with unprecedented fossil fuel prices

Whilst in the short term there are obviously potential trade-offs between these trilemma objectives (low energy costs can easily be achieved temporarily by ceasing investment and running up debt), the most essential element for delivering all three is efficient investment and innovation. Under the Climate Change Act, the UK has established a strong system of governance to give industry a stable long-term trajectory for decarbonisation and the underlying analysis points to a particularly crucial role for decarbonisation of the power sector over the next 15 years. The CMAs interest in the relationship between the energy market, investment and innovation is therefore welcome and essential.

Three pillars of policy

A general framework for analysis is that effective policies need to be attuned to the characteristics of corresponding domains of economic processes, as illustrated in Figure 4.

Markets, and cost-reflective pricing, are obviously crucial for the domain of optimizing behaviour. The relevance of markets and prices in the other two domains is indicated in this figure as being either low or medium, because it may depend substantially on the structure of the underlying market, and on the design and credibility of an economic policy instrument (such as carbon pricing).

One of the major potential trade-offs in the 'trilemma' is a two-fold tension around environmental pricing. First that placing a price on emissions (notably carbon) inevitably raises current energy prices and hence risks

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[3] All the main global datasets agree that 2014 had the highest global mean temperature yet recorded. Whilst it would be inappropriate to pay much attention to a single year given the large background variability, this clearly increases the probability that the 2010s will continue the trend of the last 50 years of each decade being substantially warmer than the previous. Stern's most recent book warns "If the world continues to emit GHGs along a ' business as usual ' path, concentrations .. of 750 ppm CO 2 e by around the end of the century would drive a median temperature increase of 4 ° C or more … physical and human geography of the planet would likely be transformed: deserts, coastlines, rivers, rainfall patterns — the reasons we live where we do — would be redrawn. .. The last time CO_2 levels exceeded 750 ppm, .. was likely about 35 million years ago during the Eocene epoch, when the planet was entirely ice-free. Today that would drive a sea level rise of 70 meters. Homo Sapiens has not experienced anything like this…"

exacerbating concerns around affordability. The major options for alleviating this tension lie in 'first pillar' policies, particularly around energy efficiency and targeted efforts to help those in 'fuel poverty. These are important but lie outside the scope of this submission.

