UTILITY 2050

Phase 1 Empirical Report

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Introduction:

This report presents the primary data gathered in Phase 1 of the Utility 2050 project. This project seeks to:

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

To these end the project is split into two phases. Phase 1 generated plausible business model archetypes for the 2035-2050 system by convening key stakeholders to rank the challenges, facing the system and investigate the implications of proposed and co-produced archetypes. This was completed on the*15th June with 40 stakeholders at the Royal Society.* Phase 2 of this work will investigate the effect of scenarios on the business models archetypes generated in Phase 1 and will operate in three work packages: Work Package #1: Stress testing Scenarios. Work Package #2: Scoping utility adaptations. Work Package #3: Defining Structural responses.

This document is the empirical report for Phase 1, and is structured in four sections. Section 1 reports the results of the challenge ranking exercise. Section 2 reports the results of the archetype interrogation exercise for 'proposed' archetypes and section 3 reports the results of the archetype interrogation exercise for the 'co-produced' archetypes.

There is no structured analysis presented, only cleaned data/results. The next step for the enabling group in this project is the definition of metrics to test archetypes against. This will be done using the headline messages from both archetype interrogation exercises and forms section 4.

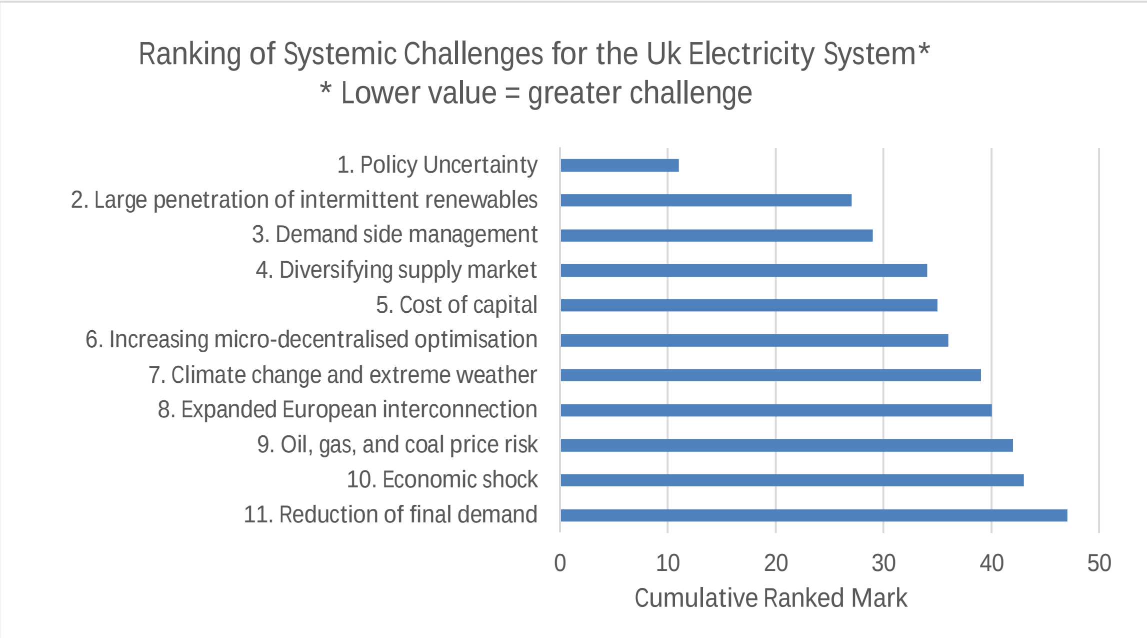
Section 1: Results from Challenge Rankings

In this activity 6 tables of 4-7 individuals (incl. table facilitator) were given 11 cards each with a short description of system 'challenges' that were identified in our literature search for this project. Facilitators also had two blank cards to capture further challenges. Tables were asked to rank each challenge in order of importance to the electricity system in the present, from the perspective of a system architect. The challenge cards are in appendix 1. The results are below in table 1:

	Rankings							
Challenges	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**	**Cumulative**	**Rank**
Policy Uncertainty	1	5	2	1	1	1	11	**1**
Diversifying supply market	4	7	3	7	4	9	34	**4**
Increasing micro-decentralised optimisation	8	4	10	5	5	4	36	**6**
Large penetration of intermittent renewables	5	4	7	6	3	2	27	**2**
Demand side management	7	8	4	4	3	3	29	**3**
Expanded European interconnection	5	2	8	8	5	12	40	**8**
Oil, gas, and coal price risk	8	7	1	13	5	8	42	**9**
Cost of capital	3	6	5	12	4	5	35	**5**
Reduction of final demand	7	8	9	14	3	6	47	**11**
Climate change and extreme weather	8	3	11	3	4	10	39	**7**
Economic shock	2	4	6	15	5	11	43	**10**
Challenges added by participants by groups								
Customer expectations of zero marginal cost e.g. broadband model.	6							
Institutional arrangements				2				
Ability of suppliers to differentiate				9				
More demand from heating and EVs				10				
Breakdown of conventional wholesale				11				
Incumbents inertia						7		
Central buyer model					2			

These results show some groups preferred to assign equal importance to some challenges while others ranked sequentially. Groups also added new challenges which will enrich the final analysis but could not be ranked using the same method as they were unavailable to other groups as this was a simultaneous process. However none of the added challenges were common. Had there been a commonality in 'missed' challenges these would have been incorporated into the quantitative ranking method. The ranked results (Figure 1) shows an emphatic message that policy uncertainty is an urgent systemic challenge. Equally most groups commented that policy uncertainty negatively affected other highly ranked challenges such as cost of capital, the viability of new demand side management, and how new suppliers enter the market.

Figure 1: Ranking of Systemic Challenges.



Some challenges that appear lower in the ranking were deemed critical but over a longer time horizon. As participants were asked to rank challenges from the perspective of a current system architect, those longer term challenges which participants felt were real and credible risks received a lower ranking. Equally, those challenges which were important, but familiar, such as fuel price risk and economic shock, received lower ranking.

At the higher end of the scale, besides policy uncertainty, two technical challenges occupy the 2nd and 3rd place ranking. Both large penetration of intermittent renewables and uncertainty over the technical potential of demand side management are causing concern over the real capacity headroom in the system and negatively affecting the business models of firm capacity providers.

This purpose of this exercise was twofold. Firstly this exercise generated new primary data from experts on the relative perceived importance of system challenges. This will be an important piece of data for final analysis. Secondly this exercise intended to place delegates in the mind-set of system architect as opposed to organisational expert, a perspective which was important for the following two activities in the workshop process on business model innovation.

Section 2: Interrogating innovative business model archetypes.

In activity two groups were asked to explore the implications of two of six innovative business model archetypes. Groups were asked to consider the implications of both archetypes on four elements of the system. Groups were considering implications of each archetype becoming a substantial system player in the 2035-2050 timeframe. The four implication categories were:

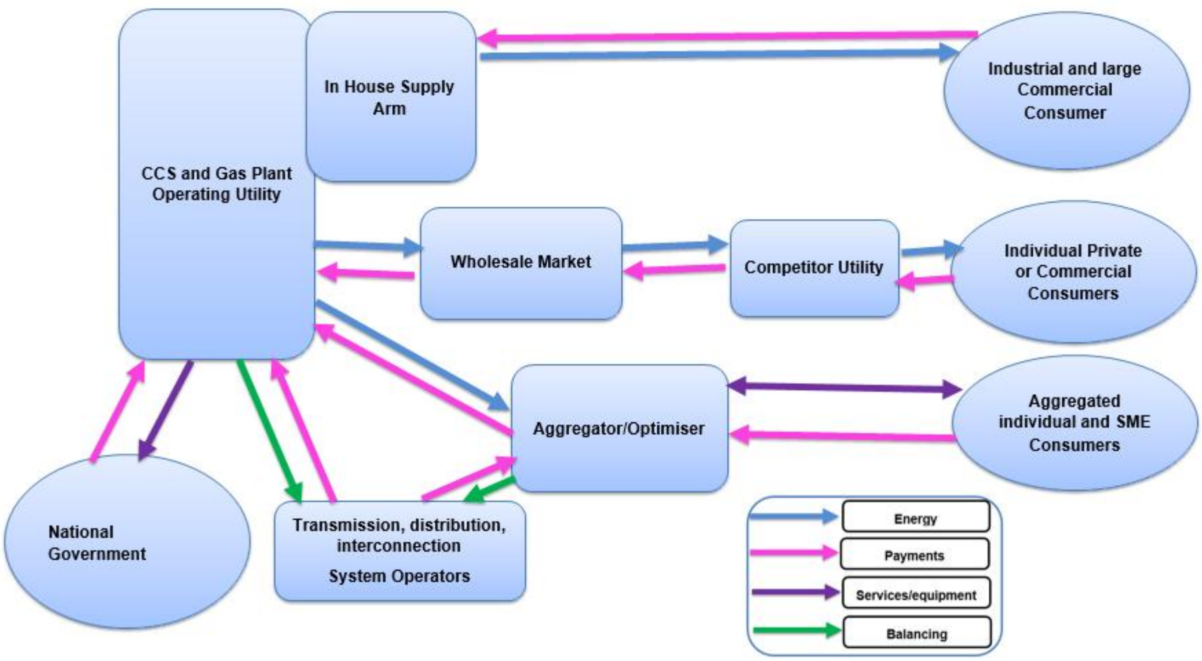
1. Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?
2. Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?
3. Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?
4. Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? Wealth funds? Citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

Each archetype was represented by a diagram showing flows of energy, payments, services and balancing; and was accompanied by circa 200 words of explanatory text. Only group facilitators had foresight over which archetypes they would be handling in their group. Each group was given an implication feedback sheet for each archetype and asked to structure responses around the four categories with space allows for ‘free responses’ which did not fall into one of said categories. Archetypes were generated by the project enabling group following grey and academic literature review and expert opinion.

