What Insights will this project provide

- **Policy Makers and Regulators**
  - Types of business models that might evolve - how regulation and policy be better designed to encourage positive system benefits;
  - The type of innovation policy that will be needed to realise desirable system benefits; and
  - Which services user groups value and their willingness-to-pay for them.
- **Investors**
  - Size in £ of value pools that might be available in possible futures
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- **Present Incumbents**
  - Assist in the development of more robust strategy to navigate possible futures.
- **User Groups (Society)**
  - Better understanding of types of services available; and
  - The degree of behaviour change required to adopt new energy life-styles.
- **ALL** engagement in a `Strategic Dialogue' as to the expectations of respective stakeholders.

ERP Utility 2050 Project Interim Update

Mark Workman (ERP) and
David Casale (Turquoise)

October 2016

- Electricity centric
- Eight industry published scenarios all of which deliver 2050 targets:
  1. BAU Nat Grid No Progress
  2. DECC 2050 High CCS, More Bioenergy
  3. RTP - Central Co-ordination
  4. RTP - Market Rules
  5. DECC 2050 High Nuclear, Less Energy Efficiency (EE)
  6. Nat Grid Gone Green
  7. DECC 2050 - Higher RE, more EE
  8. RTP - Thousand Flower
- 2035 to 2050

Why this project?

Seeking to achieve multiple societal objectives will have a major impact on many areas, including:

- How the UK electricity system operates in future
- Commercial and policy responses to risk
- Innovation and investment: what gets the green light – and what fails - under different business models?

Aim: Better understanding of these impacts, and the effect of different scenarios on different electricity business models.

Output: Set of responses – for business, political, finance audiences.

What Insights will this project provide

- **Policy Makers and Regulators**
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Steering Group*and Analytical Team

(1) David Casale (Turquoise Capital) * - **Chair**

(2) Stephen Hall (University of Leeds) *

(3) Mark Powell (University of Newcastle)

(4) Geoff Darch * and Jon Swan (Atkins)

(5) Jeff Hardy (Imperial College, London) *

(6) Jillian Anable (University of Leeds)

(7) Marie-Sophie Wagner (Imperial College, London)

(8) Chris Mazur (Imperial College, London and Climate KIC)

(9) Eric Brown or Philip Lawton (Energy Systems Catapult)

(10) Steven Schofield (Shell)*

(11) David Ball (Drax)*

(12) Andrew Burglass (Burglass Advisory)*

(13) Douglas Cheung (Hitachi)

(14) Ron Loveland (Welsh Government)*

Project Objectives:

1. Assess the operating environment of UK future electricity;

2. Assess the effect of different scenarios on different electricity business models;

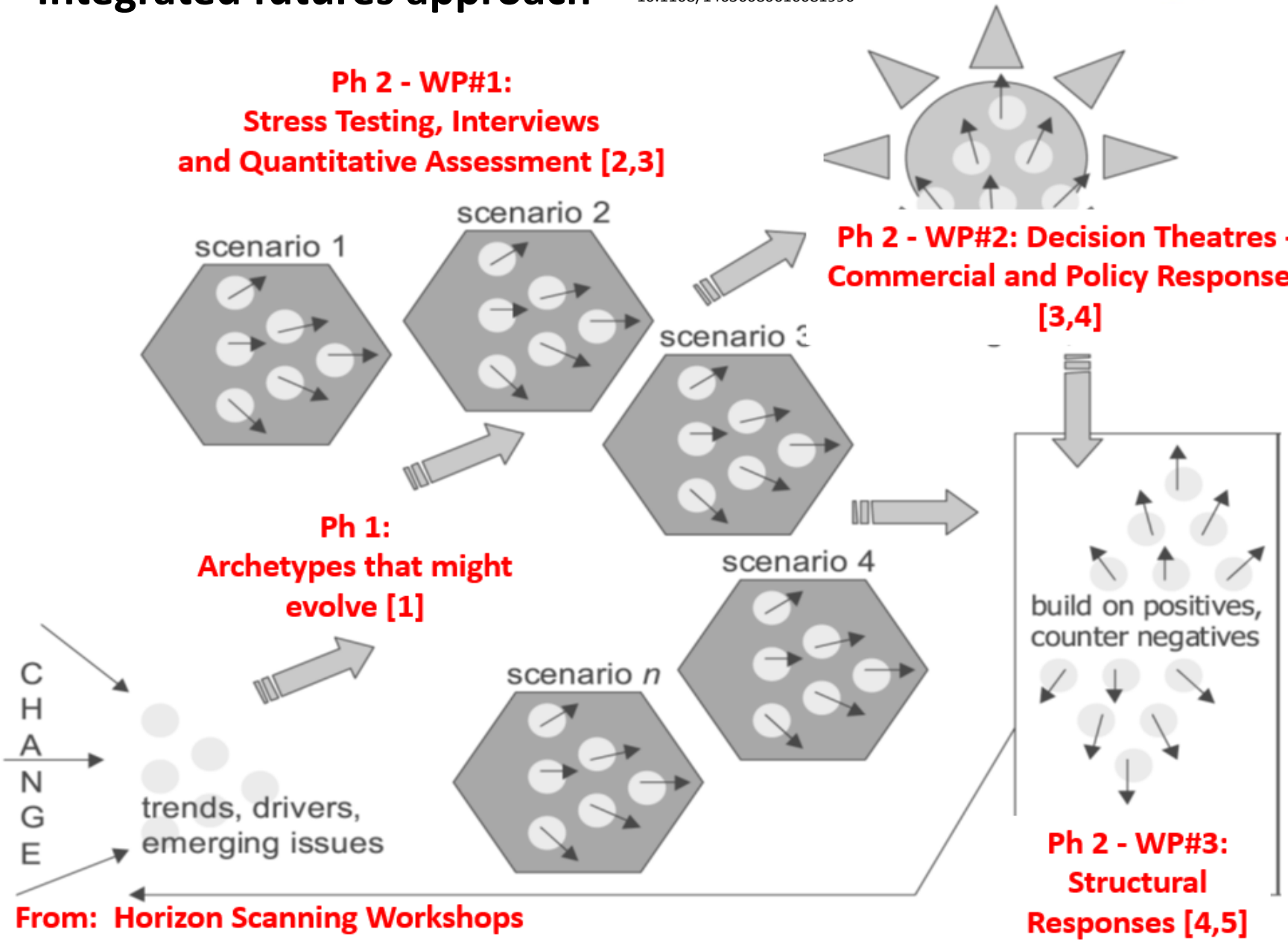
3. Assess the commercial and policy responses;

4. Assess the effect on innovation and investment;

5. Define new roles and value propositions for electricity system participants.

Integrated futures approach

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



Phase 1 progress

Undertaken since June (£8,000 budget):

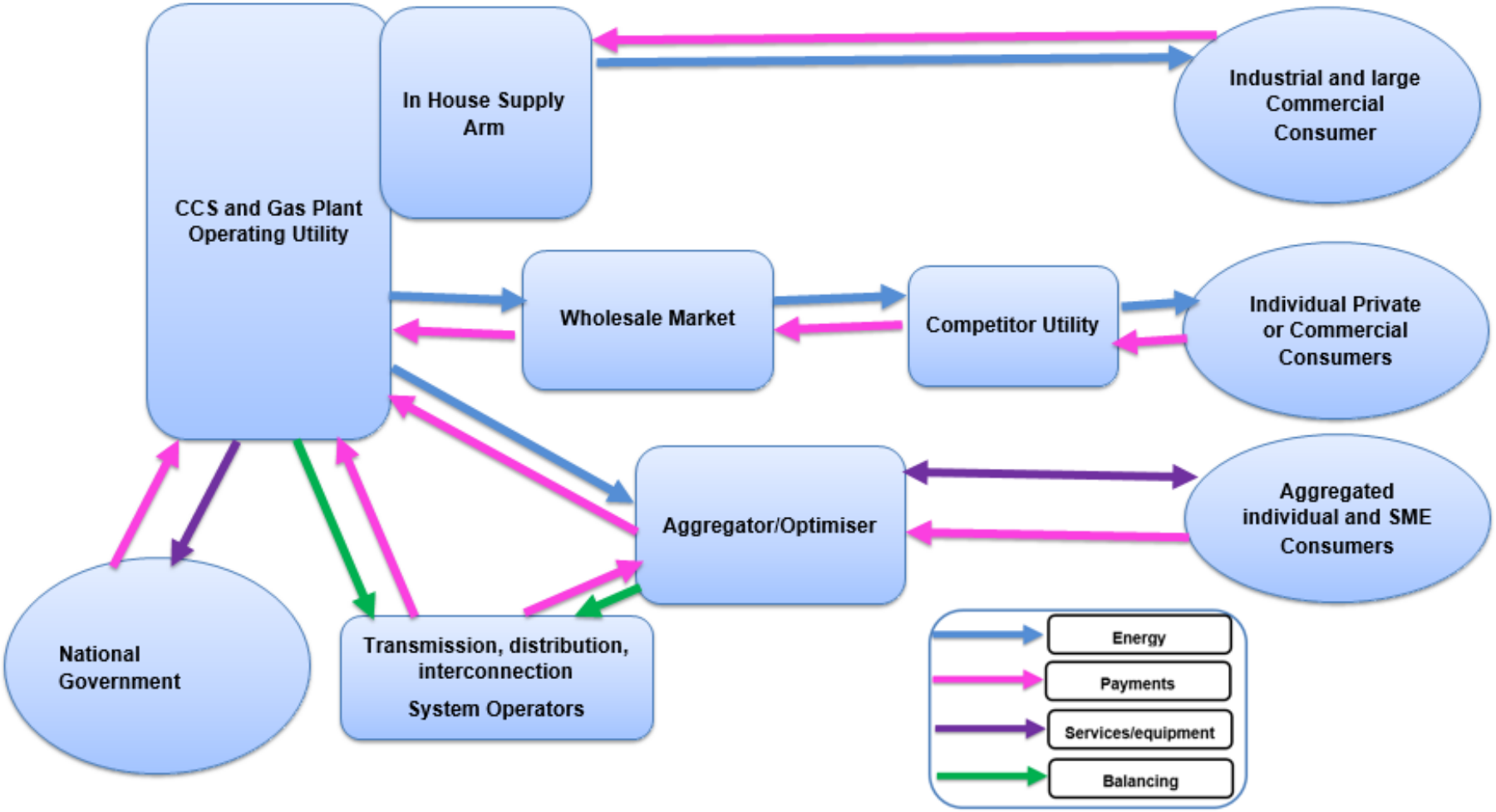
- Business Archetype Model generation workshop
- Stress Testing of Archetypes:
  - Investment and Value Pool
  - Regulation and Markets
  - Technology
  - Users / Consumers

