Programme Area: Energy Storage and Distribution

Project: Consumers, Vehicles and Energy Integration (CVEI)

Title: D4.1. Initial Analysis of Technology, Commercial and Market Building Blocks for Energy Infrastructure

Abstract:

The first project deliverable, report D1.1 “Summary of Approach, Conceptual Design and Key Research Questions”, sets out the analytical approach being taken to the identification and assessment of system options and the tool set being used.

This second project deliverable, report D4.1 “Initial Analysis of Technology, Commercial and Market Building Blocks of Energy Infrastructure”, sets out the detailed components of the framework. D4.1 comprises a report and spreadsheet. The two deliverables should be read in conjunction with each other.

It should be noted that both of these reports were written for the purpose of facilitating agreement regarding the details of the approach and consequently they are quite complex. Other reports later in the project will present the information in a more accessible manner for people not closely involved with the work; those later reports are commended to the general reader as a more suitable starting point. Nevertheless, D1.1 and D4.1 are made available for completeness.

Context:

The objective of the Consumers, Vehicles and Energy Integration project is to inform UK Government and European policy and to help shape energy and automotive industry products, propositions and investment strategies. Additionally, it aims to develop an integrated set of analytical tools that models future market scenarios in order to test the impact of future policy, industry and societal choices. The project is made up of two stages:

• Stage 1 aims to characterize market and policy frameworks, business propositions, and the integrated vehicle and energy infrastructure system and technologies best suited to enabling a cost-effective UK energy system for low-carbon vehicles, using the amalgamated analytical toolset.

• Stage 2 aims to fill knowledge gaps and validate assumptions from Stage 1 through scientifically robust research, including real world trials with private vehicle consumers and case studies with business fleets. A mainstream consumer uptake trial will be carried out to measure attitudes to PiVs after direct experience of them, and consumer charging trials will measure mainstream consumer PiV charging behaviours and responses to managed harging options.

CVEI Project: TR1006_D4.1. Initial Analysis of Technology, Commercial and Market Building Blocks for Energy Infrastructure

CLIENT: Energy Technologies Institute

DATE: 11/02/2016

Version History

Version	Date	Description	Prepared by	Approved by
V1_0	26/10/2015	Draft Final	JG, EP, NB, OR (Baringa) AS, CC, SS (Element Energy) JA (Aberdeen) NR, EC (E3)	DS (Baringa) SS (TRL)
V2_0	17/12/2015	Incorporating ETI comments	As above	As above
V3_0	11/02/2016	Incorporating final ETI comments	As above	As above

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Contents

Tables

Figures

1 Introduction

1.1 Background and context

The Consumers, Vehicles and Energy Integration (**CVEI**) Project, commissioned and funded by the Energy Technologies Institute (**ETI**), has been established to examine how to deliver mass deployment and use of ultra-low emissions vehicles (ULEVs) in the UK, and address the challenges and opportunities of integration with the full energy system (including plug-in hybrid and battery electric vehicles, and hydrogen fuel-cell vehicles).

The project is comprised of two Stages

- **Stage 1:** aims to characterise: the Market and Policy Frameworks; business propositions; and the integrated vehicle and infrastructure system and technologies; best suited to enabling a cost-effective UK energy system for low-carbon vehicles
- **Stage 2:** aims to validate key elements of the above through a mass-market trial with real users

Within **Stage 1:** there are four Work Packages (WP)

- **WP1:** Market Design and System Integration
- **WP2:** Consumer and fleet usage behaviours and attitudes to adoption
- **WP3:** Vehicle energy management systems and technologies
- **WP4:** Energy infrastructure management systems and technologies

This report represents deliverable *D4.1 (TR1006_D4.1) Initial Analysis of Technology, Commercial and Market Building Blocks for Energy Infrastructure* submitted as part of *WP4* within *Stage 1*.

The purpose of this deliverable is to provide an initial[1]:

- 'First principles' view of the key components or Building Blocks (**BB**) that need to be considered as part of understanding what technology/physical, actors/commercial, market/policy, and Customer Proposition structures are most effective to enable mass deployment and use of ULEVs, and their relative importance;
- Guide to structure the Analytical Framework, which will be created as part of deliverable D1.2. The aim is to focus the framework on areas of highest materiality, by specifying which key BBs should be considered as part of each Narrative which will be assessed within the Analytical Framework.