The following italicised implication responses are direct transcriptions from group facilitators and are often not full sentences. This data is to be used to generate metrics for stress testing archetypes against system scenarios such as DECC 2050 pathways.

2.1 Archetype: Low-carbon transmission capacity provider

Description: 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 power payments 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 a 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.



Low Carbon Capacity Provider Implications:

Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?

End consumers might not see much difference with this archetype. That said, prices could be higher, particularly the fixed cost of capacity mechanisms and / or CfDs so willingness to pay could be an issue. There could be a consumer acceptance issues, particularly on the siting of stations, CO2 transport and storage. Big industrial users (e.g. energy intensive) could benefit from stable long-term contracts / PPA (e.g. prices fairly stable because of high proportion of fixed costs).

Doesn't change much except bills. Still need to take consumers with you: why not using unabated plant routinely? Need consumers accepting move to low carbon future How apportion across household vs industrial.

Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

A beefed up capacity and CfD market could be required or an effective carbon tax. If the former, these will have to be targeted, akin to the nuclear CfD. Renewables will need to pay costs (for balancing) reflective of their intermittency. Targeted mechanism could face state aid issues (assuming we are still in EU). A regulatory framework for the transport & storage of CO2 will be required. The framework, akin to nuclear waste, will have to accommodate the fact that CO2 will be stored permanently. On consumer protection, given that fixed prices will go up and consumers do not switch, it may may be necessary to intervene with price controls (e.g. price caps or regulated fixed price of electricity). This would cause competition issues. Relative costs of abated coal/gas vs renewables. A lot of problems for system regarding intermittency. Also imposing greater intermittency on system if (gas) heating switched to electricity – need thermal storage.

Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

Carbon capture and storage and possibly utilisation are key technology requirements. Other flexibility options (storage, DSR, interconnection) would weaken business case for this archetype, as would the development of other large low-carbon power sources (nuclear, fusion, renewables, biomass, etc.). Carbon storage failure would render this irrelevant. Local opposition could also curtail its development. Low cost CCS, proven with storage including pipeline to storage. Can use biomass with CCS – negative emissions.

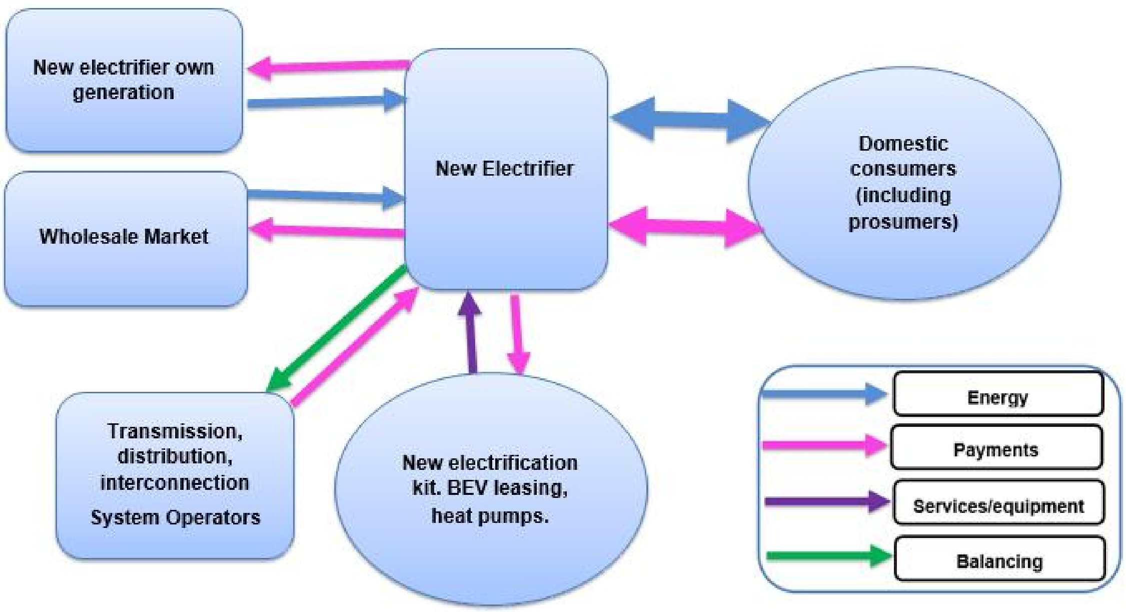
Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

Definitely capital intensive, thus attracting big investment. Question over how this could be affected by divestment strategies. Sensitive to fuel, storage and wider chemical / resource costs. Question over whether this is a sustainable business models or a stop gap until other fossil fuel low-carbon options are developed. E.g. could it be a white elephant if given a 35-year CfD? Costs uncertainty. Brings in issues regarding using coal/gas (abated) and wider issues regarding global resources. High initial capital costs; not proven in generation setting with storage. Finance-able if Government backs; but Government backed away from CCS support; at the moment backing gas (for capacity) – state aid issues, how much will Government support.

Free responses: *Just efficient gas or with CCS. Peaking plant with no CCS but big lump of mid-merit with CCS. Sleeving = single supplier; long-term PPA = several suppliers*

2.2 Archetype: New Electrifier

Description: 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.



New Electrifier Implications:

Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?

Companies like Renault could become part of the suppliers, as they could offer EVs plus the electricity for that, and the mark up would just be diluted in the electricity price. If the appliances are paid for, whom do they belong to? How can a customer switch and what happens then to the appliances? That will require standardization in order to allow switching. Why would people sign up for long-term contracts? What happens if they move? Can you take different loads from different suppliers? E.g. EV load from Nissan and other loads from EDF? Who is the architect of such a system? Who is setting the standards for smart meters? Is this what users actually want? Changes in practise re heat pumps, possibly EV leasing vs Ownership. High exit costs go against current moves to faster easier switching.

Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

New standards for transactions necessary, Who owns storage then? Who regulates and controls it? A discrepancy between the interests now (whole system) and in this system (own network). No clear efficiency incentive. If utilities want to 'create' load it may be easier to do in other ways than dealing with many households.

Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

Scale needed to provide all services, is the new Elec part of the whole network? Technologies provided by different suppliers and producers? Same data standards necessary to support all the various New electrifiers and appliances and to enable communication between them. Also when customer switches. Needs heat pumps to work and gas to be expensive. (Is utility ownership of EV needed? Just to know customer has one?) Electrical grid re-enforcement. Presumably lots of other decarbonisation policy on new electricity supply?

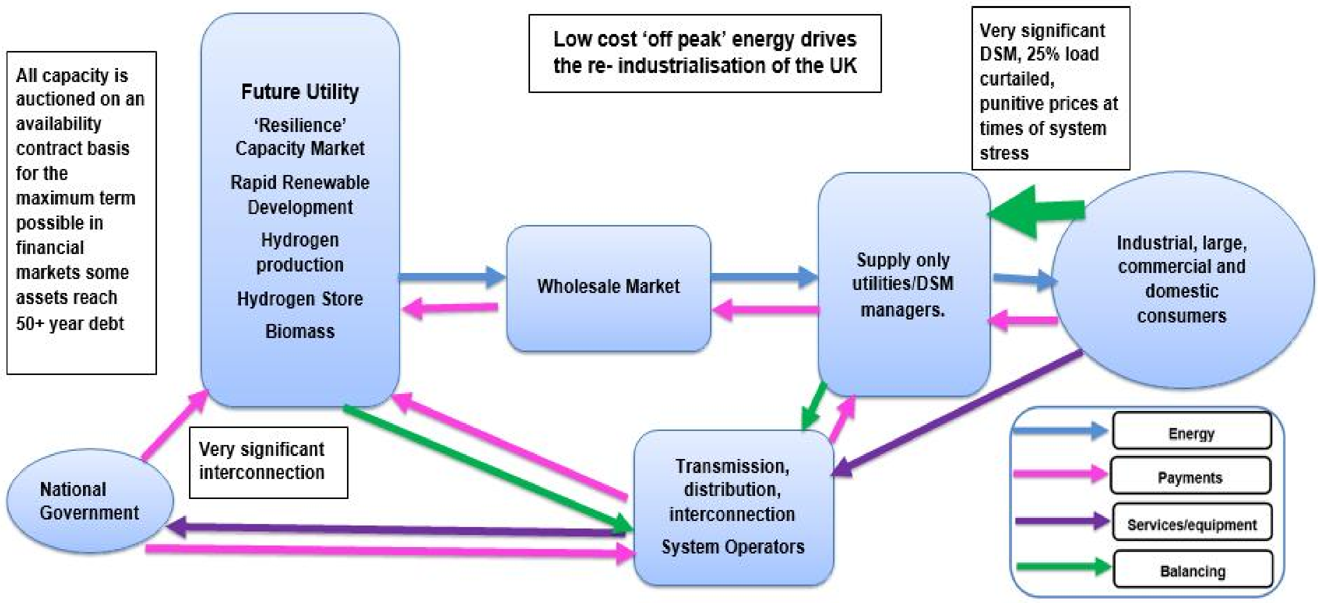
Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

The risk to maintain the network is moved downstream. Too many users, that can though create uncertainty Who finances the new appliance (electric demanders (EVs, fridges, etc…). What is the revenue stream for this kind of decarbonisation? Carbon Price?

