# UTILITY 2050

Phase 2 Empirical Report

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# Utility 2050 Phase 2 Empirical report: Executive Summary

**The Utility 2050 project will: *assess the impacts of decarbonisation on incumbents, the system challenges, innovation and deployment.***

**The Approach:** We investigate five plausible business model archetypes for utilities in the 2035-2050 time period. We test these business model archetypes against energy system scenarios. Taking a business model archetype approach allows for comparative analysis of financial, regulatory, market, technology and user impacts on business model innovations. **Phase 1** defined the existing challenges to system operation and created six business model archetypes which meet these challenges in various ways. The empirical team selected five of these archetypes to test against business as usual scenarios to determine how different business models performed under different energy futures, what their critical attributes for users and market regulation were, and what technologies they exerted 'market pull' upon.

**This empirical report:** This report presents the summarised results of Phase 2 and comprises six parts.

**Part 1** provides a context and overview of where this work contributes to the wider energy futures landscape and demonstrates Utility 2050's unique contribution.

**Part 2** presents the results of the value pool modelling of each future business model archetype. The value pool approach determines the pool of revenues and savings that can be made in different parts of the energy transition. The six value pools identified were: plant efficiency, energy service provision, local low-carbon generation, large-scale low-carbon generation, flexibility optimisation, and carbon capture and storage. These value pools were calculated across energy system scenarios and allocated to each business model archetype at 2030, 2040, and 2050 time-steps.

**Part 3** presents the regulation and markets stress testing results. This work investigates the pressures the operation of new business models places on energy system regulation and market design. This package comprised 15 semi-structured interviews across electricity system stakeholders. The two critical issues identified were: persistent wholesale price erosion, and consumer switching in the retail market. Each archetype is affected by these issues in different ways, which are detailed in this section.

**Part 4** uses the same interview bank as the regulation and markets exercise to assess user implications of the assessed business models. This work produces a suite of qualitative results and also sets the parameters for the user facing element of the Utility 2050 project, a 'future switch' experiment in which a representative sample of utility bill payers express preferences for how they might interact with utility companies in the future.

**Part 5** Investigates the technological barriers to the selected archetypes. This section demonstrates that technological innovation is not the main barrier to the emergence of new business models, but CCS and ICT applications still represent technical challenges.

**Part 6** presents 'next steps' for the Utility 2050 project which comprises the design and delivery of three 'Decision Theatres' in which these empirical results will be interrogated by system experts to define decision pathways for sector evolution. There is no further synthesis of empirical material, as this is the ongoing work of the final phases of this project.

**Five critical decision points signalled by the Utility 2050 empirical analysis:**

This empirical analysis has analysed the relative performance of the Utility 2050 business model archetypes against seven energy system pathways. Each of the four stress testing work packages has identified different elements of financial, market, regulatory, and consumer effects on the BMAs. The Phase 2 empirical report investigates a series of issues, however five critical decision points are distilled from the wider analysis. These five decision points have an impact on the viability of all business model archetypes, and will fundamentally affect the future direction of UK's energy transition. The five critical decision points are:

- **How to remunerate large thermal plant in the future energy system.**
- **How to ensure the carbon price is sufficient to incentivise large scale low carbon generation.**
- **Whether to incentivise smart energy systems by allowing long term contracting with domestic and small commercial consumers i.e. supply without switching.**
- **How to ensure key technical barriers are overcome; both capital intensive such as CCS demonstration, and non-capital intensive i.e. testing ICT platforms within the wider energy market.**
- **How to manage consent and protection for consumers in futures where direct load control and data sharing are key enablers of attractive business model archetypes.**

Each of these five decision points can be re-framed or added to by further contextual analysis or at the recommendation of project partners. The final decision points should form the basis upon which decision theatres are operated, and the results of this process should be fed directly into the national energy policy debate. They should be framed as pivotal questions for short term energy policy which will have long term consequences, costs and benefits for the energy transition.

# Part 1: Energy Futures work and the Utility 2050 Project

Core enabling team
**Mark Workman:** Project Lead ERP
**Geoff Darch - Atkins:** Enabling Team Oversight
**Stephen Hall – University of Leeds:** Enabling team lead, Markets and regulation Package
**Jeff Hardy – Imperial College London:** Consumers and users package
**Marie-Sophie Wegner – Imperial College London:** Value pools and quantitative modelling package
**Chris Mazur – Imperial College London:** Technology Stress Test Approach with Douglas Cheung
**Jillian Anable – University of Leeds:** Consumers and Users Package, Discrete Choice Experiment lead
**Mark Powell –University of Newcastle:** Decision theatre facilitator and design.

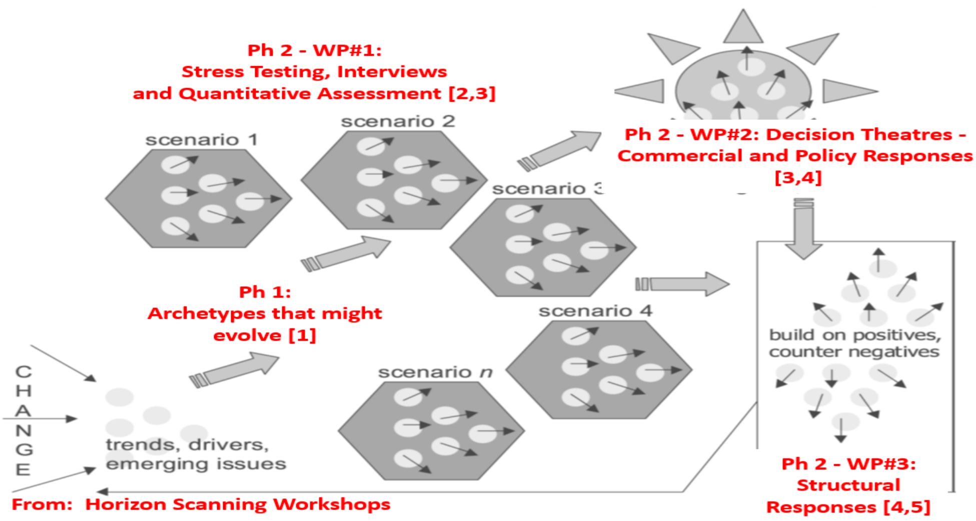
## 1.0 Introduction

The Utility 2050 Project arose from a foresight exercise undertaken by ERP 2015 which identified a pressing need for a robust strategic appraisal of the impact of energy transitions on current and future utility business models.

The ERP Utility 2050 project aim is to***: assess the impacts of decarbonisation on incumbents, the system challenges, innovation and deployment.*** Project Objectives:

1. Assess the operating environment of the UK future electricity system in seeking to achieve multiple societal objectives;
2. Assess the effect of different scenarios on different electricity business models, such as generation only and vertical integration which will emerge and can be sustained.
3. Assess the commercial and policy responses to system wide and corporate risks in the future electricity / energy sector in seeking to achieve multiple societal objectives.
4. Assess the effect on innovation and investment - what will go ahead / fail under different business models?
5. Finally, a suite of responses aimed at corporate, political, and financial audiences will define new roles and value propositions for electricity system participants in seeking to achieve multiple societal objectives.

**Figure 1:** The Utility 2050 project methodology[1] in order to achieve project objectives. Figures in brackets relate to the objectives above.



To meet the emissions targets set in the UK's Climate Change Act, a wide variety of possible futures have been envisioned and a suite of future energy scenarios investigated. Future energy scenarios provide systemic perspectives of future energy systems with characteristics such as demand, power plant capacities and generation, peak supply as well as penetration of electric vehicles or further values like population and number of households. However, these scenarios do not address the capacity of the fragmented actors to innovate and deliver the energy technologies required in these scenarios. This is because energy actors in scenarios are insufficiently well parameterised in order to allow the identification of value capture or cost saving opportunities from present and future energy service provision/markets.

As a result the concept of business model archetypes (BMA) has been adopted by this project, to develop templates of fundamental value propositions and cluster the numerous business model variations. This approach enables a comparative analysis of the theorised benefits and the barriers that these archetypes face (Hall & Roelich, 2016). A 'Value Pool' analysis was then undertaken to understand the size and accessibility of each of these value propositions under different energy system scenarios. This allows researchers to understand the relative market opportunities for new utility business models. These business models are then stress tested against non-financial constraints, in this case: regulation and markets, the user impacts, technology barriers, and user segmentation. This process is used to distil the critical decision points required in a complex system. These decision points are then taken to a decision theatre to build consensus on critical system challenges. This process is adapted from the field of 'futures' work.

### 1.1 Futures Typology and Processes

An overview of the capacity for futures work to inform policy is not warranted in this paper and an excellent summary can be found in Schultz, 2006[1].

A meta-analysis of energy forecasts and scenarios undertaken since 1978 has highlighted a number of shortcomings in the outputs to inform energy policy[2]. Many of the shortcomings were a function of the fact that the studies reviewed used one foresight activity as a stand-alone project such as horizon scanning or scenarios or visioning. This makes for weak and ineffective foresight projects.

Good futures work includes clearly identifying the theories of change underlying the work: (1) *What drives the changes that create alternative futures?* and (2) *How do impacts collide and connect in the patterns they do?* across a set of key activities within an integrated foresight process. To this end, the ERP Horizon Scanning Project sought to address the main concerns expressed in the meta-study[3] by assuming a blank slate and engaging in the process of integrated foresight called Horizon Scanning.

The next stage in the process of integrated foresight, building on the ERP Horizon Scanning exercise, was the Utility 2050 project. This project came about as a function of the outputs for the Horizon Scanning project suggesting that many of the drivers of change identified

[1] Schultz, W.L. 2006. The cultural contradictions of managing change: using horizon scanning in an evidence-based policy context. In Foresight vol. 8 NO. 4 2006, pp. 3-12, DOI 10.1108/14636680610681996
[2] McDowall et al., 2014. UKERC Energy Systems Theme: Reflecting on Scenarios. Working paper dated June 2014. Found on: http://www.ukerc.ac.uk/publications/ukerc-energy-systems-theme-reflecting-on-scenarios.html
[3] McDowall et al., 2014. Ibid

would either result in an increasingly centralised energy system or a completely decentralised system in the sense of it being a trans-active market (Barrager and Cazalet, 2014). These findings were echoed in the Ofgem Horizon Scanning exercise as well.

### 1.2: Systemic responses

Several OECD energy systems are experiencing similar change pressures to the UK. In this empirical report the findings of the value pool modelling and stress testing are presented. However in the final stakeholder report the outputs of other systems focussed research will be comprehensively reviewed. The analysis of the Utility 2050 project will also draw on this work to demonstrate where the Utility 2050 findings impact on the wider energy transition field. Examples of existing work are:

New York REV model; Leadership Vanguard; The Long View; NTR ENA Project; MIT Utility of the Future; Energy Catapult-IET FPSA work; RTP Distributing Power; Accenture 'Low Carbon High Stakes'; Sustainability First; Energy UK `Pathways for the GB Electricity Sector to 2030; ICIF and ENCORE networks; KPMG Heat Scenarios; PwC work; OFGEM Horizon Scanning and NTBM's; UKERC – Future of Retail Markets; E3G.

### 1.3 Outputs of Phase 1

The ERP Utility 2050 project workshop on 15th June generated 11 archetypes following expert opinions and literature review of which five underwent detailed stress testing: these are described in outline below (taken from Hall, et al 2016)

**Low-Carbon Transmission Capacity Provider:** Most UK energy system scenarios to 2050 require efficient gas turbine generation and some coal CCS. Given the uncertainty over future utilisation of these assets, and the long lead in time necessary, it is assumed these assets will require support through capacity mechanisms, feed in tariffs for low carbon generation, or other non-power payments. The main non-power payments are providing guaranteed low-carbon baseload and flexible response capacity. For the generator there are three routes to market envisaged, each of which is trading to larger scale, predictable clients. The first is direct 'sleeving' to industrial and commercial consumers, the second is pure wholesale and the fourth is via long term PPA with local optimisers to top up supply shortfalls. There is no direct relationship with private household or SME consumers as this archetype focuses on leveraging the large generation asset.