This document should be read in conjunction with deliverable *D1.1 (TR1006_D1.1) Summary of approach, conceptual design and key research questions.* For each Dimension the 'Key focus areas for the Analytical Framework' and the 'Areas for further research and development' in this document are replicated in D1.1, section 4.

[1] The document will be finalised as part of deliverable D4.2, with updates focused predominantly on further understanding of the potential R&D gaps.

- It should be noted that the data requirements associated with the various Building Blocks has been included in Deliverable D1.1. as this links closely to the tools used in the Analytical Framework and how the Building Blocks are treated as part of the analytical framework

1.2 Structure of this document

This document is structured as follows (with the supporting spreadsheet *ETI-026 - CVEI - TR1006_D4.1 Building Blocks Spreadsheet - Baringa - 20151026 - v1_0.xls* providing further information):

- Section 2 describes the overall approach to developing the catalogue of Building Blocks
- Sections 3 to 6 provide a more detailed description of the information for the Building Blocks related, respectively, to the
  - Customer Proposition (CP)
  - Physical Supply Chain (PSC)
  - Commercial Value Chain (CVC)
  - Market and Policy Framework (MPF)
- Section 7 describes how the underlying Building Blocks are used to inform the Narratives described in D1.1.
- Appendix A provides further information on the business models associated with the generic commercial entities on the CVC described in section 5

1.3 Glossary and acronyms

A list of key acronyms and glossary of key terms used across the project are provided in Table 1 and Table 2, respectively.

Table 1 List of acronyms

Item	Description
BB	Building Blocks
BEV	Battery Electric Vehicle
CP	Customer Proposition
CPAT	Commercial and Policy Accounting Tool
CVC	Commercial Value Chain
DNO	Distribution Network Operator
DM	Demand Management
ECCo	Electric Car Consumer Model
ESME	Energy System Modelling Environment
ETI	Energy Technologies Institute
EV	Electric Vehicle
FCV	Fuel Cell Vehicle
HRS	Hydrogen Refuelling Station
ICEV	Internal Combustion Engine Vehicle
LDN	Local Distribution Network
MCA	Multi Criteria Analysis
MCDT	Macro Charging Distribution Tool
MEDT	Macro Electricity Distribution Tool
MHDT	Macro Hydrogen Distribution Tool
MLDT	Macro Liquid Distribution Tool
MPF	Market and Policy Framework
PiV	Plug-in Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PSC	Physical Supply Chain
SGR	Stage Gate Review
TCO	Total Cost of Ownership
ToUT	Time of Use Tariffs
ULEV	Ultra-Low Emission Vehicle
WP	Work Package
V2G	Vehicle to Grid

Table 2 Glossary of terms

Item	Description
Analytical tools	The quantitative part of the Analytical Framework, used to calculate values for the quantitative Success Metrics
Analytical Framework	Overarching Multi-Criteria Assessment (MCA) framework applied to each narrative to help understand what 'good looks like' for mass market deployment and use of ULEVs and the potential trade-offs, via the assessment of the Success Metrics. This framework comprises the analytical tools which are used to help inform the quantitative assessment as well as a set of supporting qualitative assessment metrics.
Building Blocks	Individual components that influence ULEV deployment and use within each Dimension. A selected subset of BBs and their respective values or states (e.g. technology costs) constitute the tangible components of each narrative.
Build year vintage	The characteristics associated with the technology (e.g. vehicle or infrastructure) in the year it is built, as distinct from the time period it is operating in. For example, the vehicle parc in 2020 may contain new EVs built in that year with lower operating costs and higher range compared to EVs built in 2015, but which are still operating in 2020.
Dimensions	4 highest level areas categorising the BBs impact ULEV deployment and use covering: Customer Proposition (CP), Physical Supply Chain (PSC), Commercial Value Chain (CVC), and Market and Policy Framework (MPF)
Narrative	An internally consistent set of Scenarios and their underling Building Blocks covering *all* Dimensions and collectively characterising (qualitatively) a rational and distinctive model for facilitating mass deployment and use of ULEVs in the UK.
Scenarios	An internally consistent sets of BBs *within* each Dimension that are plausible and distinctive for ULEV deployment and use and can be assessed either quantitatively and/or qualitatively within the Analytical Framework.
Social Discount	Application of the Treasury's Green Book Social Discount Rate as part of financial analysis.
Success Metrics	Metrics used to determine what "good looks like" for each Dimension as part of the assessment of a narrative. These are divided into quantitative metrics, which are quantifiable via the analytical tools, and qualitative metrics.
Time period	Annual time steps on pathway from now to 2050
Time slice	Within year disaggregation reflecting characteristic days by season and in some cases further within day (or diurnal) disaggregation.