➢**Interim findings**

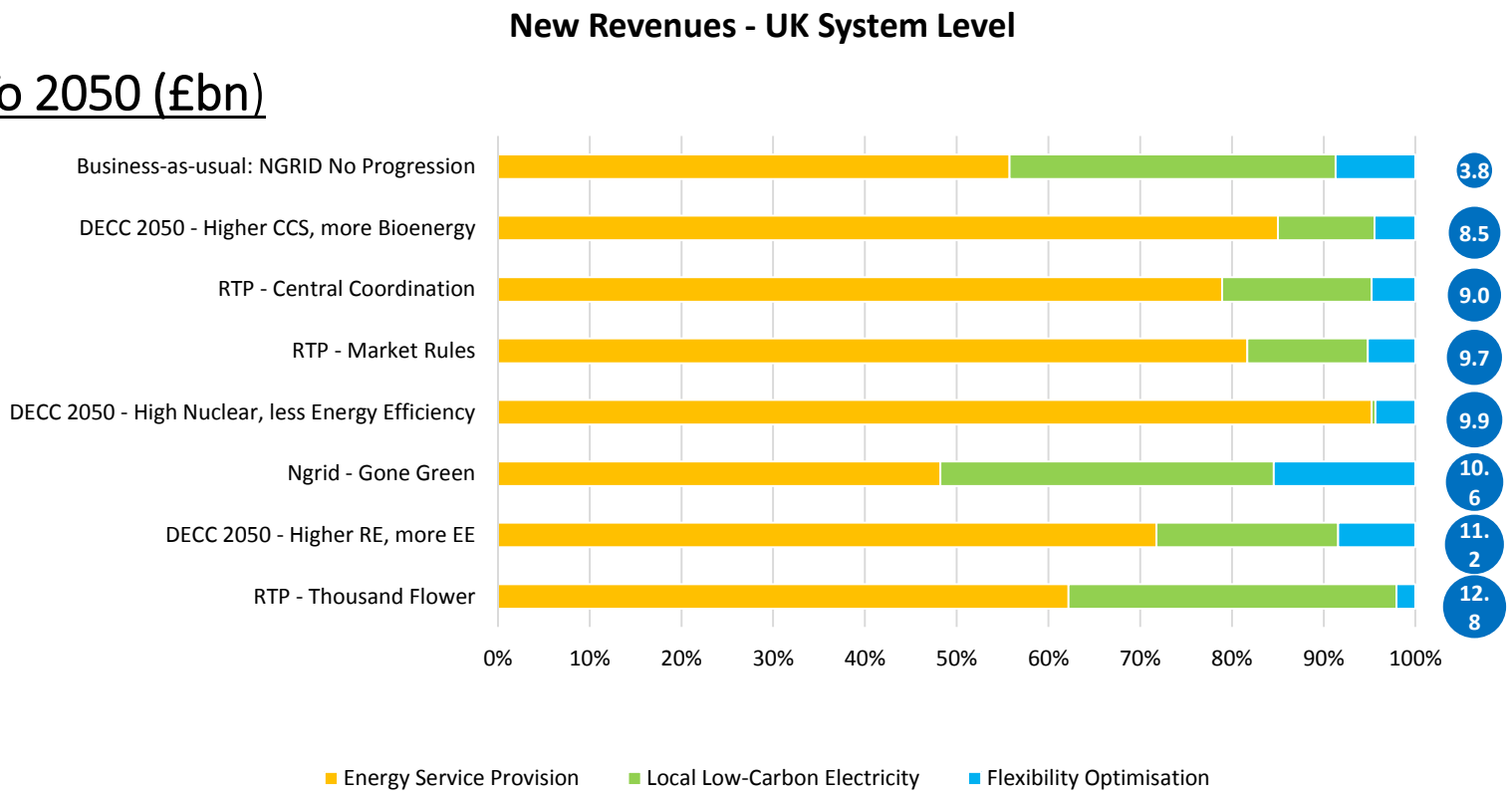
Impacts

- One of the first quantitative assessment of the business opportunities presented in plausible future energy systems:
  - Regulatory and Market implications; and
  - Technological development needed.
- Informing ESC-IET Future Power System Architecture and Ofgem activity.

Low Carbon Transmission Capacity Provider



New Revenues - UK System Level



Energy Service Provision: EE Installations, Home Energy Management Systems, Electric Vehicle Services
Local Low-Carbon Electricity: Prosumer Services, Platform Services
Flexibility Optimisation: DSR (domestic & non-domestic), Battery Storage

Interim Key Messages

- Substantial market and cost saving opportunities £5 to 24 Bn;
- To deliver large scale, capital intensive innovation, changes to wholesale a*nd* retail markets are needed.
- All technologies identified proven through a demonstrator.
- User behaviour change is significant in archetypes where the relationship with energy changes and/or where there are control and trust issues.

Phase 2 plans

Forthcoming (with £6,000 budget uplift):

- Additional investment analysis
- Societal Survey - to understand how different services valued

Work Package #2: Scoping stakeholder adaptations.

- Decision Theatres with key partners to define critical messages on Investment, market operation, and commercial transition.

Work Package #3: Structural responses.

- Adaptive pathways across three stakeholder sectors:
  (1) Government and Policy;
  (2) Industry participants; and
  (3) Finance and Investment.

➢ **Empirical Report and Academic Output**

➢ **Launch**

WP 2 Decision Theatres

- Run by Dr **Steven Hall** and Dr **Mark Powell** across three audiences

- Convenors:
  - Policy and Regulator - **Jeff Hardy** and **Karen Mayor**
  - Incumbents - **David Ball** and John McElroy (TBC'd) w. **Stephen Schofield** to be run at Shell Centre
  - Finance - **David Casale** and **Andy Buglass**

Each decision theatre must decide on 6 headline messages to send to the other two decision theatre groups, regarding their needs in the Utility 2050 future.

Phase 2 - Impacts

- One of 1st attempts at detailed assessment of impact on user groups and their representative valuation of energy services;
- One of 1st detailed assessment of response to business opportunities for different communities (1) investment (2) policy and regulation; and (3) present utilities;
- Continued collaboration with ESC-IET Future Power System Architecture project;
- Strategic Dialogue development amongst different stakeholders; and
- Possible ongoing role for project.

What Insights will this project provide

- **Policy Makers and Regulators**
  - Types of business models that might evolve - how regulation and policy be better designed to encourage positive system benefits;
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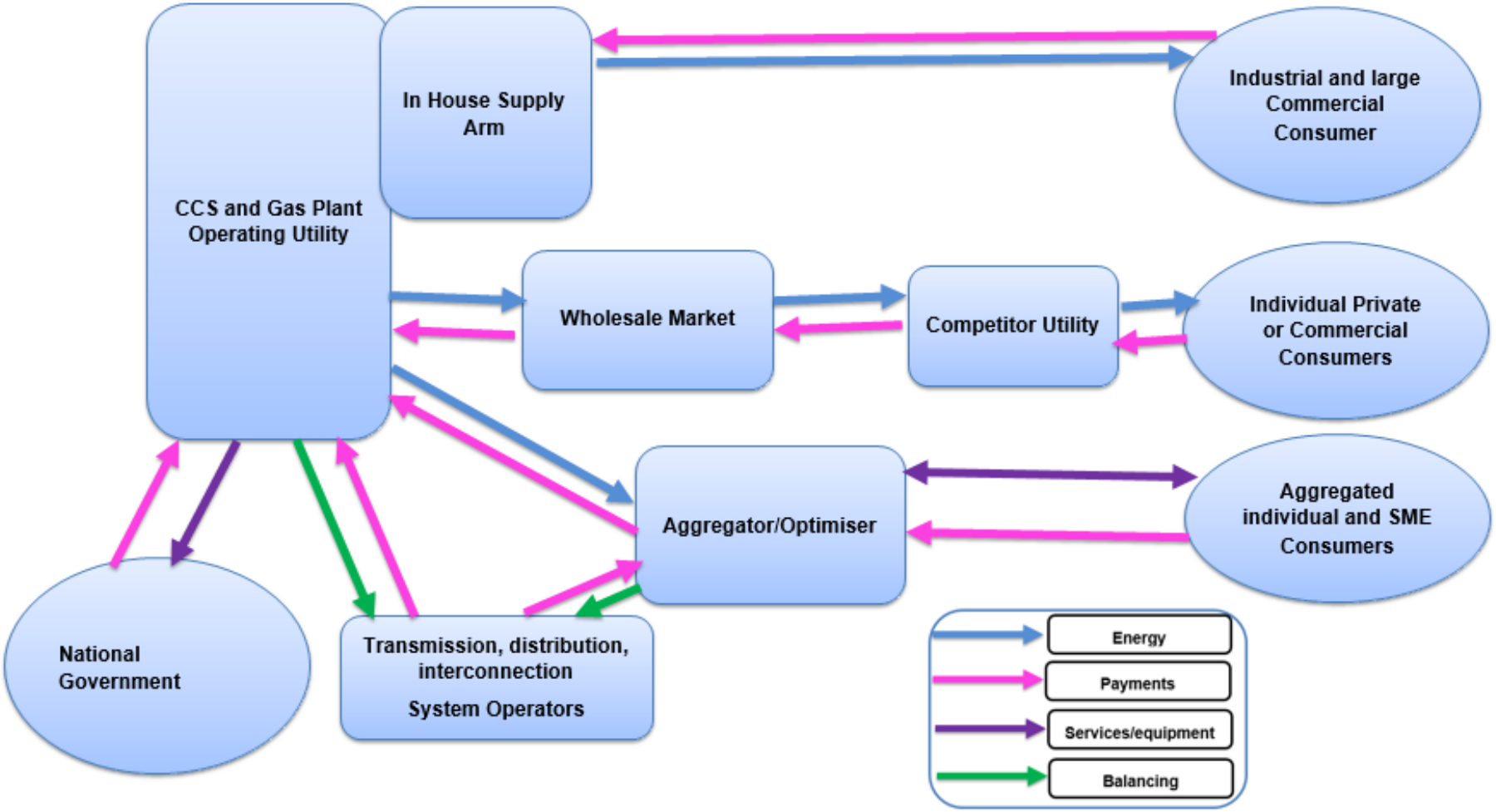
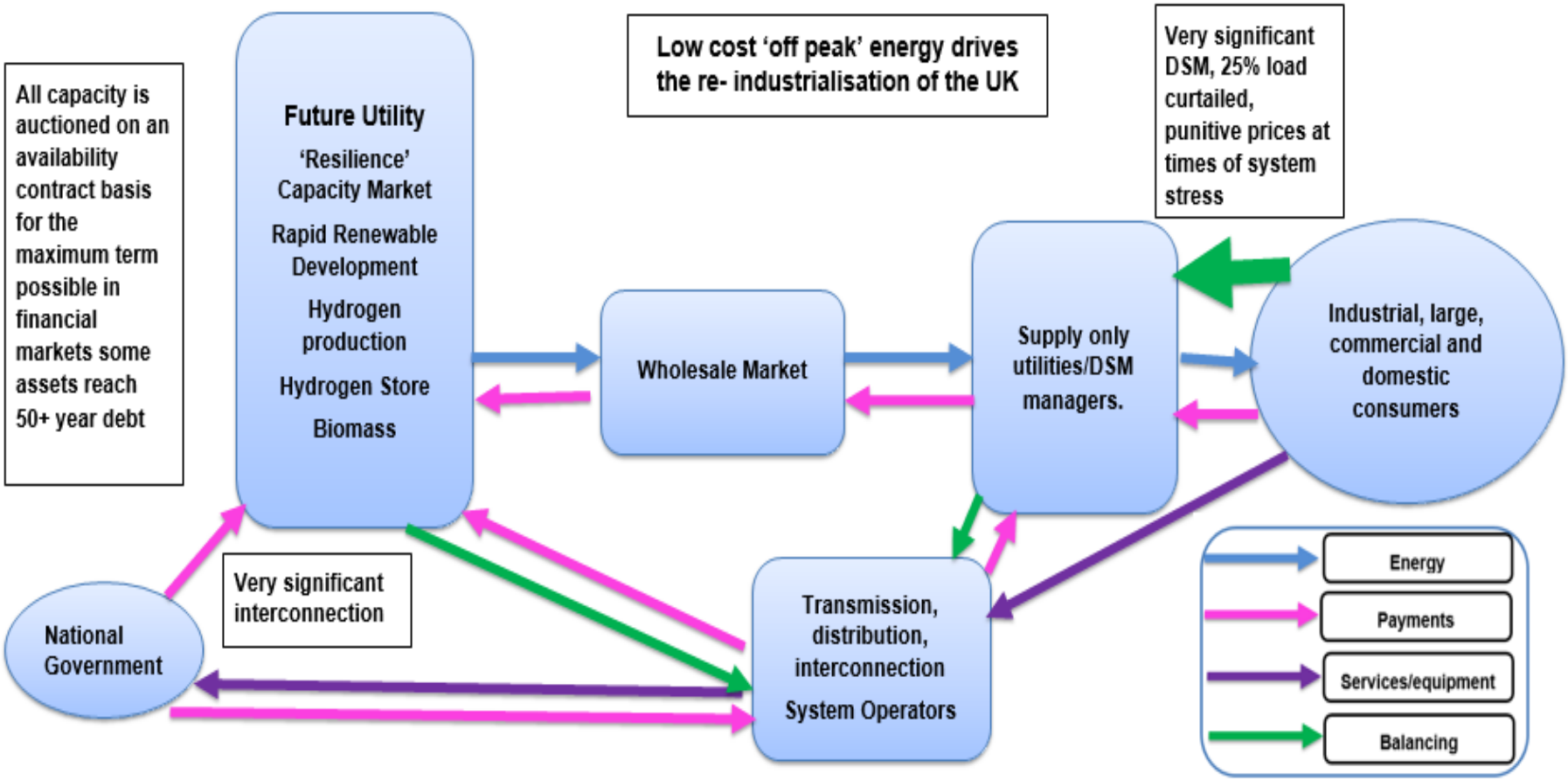
Annexes