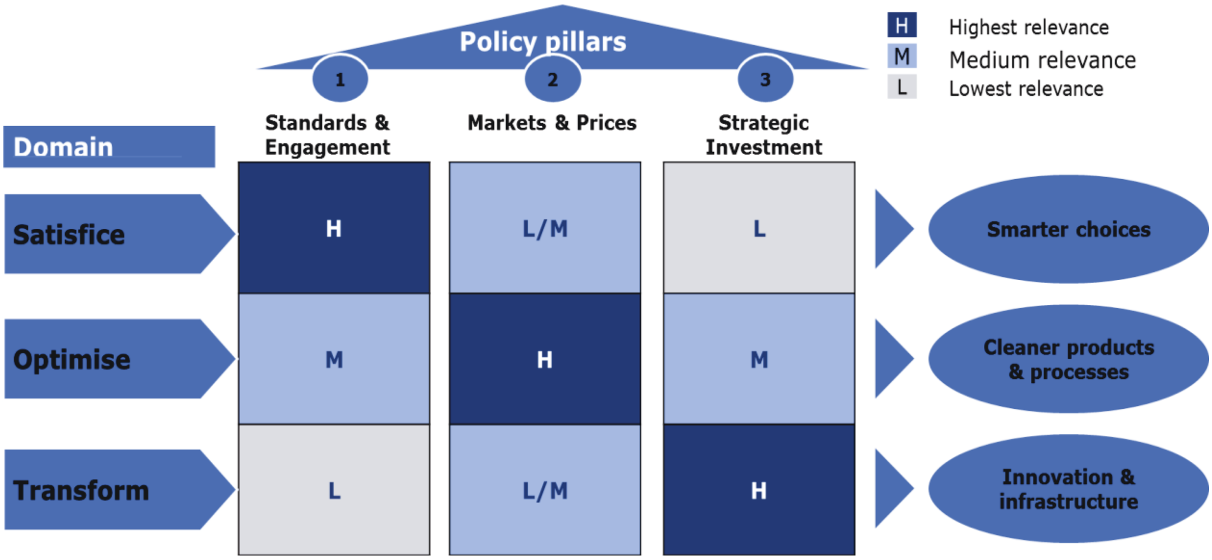

Figure 5: Three pillars of policy in relation to the three economic domains

The other question is how markets can be made more effective with respect to third domain requirements of investment and innovation, and other elements of transformative processes. Concerning the need to decarbonize, one immediate dilemma is that investment incentives depend heavily upon expectations, and hence any incentive to decarbonize – without other measures - hinges on the credibility of future commitments around carbon pricing. This is hard to achieve (particularly given the potential impact on affordability, and more generally the politics of energy pricing), and its credibility has been further undermined by repeated collapses in the European carbon price and the freezing of the UK price floor.

Fostering strategic investment

As noted in the previous section, the literature on energy innovation, particularly with respect to clean energy technologies, has been marked by a strong concern with the technology 'valley of death'. The data in Figure 3 gave a very high-level indication of the reality of this problem and Figure 4 gave an outline indication of why this is important in energy (see also the Annex summarising in more depth six generic factors).

These factors explain the central importance in energy of "strategic investments", the third pillar in Figure 5. This may be simply defined as investments which yield a larger strategic return than any individual market player can capture, or would sensibly invest in given perceived risks. Typical reasons might be the benefits of such investment for security, for environment, or innovations which can enable the future system to better address all three elements of the 'trilemma'.

The difficulty of relying too heavily on strategic investment, of course, is that in its most obvious form it is state-led, since by definition it concerns investments whose public benefits exceed private returns. The problems of purely publicly-directed investment are of course well known. Given an underlying preference for market-based solutions, the UK has placed relatively more emphasis on strengthening the "demand pull" end of the innovation chain, particularly for renewable energy sources.

Strengthening ‘technology pull’ for innovation and clean energy investments involves creating supported markets for emerging technologies. The issue then become how much the government should try to differentiate the depth and breadth of these markets. Acknowledging the justification for renewable energy supports, combined with the desire to minimise government involvement in technology choice, led the UK initially to implement a ‘one-size-fits-all’ level of support for renewable energy output with unbanded ROCs.

The result of undifferentiated technology pull support – as illustrated in **Figure 5** - was a first-past-the post effect very badly matched to the actual funding needs. The scale of support needed to bring a technology through the innovation chain at first rises with deployment and scale, and then falls as the cost gap vis-à-vis incumbents narrows. Bridging the ‘technology valley of death’ hence requires greatest overall support in the mid stages. With undifferentiated support, the most mature and lowest cost technologies (in this case, onshore wind energy developed mostly in other countries) received excessive funding as their scale grew, whilst other crucial technologies at earlier stages (but with big potential) languished.