2 Approach

2.1 Overview and high-level categorisation

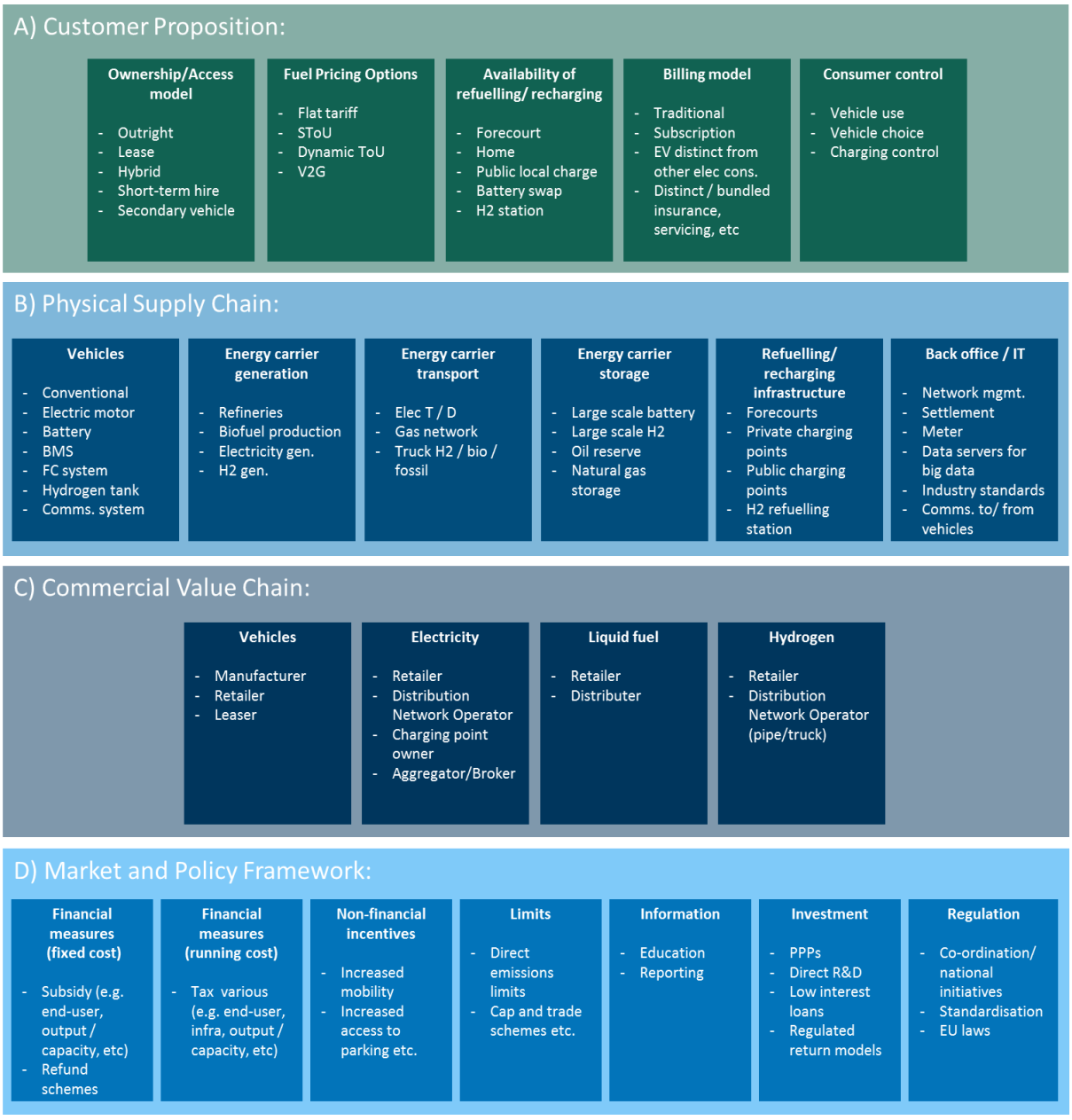
The core purpose of the BBs is to provide a bottom-up, first principles view of the core components which could impact mass-market deployment and use of ULEVs. This covers a potentially large number of BBs and the first step was to provide a MECE[2] grouping structure for them split into:

- **Dimensions** – four key overarching areas which collectively define the scope of assessment of the conditions for ULEV deployment and use. These are:
  - **Customer Proposition (CP)** – what the customer sees at the point of interacting with a ULEV e.g. is the customer buying or leasing the vehicle
  - **Physical Supply Chain (PSC)** – the technologies and infrastructure required to deliver the vehicles and their energy requirements – e.g. hydrogen production or distribution
  - **Commercial Value Chain (CVC)** – the commercial entities (and their business models) that sit across one or more parts of the PSC to collectively deliver the CP that the consumer sees – e.g. an electricity retail supplier or vehicle leaser
  - **Market and Policy Framework (MPF)** – Government intervention in the form of setting the overarching market framework for commercial entities (e.g. regulated monopolies for network infrastructure) or more direct policy intervention (e.g. in terms of taxes or subsidies on commercial entities or directly at the point of the consumer)
- **Categories** within each Dimension to help group similar types of BBs (e.g. under the PSC the category 'Vehicles' includes the BBs battery, battery management systems, fuel cell system, other components with a high technology-readiness level, electric motors for hybrids, hydrogen tanks and communication systems, whereas the category 'Refuelling/ Recharging Infrastructure' includes BBs private charging infrastructure, public charging infrastructure, hydrogen refuelling stations and diesel/ petrol forecourts).

Figure 1 provides an overview of the Dimensions and their specific categories along with a number of illustrative examples of the types of BBs that exist within each of these.

[2] Mutually Exclusive, Collectively Exhaustive

Figure 1 Overview of Dimensions and categories used to define example BBs



The supporting spreadsheet contains a wide range of more detailed information for each BB. The structure of spreadsheet is described in more detail in section 2.2, but at a high-level focuses on:

- Describing the core features of the BB
- Identifying examples that exist today or have been proposed (both in the UK and internationally)
- Providing supporting evidence on the materiality of the BBs – i.e. to help assess and filter which BBs are likely to be more important to consider in detail as part of the overarching assessment framework (or to better understand current gaps in the knowledge base)

As part of the BB assessment the project team has undertaken a review of the available public and academic literature and drawn on the expertise of the entire Project Team, through a dedicated workshop and various bilateral conversations.

The final step in this initial analysis has been to map the set of BBs assessed as most material onto each of the Narratives described in D1.1 in an internally consistent manner, such that this forms the foundation of what will be assessed via the Analytical Framework (again described in more detail in D1.1).

2.2 Structure of supporting spreadsheet

Accompanying this document is a supporting spreadsheet *ETI-026 - CVEI - TR1006_D4.1 Building Blocks Spreadsheet - Baringa - 20151026 - v1_0.xls*, which contains more detail on each Building Block of the four Dimensions.

2.2.1 Customer Proposition (CP)

The Customer Proposition is comprised of five categories: Ownership/ Access Model, Fuel Pricing Options, Availability of Refuelling/ Recharging, Billing Model and Consumer Control. Each category contains multiple BBs, classified by materiality. Each category addresses a different aspect of the offering to the customer, or the customer need.