**New Electrifier:** "This archetype is the smallest departure from the traditional vertically integrated model; there are two markets that could see significant expansion of kWh demand from both domestic and commercial customers. These are heat and mobility. Throughout the 1950s-70s electricity boards successfully promoted electrification of cooking and economy 7 heating. In this archetype a vertically integrated utility drives electrification of heat and mobility through heat pumps and battery electric vehicles (BEVs). The utility may own and lease the EV batteries and heat pumps and use these as substantial grid balancing services. This new load provides a controllable and predictable destination for the utilities own low carbon generation. Consumer relationships remain similar to today but require longer term contracting and higher exit costs. Vehicles are equipped as their own mobile smart meter, allowing utilities to control load and charging wherever the vehicle is parked. New generation capacity is de-risked and government intervention is limited. The new electrifier may offer PV with storage or other energy packages, but will still gain remuneration from unit sales.

**Serviced Home and Mobility / ESCo:** In this archetype an Energy Serve Company (ESCo) meets the energy needs of households rather than providing units of energy. At present energy service contracting means the ESCo drawing revenues from savings on a traditional commercial bill. Here however the energy service contract is the energy bill. The ESCo is charging for illumination, clean clothing, thermal comfort, hot water etc. and is incentivised to provide these services for least cost or fewest units of energy. Here consumers can expect an energy contract to include leased smart home appliances, mobility, energy efficiency audits and measures, storage technology, vehicle infrastructure and microgeneration (solar PV/Thermal) etc. The ESCo sources the residual energy demand from either its own generation or the wholesale market. Importantly the utility may also lease the vehicle and battery through a single energy service bill and charge for annual mileage, utilising the vehicle battery to optimise the consumer's consumption for different outcomes, i.e. low carbon or least cost. There is strong DSM capability and the majority of balancing services move to demand response through vehicle to grid and appliance based demand side management.

**Peer to Peer 2.0:** In this archetype the consumers interface with energy is revolutionised. Instead of switching supplier, consumers sign up to an online marketplace where they can select generation sources that meet their preferences (price, carbon intensity, local generation, social impact scores etc.). Where consumers under or over-estimate supply needs, or where generation is short or long, the trading platform tunes its position via the wholesale market or demand side response. This requires the trading platform to have access to firm demand response of the aggregated consumer base[4]. In common with crowd funding platforms, consumers can subscribe to future generation sources, guaranteeing retail offtake contracts for future generation. This reduces market price risk for future plant. The trading platform operator charges for service to consumers and generators and aggregates loads for system operator balancing.

**Third party control:** Third parties create a value proposition for domestic consumers and gains dominant market share from traditional utilities. In return for access to consumer's data and power of attorney to take decisions on consumers' behalf, the third party enters into a contract with consumers to optimise their lifestyles (taking away the stress of consumers' ever having to worry about utilities ever again). In essence this cedes control of all utilities and decisions to this third party. An analogy would be a more powerful, smart enabled 'Utility Warehouse 3.0'. The third party uses consumer data and complex algorithms to optimise across all utilities, delivering the consumers prescribed lifestyle. The third party has 'free reign' over the decisions it can take on behalf of consumers. For example, should it consider it optimal, it could insulate the consumers home, purchase them an electric vehicle or alternative heating technology or ramp up or down their energy, water, telecoms demand. As a consequence, the third party is a de-facto aggregator of domestic demand side flexibility. However, decisions it takes in consumers' interests could also result in consequential actions (such as balancing or frequency response) across the energy system (or in other systems such as water). To access demand side flexibility or to engage consumers, all other energy system participants must go through the third party, giving it significant market

[4] In the final value pool analysis the demand side response value pool was not included as the level of effective aggregation was unclear.

power. The role for government and regulation would be defined by complex consumer protection needs which require exploration.

### 1.4 Valuing and stress testing the archetypes

The remainder of this report presents the valuation and stress testing phase of this work. This phase was designed to determine how each archetype performs against different energy scenarios, policy futures and user behaviours and distill the key decision points for UK energy policy.

### 1.5 The need for an open strategic dialogue

**Notwithstanding the empirical results of this project there is clearly space for a participatory and pluralistic civil society engagement on the future evolution of the future UK electricity / energy system. This can be achieved by enrolling a wider range of actors which are directly and indirectly involved in the energy sector. The non-partisan position of the ERP makes it an ideal organisation to develop this dialogue.**

# Part 2: Value Pool Modelling

## 2.0 Introduction:

This work stream seeks to assess the financial resilience of potential future business model archetypes (BMA) to conceivable developments in the UK power market to 2050.

This research will test if the following hypothesis holds true:

*The viability of potential new business model archetypes as well as their ability to benefit from the energy transition depends on the future development of the energy system as well as the future market framework.*

This leads to a number of research questions:

- *What kind of new revenues streams, enabled by the energy transition, can the power industry tap into? What is the potential market size of these new revenue streams?*
- *Can actors from the power sector avoid cost through actively engaging in the energy transition? How large can those savings potentially be?*
- *Can the business model archetype unlock the cost saving potential and access the new revenue streams and if so, to which extent?*
- *How significant are the new revenues and avoided costs compared to the overall size of the business operation for each business model archetype?*
- *How financially resilient are the selected business model archetypes to the breadth of potential energy market futures?*

## 2.1 Methods

To quantify the financial opportunities of new business model archetypes in different energy futures a value pool modelling approach was adopted. The model determines the opportunities on a system level for a range of existing future energy scenarios. Subsequently, the values captured by the different archetypes as well as the business model viability were assessed. The developed approach builds on a value pool model recently published by Accenture Strategy in “Low Carbon, High Stakes - Do you have the power to transform?” (van Beek, Holst & Keeble, 2015). Van Beek et al. use the value pool model to quantify the magnitude of financial opportunities available in low carbon energy transitions.

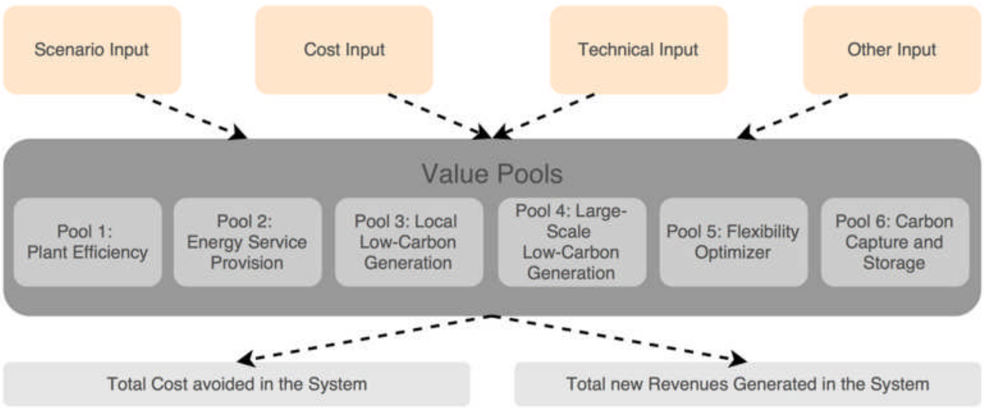
**Table 1:** Simplified value pool process.

| | |
|---|---|
| The modelling was carried out in **three main steps**:<br>1. Sizing of the value pools on a national level,<br>2. Sizing of the value pools captured by the different BMA,<br>3. Estimating the Revenues, Costs and Profits of the BMA.<br><br>The **six value pools** are:<br>• *Plant Efficiency*<br>• *Energy Service Provision*<br>• *Local Low-Carbon Generation*<br>• *Large-Scale, Low-Carbon Generation*<br>• *Flexibility Optimisation*<br>• *Carbon Capture and Storage* | The **Future Energy Scenarios** used for the modelling are:<br>*DECC 2050*<br>• Higher Renewable, more Energy Efficiency<br>• High Nuclear and less Energy Efficiency<br>• Higher CCS, more Bioenergy<br>*National Grid – Future Energy Scenarios*<br>• Gone Green<br>*Realising Transition Pathways*<br>• Market Rules<br>• Central Coordination<br>• Thousand Flowers<br>*Business as Usual-Scenario*<br>• NG FES – No Progression |

| **Table 2:** Scenarios 2050: Overview of the Scenario Data | | BAU: NGrid - No Progression[5] | DECC 2050 - Higher RE, more EE | DECC 2050 - High Nuclear, less EE | DECC 2050 - Higher CCS, more Bioenergy | NGrid - Gone Green | RTP - Market Rules | RTP - Central Co-Ordination | RTP - Thousand Flower |
|---|---|---|---|---|---|---|---|---|---|
| **Electricity Demand** | TWh | 309 | 490 | 555 | 461 | 361 | 504 | 402 | 301 |
| **Power Generation (incl. Import)** | TWh | 349 | 530 | 610 | 556 | 454 | 573 | 464 | 370 |
| **Conventional Generation Capacity (excl. CCS)** | GW | 49 | 0 | 0 | 0 | 18 | 15 | 5 | 0 |
| **CCS equipped Generation Capacity** | GW | 0 | 13 | 2 | 40 | 11 | 46 | 32 | 23 |
| **Low-Carbon Generation Capacity** | GW | 42 | 121 | 97 | 49 | 119 | 104 | 90 | 84 |
| **Number of Electric Vehicles** | mln. | 3.9 | 24.2 | 31.0 | 24.4 | 9.7 | 25.2 | 25.2 | 25.2 |

The value pool method does not include the value of capacity payments or strike prices/CfDs as there is no clarity on the provision of these mechanisms beyond 2020 and the aim of the exercise is to focus on energy market payments to establish their sufficiency for supporting business model innovation. The carbon price however is included as this is exogenous, i.e. not directly determined by energy policy.

**Figure 2:** Schematic Diagram of Structure of the Value Pool Model




The quantitative work was complemented by a series of eight semi-structured interviews with industry experts from different backgrounds such as finance, utilities, non-traditional business models and policy & regulation. The purpose of the interviews was to gain qualitative insights and fill knowledge gaps on the UK electricity market, the services included in the value pools and the prospects and hurdles of the business model archetypes.

[5] The National Grid Future Energy Scenarios 2016 cover the time horizon till 2040, hence a stable system for the time horizon till 2050 was assumed.