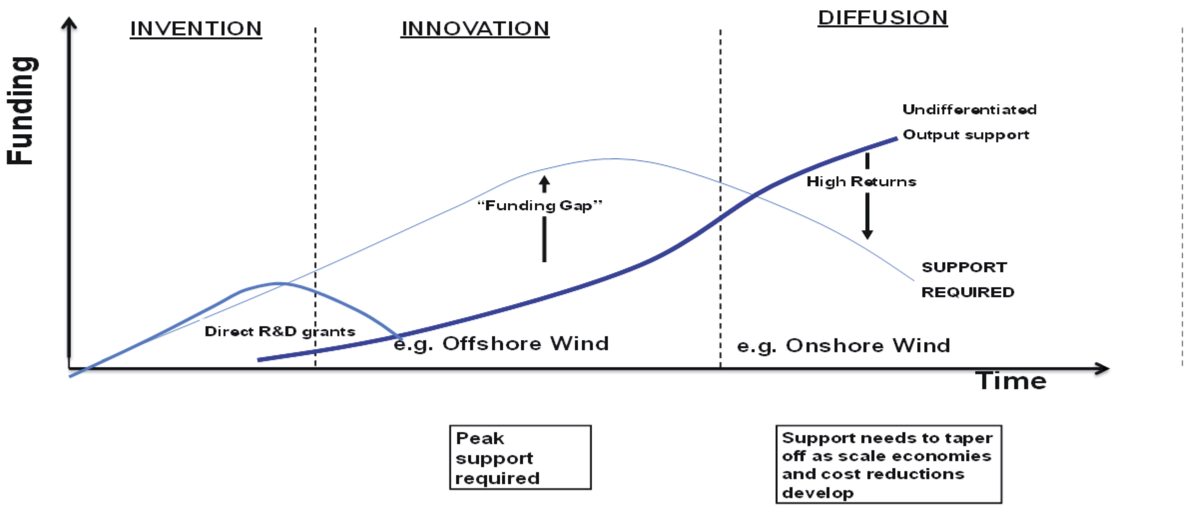

Fig.9.8 (b) The funding gap under R&D + undifferentiated supports
Graph adapted from : Carbon Trust (Haj Hassan et al, 2008)

Figure 6: Nature of funding gap and windfall profits with R&D + undifferentiated technology-pull supports

‘Banding’ the ROCs into different technology classes helped to address this problem. As the CMA note in their Capacity paper, the structure of the ROCs themselves was poorly aligned to the goal of reducing financing risks and costs, and this recognition underlay the introduction of CfDs in the Energy Market Reform. This addressed one key issue – increasing efficiency through a structure of long-term contracts that better match the capital characteristics of low carbon investment, and hence financing costs.

The CMA Capacity paper appears to accept this, but expresses concern that ‘dividing the budget into separate pots could result in inefficient allocation of support and distort competition between different technologies.’ Either is of course possible, but the converse is that *not* having separate pots could be far worse. The language used does not appear to reflect understanding of the investment-and-innovation process in energy, the strategically central importance of adequate innovation, and the resulting genuine dilemmas.

As explained and illustrated by the data and international experience, a competitive energy-only market with no differentiation leads to low levels of investment and innovation (along with other problems noted), entrenching incumbent technologies, companies and systems.[4] The reasons can be summarised in terms of the exceptional significance of First and Third domain effects in the energy sector – weak demand-side engagement due to lack of product differentiation and the other factors noted, alongside the chilling effect facing risky, inframarginal investments with large public spillover benefits. The scale of spillover benefits will vary enormously according to the nature of technology, its stage of development, and the scale of the underlying resource.

Efficient allocation therefore *requires* differentiation of support. To underline this point, in summary, three main approaches have been tried to foster adequate clean energy investment and innovation:

- ***Technology push*** with extensive and expensive state-led capital supports; the role of the state has to grow in scale as technologies move towards commercialisation and growing scale, increasingly competing against incumbents;
- **Undifferentiated technology-pull supports** for a generic class of clean energy generation, like renewable energy: as the original ROCs and as illustrated with Figure 5, this results in large windfall profits to the most developed clean technology yet may still leave others stranded;
- ***Differentiated technology-pull***, which seeks to target market supports on the technology areas where innovation and industrial development has the great potential to yield strategic benefits.

The first relies heavily on state spending and government management of direct project investments. The second – undifferentiated support - results in far *less* efficient allocation of support (for example, windfall profits to onshore wind without developing emerging technologies and industries with great potential). The last option, which is the form taken by the CfDs with its different technology pots, would appear to be in principle the most attractive option, particularly when CfD allocation introduces competitive pressures through auctions.

Thus the case for technology banding – the ‘technology pots’ - remains, to ensure that market supports are focused on technologies that are strategically important yet require substantial further technological and industrial development. Obviously this does have potential to ‘distort competition between different technologies’, but it does so for good reason, because the benefits of learning and cost reductions may vary hugely between different technology categories.