Free responses: *May need to export to the grid.*

2.3 Archetype: Abundant System

Description: This system is based on a Government becoming a Central buyer for capacity, the energy is 'delivered for free' to the system when its available similar to water before we had meters, Government matches auctions to policy aims i.e. rate of decarbonisation. In so doing, the UK embarks on an electrification of heat and transport by installing sufficient [floating] offshore wind and other renewables to enable well over 90% of energy to be renewably supplied by 2050. This capacity is sufficient to supply winter peak demand (on average windy, cold days) assuming both heat and power are demand shift-able by 7 hrs and by 25% of load curtailment. As a result energy (when available) becomes 'free to use'; for ~6-9 months of the year wholesale energy prices are negative. The wholesale market becomes the place where balancing takes place and where the price signals for system stress are generated, expect to see long periods of nil and spikes of £1,000 -£10,000/MWh? Sufficient hydrogen production capacity is built to store large quantities of nil priced electricity to meet winter peak load, coal fired and CCGT assets are maintained for biomass/hydrogen burn and for resilience, coal and gas are used occasionally. Consumers need to provide significant DSM and load curtailment 'designed in' during periods of supply shortfall, some storage, IoT, active and engaged consumers. Interconnection significantly expands.



Abundant system Implications:

Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?

Really engage with demand reduction (consumers) Consumer behaviour needs changing most around Nov-Feb. Energy poverty aspect could improve. Inflexible customers would need to be penalised. Eanbles 24 hour manufacturing, Nov-Feb need to electrify heat. Near zero marginal *reduces incentive for DSM. How get to level of DSM required? Change of mind-set: cheaper if accept times of higher price or restrictions on use Commercial / industrial demand? Need high load, not volatile. Would need more control over customer use. Storage heaters Idea regarding basic income: certain amount of energy for free on per capita / household size basis Government has to pay, so via taxes? Recovery of fixed costs via standing charge (fixed or variable?) or general tax; precedence regarding local authority fixed price heating; issue for fuel poor. Where is incentive for efficiency?*

Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

Proxy: nuclear "too cheap to meter" Different market: players regarding spikes. Competition in capacity market for cheapest generation – this will be a lot more expensive because of high fixed costs. Market needs efficiency policy incentivising, huge level of demand reduction required. How far you enable actors to charge for cost of power as a regulator, in principal view of intervention.

Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

How much capacity would be required, bearing in mid could be positive feedback i.e. more capacity required because of archetype Storage to balance? Use of hydrogen is "sinful waste of energy" e.g. 50% efficiency. Smart meters less important but need control for rationing. Need large baseload.

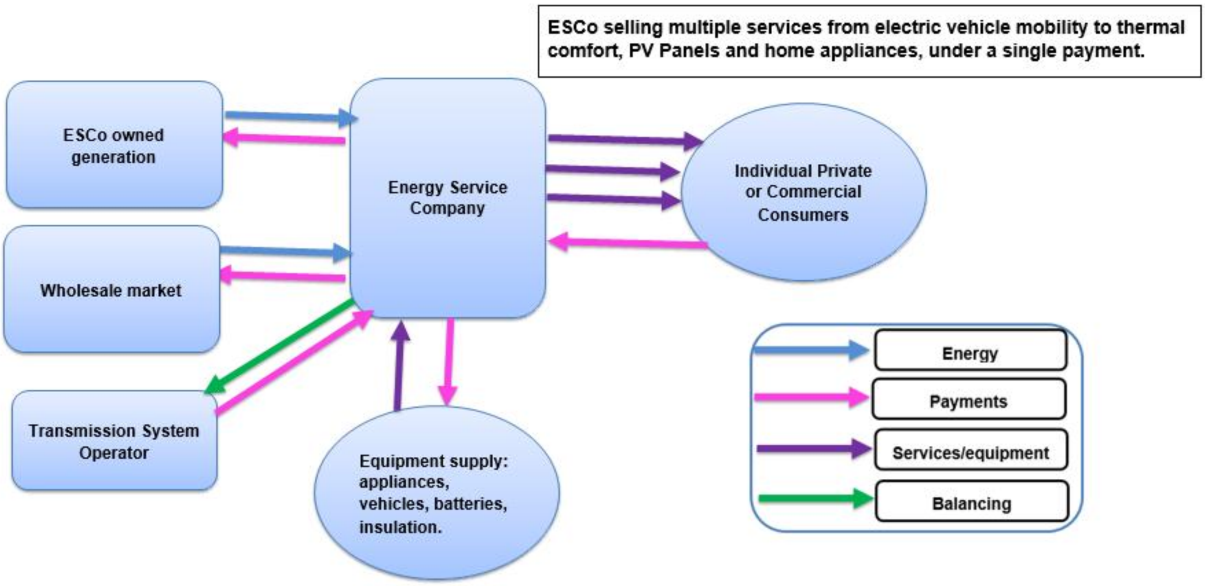
Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

Requires a lot of capacity. Overall, incredibly / most expensive. Free is a misnomer. Attractive capital finance if [guarantees] over 50 years. KfW analogous loans needed. Capital intensive, lots of small to medium (unintelligible) improvements. Need to stockpile fuels.

Free responses: *Don't like the phrase 'free to use' not true as fixed costs.*

2.4 Archetype: Serviced Home and Mobility

Description: 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.



Serviced Home and Mobility Implications:

Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?

Loss of brand specificity e.g. gadgets and vehicles due to the fact that the service provider would supply this to the consumer. However, it would be a great opportunity to promote energy efficiency as new energy efficient products could be replaced in the interests of saving energy as commercially prudent. How would the consumer benefit be measured? Would there be a situation whereby when a consumer gets into their EV and the battery is empty. What would the reconciliation process for this be? How would the heating comfort be measured? This would be attractive to the time poor but cash rich proportion of the population. How widespread the take up would be beyond this niche group is questionable. It is questionable as to whether it would be *able to be applied to distributed housing (dependent on extent of hardware/ software change required) – this is extended for its ability to be applied as a retrofit product or just new build. Could this be piggy backed onto a building/mortgage product? Missing DNOs in this archetype. Relationship to housing market trends – does it work with e.g. short term tenures? How much control for households vs ESCo on use decisions? Consumers need to understand what is being signed up to – do services provided match needs and expectations? What happens if it exceeded agreed usage? Any penalties need to be understood.*

Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

Incorporate energy efficiency. Issues around consumer protection / Monitoring, regulation and verification – how do you ensure that the consumer has had the service delivered; what is the dispute mechanism? How to address social protection. Data security issues. Market marginalisation as affluent can afford package but the less-affluent cannot. Extent of arbitrage on present system costs in terms of impact of disposable income analysis would need to be carried out e.g. no need to pay gas and petrol (assuming have EV powered by fossil free energy. Move away from prescriptive retail regs – principles based, may help free up this approach. Creates incentive for energy efficiency - would be nice if someone else pays for it.

Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

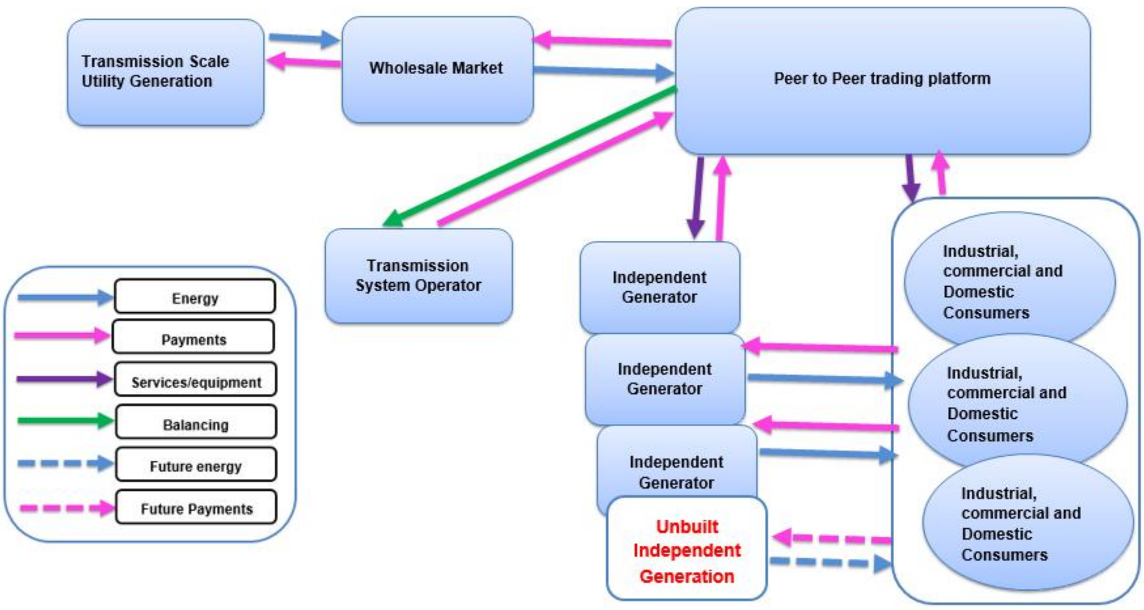
The need to measure and have cheap sensors to do this – the Internet of Things (IOT). ESCO would be dependent on the IOT being developed efficiently and the software to manipulate information (According to Hitachi) conceptually this can be done but the critical point is the system integration. Need to upgrade battery electric vehicles and ensure carbon free electricity. Each home a micro-grid. Cyber security. Smart metering access to consumer data.

Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

Is this capital intensive? Depends on the balance of software and hardware requirements and where the value capture opportunities lie? Could have the hardware as a leasing model and therefore not capital intensive? Could be a garage start up if the IP and value is in the software. How does ESCo: a) get money for upfront investment and b) assure itself of longer term payback reliability. Free responses:

2.5 Archetype: Peer to Peer 2.0

Description: 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. 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.



Peer to Peer 2.0 Implications:

Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work? Think about fixed charges and the effects?

For industrial consumers this is easy to tackle as not too complicated. They can trade directly into market. Small commercials or consumers are very limited. Far too complicated for domestic consumers, potentially automated boxes could solve that. This is a short term market, the tech savvy informed consumer will benefit, the already in fuel poverty won't know/care. Potential to feature multiple benefits – social/local/environmental. Barriers to short term relationship.

Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

Would need strong incentivising and very strong regulation. Would force a race to the bottom in cost, uninformed consumers, system architect would ultimately emerge. There will be higher socialised costs for the benefit of a little number of individuals. It will be possible to trade future capacities between p2p markets and also within. How does the platform pay for transmission? Will the wholesale market externalise these costs to the p2p? Will the costs just be passed down to the consumers? Wholesale market needs to be adapted to accommodate p2p market. How will the p2p conduct the balancing of the national grid? How to ensure with many peers and p2p markets that there is no dynamic instability? How to ensure that people actually invest and buy future capacity? Will there be spatial trade? Potentially bring gas and electricity markets together for balancing purposes. Potential of trade between platforms. This model will lead to huge geographical disparities, people will move to p2p areas with better grids and supply.

Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

Settlement system. Local wholesale market and network, mainly software driven rather than generation/distribution aided. Due to the complexity of the market and the resulting physical dynamics automatic solutions such as frequency controlled appliances will be necessary. How fast will the p2p markets will have to be to ensure balancing? What standards will be necessary for such a sophisticated market (smart meters? Frequency? Latency?). How to ensure that p2p boxes at the customers will have access to the markets and the grids?

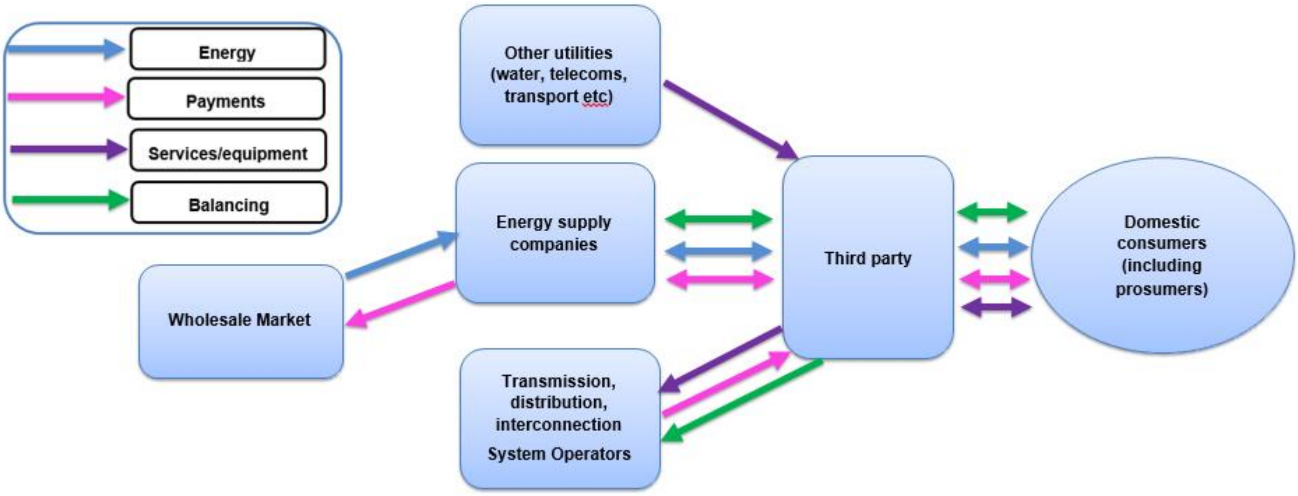
Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

Higher potential of citizen/crowd funding. Lots of small investors. Would unlock loads of capital for future capacities

Free responses: *Analogous to phone bundling. Why do you need the additional p2p layer and not just let the wholesale market introduce that?*

2.6 Archetype: Third party control

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



Third Party Control Implications:

Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?

Consumers would need to learn to give up control [note we agreed that we would explore the most extreme version where consumers delegated all control over lifestyle decisions to a 3rd party]. The consumer reaction / backlash would be huge if something didn't work as expected. Linked to this there is an issue of how consumers specified their needs to the 3rd party. This archetype could potentially engage all consumers, particularly those that are currently disengaged. There are *potential issues of panic / privacy / trust…ultimately control. This is analogous to how things might be on autonomous vehicles. Similar to Service Home and Mobility, Attractive for already serviced apartments, Highly dependent on the extent of control that the consumer gives to the 3rd Party. Suspect that this would only work for limited periods of time.*

Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

A completely different regulator would be required – multi-utility, huge and powerful. There are issues regulating the multiple data flows and consumer protection across utilities. How would the market be designed? Perhaps akin to Public Service Commission in US (noting New York REV). Could potential be national or regional (or both!). Framework would have to cover all utilities. There was a question whether regulation would drive this (enable) or play catch-up. It was felt consumers would only accept if they had a demonstrably improved standard of living as a consequence. Similar to Service Home and Mobility, Data security, Monitoring, Verification and Reporting.

Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

Key enablers include smart technologies / data; internet of things; automation. Unclear whether this would be driven via smart meters or broadband. Could be made irrelevant by grid defection, distributed energy (e.g. a hands-on local energy economy) or a very centralised system. Similar to Service Home and Mobility, Internet of things.

Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

Definitely IT intensive. Investment model depends on ownership model. Most felt that it would need a Google to start it, although some felt it could also be driven by a utility. Funding could be typical IT funding or possibly crowd-sourcing. This was described as a radical business model.

Free responses

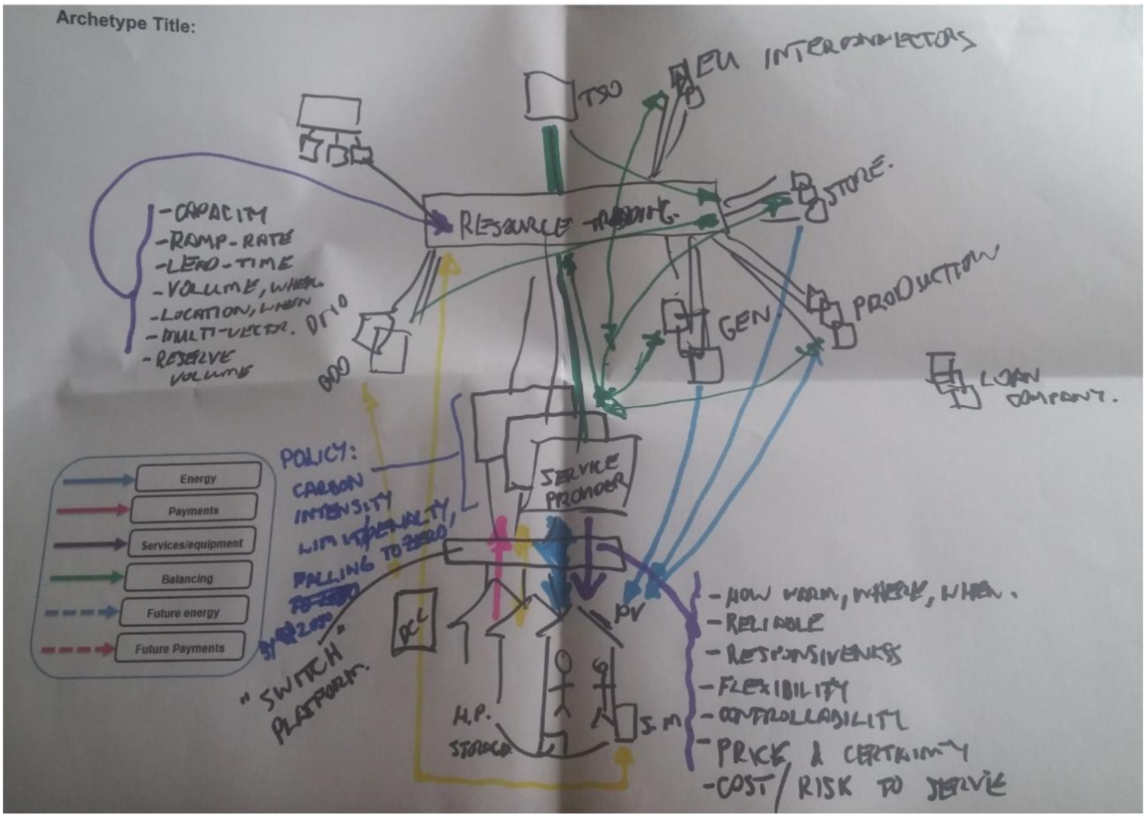
Issues over freedom and choice – "Do I want it?" was a question from a participant. The table was sceptical over it could actually happen. Questions were raised over whether it would be legal (supra-national law change would be needed according to one participant). Social housing could be a driving force / model. Could enable zero carbon housing (e.g. through 3rd party retrofit process). Question over what would happen if the State became the 3rd party control.