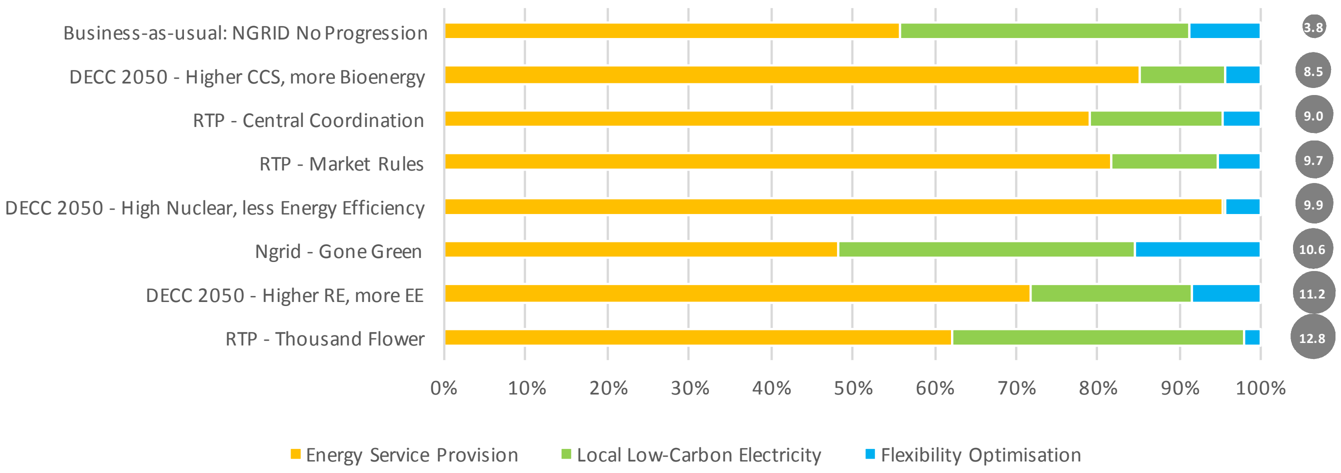
## 2.2 Results

***Value Pools – System Level***

The model demonstrated that the energy transition in UK can enable annual revenues of up to 13bnGBP by 2050 from new sources. Further, a potential for cost savings of up to 6bnGBP in 2050 exists.

However, the model showed that these benefits were extremely sensitive to the scenario used. Scenarios focussing on conventional generation technologies, while paying little attention to the supply side, offer very limited financial opportunities from the energy transition. However, scenario futures, which focus on new generation technologies and further put the consumer at the heart of the transition, will likely enable significant business model innovation. Energy service provision is a significant source for new revenues across all scenarios, whereas total benefits from the provision of flexibility are limited across all scenarios.

**Figure 3:** Percentage Composition of New Revenues & Total New Revenues for each Scenario in 2050



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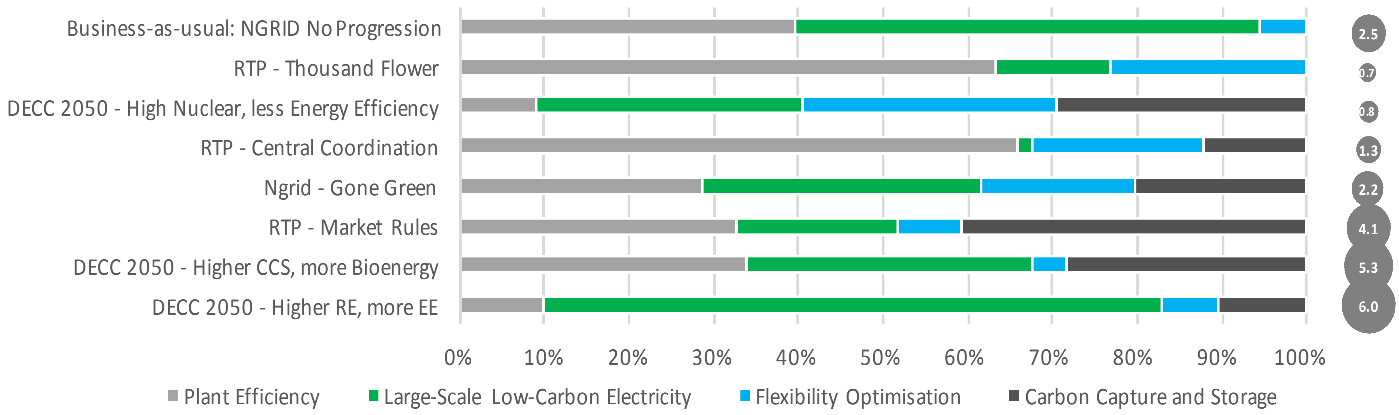
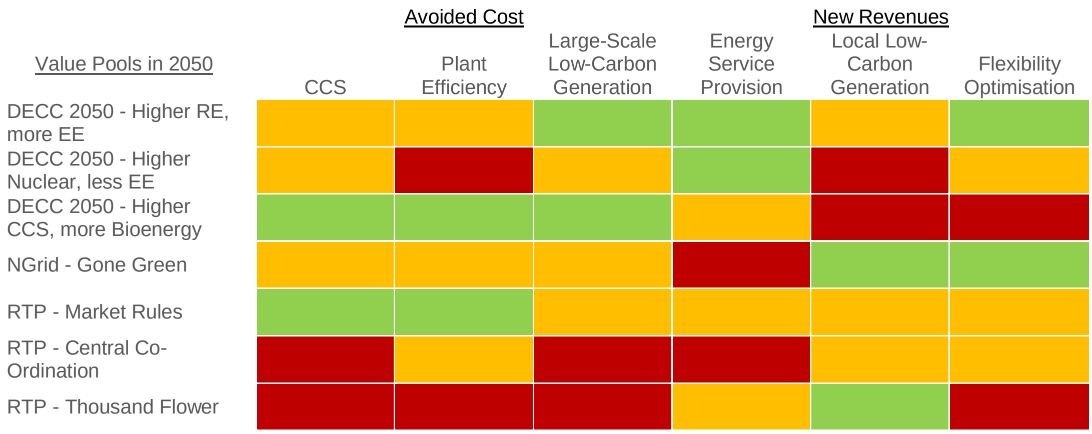



Based on the previous calculations, the following matrix demonstrates the size of value pools per scenario by applying a traffic light scheme:[6]

**Figure 5:** Ranking of the Scenarios according to Value Pool Sizes




The analysis demonstrates that the more centralised generation there is in a particular pathway the more likely it is that the majority of value is within the 'avoided cost' category. Largely this is driven by avoided costs being relative to the carbon price imposed on unabated generation. For more decentralised or smart enabled futures such as 'DECC - High RE more energy efficiency', 'NGrid - Gone Green', and 'RTP Thousand Flowers' the value pools tend towards new revenues. This demonstrates the critical effect of scenario future on the relative size of value pools. The following analysis explores this effect on business model archetypes of future utilities.

### *Business Model Archetypes*

For the ESCo archetype, the energy transition can enable annual revenues of up to 7.5bnGBP by 2050, while offering potential cost saving of up to 0.6bnGBP by 2050. The New Electrifier archetype can benefit from up to 6.3bnGBP and potential cost savings of

[6] Traffic Light Scheme: largest value pool = highest rank; green: rank 1, 2; orange: rank 3-5; red: rank 6, 7.

2.8bnGPB in 2050. The Low-Carbon Transmission Capacity Provider can capture cost savings of up to 3.3bnGBP by 2050. The smallest beneficiaries of the energy transition are the Peer-to-Peer and 3rd Party Control archetypes benefiting from up to 0.3bnGBP and 0.5bnGBP of new revenues in 2050. Their limited ability to capture value results from their position as a platform, without direct involvement in the generation or supply business. Due to this it is only able to capture a fraction of the actual value created in the transactions the archetype is involved in.

**Figure 6:** Business Model Archetypes - Avoided Cost and New Revenues captured from Value Pools compared to accessible Value Pools

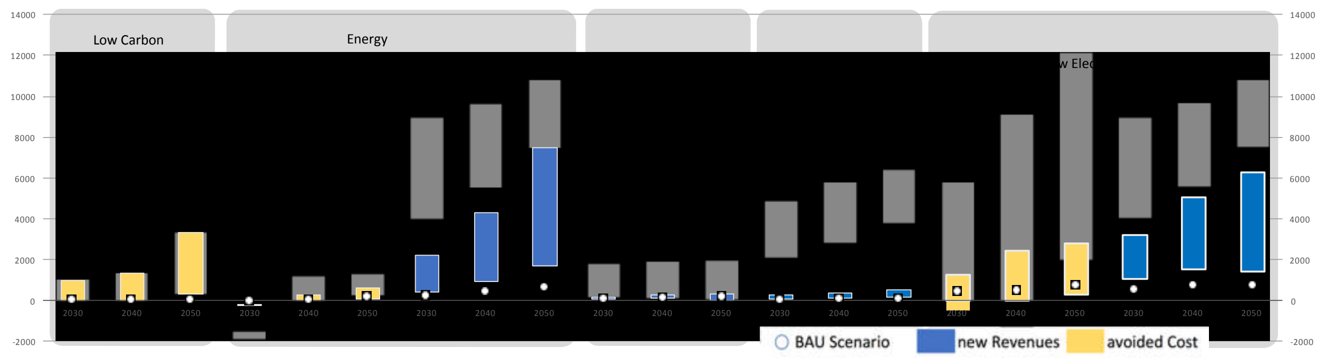



Figure 6 clearly shows that the archetypes capture a fraction of the accessible value pools and this is due to an assumed market penetration / consumer uptake achieved by each BMA. The assumptions for the market penetration were informed by the narrative of the scenarios as well as insights on the archetypes derived during the workshop in phase 1 of the project. Further they depend considerably on the conditions in the market. Each archetype requires different market characteristics to thrive thus different penetrations were assumed per BMA and scenario.

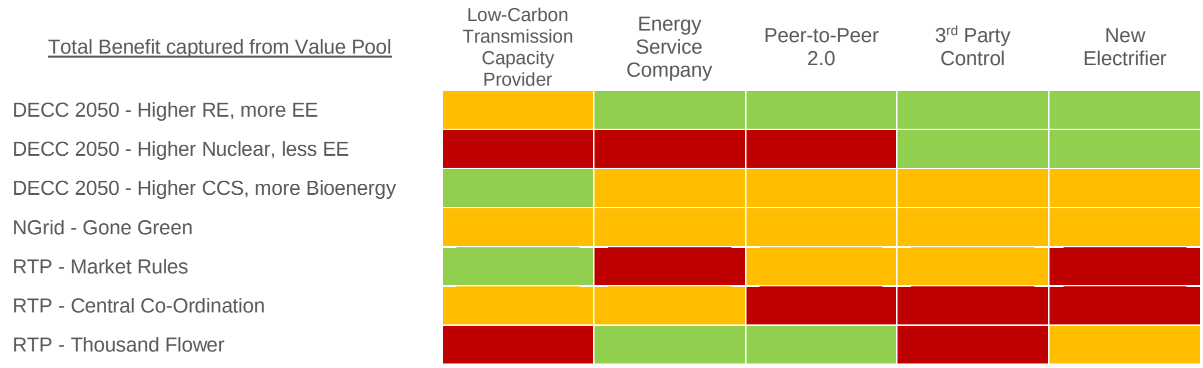
**Table 3:** Assumed market penetrations for each BMA

| Market Penetration in 2050 Domestic (D) & Commercial (C) Customer | Low Carbon Transmission Capacity Provider | | ESCo | | P-2-P | | 3rd Party Provider[7] | | New Electrifier | |
|---|---|---|---|---|---|---|---|---|---|---|
| | D | C | D | C | D | C | D | C | D | C |
| BAU: NGrid No Progression | n.a. | n.a. | 20% | 8% | 8% | 8% | 2% | 0% | 2% | 50% |
| DECC 2050 - Higher RE, more EE | n.a. | n.a. | 70% | 20% | 15% | 20% | 40% | 0% | 40% | 50% |
| DECC 2050 - Higher Nuclear, less EE | n.a. | n.a. | 20% | 8% | 8% | 8% | 52% | 0% | 52% | 50% |
| DECC 2050 - Higher CCS, more Bioenergy | n.a. | n.a. | 40% | 8% | 10% | 8% | 32% | 0% | 32% | 50% |
| NGrid - Gone Green | n.a. | n.a. | 70% | 20% | 15% | 20% | 10% | 0% | 10% | 50% |
| RTP - Market Rules | n.a. | n.a. | 20% | 8% | 10% | 8% | 9% | 0% | 9% | 50% |
| RTP - Central Co-Ordination | n.a. | n.a. | 50% | 15% | 8% | 8% | 9% | 0% | 9% | 50% |
| RTP - Thousand Flower | n.a. | n.a. | 70% | 20% | 15% | 20% | 9% | 0% | 9% | 50% |

[7] The Market Penetration of the 3rd Party Control as well as New Electrifier is derived by the following assumption: It is assumed that each residential customer with the BMA has a heat pump as well as an electric vehicle. Further the BMA has a market share of 67% in the EV/Heat Pumps market. The scenarios provide data on EV and HP uptake and thus define the market penetration of the BMAs.