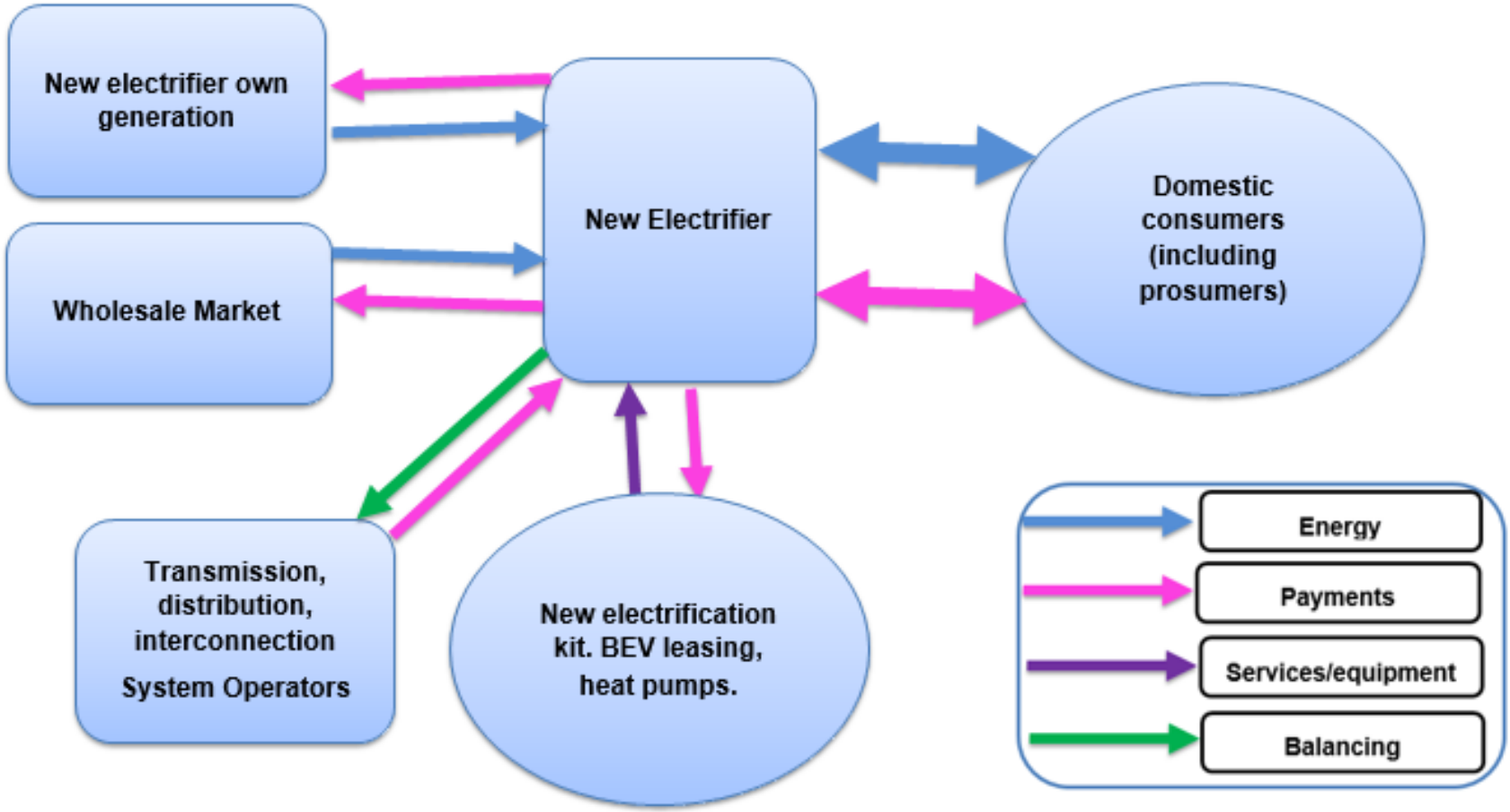
Low Carbon Transmission Capacity Provider



