Programme Area: Smart Systems and Heat

Project: EnergyPath Operations

Title: EnergyPath Operations – Demonstration Presentation

Abstract:
A working prototype of EnergyPath Operations has been used to test the dynamic operation of elements of an architecture, as a set of detailed business processes across three domains: markets, physical assets, flows of information & control. This presentation was given to the ETI to provide an update at the end of the project on achievements and outputs from the work.

Context:
DNV GL and a partnership between Hitachi & EDF worked independently on a functional specification to develop the first phase of EnergyPath Operations - a software tool that allows designers to better understand the information and communications technology (ICT) solutions they will need to implement to deliver new home heating solutions.
A first version of this tool is now being developed by DNV GL and the Energy Systems Catapult. EnergyPath Operations will provide knowledge to users on how to design ICT systems, the cost implications of such designs and the viability of various systems.
This project compliments the EnergyPath Networks software modelling tool which will be used in the planning of cost effective local energy systems.

EPO demonstration

CATAPULT
Energy Systems

Energy Systems Catapult
June 2018

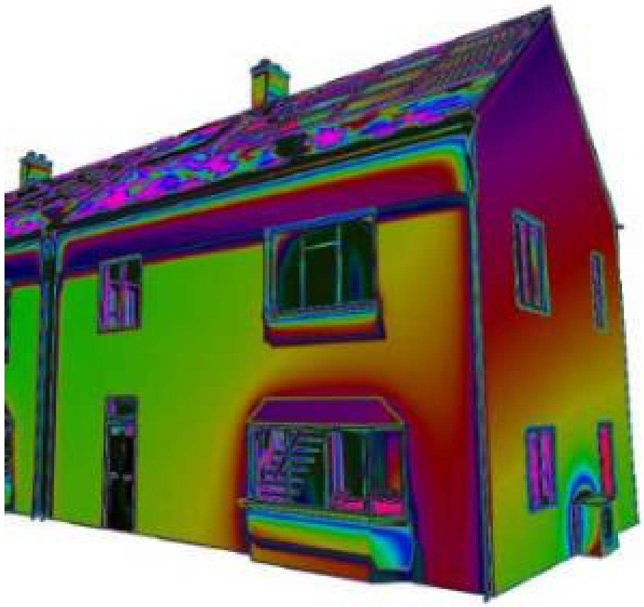
EnergySysCat

LinkedIn

ETI's Smart Systems and Heat Programme

Delivered by CATAPULT Energy Systems

energy technologies institute



"Creating future-proof and economic local heating solutions for the UK"

- Connecting together – the understanding of consumer needs and behaviour with the development and integration of technologies and new business models into…
- Delivering enhanced knowledge amongst industry and public sector
- Resulting in industry and investor confidence to implement from 2020 which enables a UK heat transition

The Energy Systems Catapult will deliver Phase One of the SSH programme as a supplier to the ETI following the transition of the SSH programme team to the Catapult. From 2017 the Catapult will be responsible for delivery of Phase Two of the programme independently of the ETI.

ETI members

bp | Caterpillar | EDF Energy | Rolls-Royce | Shell | Department for Business, Energy & Industrial Strategy | EPSRC Pioneering research and skills | Innovate UK Technology Strategy Board

ETI programme associate

Hitachi Inspire the Next

Welcome

- Housekeeping
- **No Fire Alarms Expected Today**

Agenda

CATAPULT Energy Systems

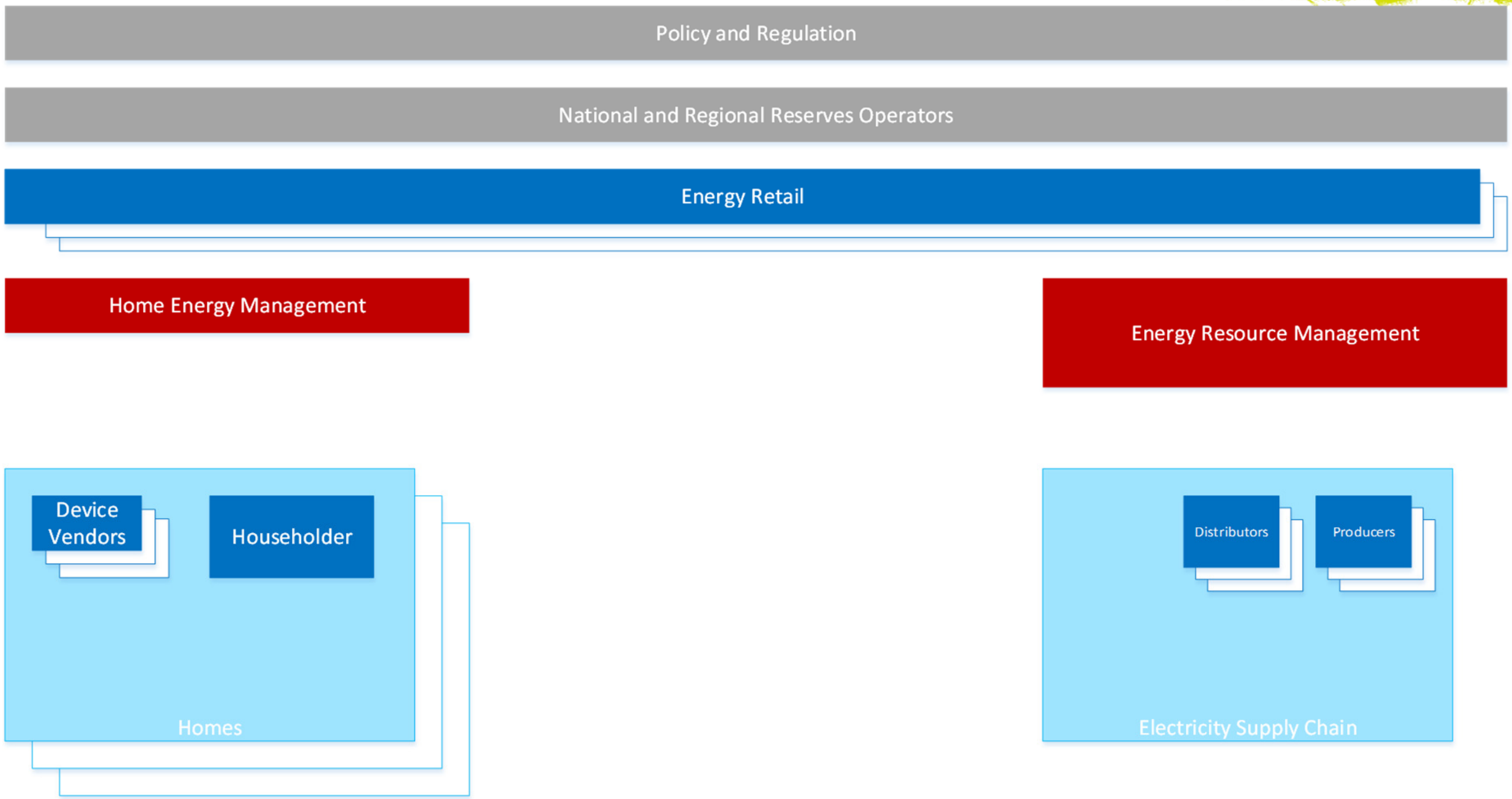
Ref	Time	Agenda Item	Attended by	Lead	Duration
1	12:45	Arrive/welcome/coffee	All	-	15mins
2	13.00	Introductions and HSE	All	RL	5 mins
3	13.05	Demonstration - Outline of problem - Demonstration of EPO - Presentation of analysis - Outline of networks development	All	Project Team	95 mins
4	14.40	Q&A	All	Project Team	20 mins
6	15.00	Close	All	RL	10 mins