Based on the previous calculations, the following matrix ranks the size of captured value pools from the BMA per scenario by applying a traffic light scheme:[8]

**Figure 7**: Ranking of the Scenarios according to Value Pools captured by BMA




The market size of the BMA is fundamentally defined by the future system characteristics. Different scenarios lead to significant variations in value pool sizes. Importantly, the supply side (i.e. consumer facing) ventures, ESCo, 3rd Party Control and P-2-P, display profitability across the assessed scenario range. The Low-Carbon Transmission Capacity Provider as well as the New Electrifier incur losses in all scenario futures; based on energy-only revenues. Hence the profitability of generation heavy business models will largely depend on the market's ability to provide sufficient remuneration through adequate pricing mechanisms. Nevertheless, through its vertical integration the New Electrifier utility is able to alleviate some of the incurred losses in the generation business through its supply business as well as accessing new value pools like of example electrification of heat and transport. The same holds true for the ESCo, which however is less struck by the missing profitability of the generation business due to its lesser involvement assumed in the modelling (1/3 own generation from large scale low carbon technologies, 2/3 bought in the market).

**Energy system scenarios have dramatic effects on the viability of new utility business models, with generation only and consumer only archetypes being the most sensitive to system scenarios. The New Electrifier and particularly the ESCo business model are viable across most scenarios, but their viability relies on securing retail market share *and* having long terms contractual arrangements in place to recoup fixed costs of generation assets and smart appliances/vehicles.**

***Parameter Sensitivity***

Apart from the future system characteristics, the estimated size of the value pools is significantly influenced by cost inputs. In order to evaluate the extent of sensitivity, the following parameters were varied separately one at a time from -50% to +50% of the original value and the impact on the value pools and BMA analysed. The results show that while the new revenues pools are insensitive to the parameter variations conducted the avoided cost pools show significant sensitivity to the cost parameter changes. Thus, the availability and accessibility of these value pools will crucially depend on the carbon price, cost of capital

[8] Traffic Light Scheme: largest benefit captured = highest rank; green: rank 1, 2; orange: rank 3-5; red: rank 6, 7.

(represented by the discount rate) as well as the investment and operational cost for the generation technologies.

**Table 4:** Sensitivity analysis effects on value pools.

| | Carbon Price | Discount Rate | Retail Price | Gen Tech. capex & opex | Wholesale Price |
|---|---|---|---|---|---|
| **New Revenues** | | | | | |
| Energy Service Provision | - | - | X | - | - |
| Local Low-Carbon Electricity | - | - | - | - | - |
| Flexibility Optimization | - | - | - | - | - |
| **Avoided Cost** | | | | | |
| Plant Efficiency | X | - | - | X | - |
| Large-Scale Low-Carbon Electricity | X | X | - | X | - |
| Flexibility Optimization | - | - | - | - | - |
| Carbon Capture and Storage | X | X | - | X | - |

The analysis showed that the value pools are not sensitive to wholesale price changes. However, the actual profitability of the archetypes involved in generation and supply crucially depends on the wholesale price in this model with energy-only revenues for power generation.

With focus on the "Large-Scale Low Carbon Generation" and "CCS"-Value Pools, Figure  highlights that **the carbon price will define if low carbon technology fleet can become cost competitive to conventional technologies. In the Gone Green Scenario a carbon price of just 10-20% below the assumed value of 65.75GBP$_{2015}$/t$_{CO2}$ in 2050 can turn avoided costs into extra costs.**

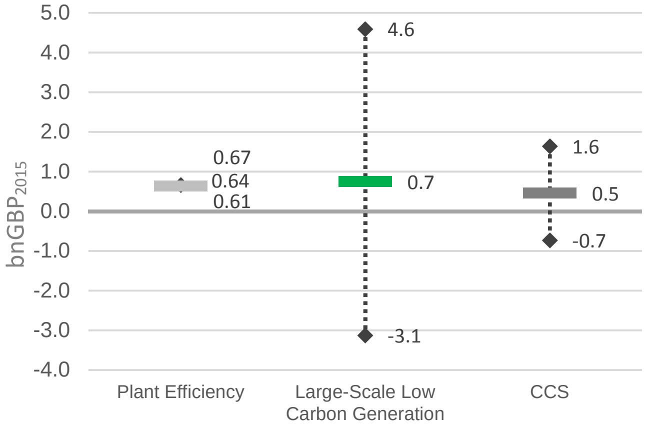



**Figure 8:** Carbon Price Sensitivity: Changes to Avoided Cost - Value Pools through Variation of the Carbon Price by ±50% in the NG FES Gone Green Scenario in 2050

## *2.3 Key Insights*

The value pool modelling and sensitivity analysis undertaken for Utility 2050 has delivered a suite of modelling results from which the following key messages can be derived:

**The UK energy transition needs adequate carbon pricing**

New revenue and cost saving value pools in the energy transition are attractive but not sufficient to incentivise an unsubsidised move from unabated gas turbines as the best technology choice for large thermal plant. Thus, the carbon price will define if low carbon technology fleet can become cost competitive to conventional technologies. In the Gone Green Scenario a carbon price of just 10-20% below the assumed value of 65.75GBP$_{2015}$/t$_{CO2}$ in 2050 can turn avoided costs into extra costs for future CCS or nuclear developers.

**Under a marginal cost approach generation heavy business models are risky propositions**

All customer facing business model archetypes assume a wholesale market of merchant plant exists to accommodate their long or short supply positions. Much energy innovation in these business models depends upon the existence of a liquid wholesale market. However, the analysis showed the profitability of generation heavy business models will largely depend on the market's ability to provide sufficient remuneration through adequate pricing mechanisms**.** The missing money problem and the missing market problem question the sufficiency of the current trading arrangements to provide adequate pricing for the market participants - old and new - and enable an efficient and cost effective energy transition.

**The most resilient future utility business models need long term consumer contracts.**

The value pool analysis demonstrated the sensitivity of business model archetypes to system scenarios. Generation heavy business models and consumer facing models perform well in some scenarios and poorly in others. Where generation and supply are linked such as in the New Electrifier and ESCo business models the archetype is less sensitive to system scenarios, but requires long term consumer contracting to link secure revenues to fixed asset and smart systems expenditure. The consumer is a central stakeholder for the success of new services and product offerings vital for the energy transition. However, limited engagement, switching regulations and the work-intensity of domestic customers make the consumer a challenging stakeholder at the same time.

### 2.4 Inferred decision points

The value pool analysis revealed a breadth of quantitative insights about the opportunities presented by the energy transition and the ability of potential new business models to harvest these opportunities. With focus to a national utility in the UK, the analysis showed that the New Electrifier and ESCo archetypes can be multi-billion pound ventures in a range of possible energy futures, while the Peer-to-Peer 2.0 and 3rd Party Control archetypes have a limited ability to capture the new value pools through their business model. Further the research showed that the P2P archetypes will more likely be an interesting archetype to the local energy markets rather than to the national utility. Also the 3rd Party Control in its role as the optimiser and middleman appears less attractive for business model transition for a current utility and more of a market threat. The 3rd party control may more likely be developed by new power market entrants or from other industries (e.g. cross-selling).

The Low Carbon Transmission Capacity Provider archetype either with CCS or nuclear power can be of large interest to a national utility type of company. However, the calculations showed that new CCS or nuclear power generation assets will not be profitable on energy-only payments with the assumed wholesale power prices. Thus, the regulatory and markets environment will define if companies will be willing to invest long-term in large-scale generation assets to provide reliable power to the transmission grid without further financial pillars in other parts of the value chain.

**The decision points inferred by the key insights are:**

- Given the critical nature of the carbon price how can a carbon price adequacy be guaranteed either within the energy system or on a broader economic base?
- A long term revenue model for transmission level capacity is needed, how can this be designed?
- Business model innovation can only provide market pull for technical innovation if the contract structure and contract length on the consumer side is re-thought, how can this be done?

# Part 3: Regulation and Markets

### 3.0 Introduction:

This section aims to describe the current market and regulatory challenges facing utilities in the development of large scale, capital intensive energy innovation. We set out to find which of the proposed archetypes are compatible with the short and medium term future of energy markets and regulation, which archetypes need market or regulatory intervention, and how specific market or regulatory pathways influence the business models analysed.

In so doing we demonstrate that decisions made now will incentive the development of different business model archetypes in the medium to long term i.e. 2030-2050.

### 3.1 Methods

These questions were investigated using 16 elite semi-structured interviews with actors across the energy spectrum. The interviews included: 3 x energy consultancies or think tanks, 3 x utility companies, 2 x energy finance providers, 2 x consumer representative bodies, 1 x officer of the regulator, 2 x civil servants, 2 x technology companies, and 1 x sector membership organisation. The interviews adopted a multi-criteria design to serve parts 1-3 of this empirical report. They covered value pool assumptions, regulatory and market impacts of archetypes and effects on user behaviour and engagement. For part 3 the interviews were iteratively coded using NVIVO 10 to discover critical themes on: business model innovation, market function, wholesale revenue risks, the supplier relationship, political economy, national policy effects, subsidy and support mechanisms, DSR and storage dynamics, and distributional effects/consumer protection.

### 3.2 Results

This work package investigates the effects of electricity market design on the resilience of the business model archetypes proposed in phase 1 of the Utility 2050 project. The findings of this work are split into the wholesale and retail ends of market design[9].

### 3.3 The wholesale market and the generation business.

In the UK electricity market both traditional utilities, i.e. those with generation assets and supply arms, and merchant plant owners sell into the electricity wholesale market on a bi-lateral contracting basis. The theory being bi-lateral contracting would allow for more efficient price discovery than the pre-existing 'pool' mechanism as trading volumes drive more competition. The creation of these bi-lateral markets however did not foresee a scenario of high renewable energy penetration, in which intermittent renewables will run whenever they can due to very low marginal costs.

> *"…effectively it* [the pool] *was an energy only market. It had effectively a fixed cost recovery element which was the availability payment. And when we moved to NETA it, NETA was explicitly a managerial market, and the market was left to price in that scarcity. Looking forward […] intermittent generation of some greater renewables means that effectively you don't have scarcity in the same way as it has been known previously, so there is an awful lot of capacity on the system. The question is whether it generates or not. […] plus the fact that that generation is effectively running at zero marginal price so when it is running you've*

[9] This project does not investigate the regulated transmission and distribution elements of the system.

*got a price depression on … through those periods. So you get less generation and a lower price for what you do* [generate].