Section 3: Archetype Co-production.

This activity followed the investigation of the provisioned archetypes with a session to identify new archetypes. Participants were asked to provide snapshots of new archetypes which were listed and given straplines. Each group then chose one of these to 'flesh out' by providing an archetype diagram and implications sheet. Five new archetypes were suggested.

3.1 Archetype Title: Holistic Provider

Description: Do not provide electricity anymore but services. Not electricity for EVs, but mobility – car and electricity. Fridge and electricity. House and light. Etc. Hence the Service provider arranges everything needed to have a good life. The service provider finds the right packages of suppliers. Similar to the new Electrifier but the service goes far beyond electricity only.



Holistic Provider Implications:

- Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?

Only people that have the right appliances can take part in it, There will be also customer aggregators such as SWITCH! For services, that gather customer use data and who handle the *process of choosing the right service provider How to overcome the process of tied customers to one service provider?*

- Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

Service providers should be regulated with CO2 targets, or CO2 intensity targets. Not electricity providers provider anymore but service providers.

- Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

How to ensure that people have access to low carbon technologies. Who is balancing the grids? Standards need to be imposed by the service providers o the suppliers of appliances. Problem regionally split resource markets. Who owns the kit? Provide frequency equipped appliances to balance a complicated market and system.

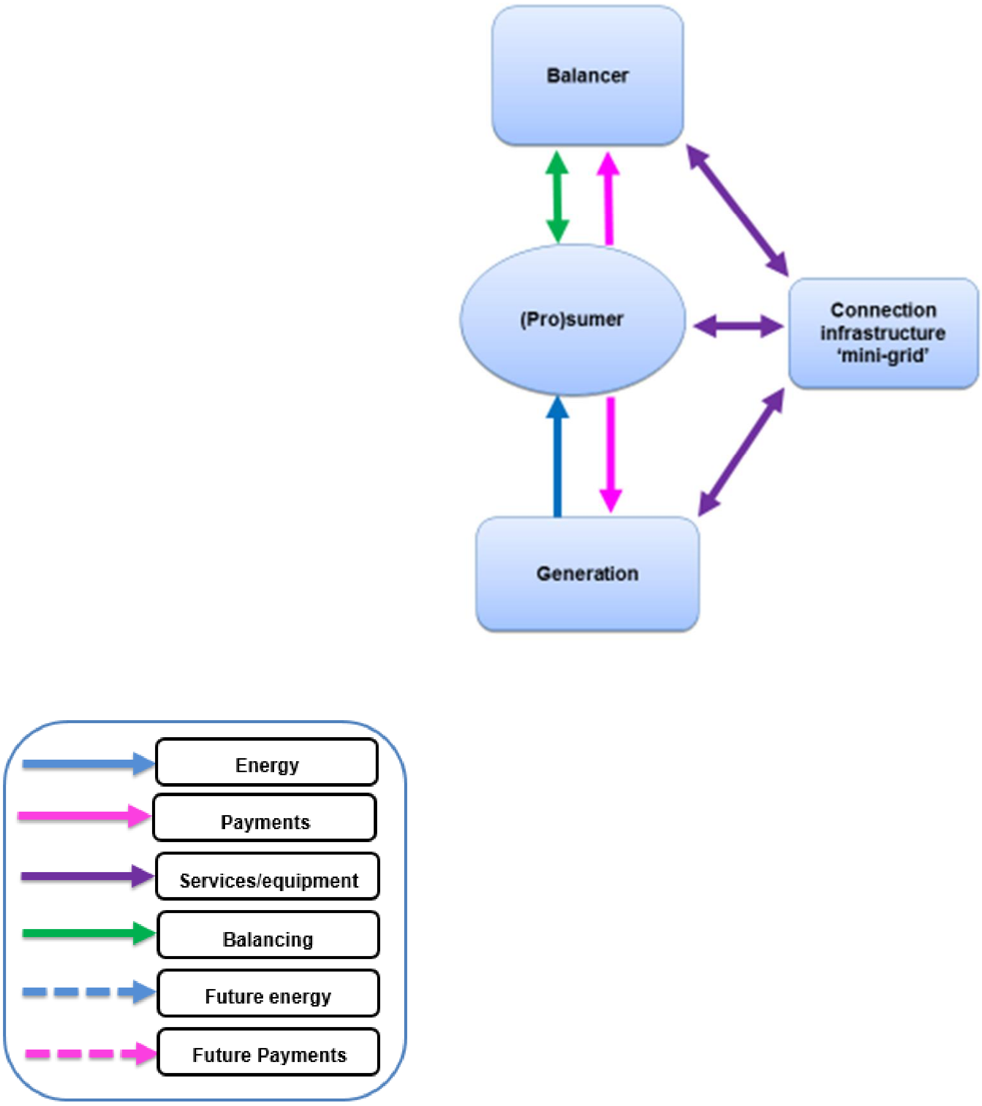
- Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

Share costs between service providers and suppliers of appliances. Cooperative model. Service providers trade-in resource market for future capacities. Someone needs to finance resource market.

Free responses:

3.2 Archetype Title: Grid defection

Description: Communities go off grid, Consumer generation plus additional community generation (e.g. wind, PV), Connection infrastructure ('mini-grid'), Balancing. Community or externally owned. Operated by community e.g. plug and play [technology], or by external provider.



Grid Defection Implications.

- Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?

How do communities decide? Cost inertia for existing communities, Easier for new communities / settlements, How community works e.g. billing (also how bills worked out), Other values being served.

- Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

What degree of regulation and licencing is required? E.g. licence to supply, legal changes regarding competition

- Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

DC, Technology allows us to do this, Still need to satisfy HSE, Standardisation? Private wires or purchase from DNO.

- Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

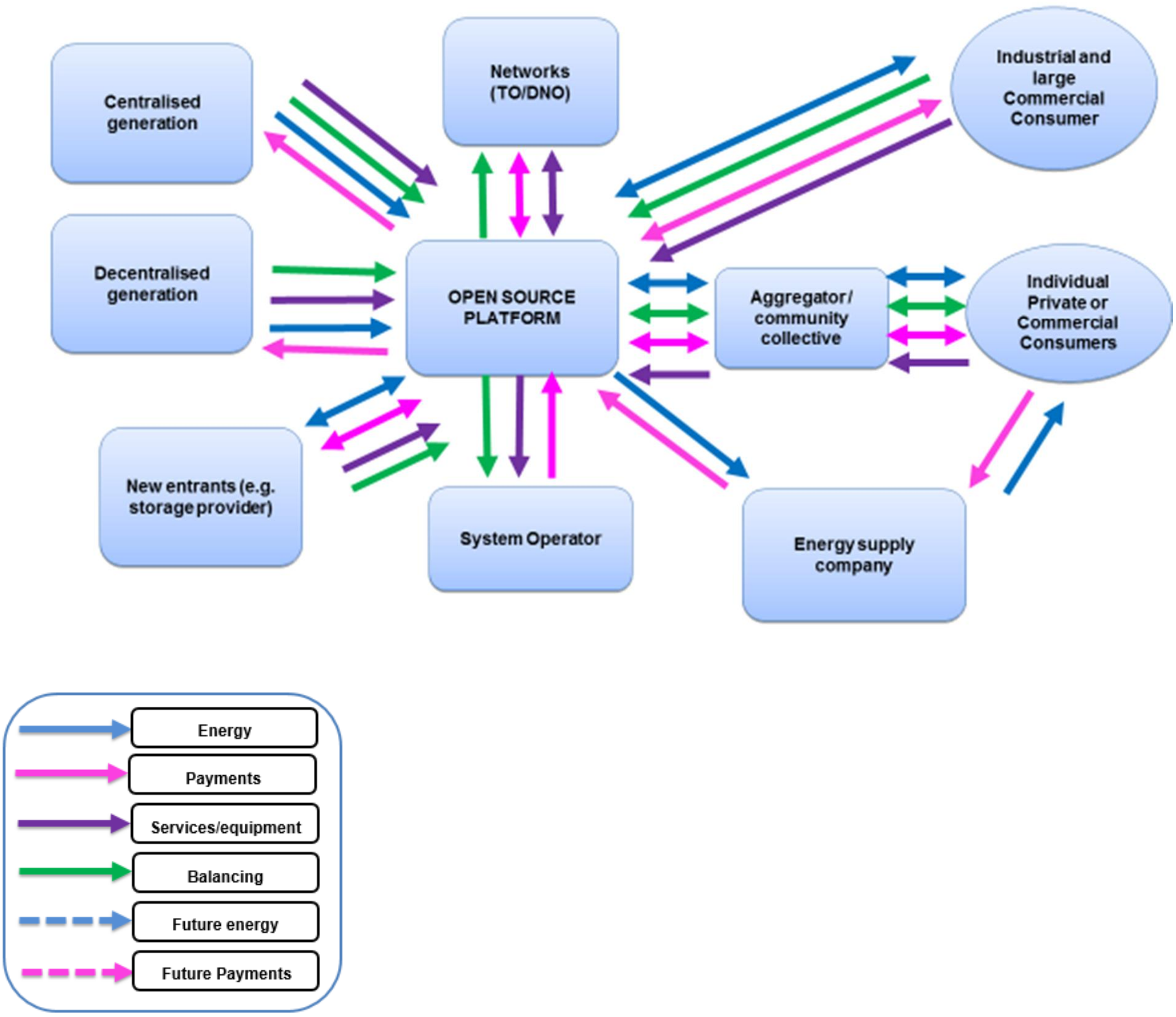
Existing infrastructure becomes very expensive – where is tipping point? Currently DNOs don't charge on basis of cost [to individual settlements]; might be attractive for DNOs if at end of difficult connection but for other reasons (e.g. logistical/geographical [e.g. where cables pass through area]) perhaps not.