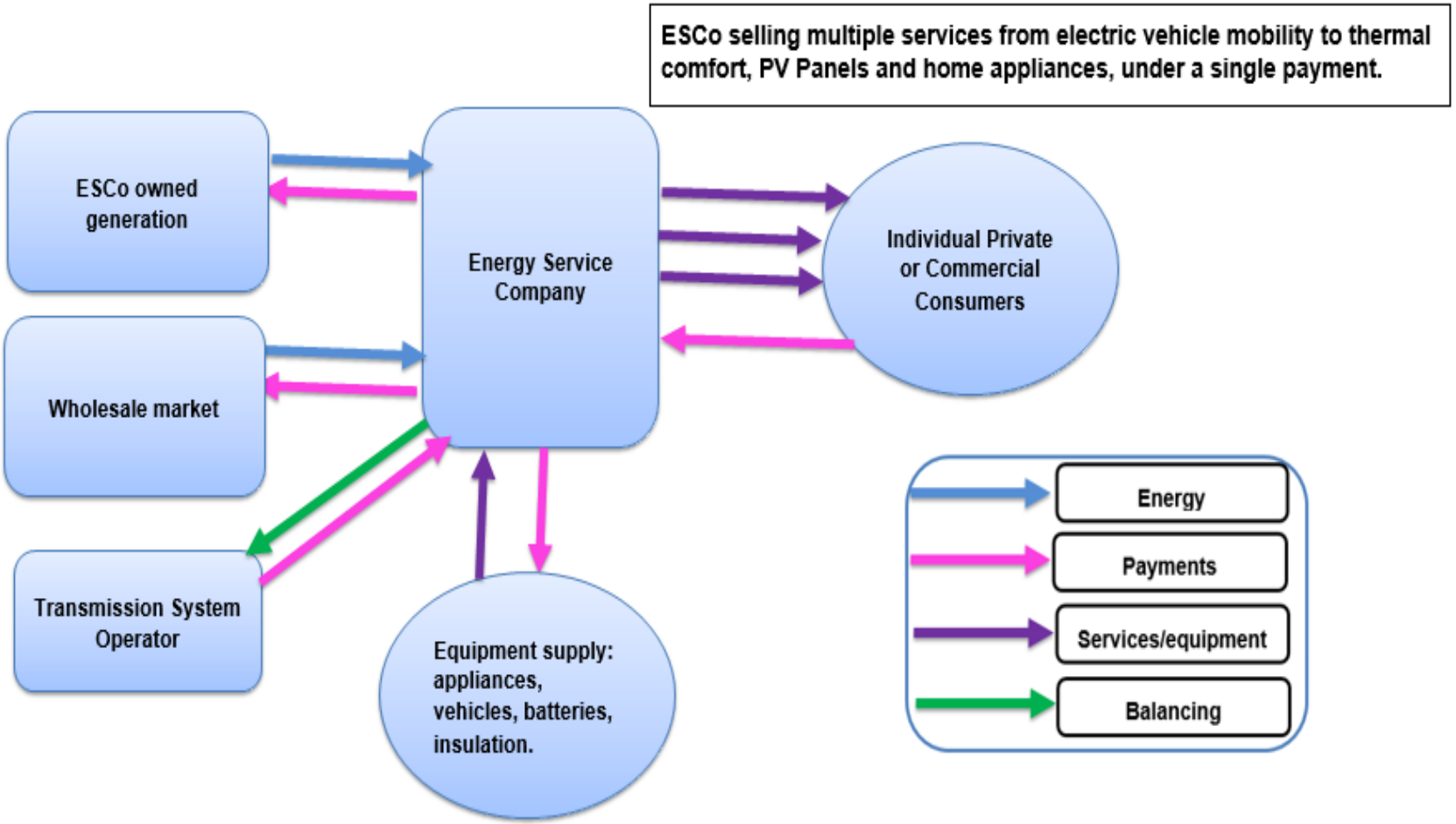
Abundant System



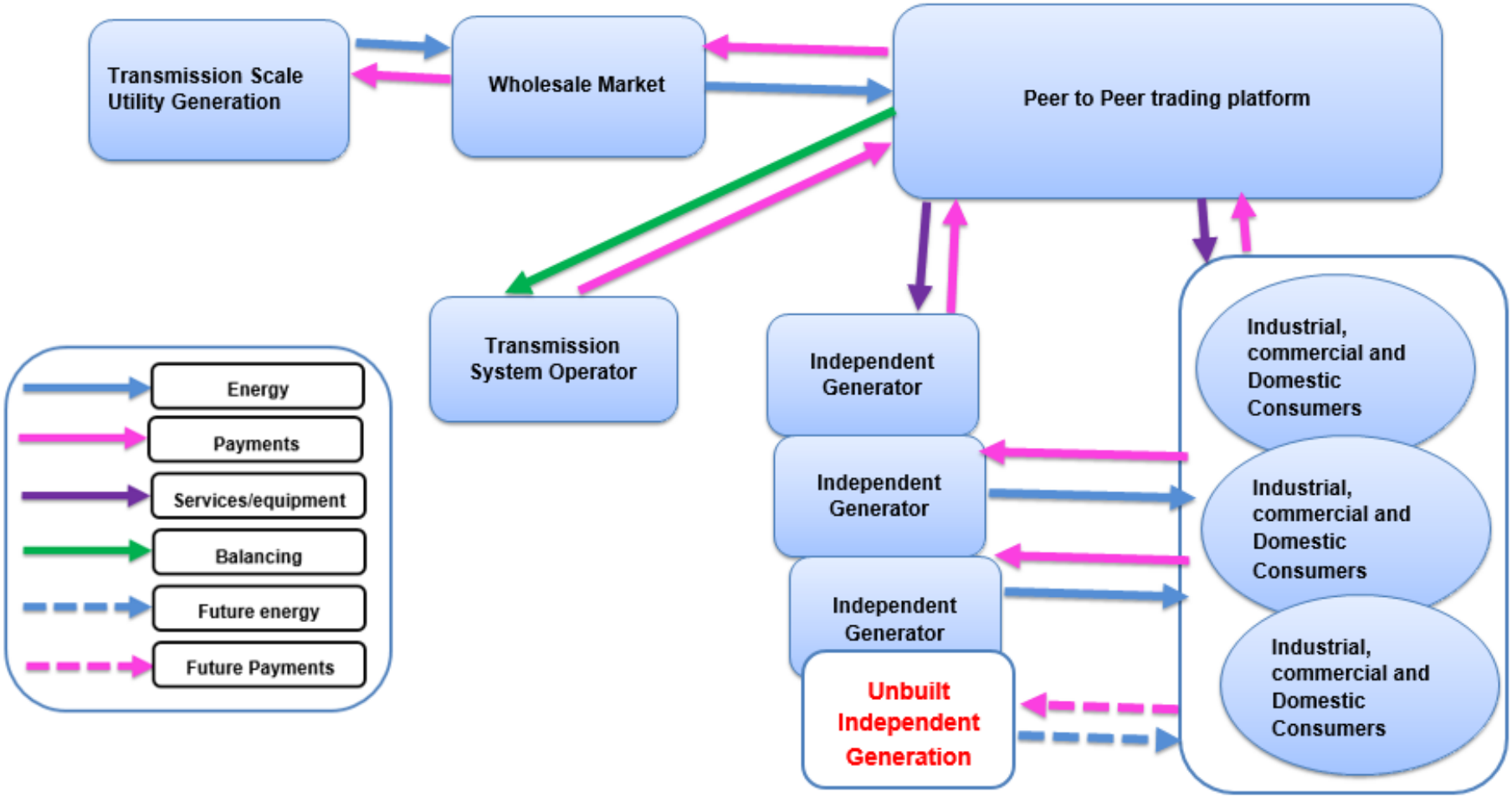
New Electrifier



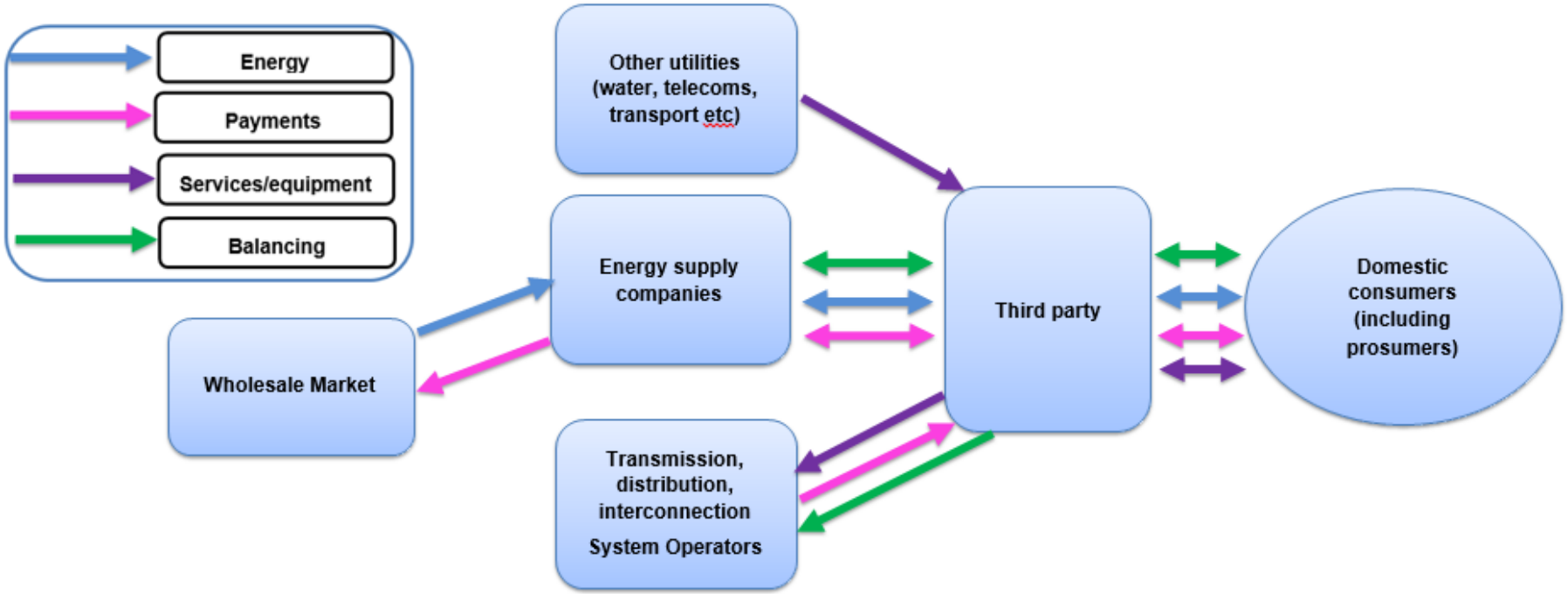
Serviced home and mobility



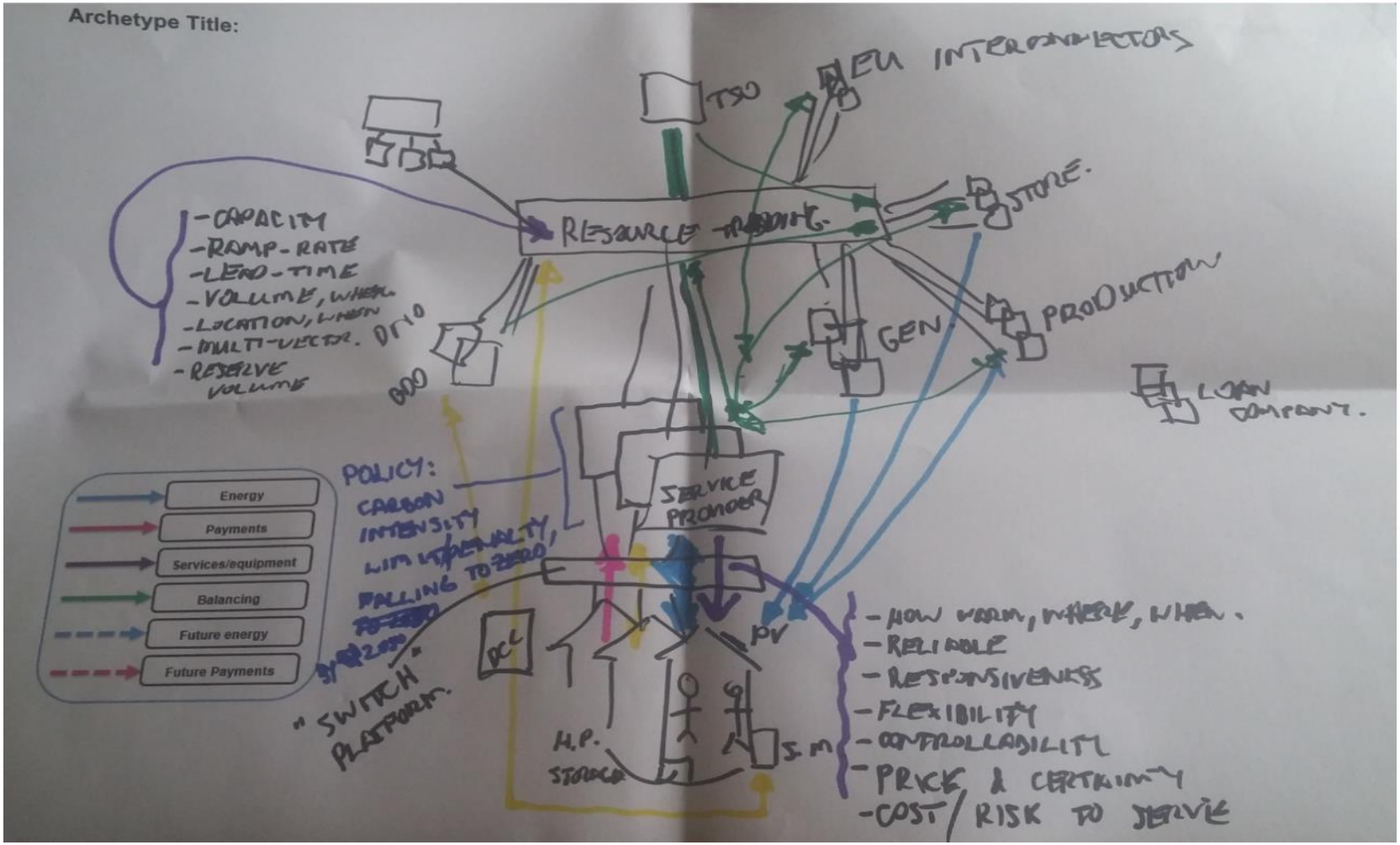
Peer to Peer 2.0



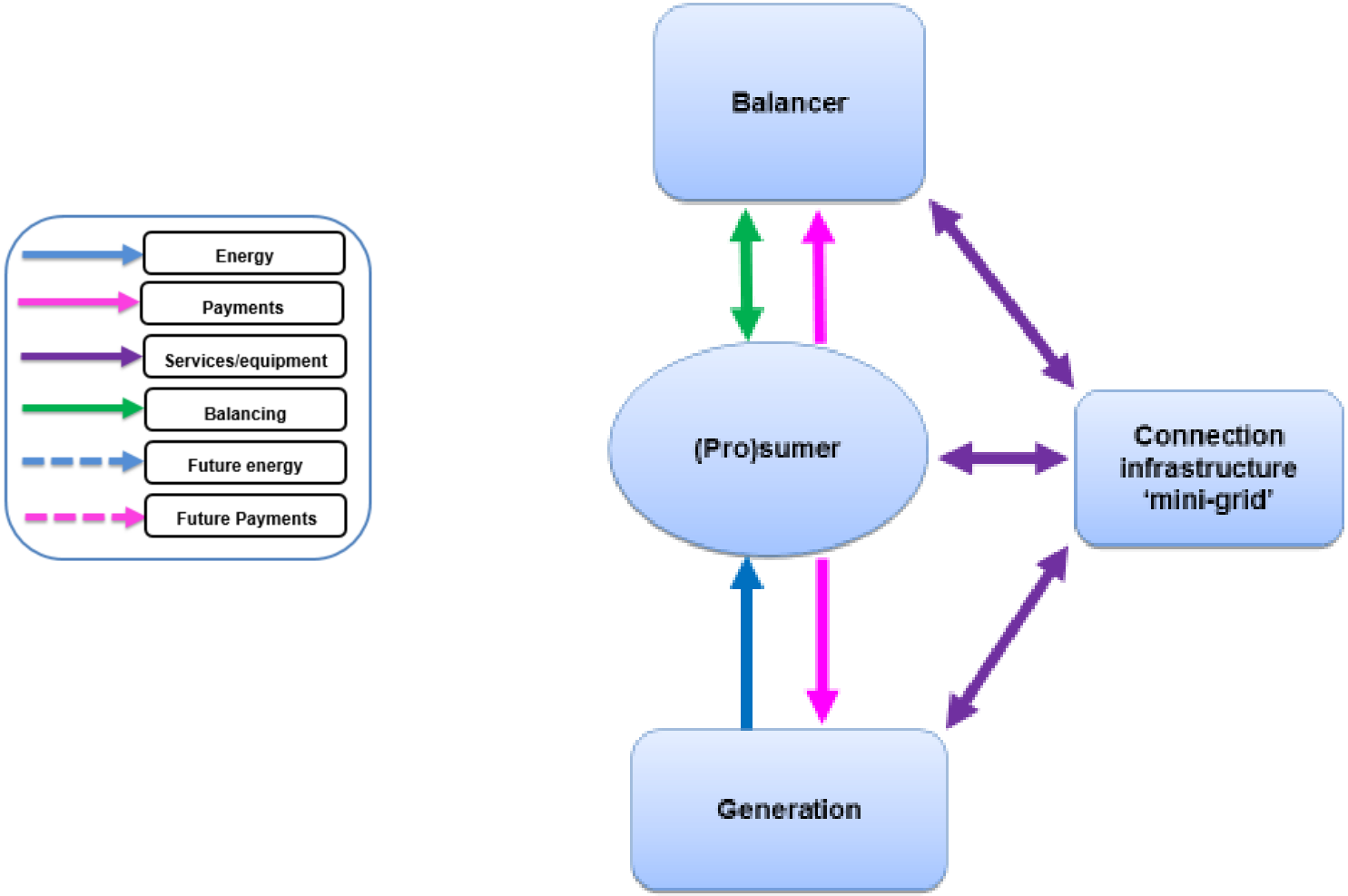
Third Party Control



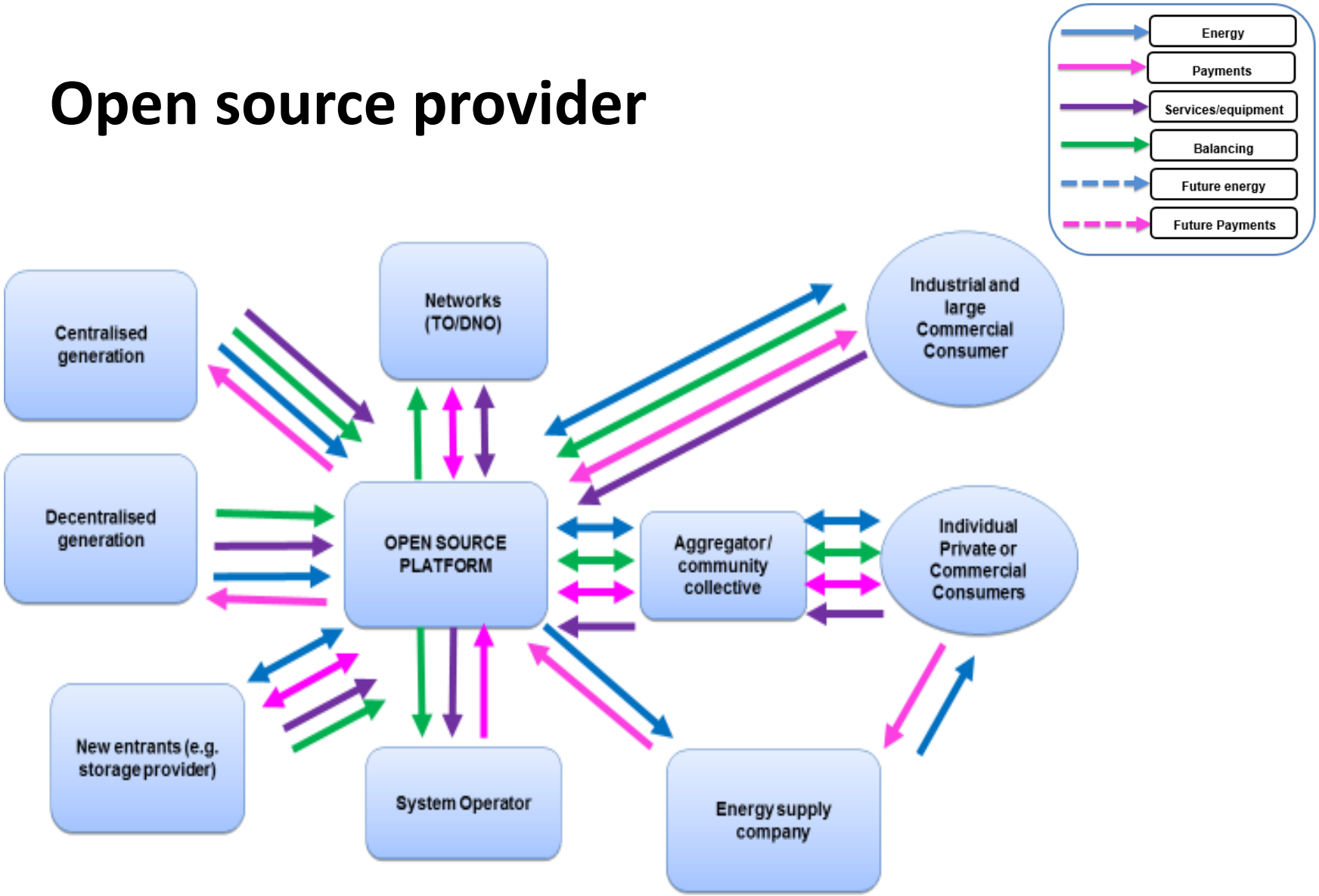
Holistic Provider



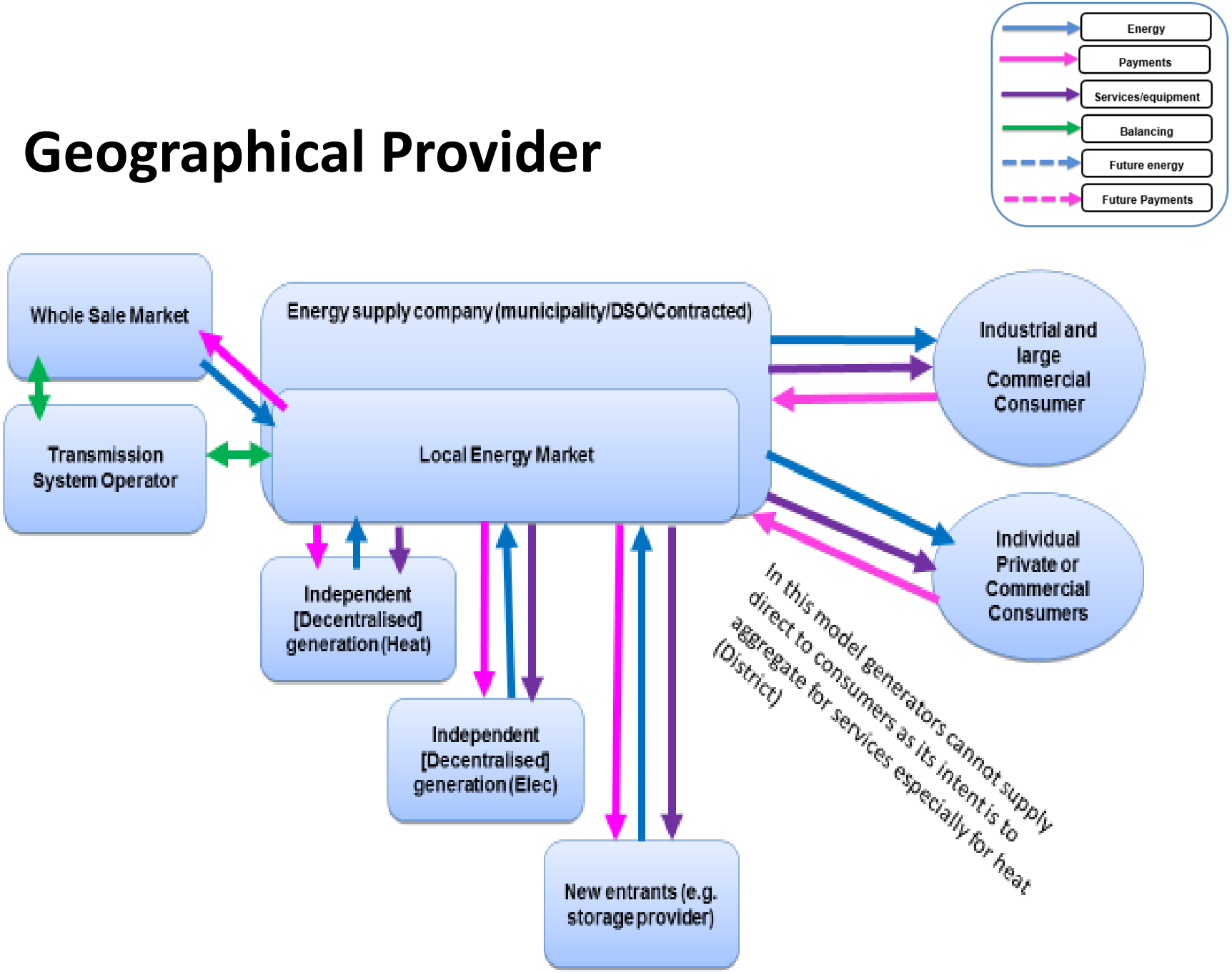
Grid defection