To my knowledge there is no generic ‘science’ that would enable us to determine exactly how many pots should exist and precisely what level of funding should be allocated to each pot. It is ultimately an empirical question, determined by the extent of differences between the stages of development or circumstance of different technology areas, the scope for cost reductions, the scale of investment required to bring costs down, and the potential strategic importance of different technologies.

In the case of the UK, for example, our biggest two renewable resources by far are solar and wind energy, with the former resource clearly dominant in summer, and the latter in winter when electricity demand is highest. Particularly given the planning constraints on onshore wind energy, it is very hard to see how the UK can secure a sizeable portion of its energy from renewables without large-scale use of offshore wind energy,

[4] In the energy literature, this has become known as the ‘lock-in’ problem (Unruh, 2002); the OECD refer to it more broadly as ‘carbon entanglement’ (OECD 2013). The wider literature on technology transition processes is adamant that short-run competitive energy markets favour incumbents at the expense of more radical potential transformations, and that any attempt to foster change in this default requires much more than just RD&D, but strategies involving support of niche markets, infrastructure and hybridization. Beyond the specifics of failures in the innovation chain, Marechal and Lazaric (2010) summarise these findings from evolutionary economics, and a wider discussion of system-level inertia and lock-in effects in given in Grubb et al (2014), Chapter 10.

where the resources are enormous. This creates a clear strategic case for ensuring adequate development of the technologies and industries.

The CMA quite rightly wishes to 'explore further the rationale for separating the budget for established and less established technologies', but the rationale is clear; the question is whether it has been right in application. Answering this must involve venturing into terrain that requires substantial knowledge of energy sector characteristics, resources and innovation potentials, to probe more deeply into whether why and how the CMA thinks DECC has got the balance wrong at present, and hence could do better in future rounds.

Energy Innovation: potential new horizons

To conclude this submission: the CMA might well consider a rather different aspect of innovation in the energy system, to focus our eyes forward rather than back on well-worn debates in energy policy.

A root cause of the exceptionally low rates of innovation in the sector has been the lack of significant 'demand pull' arising from the various First Domain behavioural and other characteristics of energy as an undifferentiated, non-substitutable, incidental and essentially continuous product.

Multiple factors are fortunately beginning to chip at this. A decade of rising energy prices and environmental concerns have increased consumer interest and engagement. New technologies for monitoring, control and demand-side management are opening up new opportunities. The dramatic fall in the cost of small-scale renewables in particular (a direct consequence of the kind of differentiated technology supports that the CMA appears to question in its Capacity paper) have engendered new types of citizen's interest and sometimes direct participation in how their energy is generated. Consumers are thus beginning to differentiate energy on the basis of how it is produced and the contractual forms through which it is offered, and by whom. As noted in a recent Ofgem discussion paper (Ofgem 2014), a raft of non-traditional business models are now knocking at the door of established energy markets.

The CMA has raised the specific question of whether the form of industry code governance may constitute a barrier to new entrants. This may be a facet of a more general question, as the academic literature on systems transitions underlines the fact that a regulatory structure optimized for one socio-technical regime may not be well fitted to another. In principle, there are three broad stances that the government and/or regulator could take:

- *Laissez-faire*, accepting the energy-only market and its governance targeted at cost-based competition for electrons as the philosophically desired state of the industry;
- *Level playing field*, aiming to identify and remove any specific identifiable barriers that might impede new entrants attempting to enter the market, notably but not exclusively relating to small players, and cognisant of the disadvantages (eg. inframarginal risk allocations) faced by renewable energy in an energy-only market with inadequate environmental pricing;
- *Pro-actively engage, encourage and support* new entrants and technologies, in effect from a standpoint of 'positive discrimination' intended to accelerate the pace of structural change and deeper innovation in the energy sector, targeted at meeting simultaneously all three aspects of the energy trilemma.