Free responses:

Is there a transition e.g. initial generation, then increasing numbers sign up. Logistical issues such as disruption for cabling. Would suit community with ready supply of energy, Can it be scaled up e.g. to 50% [of UK]?

3.3 Archetype Title: Open source provider

Description: All UK electricity and energy services are mandated (e.g. no bilateral energy contracts exist) to pass through an open source energy platform. The platform applies at the local and national level (skin to John Rhys' fractal model). This is in effect a marketplace for wholesale, balancing and ancillary services broker. Data flows are transparent and of sufficient quality and temporal resolution (e.g. millisecond) to allow these services. As a consequence, cost efficiencies are realised because the price of all transactions is transparent and fair, thus competition is 'perfect', allowing any participant, from domestic (through an aggregator) to incumbents to participate fully. Time of use tariffs are commonplace, which creates some barriers to entry for those consumers least able to participate (e.g. consumers in vulnerable situations).



Open Source Provider Implications.

Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?

Could affect domestic and SMEs, particularly if it increased the tariff availability. Those able to participate could benefit more than those unable to. As a consequence the distribution of benefits could be uneven. Possible role for 3rd parties in engaging wider consumer base.

Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

A question of whether choice is being taken away – regulator would need to consider consumer protection.

Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

Key enabler is a 'good' platform. Also important are algorithms, data security and transparency, Platform will only be as good as the quality of the data that is available. Are smart meters smart enough or quality enough?

Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

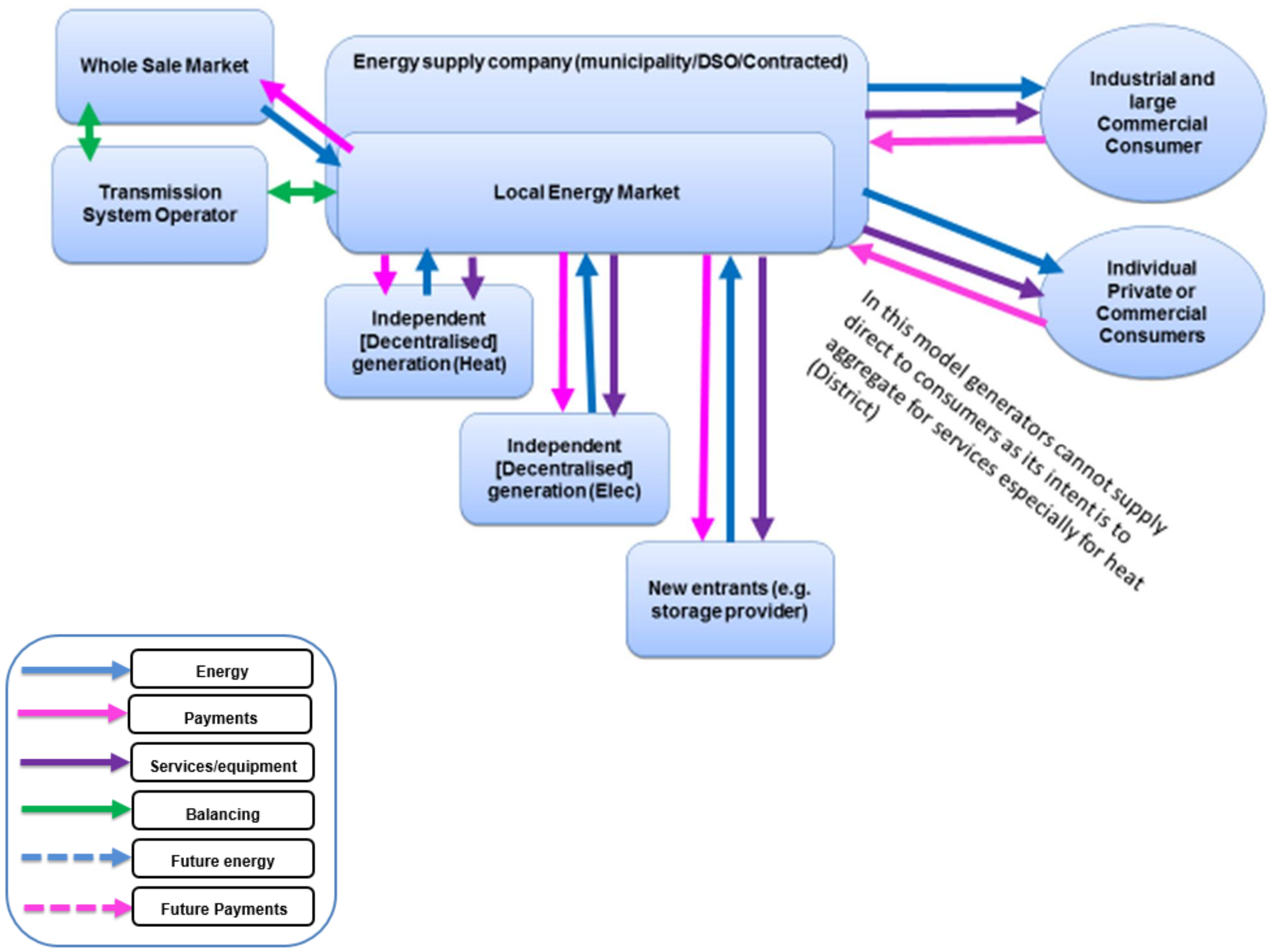
Did not feel that it would be capital intensive, although it could be resource intensive to set up and run.

Free responses:

Unclear how this helps with low-carbon deployment. Clear link to flexibility though.

3.4 Archetype Title: Geographical Provider

Description: Local Authorities auction rights to decarbonise their area, Contractors bid to be monopolist energy service providers to local areas with goal of decarbonising those localities at least cost. They may optionally have responsibility for household energy efficiency. The spatial differentiation of the UK energy `space' (energy efficiency being dependent on building fabric, DSM, distributed energy generation capacity) makes the geographical platform a viable business model. Local energy markets are developed in order to allow those institutions whom are aware of the local players and fabric of the `energy topography' who would participate in local initiatives as well as ensuring that value is captured locally (despite the possibility of costs being slightly higher than present costs). This would be particularly attractive in realising district heating systems and in order to ensure aggregation effects - generators would not be able to sell directly to consumers. It would also allow better `electrical system management' through aggregation effects. These regional geographical platforms would be connected via a transmission system which coupled other regional geographical platforms to be able to buy and sell to each other when in surplus and/or deficit. The local energy market would be either run by the regional municipality / DSO or contracted out.



Geographical Platform Implications

- Users/consumer practices: How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work?

Decisions made for consumers as to how they want their home heated. Consumer would have to adapt to the charging model which might be quite variable. There would be a socialisation of the benefits Local value capture and potential diversity of supply chains in the local community e.g. for local biomass. Light consumer role – few decisions in consumer hands. Local elections as switching, to steer direction, is this really 'democratisation' and public having a say?

Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

The need for a regional Ofgem – need to rearrange the regional mechanisms, DSO and so need for a change in regulation, Regulation of heat, If consumers are forced to source from the platform and is therefore the route to market it becomes the regional balancing mechanism. Who provides the technology – local providers or established by national standards to as to ensure interchange-ability and capacity for innovation for technology across regions. Quite a lot, puts monopoly power in contractors' hands and monopoly decision power in local authority hands. Auction as only form of cost control – what happens if 'winners curse/over spend' occurs? Is there expertise to run these auctions all over the country? Could have residual (non-monopoly) market or would you only get contractor bids if guaranteed monopoly?

Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded?