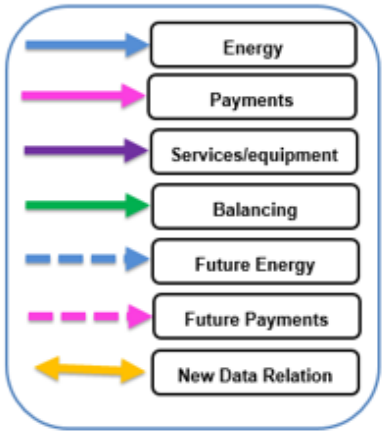
Open source provider

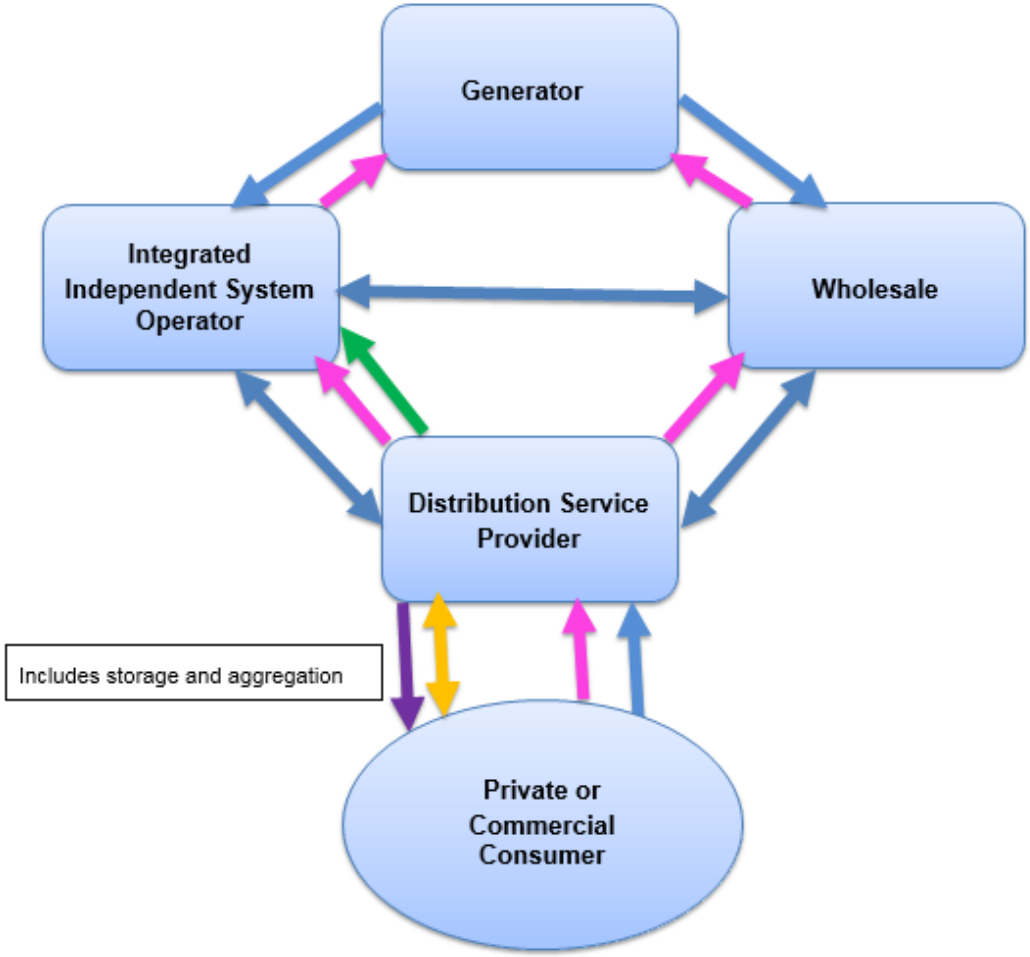


Geographical Provider



Distribution Service Provider

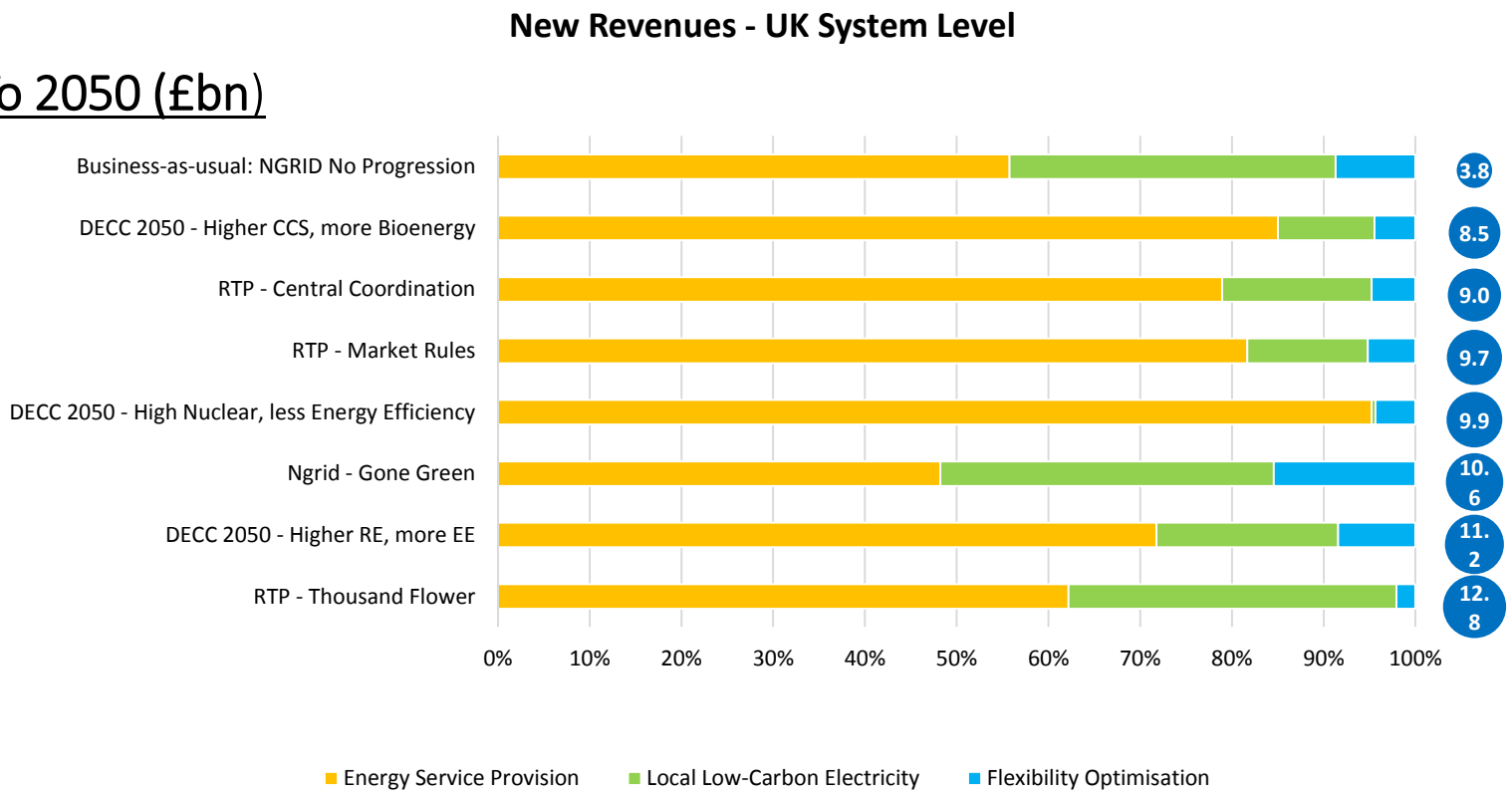




1. Investment and Value Pools: £5 to 24Bn

- Electric utilities can access new revenues streams in the order **£4 - 13bn** in 2050 across the suite of seven scenarios.
- **£1 - 11bn** in cost savings are available by 2050.