TI

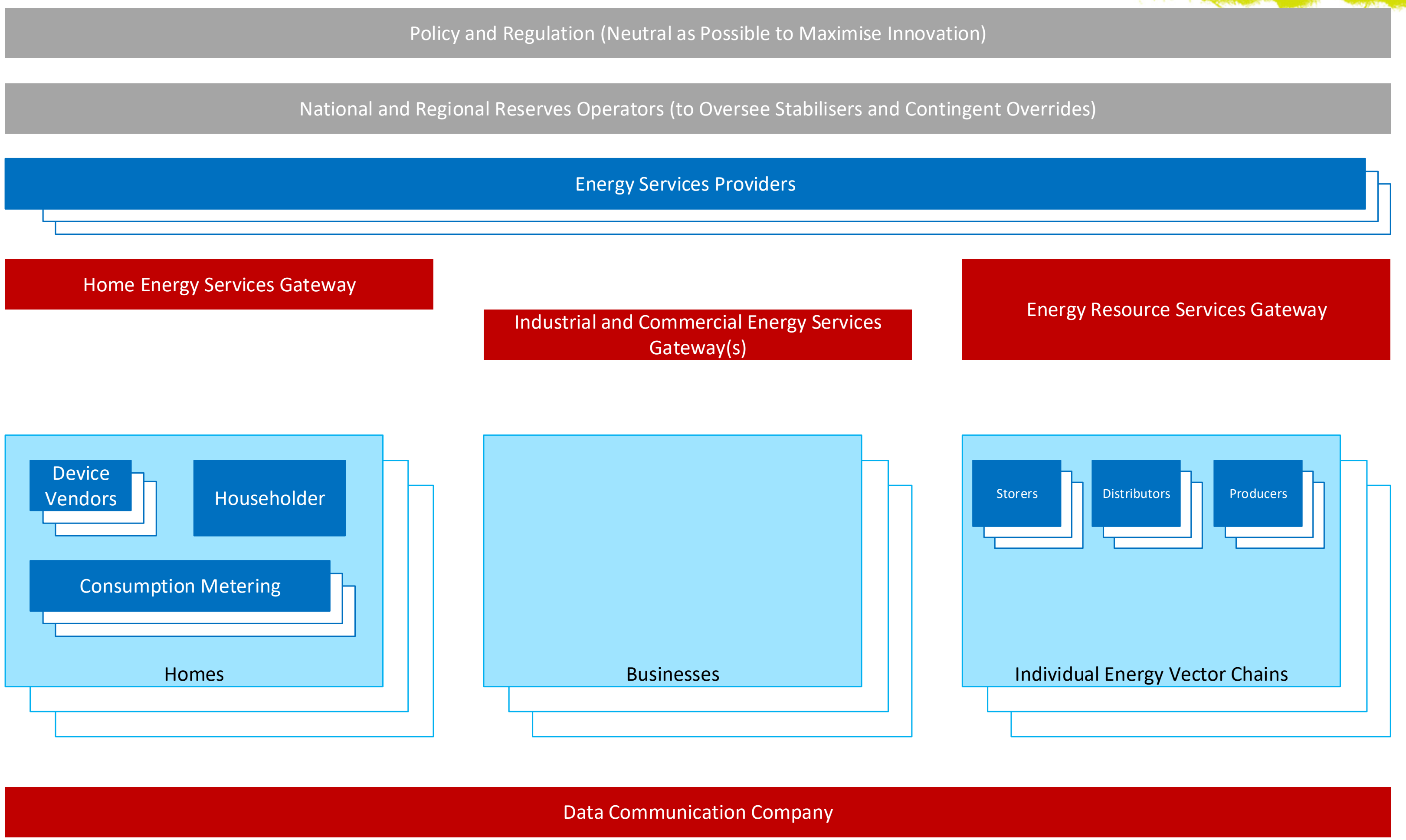
Case Study

- Question: How do you go about installing 100 000 Hybrid Heat Pumps into a city the size roughly the size of Newcastle?
- Answer: Just fit them!
- Except: We all know reasons why you can't – what are they?
- Technology problems aren't high up the list!

Architecture



Conceptual Architecture – Iteratively Developed



-

Risks

	De-risking approach		
	Paper based analysis	Whole systems model	Proto-type and trials
Whether distributed control can close out supply-demand sufficiently closely to manage system frequency, voltage, pressure, etc.		✓	?
Whether sufficient data quality can be obtained to price risk in experience based energy services			✓
Whether a shared service language can be formed to describe experience based energy services			✓
Whether the financial motivations of device vendors and service providers are sufficiently attractive to make it a commercially viable business	✓	✓	?
Whether consumers value the advanced services sufficiently to justify costs			✓
Whether weighting profiles can deliver sufficiently predictable aggregate response of distributed devices		✓	?
Whether energy service providers can build a sufficiently strong balance sheet to be a sufficiently low credit risk for long-term energy resource SLAs	✓		
Whether suitable contingency measures can be implemented, such as frequency responsive devices, to deal with major cyber-security threats		✓	?

-

Thoughts on Architecture vs Design

- Architecture is the plan for the structure of something
- Design is the plan to create something
- Consider Building Architecture ‘vs’ Interior Design