- The summary sheet sets out all of the BBs under the categories and identifies the overarching 'states' that the BB can take. For example, under the Availability of Refuelling/ Recharging category sits 'H2 Refuelling Stations', a BB that could vary in terms the extent of the network and the ease with which a consumer can refuel their ULEV. BBs are classified by materiality.
- The detailed sheet is comprised of the following for each BB
  - Explanation of BB
  - Current use in the UK, examples
  - Extent of current deployment
  - Data gaps
  - Current use internationally
  - Overall materiality, informed by the above
  - Information required in order to quantify the BB within the Analytical Framework, including potential data sources or tools in which this is used; this links closely with the 'states' in the summarised version
  - Data sources, where applicable

2.2.2 Physical Supply Chain (PSC)

The Physical Supply Chain is comprised of six categories: Vehicles, Energy Carrier Generation, Energy Carrier Transport, Energy Carrier Storage, Refuelling/ Recharging Infrastructure and Back Office/ IT. Each individual BBs is part of a category and is classified by materiality. The BBs represent different physical assets on the supply chain, with the exception of 'Industry Standards' which is particularly pertinent for the PSC and also appears in the MPF.

- The summary sheet sets out all of the BBs under the categories and identifies the underlying factors that are particularly relevant in defining each BB. For example, under the Energy Carrier Generation category sits 'Electricity Generators', a BB that depends on the cost of new plants to meet demand, electricity generation cost, grid carbon intensity, and the generation mix. BBs are classified by materiality.
- The detailed sheet is comprised of the following for each BB
  - Explanation of the BB
  - Level of technology development
  - Current use in the UK, examples
  - Initial assessment of the potential for emissions and cost reduction relative to other BBs
  - Initial assessment of the technology readiness and cost for each BB
  - Overall materiality, informed by the above
  - Information required in order to quantify the BB within the Analytical Framework, including potential data sources or tools in which this is used
  - Data sources, where applicable

2.2.3 Commercial Value Chain (CVC)

The Commercial Value Chain is defined in a different manner to the other Dimensions. This is because there are multiple ways in which an entity can create value, and hence many subtly or distinctly different business models exist along the value chain, as well as ideas for novel or new models. An added layer of complexity is that one entity will often form partnerships or mergers with another entity or multiple other entities.

As per the other Dimensions, an extensive list of BBs has been identified together with some short-listing, taking into account the relative materiality of each BB. Examples of use in the UK and elsewhere have been used to understand what constitutes a 'generic' model for each entity, and where variations exist.

The overall CVC is comprised of four categories, each of which have their own value chains: Vehicles, Electricity, Liquid Fuels, and Hydrogen.

- The overall summary sheet sets out all of the BBs under the categories, identifying for each BB name, whether it is a stand-alone entity (or a combination)
- The summary sheet for each type of entity is the business model framework, which at a high level gives information about each element of the business model
- The detailed sheets discuss the elements in greater depth and identify ways in which particular aspects may vary

2.2.4 Market and Policy Framework (MPF)

The Market and Policy Framework is comprised of seven categories: Financial Measures (Fixed Cost), Financial Measures (Running Cost), Non-Financial Incentives, Limits, Information, Investment and Regulation.

Each category contains multiple BBs, classified by materiality. Some BBs are tangible in monetary terms; others are not. Most BBs described have already been implemented in some form (in the UK or elsewhere) although 'novel' measures have also been considered.

- The summary sheet sets out all of the BBs under the categories and gives a brief explanation, including existing examples where applicable. BBs are classified by materiality.
- The detailed sheet is comprised of the following for each BB:
  - Explanation of the BB
  - Current use in the UK, examples and success of these
  - Approximate value, extent of buyers covered, importance to the consumer
  - Current use elsewhere and success of these: in particular countries with high EV share and especially those with high share for relatively less financial incentives; countries where ULEVs were not well received despite market and policy support; and countries that have seen relatively high adoption of FCVs
  - Overall materiality, informed by the above
  - Information required in order to quantify the BB within the Analytical Framework, including potential data sources or tools in which this is used
  - Data sources, where applicable

3 Customer Proposition (CP)

3.1 Overview

The Customer Proposition (CP) Dimension covers all of the aspects faced by private and fleet buyers of cars and vans in the transport sector.