(Source: utility company respondent, 2016)

*"…the market that was created in the early 90s, you know, marginal costs, clearly was based on coal and gas and, you know, duration, low duration curve, marginal price of plant, you know, mucking about with NETA and BETA and changing the price but at the fundamental pool model, we're still basically there. Now they didn't assume that you had some big kind of state intervention in the market by putting, you know, putting abundant* [intermittent renewable] *generation on the system."*

(Source: energy finance provider, 2016)

All the energy system scenarios to 2050 adopted by the Utility 2050 project depend on new build thermal plant from unabated CCGT and abated (i.e. CCCs equipped) coal and gas generation and varying degrees of new nuclear. If the wholesale price for any new thermal dispatchable asset is insufficient due to intermittent renewables penetration into load traditionally supplied by thermal assets, either wholesale prices at times of low renewable generation must reach £000's/MWh, or a non-energy payment must be made to ensure capacity is available. In the UK this problem was recognised within the Electricity Market Reform process, but its importance may not have been realised at point of design:

*"I was involved with the electricity market reform from the start […] it started off as a very simple concept of, you know, bringing more certainty into the system, so that the cost of capital would come down. So it clearly started off with the concept of CFDs, feed in tariffs make little sense, particularly the way they were operated under [previous administrations]. Then, as this started to move forward, […] all these quirks, and little unintended consequences appeared, which led, then, to the concept of the capacity mechanism, which, you know, a lot of people around the table argued, "Put it in as a fall-back, but we won't need it". So, you come to today, when it's clearly the only thing that's going to keep the lights on, moving forward, because people hadn't worked out that giving renewable full licenses, preference over everything else, would lead to problems with other generation."*

(Source: Civil Servant, 2016)

The capacity market in the UK began in 2015 and offered contracts for capacity to be delivered from winter 2018 onwards. There has been substantial criticism over the outcomes secured in the capacity market. Interviewees described the difference between the intended outcomes of the capacity mechanism, and the actual outcomes:

*"The final justification [for the capacity market], which is probably the one that politically is most true is that they just wanted to get new gas power stations built and particularly when you think about when it was sort of started or at least when it was designed in 2013, if you had a mechanism that build gas power stations in four years or had them built quicker and then subsidies them that probably is something that people in the centre of government were very, very keen to have happen."*

(Source: think tank respondent, 2016)

However the eventual results did not deliver substantial new gas CCGT capacity, and instead led to the life extension of legacy thermal plants and the creation of new small scale diesel capacity.

*"…the fact that large amounts of diesel and gas reciprocating engines have turned up through the capacity mechanism is because whilst government asked – thought they asked a certain question, they didn't understand the question they were actually asked, but that is definitely the right answer. And it's the right answer because the market has told you so. Therefore by definition it's the right answer. They wanted the lowest cost generation capacity that could be found in the market"*

(Source: utility company respondent, 2016)

A detailed analysis of the capacity mechanism is beyond the scope of this investigation. What is important is the effect of existing market design on the viability of the business model archetypes presented by this project. Ultimately, a non-energy payment or subsidy has had to be created in the form of a capacity payment. This is largely due to the increasing low prices affected by low/zero marginal cost plant having to feed into the system. However, low marginal cost renewables are not the only threat to the construction of new thermal capacity:

*"…there's already a problem that there aren't enough incentives in the system, to get people to build new power stations, and so on. I said to these people, "You know, okay, we've got this problem already, and you're advocating a lot more interconnectors, a lot more demand-side management, a lot more renewables, and a lot more battery storage – all of those which kill the need for, or the commercial attractiveness of, new big stations even more. So what's your solution to this?"*

(Source, civil servant, 2016)

The twin challenges of a diminishing wholesale price for thermal generation and the threat that battery storage and demand response has the potential to capture capacity payments as well as fossil fuelled decentralised generation, means the investment decision even for conventional gas plant is too uncertain to justify for many utilities.

A further dynamic is the way in which more low carbon generation is added with CfD support further drives down wholesale costs so intermittent generation becomes ever more subsidy dependent. Thus subsidy operates across all generation technology.

*"…and all the zero carbon generation that's on the market won't be able to be reinvested in then if there's nothing to actually price into the market, so your fundamental economic – so this, the kind of the, your point about what sets the power price kind of writ large, if there's a zero power price how do you actually invest into that market?"*

(Source: utility company respondent, 2016)

Together these issues mean that there is almost no price discovery in the system and that the notion of the wholesale market has been fundamentally undermined. **Interviewees felt there was no foreseeable future under current market design where any form of generation will be constructed without some form of non-energy payment (subsidy).**

*"High-level I think we are in a situation where policy makers and civil servants like to feel that there is a market that makes decisions on technologies. I do not believe that this is the case anymore."*

(Source: Energy finance provider, 2016)

### 3.3 Key Insights

Part 2 of this report found that there was a key decision to be made about how large scale thermal generation, be it unabated gas, thermal CCS or Nuclear is remunerated into the future. The current capacity mechanism has achieved one aim, of ensuring sufficient capacity exists to cover winter peak shortfalls in the near term. However the capacity market does not provide a long term revenue model for transmission level capacity.

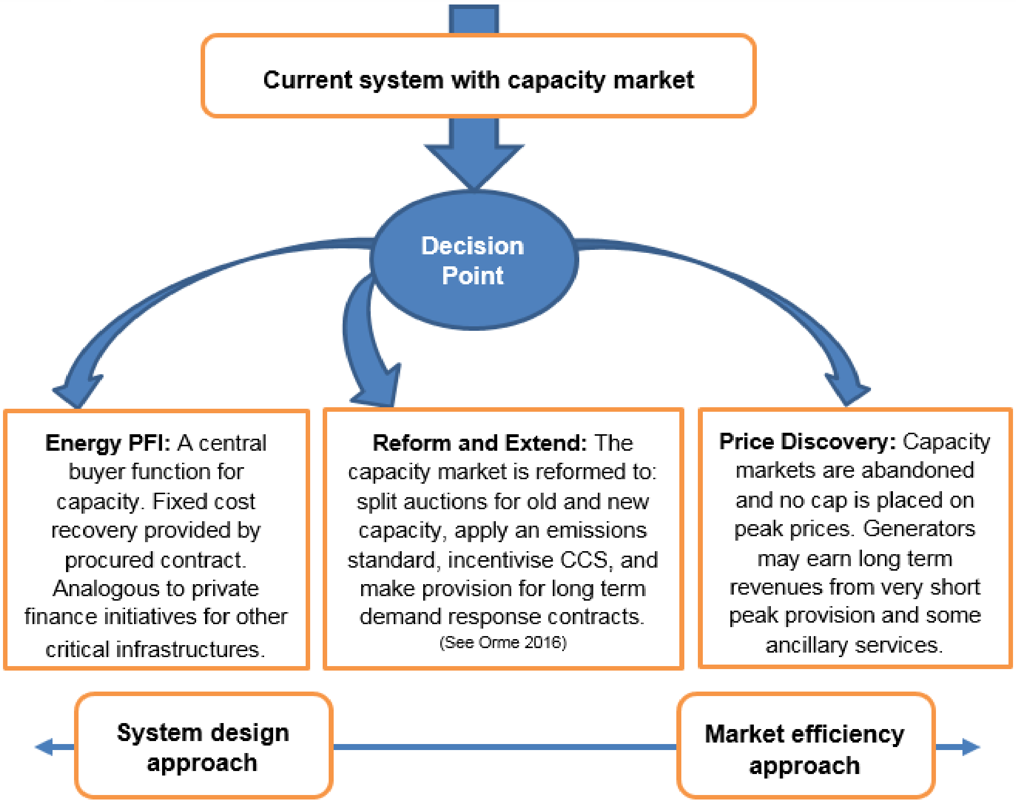
The key issue identified was the way in which flexible transmission level asset is to be constructed. Across the energy system scenarios used there are varying needs for this capacity but in all scenarios new Gas CCGT, abated coal, or nuclear require substantial investment. Phase 1 of the Utility 2050 project and the interviews undertaken investigated options for the remuneration of this plant, the three emergent options with their key characteristics are:

1. **Remove all capacity payments and allow for market based price discovery, i.e. a very 'peaky' system and allow this to drive both transmission level investment and demand side innovation.**
2. **Reform and extend capacity markets to cover longer time periods and re-design to capture desired technologies.**
3. **Establish a central buyer function with government procurement of essential transmission level assets which may include Gas CCGT but could also include offshore wind, nuclear or coal CCS.**

The decision on which of these options to take will result in a branching point for the energy system (Figure 9) which will favour each business model archetype presented by the utility 2050 project differently. This is a qualitative analysis and no value pool modelling of these options has been undertaken. Their necessity however is demonstrated by the qualitative data above and the value pool analysis presented in part 2. Similarly the Utility 2050 enabling group has synthesised the workshop and interview data to assume likely effects of each option on the business model archetypes, these likely effects may be a useful avenue for the decision theatres to explore.

Option 1, the removal of capacity payments would favour business model archetypes that derive benefits from flexibility optimisation, particularly the **ESCo and New Electrifier** archetypes. This is due to consumers seeking to avoid high peak prices charged by peaking generators. Option 1 may be less favoured by the generator utilities as increasing flexibility will only push non flexible peak prices higher. This may have inequitable outcomes on domestic consumers with little flexibility and negatively impact I&C consumers with fixed production/service schedules. The value pool modelling assumes the **Third Party Control** model would earn little from flexibility due to low market penetration and thus little aggregation potential, high peak prices could substantially improve its attractiveness to consumers and increase market share and with it, flexibility revenues.

**Figure 9:** Decision points for thermal generator revenues[10]




Option 2 could provide less benefit for the flexibility optimiser archetypes, though the provision of a longer term market for DSR would be beneficial. This approach is likely to benefit the generation heavy business models: **Low carbon transmission capacity provider and New Electrifier**, have both positive and negative effects on the **ESCo model** and have positive effects on the **Peer to Peer** model by securing wholesale liquidity.

Option 3 would likely be welcomed by generation heavy archetypes such as the **Low carbon transmission capacity provider** and **New Electrifier** as fixed costs of operation would be removed from the market bidding process and come closer to marginal cost of production for existing plant. However this is likely to smooth peaks and reduce price volatility. This may have a negative effect on flexibility revenue streams.

Each of these options requires further qualitative and quantitative analysis but each solves in various ways the problems faced by thermal flexible plant in the current energy market and aims to secure large scale capital intensive innovation into the future such as new nuclear and gas/coal CCS.

[10] Orme, B., (2016) Incapacitated: Why the capacity market for electricity generation is not working, and how to reform it, IPRR. Accessed December 2016 at: http://www.ippr.org/publications/incapacitated

### 3.4 Retail Markets

Part 4 deals with the individual consumer impacts of the business model archetypes in relation to supplier switching, impacts on behaviour and distributional effects. Here the aggregate effect of retail market design on the business model archetypes is investigated.

In the UK and across the EU domestic consumers have the right to switch supplier within a 28 day period, though some longer term fixed price deals are available. The Competition and Markets Authority has undertaken a recent investigation into the energy market and found persistent overcharging and consumer apathy in energy retail switching. The Utility 2050 project is concerned with how consumer switching dynamics affect the viability of the proposed business model archetypes. In this part of the stress testing the ability as opposed to the likelihood of the consumer to switch supplier is at question. This is because of the four archetypes which offer domestic and small commercial supply, none has the same requirements on contract length. They sit on a spectrum between the Third Party Control archetype, which would likely use smart meter and other data to automatically switch suppliers, and may do so in very short time periods. Though the consumer relation to the 'Third Party Controller' may be long term, switching regulations may need to be amended to accommodate much shorter consumer tenures with individual suppliers. For the Peer to Peer 2.0 archetype, contract lengths would be flexible and consumers may commit their load ahead of time for as yet un-built projects. Most importantly however the New Electrifier and particularly the ESCo business models require longer fixed term contracts with consumers than existing market regulations allow.