This submission has explained why liberalization *on its own* could not achieve the latter goal, for clear structural reasons associated with the physical nature of the system. CMA consideration and guidance in this area of how actively we should foster change would, I believe, be extremely helpful both to Ofgem, and to many others in the energy business trying to navigate a world in which new technologies, opportunities and objectives increasingly appear to be in tension with old ways of running electricity systems.

References

Unless otherwise stated, material in this submission is drawn from:

M.Grubb, J.C.Hourcade and K.Neuhoff (2014), *Planetary Economics: Energy, Climate Change and the Three Domains of Sustainable Development*, Routledge, 2014; principally Chapter 2 ('The Three Domains'), Chapter 4 ('Why so Wasteful?'), and Chapter 9 ('Pushing further, pulling deeper: bridging the technology valley of death').

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Annex: Typical causes of under-investment in innovation

Different factors inhibit progress across the four central components of the innovation chain (applied R&D, demonstration, commercialisation, and market development). **Three in particular impede the 'technology push'** into the commercial world:

- *Uncertainties and knowledge divisions around risks and rewards* are fundamental to investors. Risk and uncertainty is endemic in many economic activities but "R&D investment appears qualitatively different": rewards to invention are not only uncertain but may be dominated by low-probability high-consequence outcomes. For any individual investor there is therefore a strong temptation to wait and see what emerges. From a public policy standpoint this simply defers the process of innovation and diffusion. Even if there were no IP/spillover problems, a better pace of innovation thus takes public money.

- *Transitions from technical to management and commercial skills* are particularly problematic in the earlier stages of innovation. A good technology development team will be dominated by researchers, but investors are more likely to back projects proposed by groups with greater business expertise. This also exacerbates the risk of uncertainty and information asymmetry that drive 'adverse selection': an inability to discriminate between better or worse technologies may mean that investor's money becomes easily diverted to those with inferior technology, but the best sales pitch.

- *High capital costs and long timescales* are typical of renewable energy, since the resulting fuels are largely free. The more investors have to commit up front, and the longer they have to wait to see a return on their investment, the greater the uncertainties (including around government policies) and risks. , thus deterring investors. Investors are in effect being asked to bear not only the technology and market risks, but those of public policy and politics over successive election cycles.

As a result, private investors prefer to support projects at more advanced phases, when they can better assess and manage the risks. **Three additional factors undermine finance for potential 'demand pull',** given the absence of the strong potential driver associated with producing new consumer products:

- *Economics of scale and experience.* Innovation requires ongoing improvement of the product, including learning by doing and scale effects. Yet initial plans have to focus on market niches and not on a large customer base. Learning-by-researching may be of declining value as a technology moves into production, but there is insufficient market volume to fuel enough learning-by-doing to reach a sustainable market. Bankrolling scale-up as the R&D funding declines involves much higher funding and thus amplifies the risks. The resulting hesitation can interrupt growth – perhaps fatally. The 'solar surprise' happened largely because special tariffs (particularly in Germany and Spain) generated high returns whilst some countries – notably China - took the investment plunge with a big leap in the scale of production facilities.

- *Misalignment of private and public goals.* Government involvement for public policy purposes - such as to encourage environmental innovation – may not sit well with the motivations of investors, particularly if governments do not 'put their money where their mouth is' in terms of emissions pricing or other policy. To get R&D funding, the innovators themselves may have been focussed on the public goal (eg low emission technology), but investors discount public policy promises, and may conclude that technologies backed by governments have been motivated for reasons not aligned with commercial interests, and are thus more risky.

- *Incompatible public policies and understanding of the full innovation chain.* A key problem can be the failure of policy in some areas to reflect the intent in other policy areas or processes. In-firm innovation requires companies to have some financial surplus and an eye to the strategic future, which may be hard to sustain in the face of potentially hostile takeovers based on maximising short-term return for shareholders. Yet, EC merger assessments tend to focus solely on maximising competition in the short-run, and not consider impact on innovative capacity. More generally, establishing new industries requires the coordination of many elements, including associated infrastructures and regulatory frameworks.

Source: Abbreviated from analysis in Grubb et al (2014), Chapter 9 "Pushing further, pulling deeper"