- Large scale, capital intensive energy innovation is extremely challenging under a marginal cost pricing approach; particularly in high renewables futures.

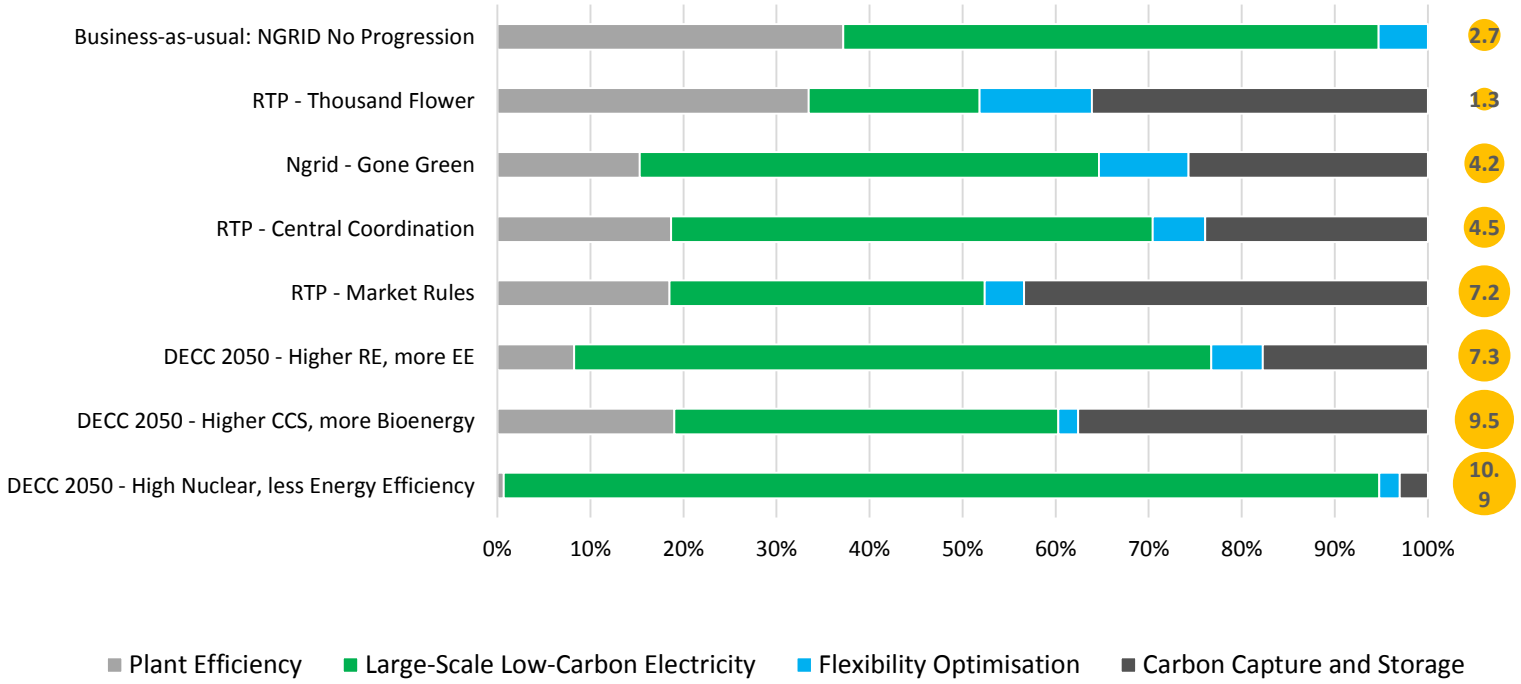
New Revenues - UK System Level



Energy Service Provision: EE Installations, Home Energy Management Systems, Electric Vehicle Services
Local Low-Carbon Electricity: Prosumer Services, Platform Services
Flexibility Optimisation: DSR (domestic & non-domestic), Battery Storage