*"So switching is a big problem with those domestic properties, or who owns the contract in the end. […] You'd have to have a business case and get investors like any other investment effectively. But the back side of that is that you have to have the contracts in place with all the customers, or at least the confidence that you can sign customers up to this sort of deal. And probably the consumer markets is what they are, this is what they are, you actually can't lock customers in for a long time so they need, the contracts themselves need to be quite portable between the company that sets it up. You can see it being quite a difficult concept to set up domestically."*

(Source: Energy Consultancy Respondent, 2016)

*"I think you have to question how important the ability to switch is, if you're being offered a long-term deal for your house supply."*

(Source: Civil Servant, 2016)

*"…Part of the risk is that customers can change suppliers. And it is an interesting concept there: If you can change suppliers, can you also change the ESCo? If you can change the ESCo and don't get locked in – What you don't want is an ESCo investing in solar panels on a roof of properties and then the customers subsequently switch away from a supplier which the ESCo works with. Or if the supplier is the ESCo, will the regulation allow them to tie somebody in as in "now you have to buy your power from us for 10 years in the terms of putting the solar panels on the roof"? If customers continue to be allowed to move around freely then the risk goes up and the return on your investment and so the price goes up."*

(Source: utility company respondent, 2016)

Across the interviews and Phase 1 focus groups there was a clear tension between the ability of smart metering with new consumer platforms to enable faster switching between retail suppliers, and the need for the innovative or 'smart' energy systems to be tied to long term contracts to recoup the fixed costs of investment.

If an inactive consumer base is assumed then a move to automated switching may offer the consumer the most short term benefit, this model would be facilitated by the Third Party Control archetype, depending on how much control is being ceded (see Part 4). However, given the decision point above on wholesale remuneration and the effect on peak pricing, the inactive consumer base may not persist into the future if time of use pricing begins to reflect real costs of system peaks. In this scenario consumers may wish to stand at one remove from real time pricing and be willing to commit to longer term relationships and undertake some behaviour change to avoid peak price penalties.

### 3.5 inferred decision points.

The inferred decision point on supplier switching relates to how the regulator can accommodate new types of contract. The choice is between supporting long term contracts for smart services and technology innovation, or supporting automated switching with a short term price only measure of success.

Discrete decisions are:

- How will the decision on wholesale generator remuneration affect peaks, and therefore knock onto consumer experiences of supply?
- Are the benefits of the ESCo and New Electrifier business models sufficient to amend supplier switching regulations?
- If so how could consumers be protected when committing to a 5-10 year contract for energy services?

### 3.6 Summary

The regulation and markets stress testing package builds on Part 2 to demonstrate the need for a clear direction on wholesale price remuneration of transmission level thermal generation, and a new regulatory settlement for the supplier switching requirement. Both are related to how peak pricing emerges in future markets and both have an iterative effect on each other. E.g. if 50% of SME and domestic customers were signed up to a New Electrifier or ESCo in 2030 there would be a material impact on wholesale prices given the level of available demand response and efficiency improvements. This analysis concurs with Part 2 in that it concludes that wholesale price risk and consumer mobility deeply affect the viability of future utility business models and the market pull for energy technology innovations.

# Part 4: Consumers and Users

**4.0 Introduction:**

The aim of this work was to first understand the user behaviour change entailed by the five archetypes. A second aim was to understand to what extent the scenarios engendered these changes.

The work links strongly with the value proposition and market and regulatory work streams. For the former the link is insight on how attractive the archetype is to consumers – an archetype might have a strong value proposition, but if no-one will sign up it will not realise it. On the latter, the link is the consumer protection issue (a matter of regulation) and other policy and regulatory issues, such as access to data.

**4.1 Methods**

The outputs from the June workshop were analysed in two ways.

1) Insight from what participants at the workshop said about user behaviour
2) Insights from wider participant information on what scenarios would engender change required.

This stress testing phase drew on the same 16 interviews as Part 3 and has the same stakeholder breakdown. For the user work stream, business and domestic consumer representatives were targeted. There was also useful insight from interviews focused on other work streams.

To manage the complexity of the project during interviews, the archetypes were simplified into four types – these covered all five of the archetypes used in the analysis and abundant system (see Fig. 10). The interview focused on the interviewees understanding of the overall project, the four archetypes and the analysis of user behaviour change from the workshop.

The transcriptions of all 15 interviews were analysed using qualitative data analysis software.

**4.2 Results**

**4.2.1 High level insights into user behaviour change emerging from workshop**

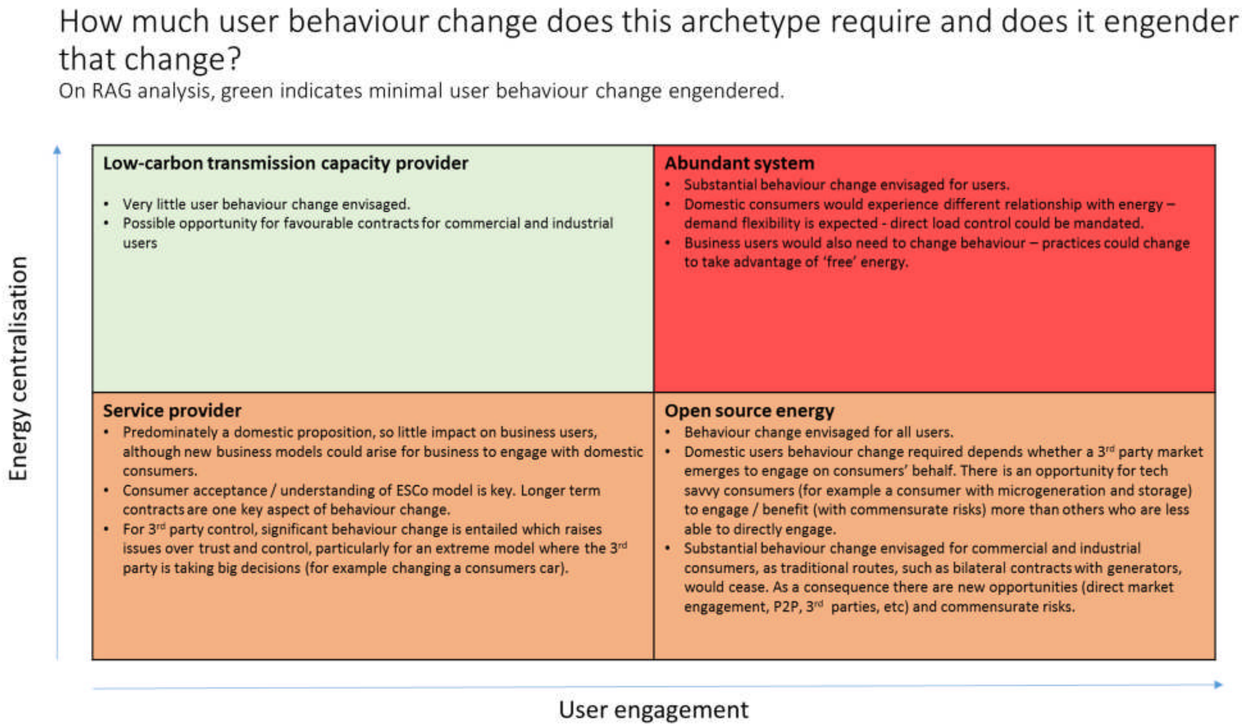
These are summarised in figure 10 below.

The rationale for reducing the number of archetypes discussed in the interviews was to simplify the complexity for the interviewee and to ensure the interview could be conducted within one hour.

There are essentially three archetypes under 'Service Provider' – New Electrifier, Serviced Home and Mobility and Third Party Control. This was possible as these three archetypes are a spectrum of user engagement with an energy service model, from shallow to very deep (or rather how much control and trust a user gives to the archetype).

Under 'Open Source Energy', the Peer to Peer 2.0 archetype was explained and discussed.

**Figure 10:** Summary of user behaviour change insights from the workshop.




During interviews, stakeholders broadly agreed with the RAG analysis and key issues in Figure 10 above. It is important to state that for 'Service Provider' the RAG analysis would be closer to green for New Electrifier and closer to red for a 3rd Party Control archetype. The key issues are discussed further below.

#### 4.2.2 High level insights into the extent to which scenarios engendered the user behaviour required

All the archetypes (including those generated at the workshop) where analysed against the seven scenarios. The following insights were apparent:

1) In highly centralised energy system scenarios (for example NG higher CCS) the peer to peer 2.0 archetype appears less attractive due to reduced availability of local renewables for consumers to source their energy from.
2) In highly centralised scenarios, the user behaviour change required in Abundant System would be reduced, because the electricity capacity would be firmer (e.g. less peaky) in winter
3) The RTP Thousand Flowers scenario, which has a high penetration of combined heat and power led heat networks has three notable effects:
    a. It reduces the attractiveness of new electrifier as less users would need electric heating
    b. It increases the flexibility and heat availability in Abundant System, meaning less flexibility required by consumers in winter months
    c. It increases the prevalence of local energy options, possibly increasing the market for Peer to Peer 2.0.

### 4.2.3 Themes emerging from in depth interviews

**Archetypes that have the potential to work today**

***Automated switching (possibly leading to 3rd party control later)***

Several interviewees indicated various approaches to automatic switching were close to market.

*…it feels like we will be inevitably moving to some of this model whatever, and you can see it already with the rise of automatic switching services, I forget what they are called but there are two or three already, that kind of provide some of this already.*

(Consumer representative A, 2016)

One interviewee demonstrated a Loop Energy Saver device, which uses clip on devices to monitor real time electricity and gas usage. This data, which is uploaded via home broadband, is used to track whether the customer is most cost effective tariff, although it doesn't yet do automatic switching. The service also provides suggestions for energy efficiency measures.

***Bundled services***

New electrifier, ESCo and 3rd party control all contain some element of bundled services, from energy services such as power, heat and mobility in the case of the first two and wider services such as entertainment and telecommunications in the case of the latter.

Interviewees referred to several existing bundled packages, including quad (TV, broadband, landline and mobile phone) packages and the multi-utilities offered by Utility Warehouse (landline, broadband, mobile phone and energy). Convenience and high consumer satisfaction were noted as key aspects of the proposition.

*I think the value proposition is instead of having another interface with other people, you can get a one-stop shop to get all your different services.*

(Consumer representative A, 2016)

Some issues were raised with current practice on bundled products, particularly around consumer trust and understanding.

*And interesting indeed with packaged bank accounts, where the number of complaints to the financial ombudsman are really, really high.*

(Consumer representative B, 2016)

**What behaviour change is engendered?**

***People just want to get on with their lives***

For domestic consumers, several interviewees suggested that people don't want to have to think about electricity consumption, they just want to live their lives.

*You don't consume electricity because you want to consume electricity but something else that you want, so demand side response should always be a secondary value stream, secondary market.  Otherwise what do you do for a living?*

(Large vertically integrated utility, 2016)

It follows that there is an expectation that someone else should be sorting out issues, like system flexibility. Domestic consumers normally assume that is a role for government.

*And what our kind of polling over the last five or six years has suggested is that people frequently look past … if you look past pretty much everyone from the government in the energy space, to be the arbiter of fairness and making things work, and so while as an organisation we are very supportive of independent economic regulation, we have always been quite realistic that actually the consumer, a lot of the time in energy, more than I think in a lot of other markets, really looks to the government.*

(Consumer representative B, 2016)

***Business models that rely on time of use pricing***

Several of the business models could entail some form of time of use (ToU) pricing of energy, most explicitly Abundant System. Interviewees expressed two concerns about this approach.

*I suspect that time of use pricing it sounds quite exciting until you get a kind of Uber style surge pricing and that will be unbelievably unpopular.*

(Business community representative, 2016)

An approach to overcome this would be to use approaches such as direct load control (e.g. where the energy service provider directly controls energy using devices in a household or business). An important issue is that direct control does not cause the consumer problems.