A summary of the Building Blocks and their materiality is shown in Table 3. Materiality has been assessed through considering how each Building Block might impact on the total ULEV vehicle km travelled (consistent with the quantitative Success Metric outlined in Deliverable D1.1).

Table 3 Summary of BBs included in the CP

Materiality for framework
High
Medium
Low

ACCESS MODEL	FUEL PRICING OPTIONS	REFUELLING AVAILABILITY	BILLILNG MODEL	CONSUMER CONTROL
1. Outright purchase *	10. Static ToU *	15. Private charging *	24. Subscription model	29. Sole vs shared use *
2. Contract Purchase *	11. Dynamic ToU *	16. Public charging in motorways and A-roads (rapid) *	25. Support for price certainty	30. Charging control *
3. Hybrid (battery lease)	12. Demand Management Payment *	17. Public charging in local points (mid-level) *	26. Traditional pay per unit model	31. Vehicle choice *
4. Contract hire *	13. Flat tariff *	18. Workplace charging *	27. Multi-modal	
5. Short-term hire/car club *	14. Vehicle to Grid/House (V2G/H)	19. H_2 refuelling stations *	28. Own account	
6. Secondary market *		20. Battery swapping		
7. Bundled installation of charge points *		21. Electrolyte charge		
8. Maintenance, servicing and insurance *		22. Dynamic/novel charging methods		
9. Access to other vehicles when ULEV unsuitable		23. Forecourt *		

Note that perks (i.e. congestion charge exemptions or parking benefits), which are a part of the Customer Proposition, have been captured in the Market and Policy Dimension. A more detailed

description of each Building Block is included within the supporting spreadsheet, and Figure 2 represents this for one of the Building Blocks.

Figure 2 Example of detailed BB view in the supporting spreadsheet for the CP

Category		Access model
Building block number		**1**
Building block name		**Outright Purchase**
Explanation		Vehicle purchase through own finance directly from manufacturer or dealerships; vehicle usually counted as a fixed asset for accounting purposes. The customer captures indirectly any government subsidies provided to the manufacturer (e.g. the plug-in car grant)
Currently used in UK?		**Yes**
Explanation/ examples		Outright purchase constitutes a third of total new car sales and a half of new vans sales
Impact on ULEV vkm (High / Med / Low, based on literature review experience)		**High -** the premium of PiV's capex over ICEVs is one of the most critical factors for private car purchase decision making, together with an 'anti-EV' bias. **Highly critical for economically rational fleet manager decision making**
Data gaps		**The relative depreciation of PiVs in comparison with ICEVs is not well understood and it is critical for outright purchase deals, as it is a popular ownership model among fleets. There is little evidence on PiV owner experience on battery life and resale value** Depreciation is as critical parameter for fleet, but not for private purchasers. Fleet managers base their decisions on rational TCO assessments, for which depreciation is a significant parameter. However, for the private purchasers, other attributes such as capex, fuel economy, availability of charging infrastructure, range or brand are the ones on which the customer bases his or her purchase decision
Extent of current deployment, across: (% of new sales for 'Access model'; % of PiV users with access to each type of charging for 'Availability of recharging')	a1. private cars	30% (ca. 350k cars pa)
	a2. fleet cars	25% (ca. 320k cars pa)
	b2. fleet vans	50% (ca. 160k vans pa)
International examples of commercial propositions		Figenbaum et al (2014) found that 56% of owners in **Norway** cited uncertainty over the resale value of their EV as a disadvantage (being the third most cited element, behind range and uncertainty over continuation of incentives)
Information Required: **States** - they are ranked in order of importance. The first(s) one(s) are be used for the quantitative assessment, above	1	**Finance model prevalence:** - dependent on the Narrative traditional or new finance models
	2	**Pricing strategy:** OEMs selling at a reduced margin/at a loss to support early deployments, cross-subsidising from other models etc. (unlikely to persist in long term)
	3	**Depreciation :** BaU (ULEVs higher depreciation than conventional cars) or same for both
	4	**Indirect subsidy**