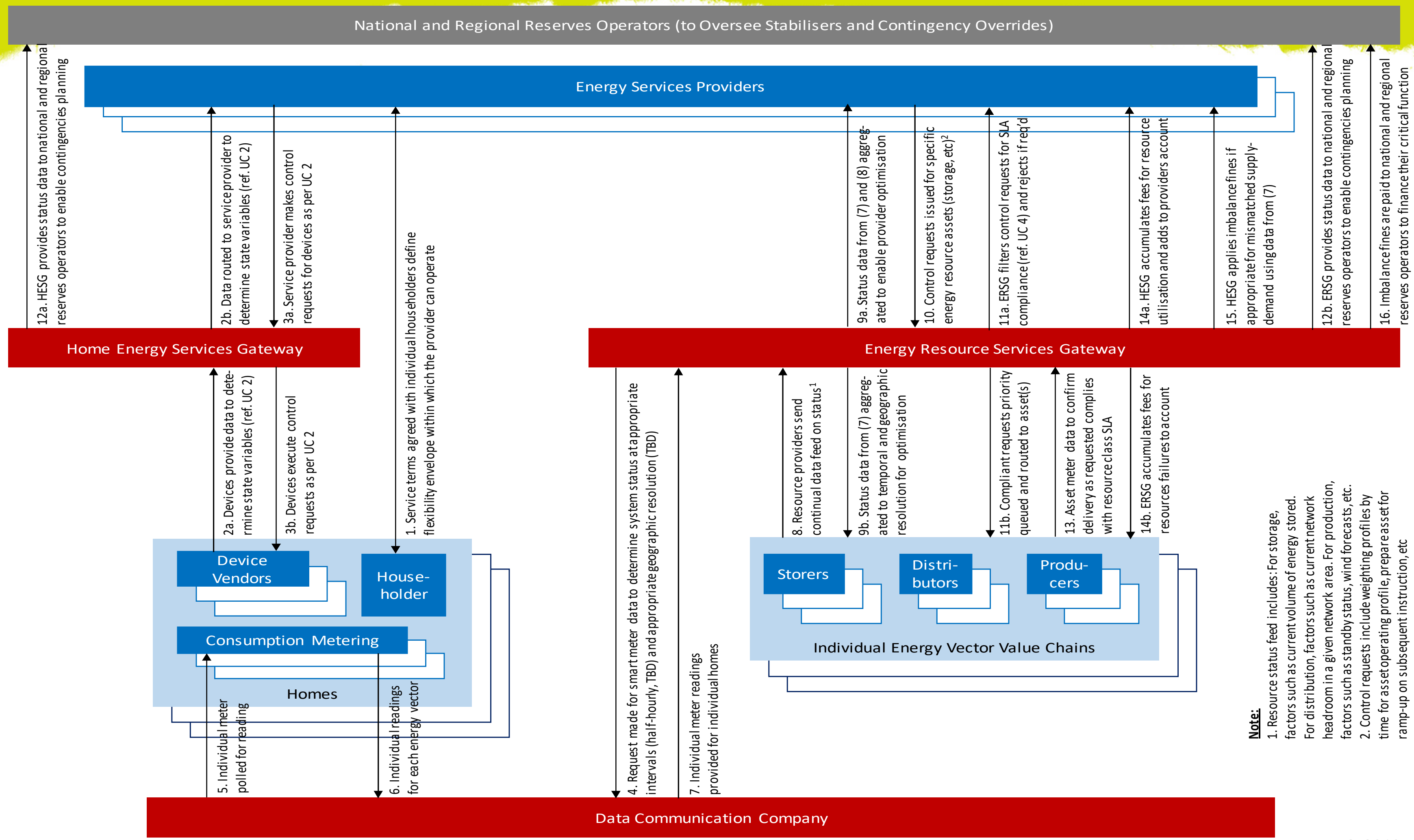
Conceptual Logical Physical

More Abstract More Certain

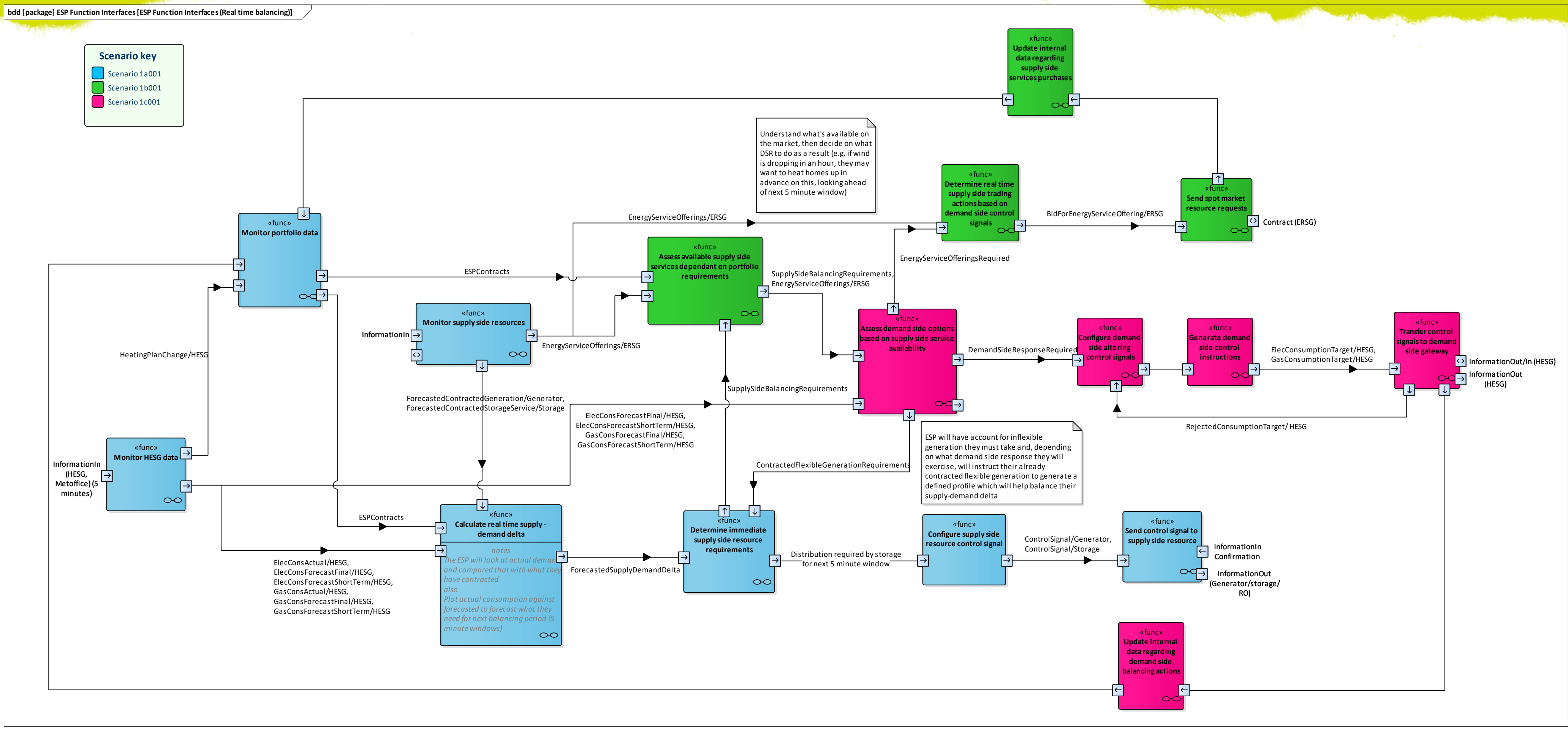
- Working with stakeholders

-

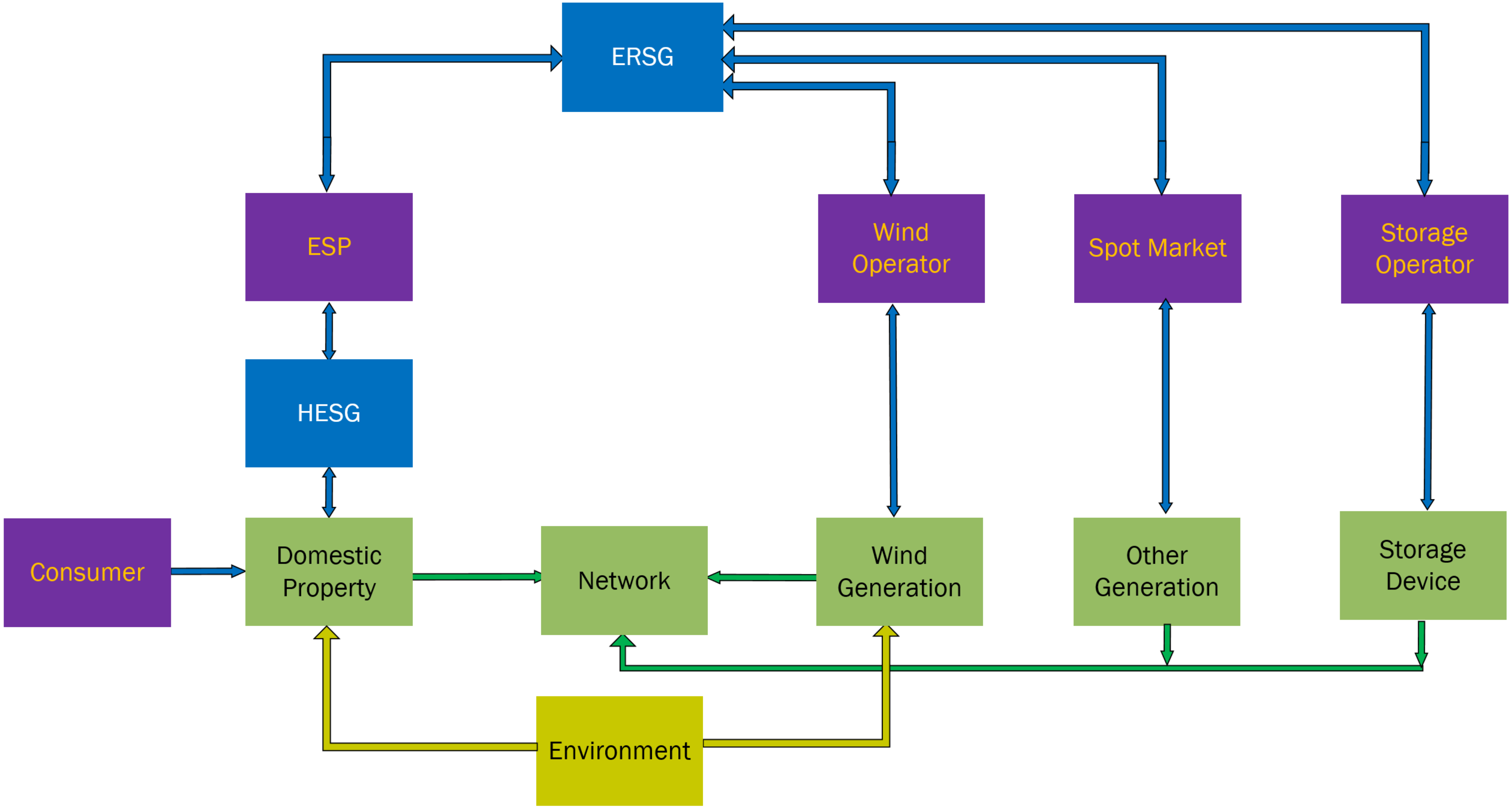
Logical Architecture



Physical Design



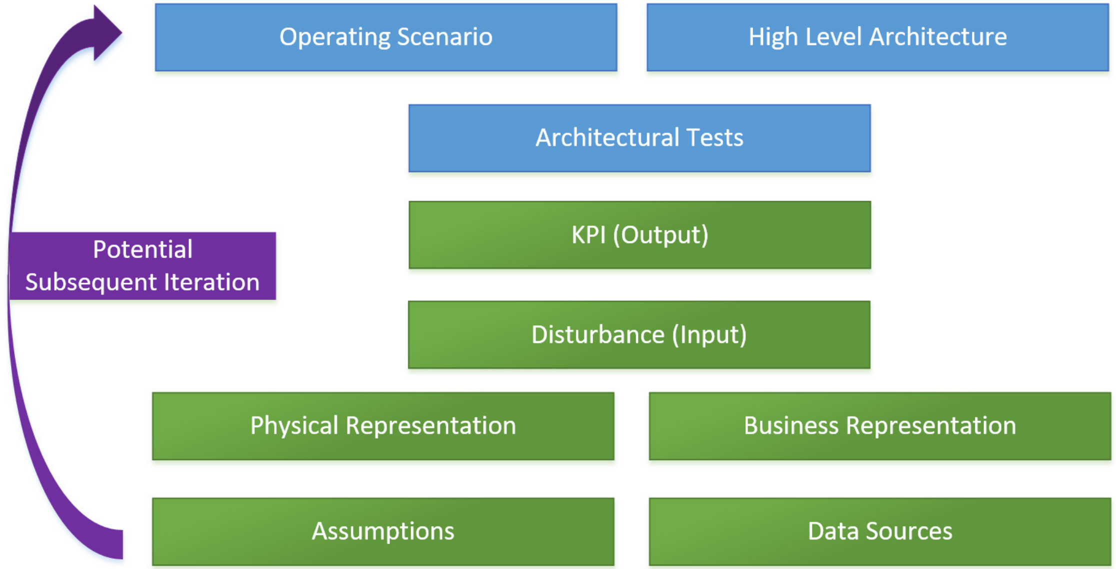
Example Operating Scenario – High Level Architecture