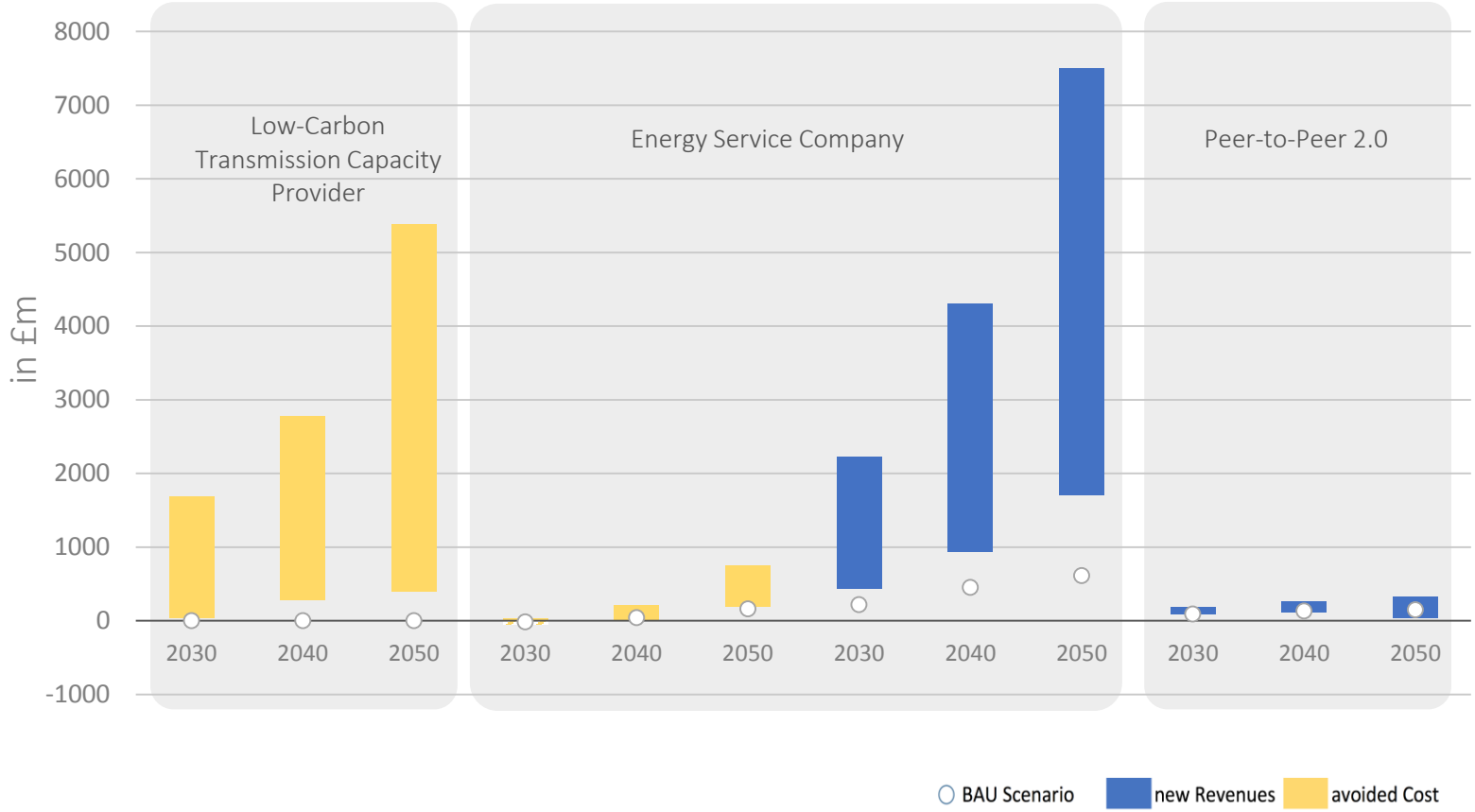
Avoided Costs – UK System Level

To 2050 (£bn)

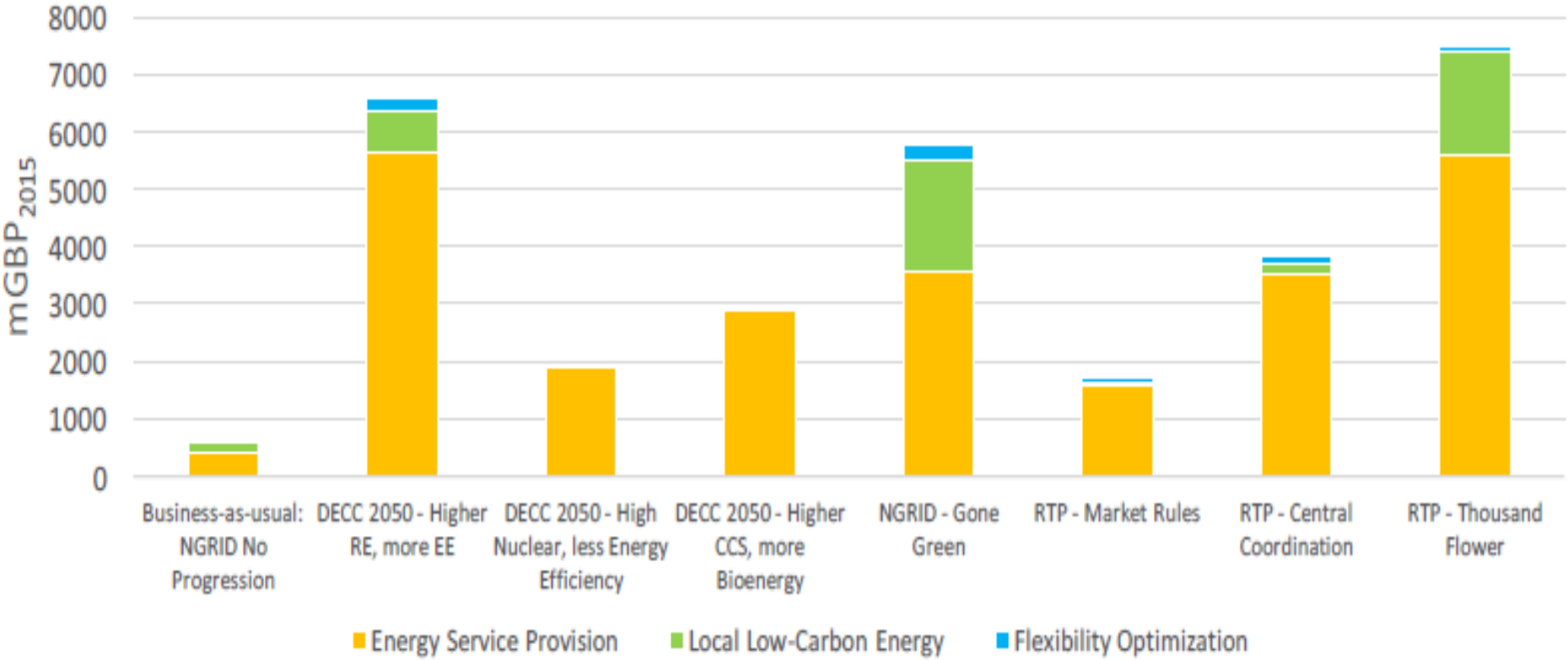


Plant Efficiency: OPEX Reductions and Carbon Avoidance
Large-Scale Low-Carbon Electricity: Carbon Avoidance and Cost Reductions Low-Carbon Technologies
Flexibility Optimisation: Energy Arbitrage from DSR (domestic & non-domestic)
Carbon Capture and Storage: Carbon Avoidance

Matching to Archetypes



ESCo Business Model Archetype - composition of new revenues by different value pools for each scenario in 2050



Regulation and Markets

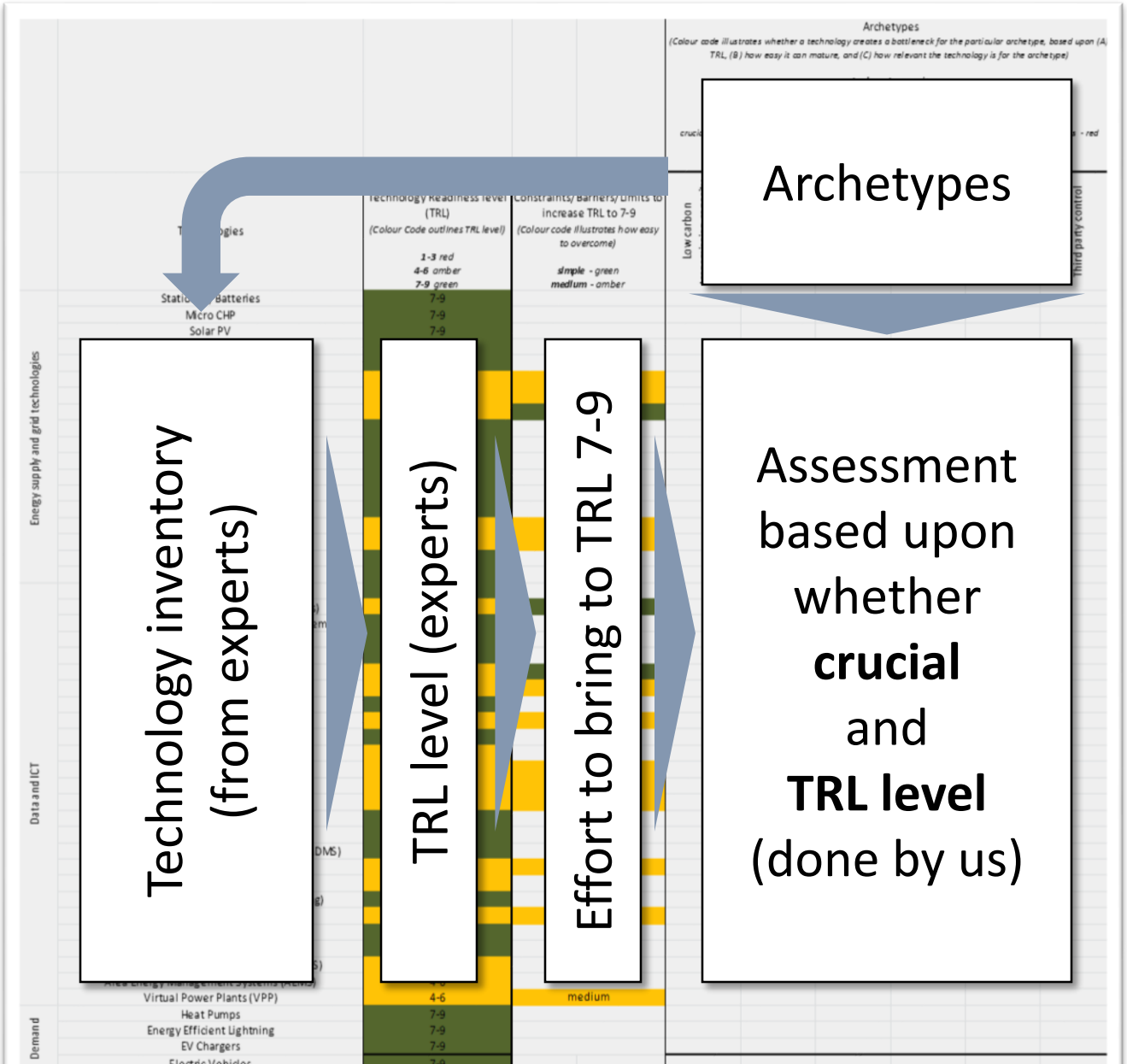
To deliver large scale, capital intensive innovation, changes to wholesale a*nd* retail markets are needed:

- The only way to persist with a disaggregated wholesale and retail market without massive wholesale volatility is:
  - For Government to continue non-energy payments, i.e. CfD's, FiTS, Capacity Markets, OR Central Buyer; and
  - To capture longer term new load one needs longer term contracts for Evs and electrified heating.
- The only way to get government out of building capacity is to link new capacity more closely to retail load, however 28 day consumer switching disables some key opportunities to link new load to new plant.

Technology stress test approach

1. Analysis of archetypes and the outcome of the workshop to derive Technology Inventory with technologies that are necessary to enable these archetypes.
2. Outline how crucial these technologies are for each archetype
3. Review of these archetypes by project team
   - Added technologies we believe are relevant
   - First internal selection of TRL levels, and how difficult it is to overcome these based upon own expertise
4. Prefilled version send out to experts in this field to assess
   - Whether technologies have been left out
   - Whether the right TRL levels have been assigned
   - Whether the right effort to overcome these has been assigned
5. In the last step we identify whether there are technologies that can be of concern for an archetype

Technology stress test



Technology: Archetype inventory

Stationary Batteries
Micro CHP
Solar PV
Solar Thermal
Heat Storage
Fuel Cells
CCS
Synthetic Fuels
District Heat Networks
Gas Fired Power plants
Interconnection
Nuclear
Wind
Biomass supply chain
Hydrogen Storage
Hydrogen infrastructure
Combined Heat and Power (CHP)
DC
Smart Meter Technologies
HEMS (Home Energy Management Systems)
BEMS (Building and Energy Management Systems)
Demand Side Response
Sensors (IoT)
Vehicle Comms (V2G)

Communication for Wholesale market
Cyber security
Blockchain
Peer-to-peer communication
Smart appliances
Reactive Power Control
Local Network Balanacing
Peer-to-peer trading agents
Market / Trading platform
Trading Optimisation
Advanced Distribution Management System (ADMS)
Machine-Learning
M2M Communications
Common Information Platform (data sharing)
Generation Opimisation
Storage heaters (remote controlled)
Big Data / Data processing and analysis
Factory Energy Management Systems (FEMS)
Area Energy Management Systems (AEMS)
Virtual Power Plants (VPP)
Heat Pumps
Energy Efficient Lightning
EV Chargers
Electric Vehicles

Technology: Results so far and next steps

Preliminary results

In our internal demonstrator and with the input of external experts we have not found any show-stoppers so far. So far the message had been that all of these technologies have been already somewhere demonstrated

Next Steps

The tables are to be finalized and to be send to a number of experts. List to be shared.

Users

- User behaviour change significant when relationship with energy changes and/or where there are control and trust issues

- Abundant system has greatest behaviour change requirements due to expectation on winter flexibility and changing business practices to use ‘free’ energy.

- Long-term contracts and possibility of leased equipment in energy service type models would require a different relationship between service providers and end-users. 3rd party control is an extreme version of this, with significant trust and control issues.

- Under ‘open source’ energy models, 3rd party business models could arise to enable domestic participation, however, those best placed to engage are likely to benefit most. New opportunities and commensurate risks arise for business users.

Introducing the archetypes

ERP held a workshop on 15 June 2016 in which participants discussed drivers of energy system change, peer reviewed a series of archetypes and proposed and explored further archetypes. The four archetypes below combine the characteristics of the range of archetypes discussed.

I am addressing the question: "How much user behaviour change does this archetype require and does it engender that change?"

Energy centralisation

Low-carbon transmission capacity provider

This archetype provides guaranteed low-carbon baseload and flexible response capacity (such as gas and coal with CCS). It is supported by capacity mechanism payments or equivalent. 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 selling to industrial and commercial consumers, the second is selling direct to the wholesale market wholesale and the third is to sell to 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.

Abundant system

This archetype occurs in system where Government, acting as central capacity buyer, has procured a system where 90% of **energy** (eg electricity, heat, transport, etc) is supplied by renewables. As a consequence, for much of the year, energy becomes 'free to use' as wholesale prices are negative- interconnection greatly increases. During the times of plenty, excess power is used to produce and store sufficient hydrogen to meet winter peak load. However, during winter, when renewable resources are low (e.g. the wind isn't blowing) consumers will need to provide significant demand side response (or face very high prices) and load curtailment 'designed in' during periods of supply shortfall, some storage, IoT, active and engaged consumers.

Holistic provider

This archetype provides consumers with energy and (possibly) wider services.

At one extreme, there is a Energy Service Company which provides energy services to customers, such as illumination, thermal comfort hot water, etc. The energy contract could include leased smart home appliances, mobility, energy efficiency audits and measures, storage technology, vehicle infrastructure and microgeneration (solar PV/Thermal) etc.

At another extreme, under a third party control model, the value proposition to offer customers a 'lifestyle package'. Here the 3rd party enters into a contract with a customer to optimise their lifestyle – in essence free reign to take decisions to optimise customers lifestyle across all their utilities (energy, water, communications, mobility, etc).

Open source energy

This represents a myriad of possible archetypes enabled by a system in which all energy transactions are mandated to pass through an open source energy platform. The platform applies at the local and national level. This is in effect a marketplace for wholesale, balancing and ancillary services broker. 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 (either peer-to-peer or 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).

User engagement

How much user behaviour change does this archetype require and does it engender that change?

On RAG analysis, green indicates minimal user behaviour change engendered.

Energy centralisation

Low-carbon transmission capacity provider

- Very little user behaviour change envisaged.
- Possible opportunity for favourable contracts for commercial and industrial users

Abundant system

- Substantial behaviour change envisaged for users.
- Domestic consumers would experience different relationship with energy – demand flexibility is expected - direct load control could be mandated.
- Business users would also need to change behaviour – practices could change to take advantage of 'free' energy.

Service provider

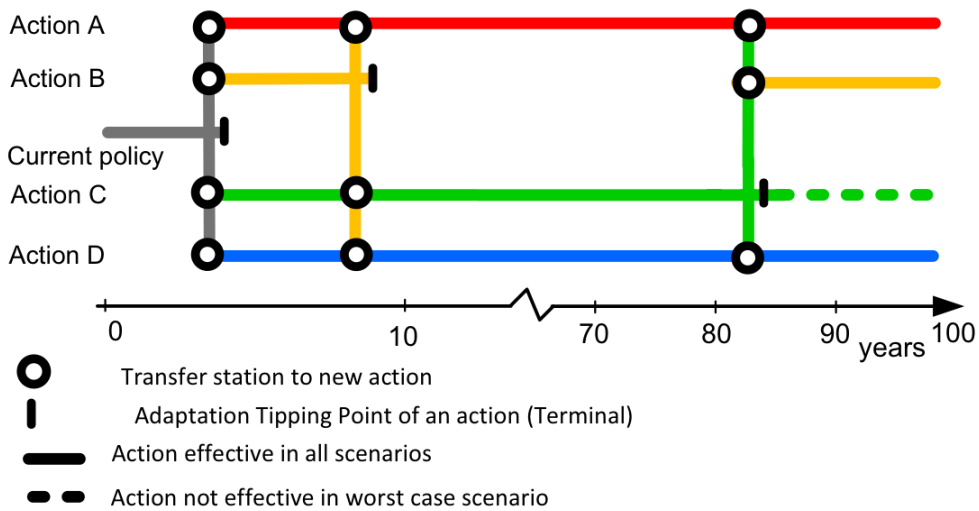
- Predominately a domestic proposition, so little impact on business users, although new business models could arise for business to engage with domestic consumers.
- Consumer acceptance / understanding of ESCo model is key. Longer term contracts are one key aspect of behaviour change.
- For 3rd party control, significant behaviour change is entailed which raises issues over trust and control, particularly for an extreme model where the 3rd party is taking big decisions (for example changing a consumers car).

Open source energy

- Behaviour change envisaged for all users.
- Domestic users behaviour change required depends whether a 3rd party market emerges to engage on consumers' behalf. There is an opportunity for tech savvy consumers (for example a consumer with microgeneration and storage) to engage / benefit (with commensurate risks) more than others who are less able to directly engage.
- Substantial behaviour change envisaged for commercial and industrial consumers, as traditional routes, such as bilateral contracts with generators, would cease. As a consequence there are new opportunities (direct market engagement, P2P, 3rd parties, etc) and commensurate risks.

User engagement

Phase 2 Outputs for Decision Making: e.g. Adaptation Pathways Outputs



Adaptation Pathways Map

	Path actions	Relative Costs	Target effects	Side effects
1		+++	+	0
2		+++++	0	0
3		+++	0	0
4		+++	0	0
5		0	0	-
6		++++	0	-
7		+++	0	-
8		+	+	- - -
9		++	+	- - -

Scorecard for pathways

Fig. 1 An example of an Adaptation Pathways map (*left*) and a scorecard presenting the costs and benefits of the 9 possible pathways presented in the map. In the map, starting from the current situation, targets begin to be missed after four years. Following the grey lines of the current plan, one can see that there are four options. Actions A and D should be able to achieve the targets for the next 100 years in all climate scenarios. If Action B is chosen after the first four years, a tipping point is reached within about five years; a shift to one of the other three actions will then be needed to achieve the targets (*follow the orange lines*). If Action C is chosen after the first four years, a shift to Action A, B, or D will be needed after approximately 85 years in the worst case scenario (*follow the solid green lines*). In all other scenarios, the targets will be achieved for the next 100 years (*the dashed green line*). The colors in the scorecard refer to the actions: **a** (*red*), **b** (*orange*), **c** (*green*), and **d** (*blue*)