*So, you know, for that tariff you agree that you have a smart fridge, or that you have some sort of little plugin device that your fridge plugs into, and that you don't mind that for 15 minutes during the winter peak that your fridge is off.*

(Civil Servant, 2016)

*I don't care how my phone works, it just does it. I don't care how my fridge works, it does it. And it needs to be that – you don't – consumers don't want engagement. Equally the last thing they want is to have to make a phone call because it's gone wrong.*

(Large vertically integrated utility, 2016)

The second concern, somewhat related to the first, was around the ability of those in vulnerable situations. Here the concern was that high prices would coincide with sensitive moments, for example when the weather is coldest.

*I share your kind of ranking or least to most requirement for behaviour change and that one is the one that both requires the most behaviour change, but also requires it at the most sensitive moments potentially by as you say, making that happen or suggesting that that's very likely to happen, cold winters.*

(Consumer representative A, 2016)

**<u>Who will benefit?</u>**

***Will those currently disengaged benefit?***

Around 70% of domestic consumers in the electricity market are currently disengaged, meaning they do not switch supplier. The incentive for switching is hundreds of £s. Therefore, business models that allow greater segregation of consumers or that rely on deeper engagement, may not benefit those who are currently disengaged. In fact, they could be detrimental if market participants subsidise those who are engaged by placing higher costs on those who are disengaged.

*…we are already in that situation aren't we, where the disengaged can be paying on average £300-£400 a year more for their energy bills than the engaged. And it seems to be an increasing trend across a whole range of essential utilities.*

(Consumer representative B, 2016)

***Will the hyper-engaged benefit most of all?***

Around 30% of electricity consumers are to some extent engaged. Amongst that 30%, it is perceived that there are consumers who are hyper-engaged (e.g. "energy geeks"). Peer-to-peer energy and other business models where very active participation (for example, responding price signals via ToU tariffs) would be rewarded are examples where this hyper-engaged group could 'cash in'.

*And so the holistic provider as I said I think it's very interesting but I think the flipside to that is a world where the consumer has much more control themselves and they choose to do one or two of these things. And it's this whole sort of plug and play, put it in yourself that people really quite enjoy.*

(Business community representative, 2016)

**Issues of trust and control**

***Losing control***

In discussions about business models where consumers must give up control (for example 3rd party control), some suggested that the initial first step to relinquish control is a key one.

*But that first initial change, the one where you relinquish all the power, call the control is much more, much higher hurdle to overcome*.

(Consumer representative A, 2016)

***Data protection***

Smart meter and other consumer data is an important issue with regards to trust and control. This came up in the context of 3rd party control, whereby one interviewee felt that it should be at the users' discretion to what extent their data gets shared and what it is used for.

*I mean, I think it's possible, I think some of the restraints that have been put around, particularly smart meter data sharing at the moment or at least in principle meant to resist some of that, it's again, in principle at the users' discretion how much information gets shared, what that can be used for.*

*I think we would hope and expect that that relationship would stay so it would always be the user data first and foremost and if they want to put themselves, open themselves up to offers and suggestions of that kind that would be okay.*

(Consumer representative A, 2016)

**Energy as a service**

There were several issues raised in relation to energy as a service, which relate to three of the archetypes examined: New electrifier; ESCo; and 3rd party control.

***Long-term contracts***

Archetypes, such as ESCos are likely to require longer term contracts with customers compared with traditional supply contracts. Several issues were raised including required scrutiny of terms and conditions of such contracts to avoid issues of introductory bonuses and also what happens if the customer moves house. The former is a potential misselling issue.

*And it raises a whole range of questions doesn't it, around … it raises so many questions around terms and conditions, around like you say with long term contracts and the other thing that it raises around continuous payment authority, which you have in lots of markets already, where people just repeatedly … you know where people just repeatedly take payments from your bank account*.

*Could you have the situation that you have with savings, where … or indeed loads of markets, where you are beckoned in with a year one offer, and then years two to five are something completely different?*

(Consumer representative B, 2016)

***Technology lock-in and interoperability***

For archetypes that will install equipment in homes and businesses there is an issue technological lock-in if the equipment isn't interoperable with another supplier. Several analogies were raised with TV packages (inability to take your recorded TV programmes to a new supplier) and mobile phones (Apple vs. Android).

*So inter-operability and stuff like that becomes a massive issue, doesn't it?  Because if you have invested in all of this kit, and then after five years you look around the market and there is someone else great, but they say yes fine we can do that but you are going to have to rip out all this stuff, and put this new stuff in, now over five years that might be fine, because actually they might be relatively obsolete and whatever that new kit is might be fantastic and great, and you might like that.*

(Consumer representative B, 2016)

### 4.3 Key technology innovation

In section 4.2.2. interactions between the user implications of the archetypes and the energy system scenarios were identified – these are predominately technological in nature.

In addition to this, four issues are raised by the user analysis.

1) The 3rd party control archetype was believed to be close to market, initially as a power of attorney switching site. As this will be a data driven business model in the first instance, availability of data and ICT technologies is a requirement, including potentially access to smart data. According to the TRL analysis, there is no apparent technological barrier to this archetype.
2) For ESCo and deeper 3rd party control archetypes, where energy technologies such as solar PV, energy storage, HEMS and EV chargers could be fitted as part of the service, there are some technologies that are less advanced than others, such as HEMS and EV charging. The constraints to further development of these technologies are not considered to be prohibitive.
3) For peer-to-peer networks, and for other archetypes where flexibility transactions are important, such as DSR from homes, several of the requisite technologies (for example V2G, P2P networks, smart appliances, etc) are at TRL4-6, however, no significant barriers to future development are anticipated.

4) That there could be consumer barriers (e.g. non-technical) to the adoption of certain technologies, such as those that automate control of electrical appliances and devices in homes.

### 4.4 Key metrics

The main factors the analysis pivoted around are:

- Barriers to consumer uptake of archetype (e.g. consumer acceptance of business model)
- Benefit distribution of archetypes (e.g. winners and losers)
- Consumer protection issues (e.g. potential legal or regulatory issues that could affect archetype)
- Degree of behaviour change required (e.g. insight into how long the behaviour change could take to manifest)

### 4.5 Inferred decision points:

- Some of the archetypes are already close to market (3rd party control and ESCOs for example), so consumer issues could manifest faster for some archetypes.
- There was limited belief that consumers will respond to price signals such as those through ToU tariffs. This could be an issue for consumers in vulnerable situations. Direct load control is one approach that could overcome this, but only if it is a non-disruptive intervention.
- There were concerns that several of the archetypes will engage predominately those who are already engaged. The 70% of consumers who are disengaged could be disadvantaged.
- On some consumer protection issues, such as misselling of bundled products, there is learning available from other sectors, such as banking. Clear and transparent terms and conditions for new sorts of energy contracts will be important in this respect.
- The issue of technology lock-in was raised for energy service business models where the technology isn't interoperable with other service providers meaning switching is hard. Standards is an important aspect of this.
- On data protection, there was an assertion that data sharing should be wholly at the users' discretion.

# Part 5: Technology stress testing

## 5.0 Introduction:

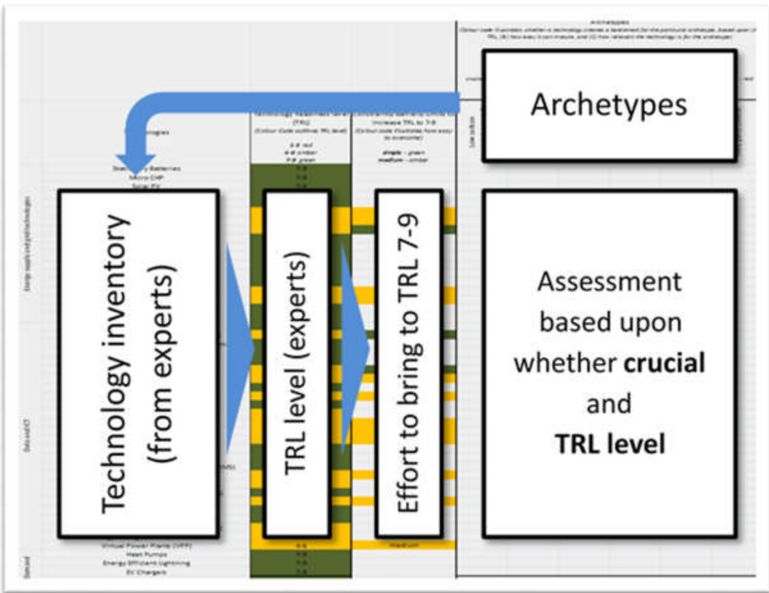
While the other work streams focus on the socio in the socio-technical analysis, this work stream has the aim to determine whether the identified scenarios are, from a technology maturity perspective, realistic. To do so we have used the future archetypes as starting points, have identified necessary technologies, and assessed their current maturity. This provides insights on whether any of the potential archetypes are facing technological barriers that cannot be or are difficult to overcome.

## 5.1 Methods

In order to comprehensively analyse whether there are technology barriers, affecting the archetypes an executive opinion study has been executed. This was undertaken by constructing an expert assessment panel. The panel included 11 stakeholders from academics, the public sector and energy technology companies to solicit a broad range of opinion on the technological barriers to the business model archetypes presented in Phase 1 of the Utility 2050 project. There is a lack of comprehensive comparative analysis on this issue, however the Utility 2050 team engaged a wide community of experts on technological barriers to energy innovations.

Firstly, based upon the identified archetypes, an inventory of technologies was created by the enabling group. For this, inputs on technology requirements of each archetype were provided by the participants of the first workshops, and expert input from the enabling group was collated into a matrix summarised in figure 11:

**Figure 11:** simplified technology assessment matrix.



For the assessment of the technologies, the Technology Readiness Level (TRL) ranking method was adopted. The TRL levels are represented as follows:

- TRL 1 – 3: In the laboratory or invention stage
- TRL 4 – 6: In the demonstration stage
- TRL 7 – 9: Ready for deployment or already deployed

The expert assessment panel ranked each constituent technology by TRL as well as by necessary effort to increase TRL. In order to efficiently assess the level of change required to bring the technology to deployment, i.e. TRLs 7-9, the team has assessed each technology by *Simple* or *Difficult*.

**Technology: Archetype inventory**

| | |
|---|---|
| Stationary Batteries | Communication for Wholesale market |
| Micro CHP | Cyber security |
| Solar PV | Blockchain |
| Solar Thermal | Peer-to-peer communication |
| Heat Storage | Smart appliances |
| Fuel Cells | Reactive Power Control |
| CCS | Local Network Balanacing |
| Synthetic Fuels | Peer-to-peer trading agents |
| District Heat Networks | Market / Trading platform |
| Gas Fired Power plants | Trading Optimisation |
| Interconnection | Advanced Distribution Management System (ADMS) |
| Nuclear | Machine-Learning |
| Wind | M2M Communications |
| Biomass supply chain | Common Information Platform (data sharing) |
| Hydrogen Storage | Generation Opimisation |
| Hydrogen infrastructure | Storage heaters (remote controlled) |
| Combined Heat and Power (CHP) | Big Data / Data processing and analysis |
| DC | Factory Energy Management Systems (FEMS) |
| Smart Meter Technologies | Area Energy Management Systems (AEMS) |
| HEMS (Home Energy Management Systems) | Virtual Power Plants (VPP) |
| BEMS (Building and Energy Management Systems) | Heat Pumps |
| Demand Side Response | Energy Efficient Lightning |
| Sensors (IoT) | EV Chargers |
| Vehicle Comms (V2G) | Electric Vehicles |

This pre-populated matrix was presented to the expert panel for free qualitative response and panel members asked to comment on their particular area of expertise. Where the team was unsure, or where there was a lack of knowledge, the technology has been ranked lower and with a higher effort level to bring it to deployment levels.