Example Operating Scenario – Propose Analysis

CATAPULT Energy Systems

- Evaluating (KPI):
  - Energy coming from Renewables (Wind)
  - Cost to the ESP of supplying energy (Electricity and Gas)
  - Delta between ESP physical supply and demand
  - Storage capacity required
- Based on:
  - Weather (Wind, Temperature) and Chaotic Occupant Behaviour
- Simulating:
  - Topology – HV Sub from Bridgend (7,484 domestic properties)
  - Variation in – Occupant Behaviour, HHP Allocation
  - Forecasting Metric – Smoothed Actual Demand
- Assuming:
  - Heat losses based on lumped convection and conduction
  - Energy Pricing – Ofgem values (assumed change for future)



Demonstration

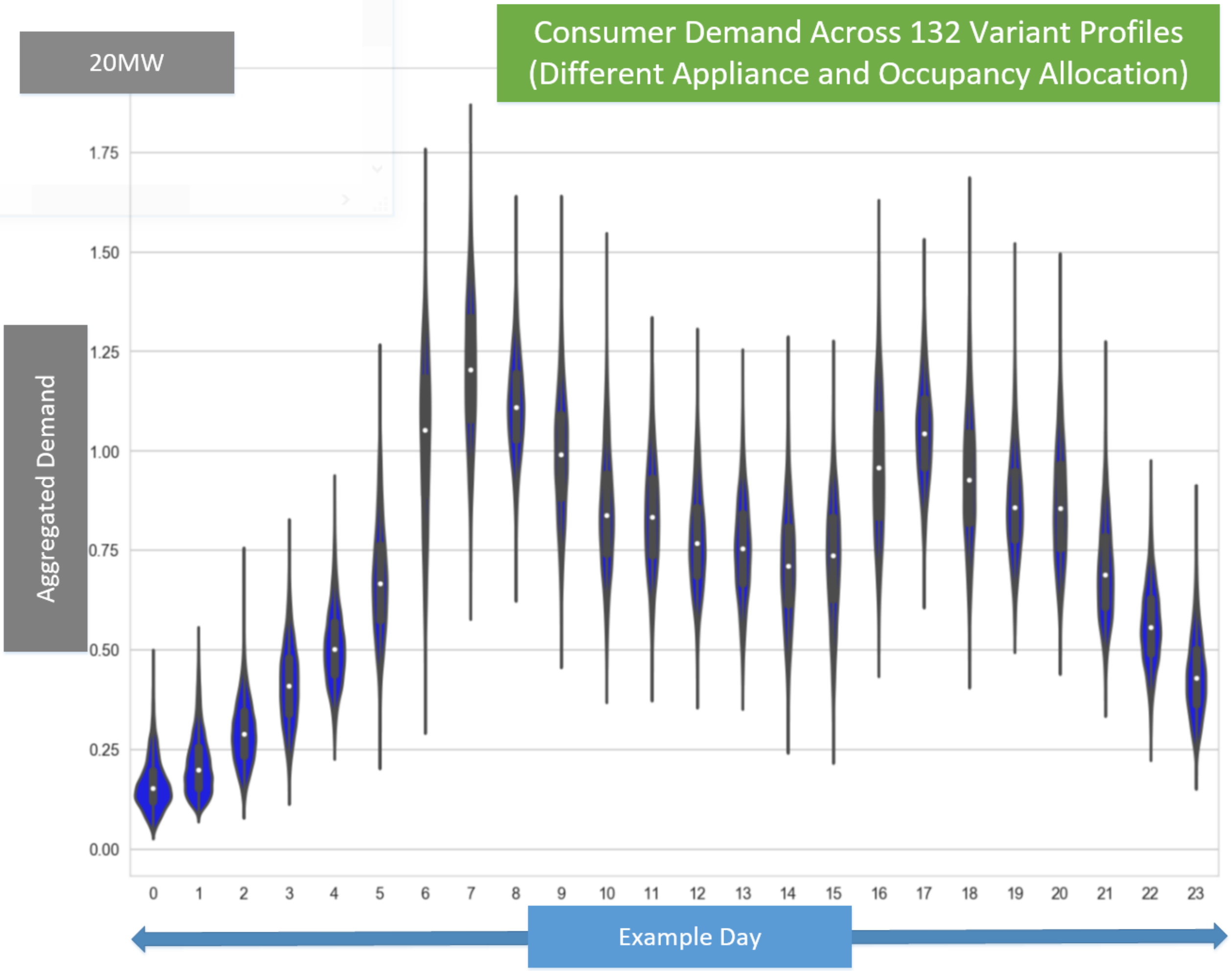
Analysis : Simulation Test Cases

- Impact of Allocation of HHPs / Occupants to Domestic Properties
- Impact of weather over the heating season (Oct – Dec, Jan - Apr)

<table>
<tr><th>Case</th><th>Heating Appliance</th><th>Wind Turbines</th><th>Storage Charge / Discharge Rate</th></tr>
<tr><td>1</td><td>All Gas Heating
100% Combi-Gas Boilers</td><td>2</td><td rowspan="2">Infinite</td></tr>
<tr><td>2a</td><td rowspan="2">Penetration of HHP
70% Combi-Gas Boilers
30% HHP</td><td rowspan="2">4</td></tr>
<tr><td>2b</td><td>10 MW Rate Limit</td></tr>
</table>

- 30% HHP – Double Electricity Consumption – Heating Same Contribution as Background
- Wind Turbines – Generation to Match Demand
- 10 MW Capacity – Charge Maximum Wind Generation