Need for the platform to have technology to allow balancing and charge units of energy rather than providing a service, Questionable as to the size of the market to allow delivery at the appropriate costs. Each consumer would need to interface with the system – Internet of things – e.g. Nobel http://nobelgrid.eu/about-nobel-grid/ . Probably only makes sense if no economies of scale – e.g. solar, storage incredibly cheap. If this happens would this drastic a change be needed to decarbonise – wouldn't it be happening anyway?

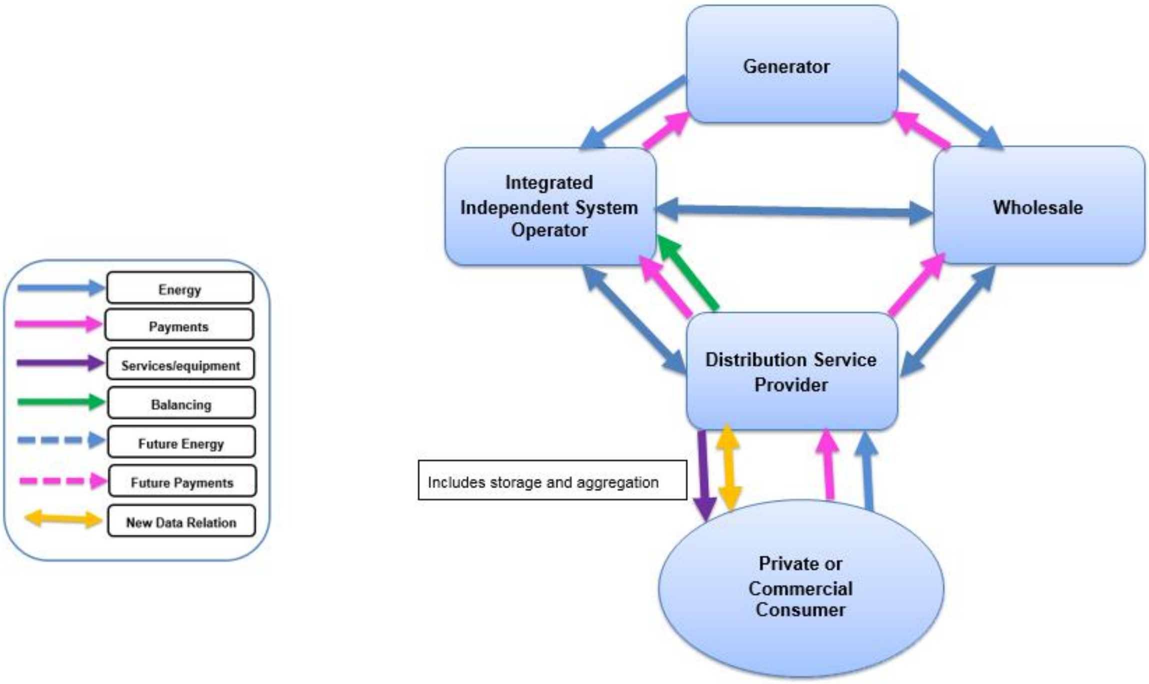
Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this… pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs?

Linked to extent to which markets regulated and the extent of the Regulated Asset Base. Would need to raise capital for heat component of the system and for power the infrastructure is sunk. How to transfer massive valuable assets (of energy companies and possibly energy demand) to LA's. Trade needed between areas – autarky is basically never a good idea…

Free responses:

3.5 Archetype Title: Distribution Service Provider

Description: DNO is incentivised to offer bundle of services. DNO Balances system locally, different incentive to DNO at present. (Outcome focussed)



Activity 3 Implications sheet, 2035-2050: Archetype Title: Distribution Service provider.

Users/consumer practices: *How would domestic and commercial consumers need to adapt to this archetype? What behaviours need changing? What kinds of consumer would benefit from this archetype? What are the consumer barriers to making this work? Disbenefit that could become a postcode lottery. Poor service for poorer network areas. Data sharing and data protection. Consumers with the capacity. Could be mandated to deal with the fuel poor + socialised costs across area, could stimulate local interest and involvement due to location. Incentivises energy efficiency.*

Regulation and Markets: How would current system regulation or market design need to change? What incentives are needed? How are consumers protected? Are there regulatory barriers?

Geographically limited, Ofgem sublet – ofgem lite? Incentives needed, would want to optimise – different incentive for demand side participation. , needs a local system architect, socialise across area. Technological requirements: What technology needs to change, develop, or get cheaper? Which existing development may render this irrelevant? Are there enabling technologies like smart grids or meters that need to be upgraded? *Data processing/software heavy – DSP becomes much more ICT Based. Energy storage and smart grids. Frequency sensitive inverters.*

Resources and Capital Finance: Is this archetype capital intensive? Does it need lots of small investments or very few big ones? Who is likely to finance this... pensions funds? wealth funds? citizen finance and crowd funding? Also consider natural resources, water needs, fuel import needs? *Pension fund and or wealth funds. Not overly capital intensive.*

3.6 Missing Pieces

During the workshop participants were asked to reflect on whether there were any missing pieces in the analysis that was both presented and co-produced. Comments fell into four main groups:

1. The upstream needs to be covered in greater depth: Of the business model archetypes presented, the Low Carbon Capacity Provider, New Electrifier, and Abundant System, have the most to say about the upstream provision of firm or large capacity generation. Further, these archetypes rely on various scales of deepening capacity auctions or new load for vertical integration of utility assets. To deal with this the analysis team intends to explore the metrics that can usefully explain how and where these upstream considerations can be stress tested.

2. Lack of DNO representation: Distribution network operators will be critical enablers of some of the more downstream or consumer focussed archetypes in this study. These are Peer to Peer 2.0, Third Party Control, and Serviced Home and Mobility. Equally the co-produced archetypes 'Distribution Service Provider' and 'Geographical Provider' clearly require more focus on the infrastructural element of the transition. As such the analysis team will seek specific DNO input through the Energy Networks Association and has already begun discussions as to how these organisations can contribute to further analysis.

3. Need to consider cross-vector issues not just electricity: The focus of this project has been predominantly on electricity provision, however archetypes such as Third Party Control and Serviced Home and Mobility do consider other vectors such as heat, mobility and telecoms. However, to keep our analysis focussed the team is likely to assume these vectors remain somewhat stable. However, Dr Stephen Hall is involved in further work on the mobility provision side and Dr Jeff Hardy is investigating the consumer impacts of multi-utility archetypes.

4. Can there be analysis / processing of the other archetypes that were proposed by the attendees: Yes. In section 4 below we explain the process of selection and refinement of archetypes, some of this requires incorporating elements of the co-produced archetypes into existing ones, and some may include standalone analysis. This will be determined by the project team in phase 2.

Section 4: Next steps

The next steps for this work are to refine the suite of archetypes the analysis team will take into the stress testing phase, define the metrics against which archetypes will be tested, and select which energy system scenarios are to be used to frame the stress testing.

4.1 Refining the archetypes

There are some similarities between archetypes generated by the analysis team and the co-production exercise. The 'Peer to Peer 2.0' and 'Open Source Platform' archetypes share many characteristics, from operation of a user centred e-platform to a relative silence on the operation of the generation end. The 'Holistic Provider' archetype is closely analogous to both the 'Third Party Control' and 'Serviced Home and Mobility' Archetypes. The 'Holistic Provider' archetype however has a much clearer narrative on the importance of consumer data management. The 'Grid Defection' archetype is interesting in the context of this work but does not represent a national value proposition as such. Equally the local concession archetype is an important possible model for future energy systems but is too locally focussed to represent a national proposition. Equally work by the Realising Transition Pathways Consortium[1] and Hall and Roelich (2016), has investigated the local authority ESCO model, which this closely resembles, and limited value is seen from further scrutiny in this process. The 'Distribution Service Provider' archetype however does present a novel contribution beyond prescribed archetypes and will be considered for stress testing. It is not in the scope of this document to present final refined archetypes, only to signal that an interactive process is being undertaken by the enabling team to ensure maximum value is derived from the stress testing phase by refining considered archetypes.

4.2 Defining metrics

On the 30th June 2016 four members of the enabling group tasked with leading the stress testing work package met to define archetype metrics and testing methods. The stress testing of the archetypes is intended to investigate how each business model may fare in a range of possible futures. To do so each archetype needs to be tested against common metrics and common scenarios. Geoff Darch form Atkins gave an overview of metrics and scenario methods for complex systems. Marie-Sophie Wegner presented a matrix using a simple traffic light system showing how each archetype performs in each scenario Figure 4.1:

[1] RTP Engine Room (2015) Distributing Power, a transition to a civic energy future, RTP Consortium, Bath.

Figure 4.2.1: How archetypes perform in each scenario (indicative, not empirically backed)

	Low-carbon transmission capacity provider	New Electrifier	Abundant System	Serviced Home and Mobility	Peer to Peer 2.0	Third party control
DECC - Higher renewables, more energy efficiency	Yes	Yes	??	Yes	Yes	Yes
DECC - Higher nuclear, less energy efficiency	No	Yes		Maybe	No	
DECC - Higher CCS, more bioenergy	Yes	Yes		Yes	Maybe	
NGrid - Gone Green	Maybe	Yes		Yes	Yes	
NGrid - Consumer Power	No	Maybe		Yes	Maybe	
NGrid - Slow Progression	Maybe	Maybe		Yes	Maybe	
NGrid - No Progression	No	No		Maybe	Maybe	
RTP - Market Rules	Yes	Yes		Yes	Yes	
RTP - Central Coordination	Yes	Yes		Yes	?	
RTP - Thousand Flower	Maybe	Maybe		Maybe	Yes	

This work is illustrative of the intended outputs of the stress testing phase and the empirics behind the traffic light system will be driven by the stress testing metrics. I.e. where an archetype performs well in a particular scenario across all metrics it may be deep green, not so well, amber etc.