The expert panel comprised:

| Affiliation | Area of expertise |
|---|---|
| Imperial College London | Mobility and Smart Urban Systems |
| Hitachi UK | |
| Imperial College London | Energy Systems and Markets |
| Imperial College London | Centre for Process Systems Engineering, Infrastructure, Energy Systems |
| Imperial College London | Clean Energy Processes |
| Imperial College London | Energy Systems and the Built Environment |
| Greater London Authority | (Sustainable Energy) Development & Environment |
| Sustainable Gas Institute | Energy Systems |
| Moixa Energy | |
| ARUP | Energy Systems Engineer |
| Grantham Institute | Climate Change Mitigation Technology Expert |

The results have been then collated and the TRLs and barriers incorporated. This method aimed to discover if there were any critical technology barriers that would prevent any of the proposed business model archetypes from achieving market entry in the assessed time period.

### 5.2 Results

The technologies have been clustered into three groups:

- Energy supply and grid technologies
- Data and ICT
- Demand technologies

#### 5.2.1 TRL Energy supply and grid technologies

For energy supply and grid technologies, predominantly hardware, the expert panels collated responses showed no technologies which need to be further developed in a significant way. Most of the presented technologies have been already deployed somewhere. While no technology barriers have been outlined, the expert panel mainly identified challenges with regards costs and policy support. Hydrogen storage, hydrogen infrastructure and CCS had the highest perceived barriers. CCS in particular is identified as a transitional technology that has some existing barriers to deployment. This is important as CCS is assumed to be deployed from circa 2030 in the majority of energy system scenarios that meet long term carbon targets, and in all the scenarios tested by this project.

| | | Initial setting after internal review | | | After External Review | | |
|---|---|---|---|---|---|---|---|
| | Technologies | **(A)** Technology Readiness level (TRL) *(Colour Code outlines TRL level)* ***1-3*** *red* ***4-6*** *amber* ***7-9*** *green* | **(B)** Constraints/Barriers/Limits to increase TRL to 7-9 *(Colour code illustrates how easy to overcome)* ***simple*** *- green* | | **(A)** Technology Readiness level (TRL) *(Colour Code outlines TRL level)* ***1-3*** *red* ***4-6*** *amber* ***7-9*** *green* | **(B)** Constraints/Barriers/Limits to increase TRL to 7-9 *(Colour code illustrates how easy to overcome)* | Comment on the issues, or justification on the choice where a barrier exists |
| Energy supply and grid technologies | Stationary Batteries | 7-9 | | | 7-9 | | |
| | Micro CHP | 7-9 | | | 7-9 | | |
| | Solar PV | 7-9 | | | 7-9 | | |
| | Solar Thermal | 7-9 | | | 7-9 | | |
| | Heat Storage | 7-9 | | | 7-9 | | |
| | Fuel Cells | 4-6 | simple | | 7-9 | | |
| | CCS | 4-6 | medium | | 7-9 | | |
| | Synthetic Fuels | 4-6 | simple | | 7-9 | | |
| | District Heat Networks | 7-9 | | | 7-9 | | |
| | Gas Fired Power plants | 7-9 | | | 7-9 | | |
| | Diesel generators | 7-9 | | | 7-9 | | |
| | Interconnection (e.g. HVDC) | 7-9 | | | 7-9 | | |
| | STATCOMs / SVCs | 7-9 | | | 7-9 | | |
| | Programmable Logic Controllers (PLC) | 7-9 | | | 7-9 | | |
| | SCADA equipment (e.g. switches, sensors, etc) | 7-9 | | | 7-9 | | |
| | Nuclear | 7-9 | | | 7-9 | | |
| | Wind | 7-9 | | | 7-9 | | |
| | Biomass supply chain | 7-9 | | | 7-9 | | |
| | Hydrogen Storage | 4-6 | medium | | 7-9 | | |
| | Hydrogen infrastructure | 4-6 | medium | | 4-6 | simple | |
| | Combined Heat and Power (CHP) | 7-9 | | | 7-9 | | |
| | DC | 7-9 | | | 7-9 | | |

### 5.2.2 TRL Data and ICT

For Data and ICT, the experts' panel concluded that there is still progress needed. While there was no technology barrier envisaged that could not be overcome, the experts agreed that many theorised trading platforms and communication technologies have yet to be meaningfully applied to the energy system. However, the panel acknowledged that the basic technologies that are being used for these platforms (peer to peer, IoT, machine learning, etc.) have been already successfully deployed in other sectors.

| | | Initial setting after internal review | | | After External Review | | |
|---|---|---|---|---|---|---|---|
| | Technologies | **(A)** Technology Readiness level (TRL) *(Colour Code outlines TRL level)* ***1-3*** *red* ***4-6*** *amber* ***7-9*** *green* | **(B)** Constraints/Barriers/Limits to increase TRL to 7-9 *(Colour code illustrates how easy to overcome)* ***simple*** *- green* | | **(A)** Technology Readiness level (TRL) *(Colour Code outlines TRL level)* ***1-3*** *red* ***4-6*** *amber* ***7-9*** *green* | **(B)** Constraints/Barriers/Limits to increase TRL to 7-9 *(Colour code illustrates how easy to overcome)* | Comment on the issues, or justification on the choice where a barrier exists |
| Data and ICT | Smart Meter Technologies | 7-9 | | | 7-9 | | |
| | HEMS (Home Energy Management Systems) | 4-6 | simple | | 7-9 | | |
| | BEMS (Building and Energy Management Systems) | 7-9 | | | 7-9 | | |
| | Demand Side Response | 7-9 | | | 7-9 | simple | Domestic level to be further developed |
| | Sensors (IoT) | 7-9 | | | 7-9 | simple | Domestic level to be further developed |
| | Vehicle Comms (V2G) | 4-6 | medium | | 4-6 | medium | Already tested by Tesla though |
| | Communication for Wholesale market | 4-6 | medium | | 4-6 | medium | |
| | Cyber security | 7-9 | | | 7-9 | | |
| | Blockchain | 4-6 | medium | | 4-6 | medium | |
| | Peer-to-peer communication | 7-9 | | | 7-9 | | |
| | Reactive Power Control | 4-6 | medium | | 7-9 | | Done for years by TSO/DNO |
| | Local Network Balancing | 4-6 | medium | | 4-6 | medium | |
| | Peer-to-peer trading agents | 4-6 | medium | | 4-6 | medium | |
| | Market / Trading platform | 7-9 | | | 7-9 | | |
| | Trading Optimisation | 7-9 | | | 7-9 | | |
| | CRM Systems | 7-9 | | | 7-9 | | |
| | Automated Payment Systems | 7-9 | | | 7-9 | | |
| | Car Sharing Systems | 7-9 | | | 7-9 | | |
| | Advanced Distribution Management System (ADMS) | 4-6 | simple | | 4-6 | simple | |
| | Machine-Learning | 4-6 | medium | | 7-9 | | Already in place |
| | M2M Communications | 4-6 | simple | | 4-6 | simple | |
| | Common Information Platform (data sharing) | 7-9 | | | 7-9 | | |
| | Generation Opimisation | 4-6 | medium | | 4-6 | medium | |
| | Big Data / Data processing and analysis | 7-9 | | | 7-9 | | |
| | Factory Energy Management Systems (FEMS) | 4-6 | simple | | 4-6 | simple | |
| | Area Energy Management Systems (AEMS) | 4-6 | simple | | 4-6 | simple | |
| | Virtual Power Plant (VPP) or Aggregation Platform | 4-6 | medium | | 4-6 | medium | There are already companies like KiwiPower |

### 5.2.3 TRL Demand technologies

For Demand technologies, the expert panel results showed similar technical maturities as for supply and grid technologies.

| | | Initial setting after internal review | | | After External Review | | |
|---|---|---|---|---|---|---|---|
| | Technologies | **(A)** Technology Readiness level (TRL) *(Colour Code outlines TRL level)* ***1-3*** *red* ***4-6*** *amber* ***7-9*** *green* | **(B)** Constraints/Barriers/Limits to increase TRL to 7-9 *(Colour code illustrates how easy to overcome)* ***simple*** *- green* | | **(A)** Technology Readiness level (TRL) *(Colour Code outlines TRL level)* ***1-3*** *red* ***4-6*** *amber* ***7-9*** *green* | **(B)** Constraints/Barriers/Limits to increase TRL to 7-9 *(Colour code illustrates how easy to overcome)* | Comment on the issues, or justification on the choice where a barrier exists |
| Demand | Heat Pumps | 7-9 | | | 7-9 | | |
| | Electric storage heaters (remote controlled) | 7-9 | | | 7-9 | | |
| | Energy Efficient Lightning | 7-9 | | | 7-9 | | |
| | Intelligent heating controllers | 7-9 | | | 7-9 | | |
| | In-home displays | 7-9 | | | 7-9 | | |
| | Smart appliances | 4-6 | medium | | 7-9 | | Standardization issues only |
| | EV Chargers | 4-6 | simple | | 7-9 | | Standardization issues only |
| | Hydrogen Vehicles | 4-6 | simple | | 4-6 | simple | Being roled out |
| | Hybrid Vehicles | 7-9 | | | 7-9 | | |
| | Electric Vehicles | 7-9 | | | 7-9 | | |

### 5.2.4 TRL Summary

In summary, apart from a number of Data and ICT technologies that have not been deployed yet, as they are related to future Energy Systems, there are no technologies that act as a substantial block to the majority of business model archetypes proposed. The two platform based archetypes, Third Party Control and Peer to Peer 2.0 may experience some technological barriers on rote to market, however it is unclear whether the value pools calculated in Part 2 will act as strong enough market pull's to overcome these barriers.

### 5.4 Key metrics

The Key metrics in this element of study is the Technology Readiness Level (TRL) and the effort needed or barrier to overcome the technology barrier. It has to be emphasised that in this section we purposely focus on the technology status, and not policy or cost barriers, as these are already tackled by the other parts of this analysis.

### 5.5 Decision Points

The key inferred decision points are the need to establish a clear support structure for CCS demonstration and to create market space for the testing of platform enabled energy trading.

# Part 6: Next Steps

### 5.1 Progress with consumer facing survey

Oral and separate paper presentation to ERP Utility 2050 Steeping Group, 13th December 2016.

### 5.2 Design of decision theatres

Notwithstanding the upcoming societal facing experiment, this stress testing analysis has delivered rich qualitative and quantitative results of the relative performance of the Utility 2050 business model archetypes. Each of the four stress testing work packages has identified different elements of financial, market, regulatory, and consumer effects on the BMAs. There are consistent themes emergent across the stress testing which can be summaries into five critical decision points which will affect both the future energy scenario pursued and the business models that will thrive within that scenario. The five decision points presented by this analysis are:

- How to remunerate large thermal plant in the future energy system.
- How to ensure the carbon price is sufficient to incentivise large scale low carbon generation.
- Whether to incentivise smart energy systems by allowing long term contracting with domestic and small commercial consumers i.e. supply without switching.
- How to ensure key technical barriers are overcome; both capital intensive such as CCS demonstration, and non-capital intensive i.e. testing ICT platforms within the wider energy market.
- How to manage consent and protection for consumers in futures where direct load control and data sharing are key enablers of attractive business model archetypes.

These are the five key decision points signalled by this stress testing exercise. The final empirical stage of this project will be to take three of these decisions to three decision theatres which will convene system experts and wider stakeholders to build consensus on the consequences and desirability of taking these decisions in UK energy policy.