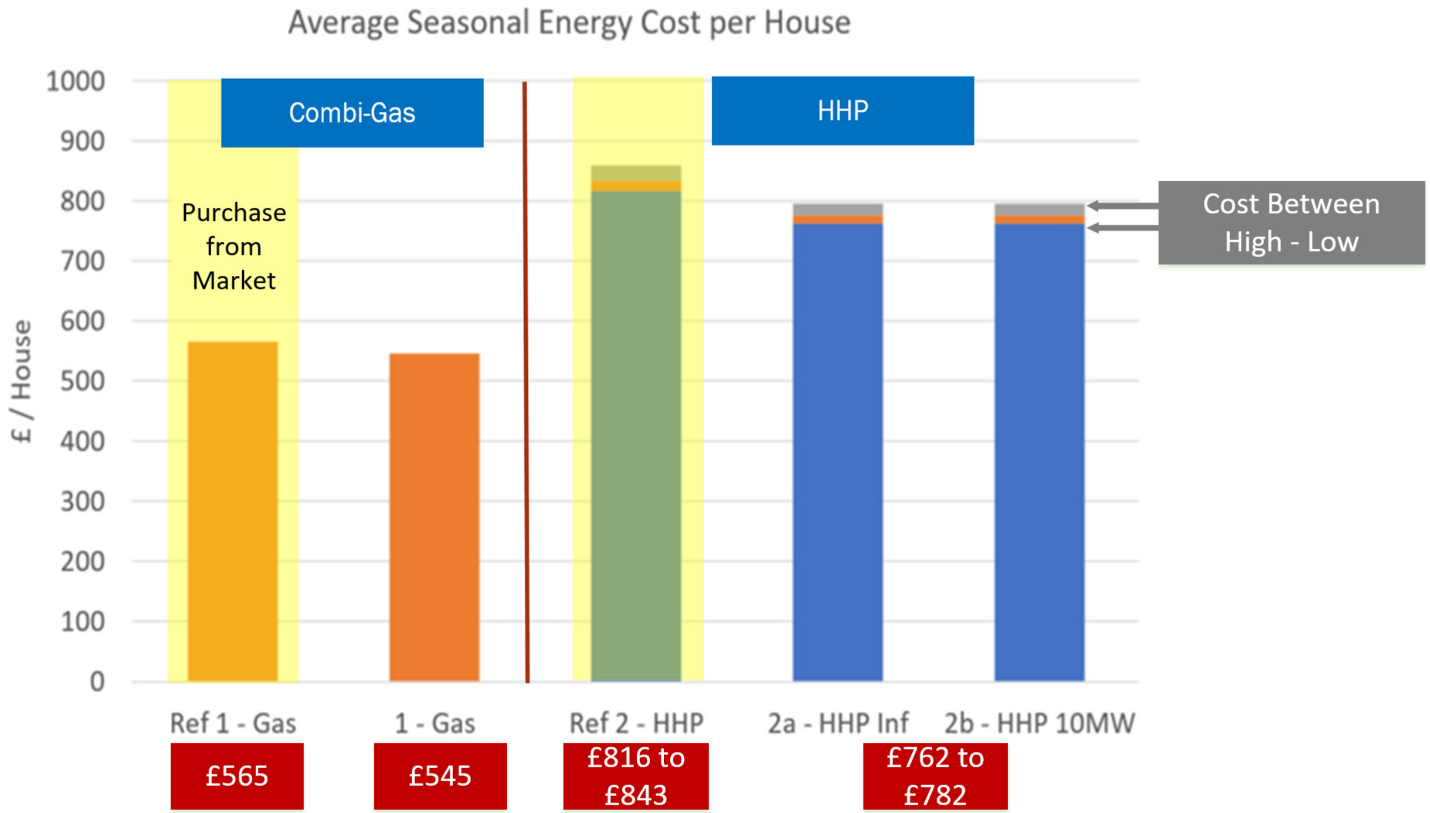
Analysis : Approach



- Impact of Allocation of HHPs / Occupants to Domestic Properties (shown left)
- Same general trend, but have outliers – which depend on the variant topology:
  - combination of occupant profile and appliance – assigned to specific domestic properties
- Selected 'high', 'mid' and 'low' cases for a week, used these to run throughout season
- … then look at impact of weather over heating season
  - which follows a general trend but has chaotic variations

KPI – ESP Total Energy Cost

- Introducing HHP increases Energy Cost
- But Using Wind and Storage Helps to Reduce Cost

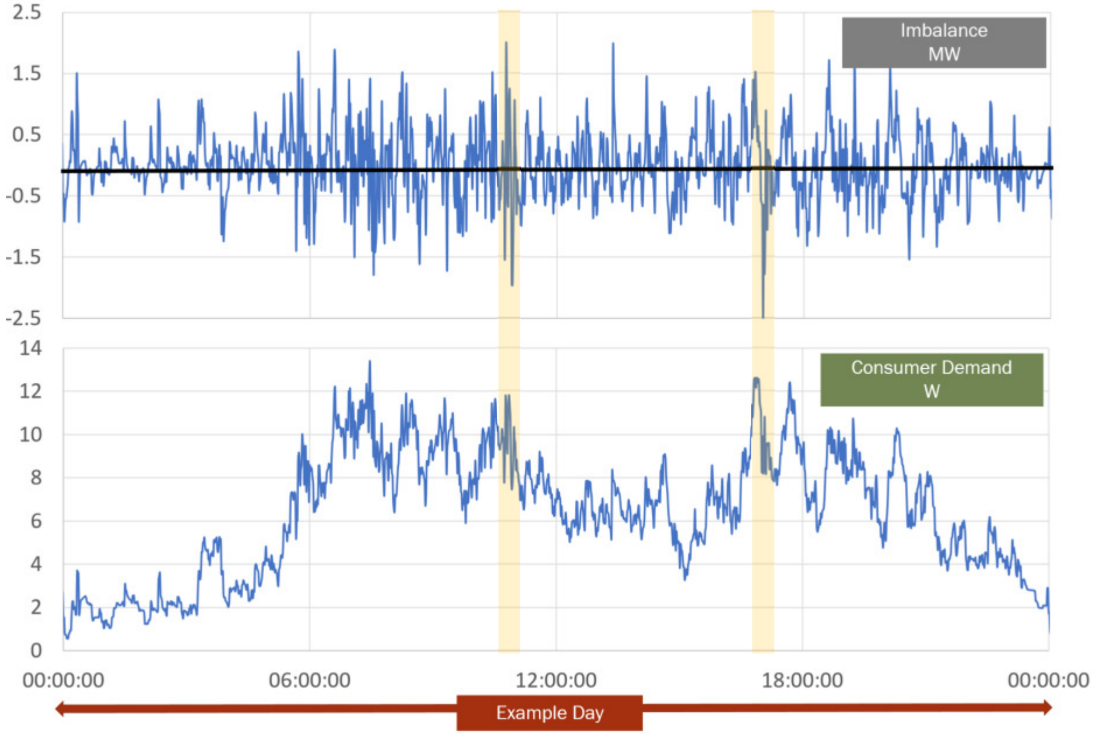


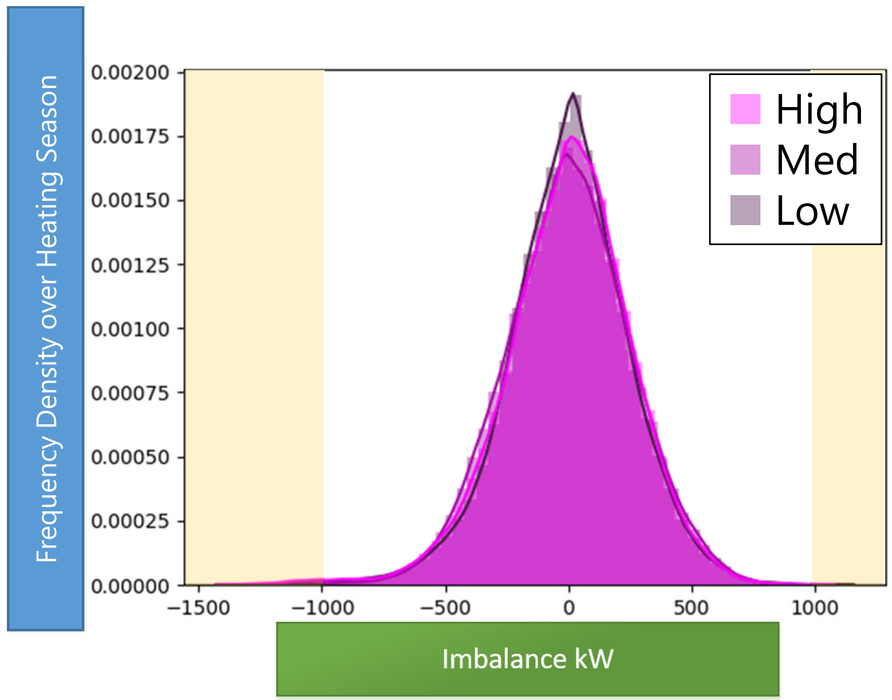
- Cost per House over Heating Season
- Reference Case Electricity bought from Spot Market
- Costs from Ofgem assumed price changes and assumed storage margin

KPI - Imbalance

Energy Systems

- Periods of significant imbalance (>10% of demand) … generally occur at volatile peaks in demand