The metrics to be used will mirror, and be informed by the categories used for archetype interrogation in the workshop. Each will be led by a team member under a specific question. The metric question is designed to deliver binary or spectrum based answers i.e. yes/no, higher/lower. At this meeting the following metrics questions were. The metric development is live at time of writing.

Users and user practises: Lead Jeff Hardy.

> How much behaviour change does this archetype require and does the scenario engender that change?

Metrics:

Data Sources:

Technologies: Lead TBC

Which technologies does this archetype rely upon and what is their realistic potential for deployment?

Metrics: Working with TRL levels, Time to market indicators.

Data Sources:

Markets and Regulation: Steve Hall

How does this archetype ensure consumer protection? How does this archetype perform in terms of market entry and competition?

Metrics:

Data sources:

Resources – Capital finance: Lead Marie-Sophie Wegner

What is the size of the value pool this archetype can access within each scenario? How investable is this proposition?

Metrics: Value Pool. Qualitative investability metrics around David Casale's '5 rules'

Data sources: Energy scenario's, secondary analysis, Accenture methodology.

Geoff Darch has assumed the role of strategic oversight and 'quality control' across the metrics team. This both makes best use of Atkins constrained resources and ensures each metric testing exercise feeds into each other. The team are fully aware that user practise and consumer protection are linked, as are investability. and market entry metrics.

4.3 selecting scenarios.

There are a number of energy system scenarios against which the analysis team can choose to stress test archetypes. There is a wider narrative to be drawn out around the suitability of system scenarios, however for now those under consideration are: The DECC 2050 pathways, The Realising Transition Pathways consortium pathways, and the National Grid Future Energy Scenarios. At present there are ten pathways under consideration. The group agreed the primary stage gate for scenario analysis was their compatibility with Committee on Climate Change Advice for energy system emissions to meet obligations in the Climate Change Act 2008. This has already facilitated some scenario attrition and further selection is ongoing.

Section 5: Summary

This document has reported the empirical results from Phase 1 of the Utility 2050 project. These results were primarily drawn from the Business Model Innovation Workshop, 15th June 2016 at The Royal Society. These data included the ranked system challenges, the implications of business model archetypes provisioned by the analysis team, and the implications of archetypes generated in the co-production activity. These implications are under analysis for Phase 2 of the project and have already informed the high level questions the analysis team will answer using the stress testing metrics approach.

As the second phase of this project progresses the analysis team looks forward to the continued enthusiastic engagement of the initial stakeholder group and also to building new relationships with sector experts.

Any questions about or additions to this document should be directed in the first instance to:

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Appendix 1. Challenge cards activity (copy of table facilitator activity 1 instructions and cards)

Activity 1: Ranking the Challenges.

These cards characterise systemic challenges to the current formation, regulation and operation of the electricity market. They will have a disproportionate effect on the incumbent vertically integrated business model, which still meets the majority of electrical demand in the UK, through generation and supply markets.

In most energy system scenarios, transmission level generation (be it Nuclear, Thermal with CCS, or highly efficient gas) is needed to meet demand. Equally, business model innovation in complex systems must leverage existing skills, institutional competencies and substantial balance sheets *as well as* fostering tech start-ups and small entrepreneurship.

Our task here is to rank the 'systemic challenges' that face the ability of incumbent and other larger market players to deploy new transmission level capacity *and* scale out innovative value propositions in the supply space.

Rank	Challenge
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	

System Challenge: Policy Uncertainty
The policy and regulatory environment is fluid. From emissions performance standards, to ups and downs in CCS funding and renewables subsidy; governments have seismic impacts on energy systems. Apart from the implemented policies and regulations there are currently a number of pending political decisions and uncertainties that create severe instability for market actors. This uncertainty results in deferred or even cancelled investment decisions for new projects, raised cost of capital and a general environment of distrust and instability. Recent announcements that the UK will need to accelerate GHG reductions under the Paris Agreement, and that all coal is to be phased out by 2025, add further confusion as to the future shape of the system.

System Challenge: Diversifying supply market
Tomorrow's consumers demand more bespoke and tailored services. Until recently, electric utilities have benefitted from a relatively stable retail market share for domestic consumers and a moderately competitive environment for commercial consumers. As barriers to market entry are reducing in both domestic and commercial markets, direct competition from challenger utilities is eroding these market shares. As challenger utilities emerge with packages tailored to specific consumer groups, larger utilities with more homogeneous offerings will see retail market shares continue to dwindle. The erosion of supply market share force vertical integration models to disintegrate.

System Challenge: Increasing micro-decentralised optimisation
Smart meters, home batteries, and second life auto batteries are being linked with micro and decentralised renewables. This creates myriad options for decentralised optimisation of small to medium sized loads on street to city geographies. This increasing decentralisation of demand undermines the unit volume business model of both infrastructure operators such as National Grid and erodes reduces asset utilisation of transmission level generation. Much of this optimisation is 'invisible' at the system scale, as it only appears to be reduced load and may mask significant trends.

System Challenge: Large penetration of intermittent renewables
Unlike conventional thermal power plants, which require long lead times and teams of highly skilled staff, decentralised renewables can be modular, quick to deploy, and benefit from guaranteed revenues from FIT & Certificate schemes partially with guaranteed take-off. This has led to turnkey developments and full-service offerings for O&M allowed investors without technical knowledge and operational capacities to acquire and own power plants and to enter the power market with a limited risk exposure. Their proliferation can force wholesale prices down and retail prices up (through subsidy), distorting market signals.

System Challenge: Demand side management
Demand side management has the potential to offer market services such as operating reserve, enable time of use pricing savings, provide long term capacity margins, and avoid network re-enforcement costs. However, expanded DSM capability would be called upon by different parties for different reasons. Not enough is known about how reliable expanded demand side management can be, what penalties may be placed on non-compliant parties, and how smaller scale demand responses can be remunerated to households and SME's.

System Challenge: Expanded European interconnection
Ambitious endeavours within the European Union are taking place to create a transparent and fully connected single European electricity market which requires strong interlinkages between all networks within the union. The UK grid has recently expanded connection with Ireland the EU mainland in the past years. Nevertheless, those connections are still minor in capacity compared to the overall electricity demand. Through the expanded interconnections an increased flow of lower cost electricity produced by e.g. nuclear power plants in France or hydro power in Norway could replace significant amounts of firm capacity power generation as well as decrease constraints during peak hours and reduce wholesale power prices.

System Challenge: Oil, gas, and coal price risk
The global commodity markets are subject to complex international market interactions and as the recent oil price crash has shown, to a significant extent they are unpredictable in the medium to long term. The reliance on fossil fuels from other countries carries risks, creates dependencies and makes importing nations increasingly prone to energy geo-politics. Many nations are actively trying to reduce their fuel import dependencies. Due to the low margins to be generated from conventional power plants in the current market, minor fuel prices changes can be of great significance to the profitability and short run competitiveness of thermal generation.

System Challenge: Cost of capital
Historically the generation and distribution of electricity from conventional dispatchable power sources in UK was predictable, generated long-term stable returns and was considered sufficiently low risk for investors and financial institutions to provide capital at a low cost. However, recent disruptive changes though technology development, emission reduction targets as well as policy uncertainty have led to an increased risk perception of the market as a whole, increasing the cost of capital and raising return expectations for new projects. Higher revenue streams potentially obtained through higher domestic electricity prices may be required to satisfy this increased risk perception.

System Challenge: Reduction of final demand
Appliance efficiency, slow economic growth, and increased energy visibility through smart metering is driving down final demand. Previous assumptions of exponentially increasing demand may no longer be valid, particularly if heating and transport electrification do not materialise. Decentralised optimisation may erode asset utilisation of centralised power plants, but reductions in final demand may also undermine the business case for these decentralised solutions. Reductions in final demand undermine the value pool for all unit based business models.

System Challenge: Climate change and extreme weather
With regard to the global climate change, projections forecast substantial temperature rises accompanied by changes in weather patterns. Increased temperatures and changes in rainfall patterns are also expected in Europe. Experts predict water scarcity and increased cooling demand for conventional power plants. Progressive climate change increases the revenue losses caused by weather related risks and will pressurise the viable operation of power plants requiring substantial water abstraction for their operation.

System Challenge: Economic shock
The global financial crisis caused serious harm to centralised utilities for various reasons, over exposed balance sheets, a reduction of final demand due to economic slowdown and an increase in the cost of capital due to wider constraint on capital markets created a hostile operating environment for utilities. It is likely this is not the last economic shock the system will face. The challenge is to build utility business models that are robust in the face of cyclical crises.

System Challenge……..

System Challenge……..

Appendix 2: Workshop Attendees

** redacted for publication for confidentiality reasons**