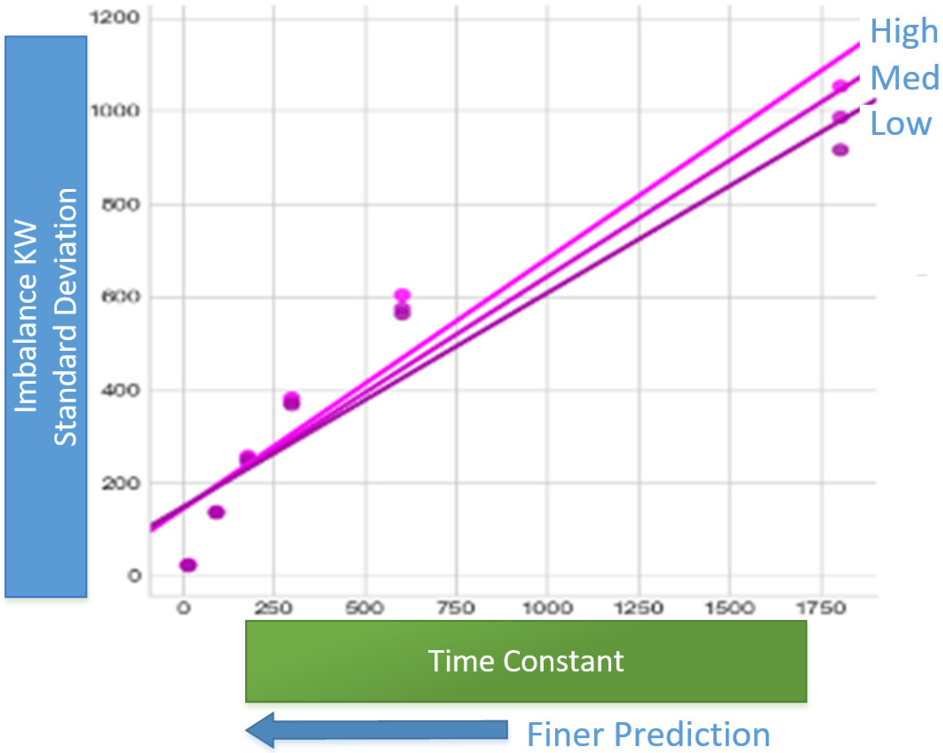


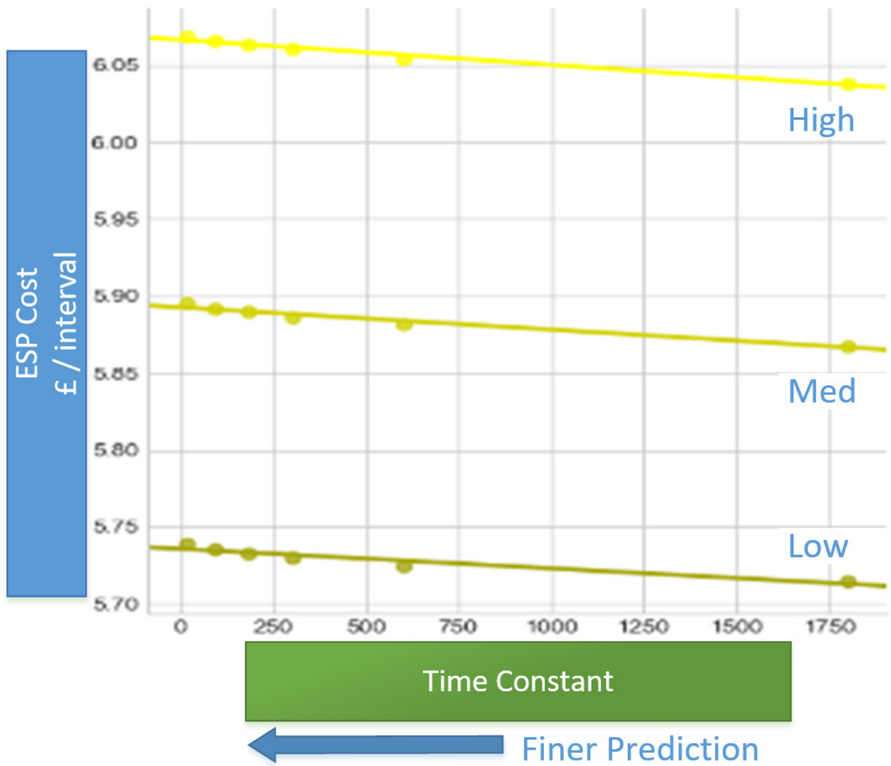


- … depends on local appliance control and consumer behaviour.

KPI - Imbalance

- Forecasting (defined as low pass filter)
- ... improved prediction (lower time constant) ... reduces imbalance





- ... can look at different forecasting metrics and impact of prediction against technology cost

Analysis Conclusions

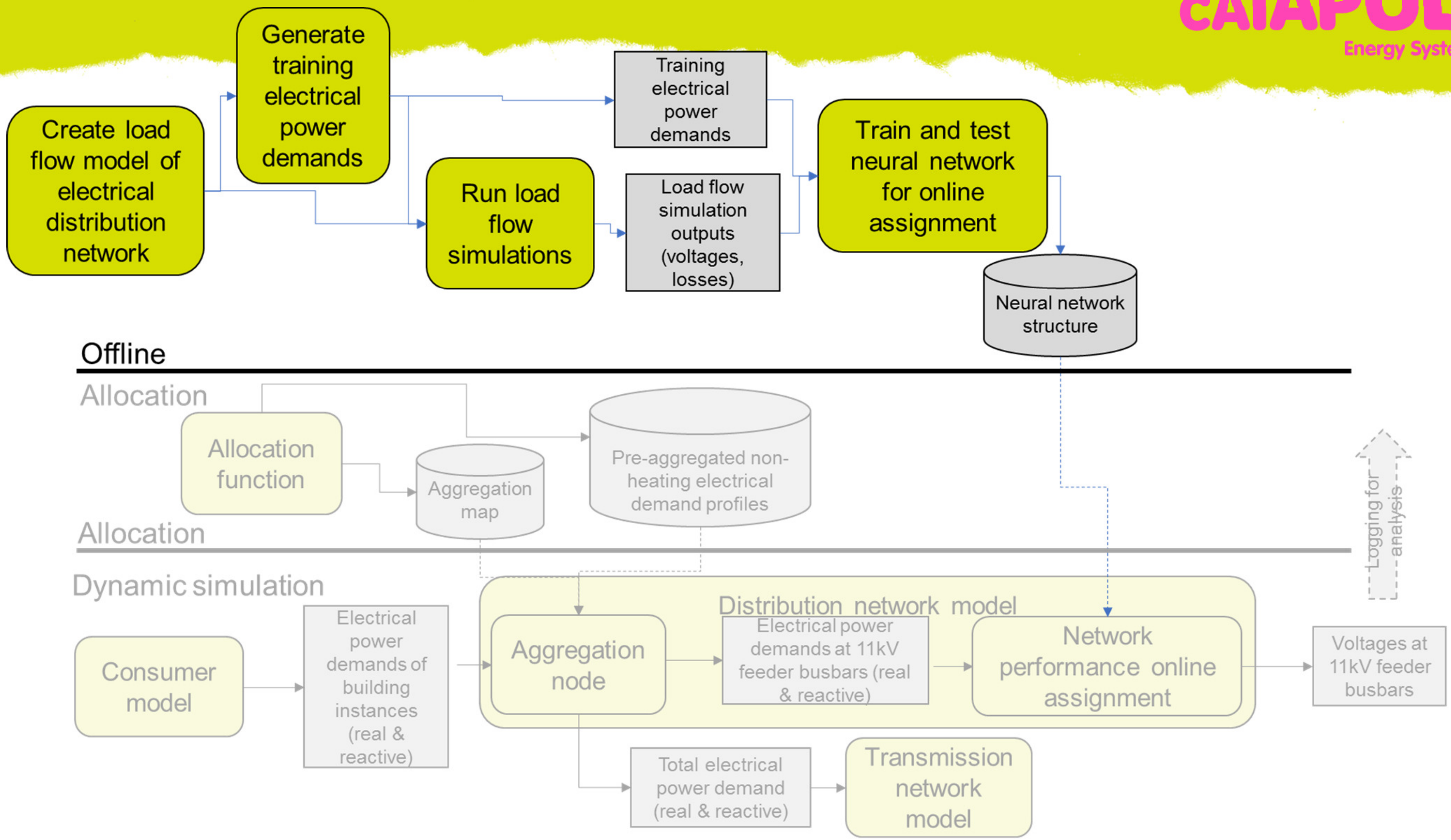
Example Scenario

- **SOCIETAL OBJECTIVES:** Facilitates decarbonisation, by increasing renewable energy (wind generation) and decreasing gas usage.
- **COMMERCIALLY ALIGNED:** Replacing Combi-Boilers with HHP more expensive. Using storage / wind has potential to reduce costs. Further economic analysis required.
- **SECURITY AND RESILIENCE:** Imbalance in supply and demand is pronounced during peak heating times when customer demand has significant volatilities.
- **PHYSICALLY CONSTRAINED:** Storage power and capacity greater than available at local level. Future scenarios may want to consider business models that manage inventory.
- **CONSUMER CENTRICITY:** Aggregated behaviour of customers and local appliance control have significant impact. Analysis motivates obtaining better understanding of this area.

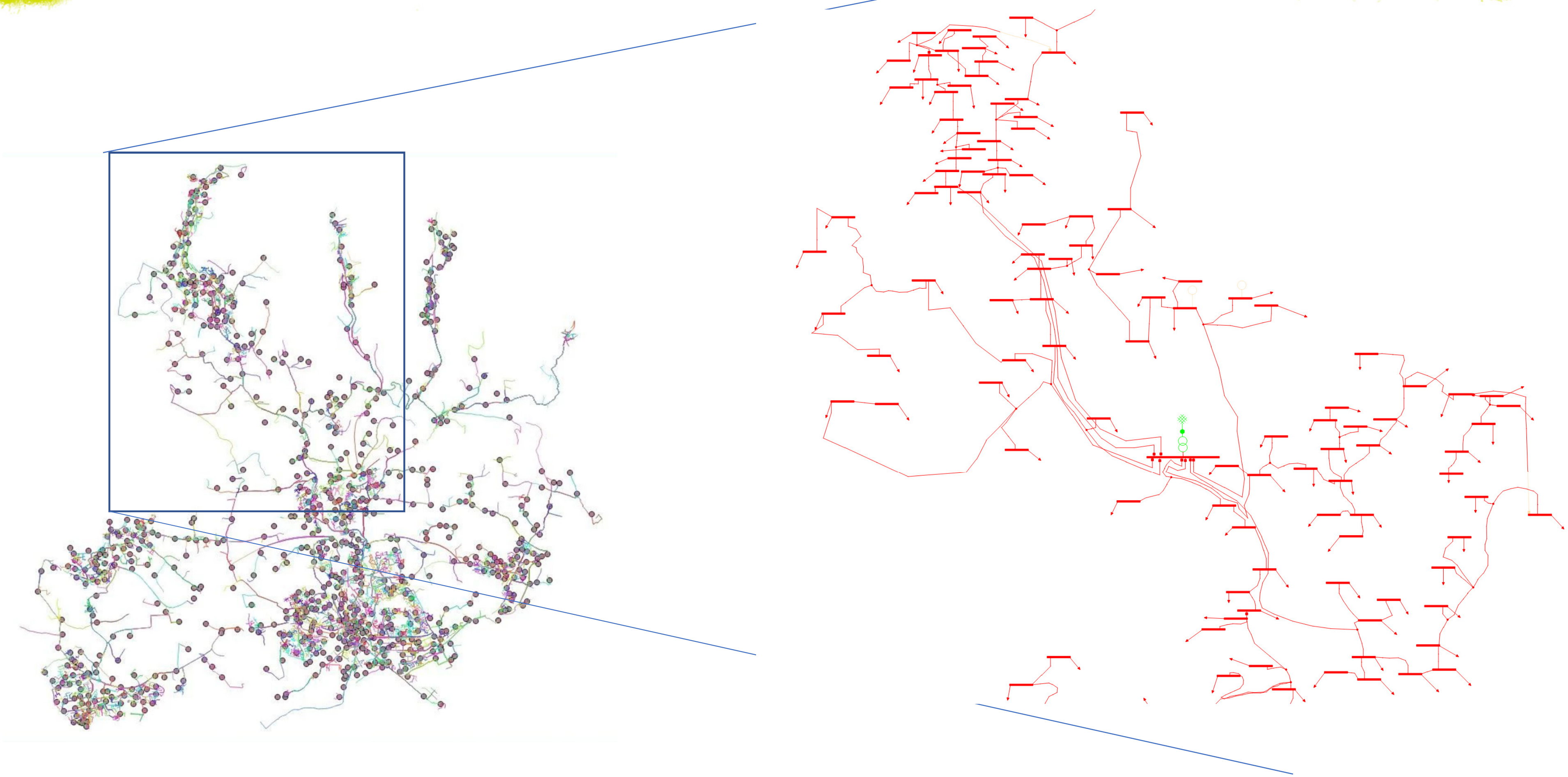
Structure of analysis allows iterative development of scenario:

- …. Different Questions, Increase Scenario Scope, Enhancements to Modelling …..

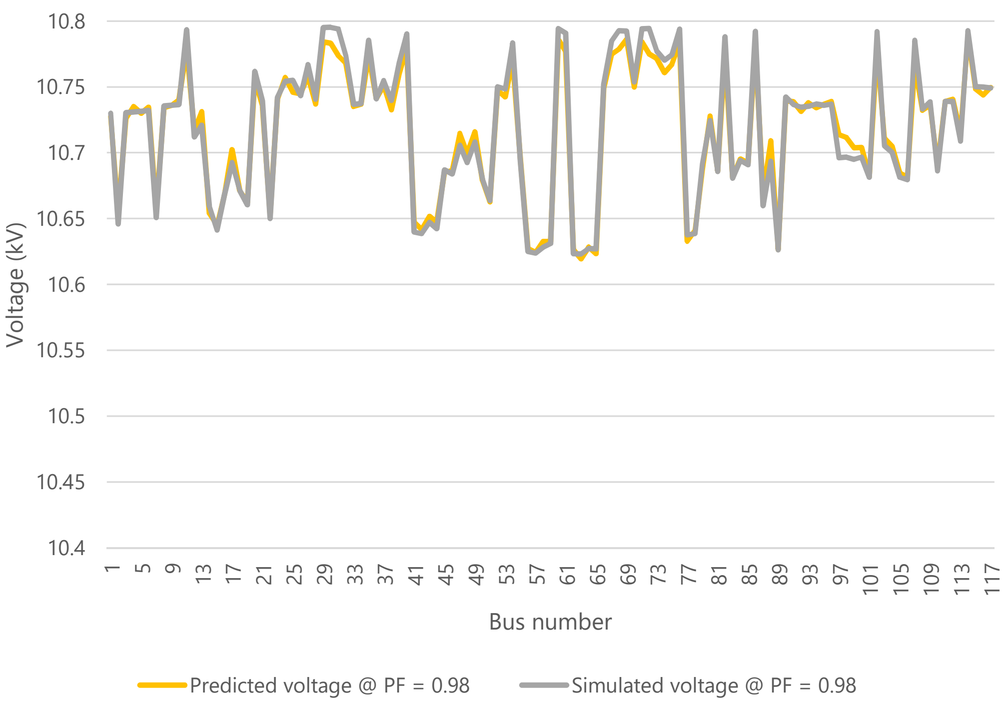
Electrical Networks Component

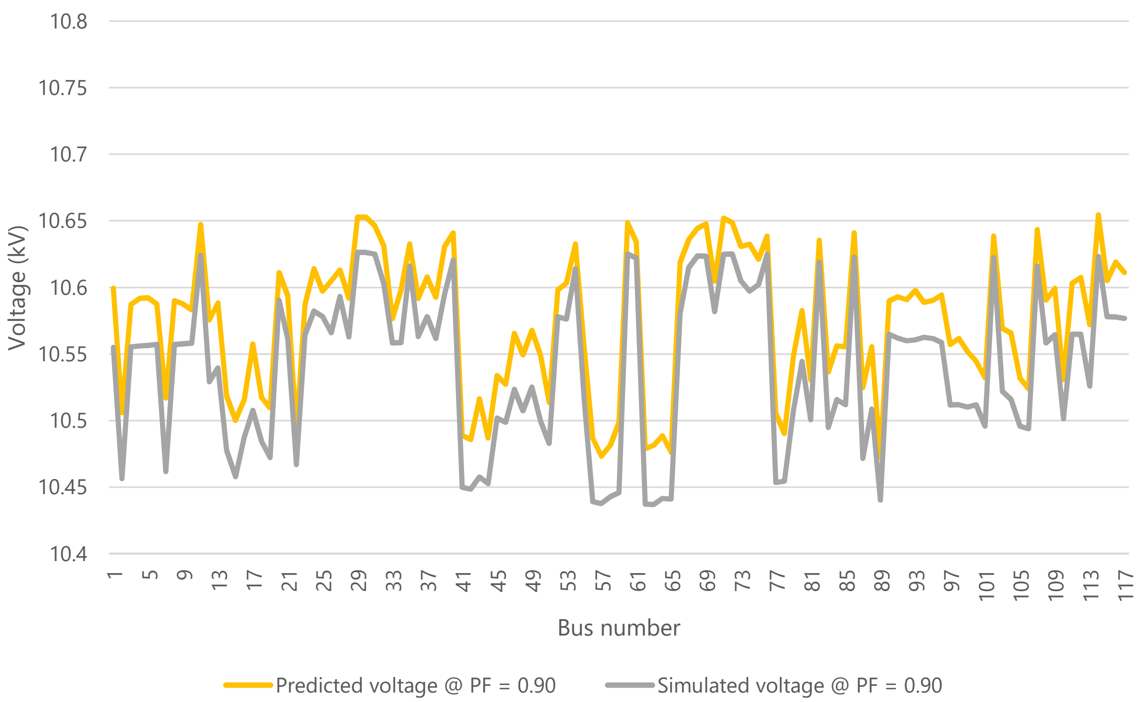


Electrical Network Topology



Predictive Performance





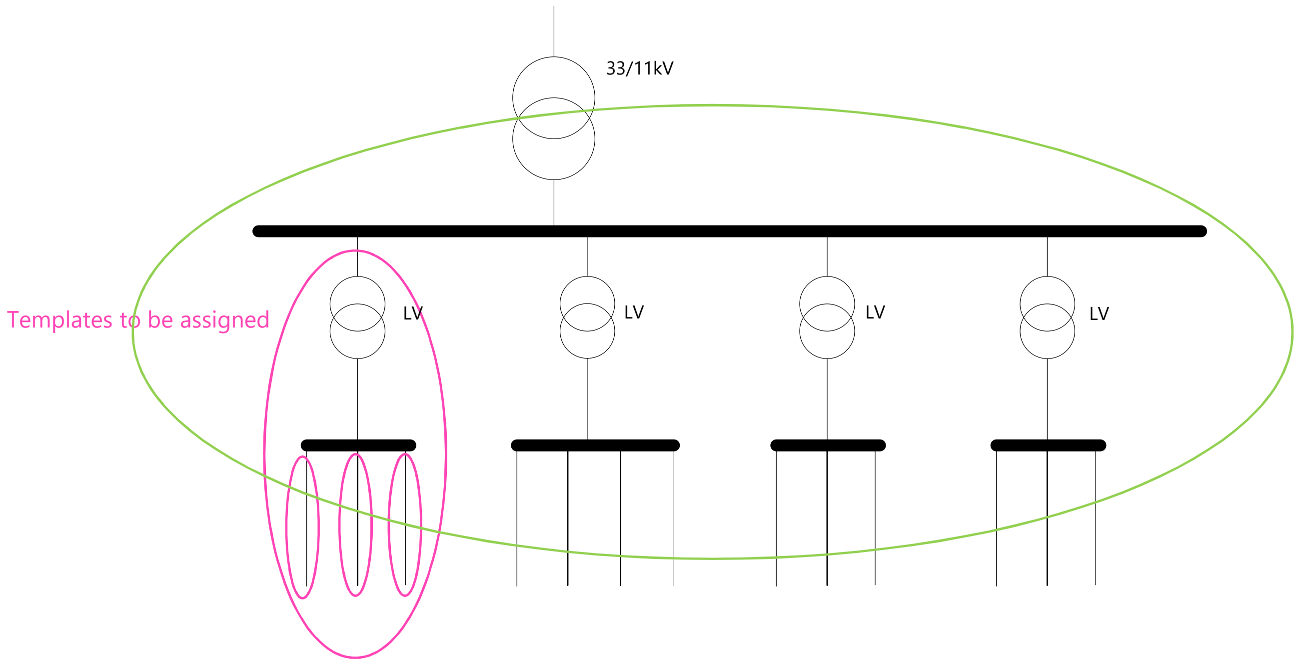
Future Challenges – Distribution Control

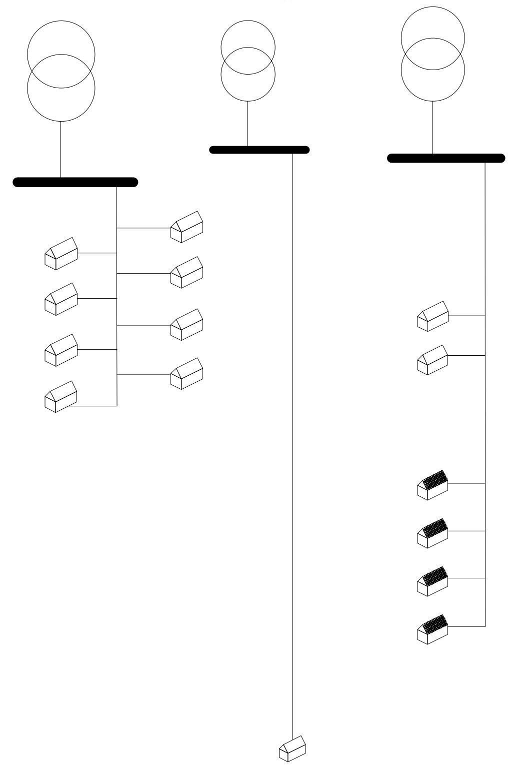
- At each voltage level, the distribution network will encounter technical issues – what are the potential control strategies to deal with them:

Control type	Description
Tap changer	mainly used for voltage control and keeping the system within limits
Energy storage system	Aggregators could use this for arbitrage but advantageous for the DNO in solving technical constraints – examples include voltage control and reverse power flow
Soft open points	Power flow between adjacent networks is automated based on network conditions
Demand side response	Turn up/ turn down of customer loads in periods of high and low network stress

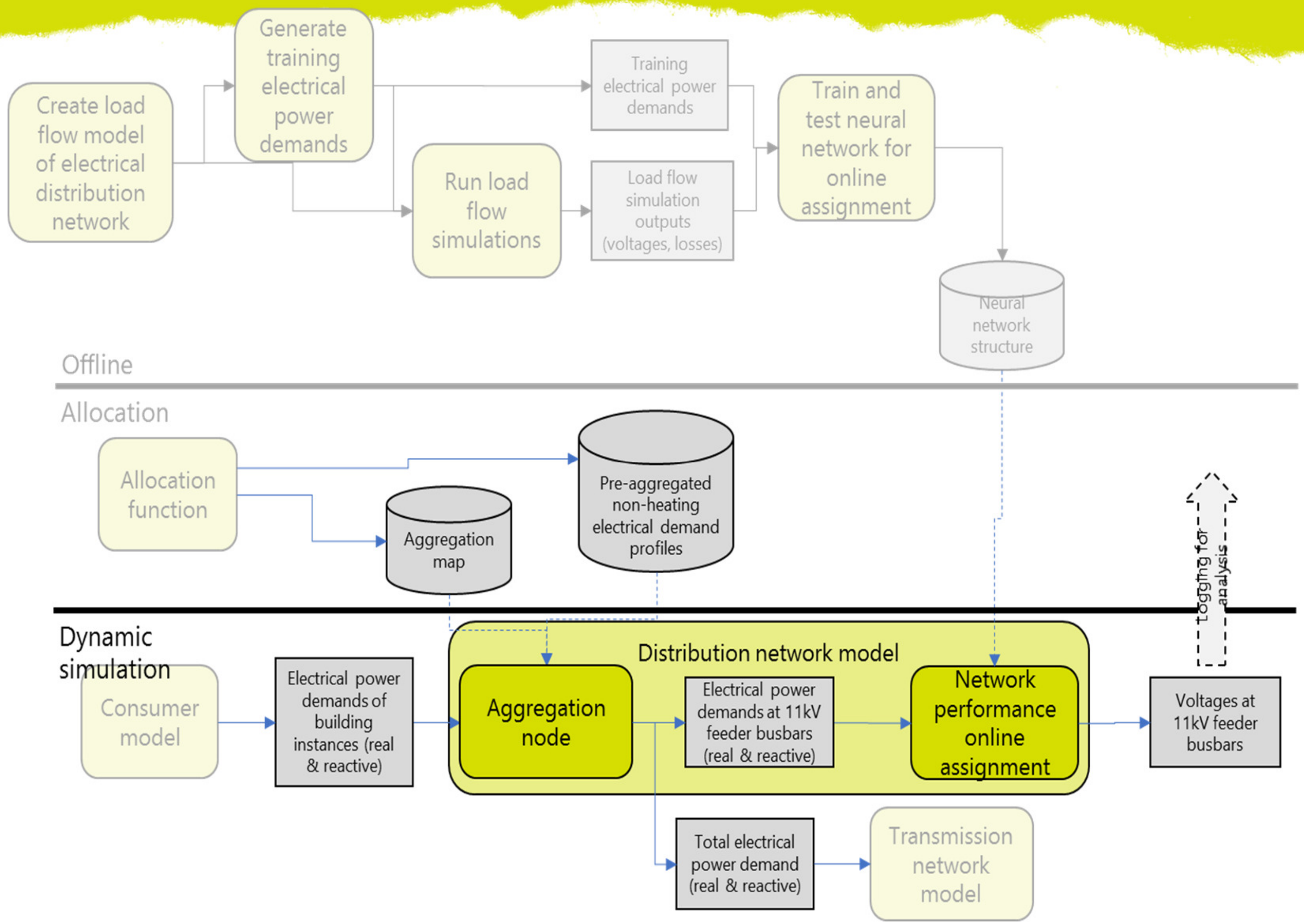
Future Challenges - Electrical Network Hierarchy

CATAPULT Energy Systems





Next Stages



Create load flow model of electrical distribution network
Generate training electrical power demands
Training electrical power demands
Run load flow simulations
Load flow simulation outputs (voltages, losses)
Train and test neural network for online assignment
Neural network structure
Offline
Allocation
Allocation function
Aggregation map
Pre-aggregated non-heating electrical demand profiles
Logging for analysis
Dynamic simulation
Consumer model
Electrical power demands of building instances (real & reactive)
Distribution network model
Aggregation node
Electrical power demands at 11kV feeder busbars (real & reactive)
Network performance online assignment
Voltages at 11kV feeder busbars
Total electrical power demand (real & reactive)
Transmission network model

Conclusions

- Analysis is testing an implementation (a design) for an architecture, rather than the architecture itself.
  - Building support for a possible method or;
  - Triggering risk

- Program goals at April 2017:
  - to create and test a workflow for gradually defining 'slices' (successive layers of design detail) of a future Great Britain Energy System;
  - to explore options for a future Shared Ecosystem (markets which enable and encourage collective impact to create shared value); and
  - to build a first of a kind holistic simulator (EnergyPath® Operations) to enable interactions of a diverse range of Individual Actors within different options for the Shared Ecosystem to be understood.