3.2 Synthesis of evidence and literature

As part of the review of available evidence and literature for the Building Blocks, early insights were also drawn upon from the separate literature review being undertaken for Work Package 2, which focuses largely on aspects of the customer proposition for consumers and fleets. The final outputs of the Work Package 2 review will be included in the corresponding Work Package deliverables

The research questions that have been explored are:

- *What is the relative importance of purchase cost, price, maintenance, insurance, depreciation, tax incentives/grants/subsidies on the uptake of ULEVs?*
- *What is the relative importance of access to bus lanes, access to High Occupancy Vehicle lanes, parking incentives, road user charging incentives on the uptake of ULEVs?*
- *What is the role of access models on the uptake of ULEVs?*
- *What is the relative importance of the availability of different refuelling/charging propositions in the uptake of EVs?*
- *What is the relative importance of fuel pricing/payment/ demand management options in the uptake of EVs?*

The literature review exercise provided evidence on what the most critical parameters for the Customer Proposition are and highlighted those elements of the Customer Proposition in which there is no evidence on their impact to ULEV uptake.

- *Costs of ownership*
  - Purchase price is more critical to the Customer Proposition than running costs; recharging and driving range are also important (as these are the two most important 'anti-bias' factors putting-off potential purchasers of buying a PiV)
  - Other incentives, such as parking fee exemptions/rebates, congestion charge, or High Occupancy Vehicle lanes, appear likely to be less important than purchase price incentives and are highly context dependant. However, despite the lower impact on their own, evidence suggests that a package of well-designed financial incentives plus non-financial incentives may be the most effective means of increasing EV uptake.
- *Infrastructure availability*
  - Regarding charging infrastructure, home charging is seen as a pre-requisite of PiV ownership at this stage of the market development, and a combination of home and public charging is more valued than home and work charging infrastructure. Rapid chargers enabling longer trips (e.g. on motorways and A-roads), are highly valued by PiV owners, particularly BEVs, and they are regarded as the most efficient way to complement overnight charging and key for mass uptake of ULEVs.
  - Infrastructure availability or range 'anxiety' remains an important factor for many prospective ULEV drivers who often anticipate higher usage of charging points away from their home than actually transpires. This is compounded in some cases by lack of interoperability between public charging schemes (e.g. via 'roaming billing' models or standardisation of charging connections) which is flagged as a current source of frustration for some PiV owners
- *Charging behaviour*
  - There is no clear evidence in the literature of the impact of electricity pricing structures (i.e. ToUT) and controllability of charging (i.e. direct control) on the uptake of ULEVs, as the focus has been on understanding how those parameters affect electricity consumption behaviour on ULEVs and the acceptability of those tariffs.

- A recent UK survey (sample of 4,000) to measure consumer demand in Great Britain for a range of demand-side response tariffs[3], shows that EV owners are more likely to switch to static ToUT and that a direct load control tariff was the most popular, provided that it does not compromise end-user satisfaction[4] and that overriding facilities are offered.
- Additionally, *My electric Avenue*, a two-year demonstration trial, is testing ULEV customer acceptance to direct control propositions, and results will be available in December 2015.

3.2.1 Combined Customer Propositions

Whilst the Customer Proposition BBs reflect individual components of a Customer Proposition it is also important to understand what is likely to be effective in terms of a combined proposition. Table 4 presents a summary of currently available commercial propositions.

Indicative examples present the interactions between entities and benefits for the end-users arising from the Customer Propositions. For each Customer Proposition, some supporting facts are presented to illustrate the plausibility of the proposition.

Table 4 Examples of combined Customer Propositions

Description	Proposition
Fleet electric van in London	A fleet manager purchases the Nissan eNV200 through **outright purchase** benefiting from the Plug-in Van Grant. British Gas, the charging point partner of Nissan, installs **charging points at central van locations**, which have been supplied by the manufacturer ChargeMaster. They benefit from the Electric Vehicle Homecharge scheme. The van also has access to **Polar Network's public charging points**, owned by ChargeMaster. The user has to register online with the charging point network operator and then has access to all of the charging points in that network; billing is smart (e.g. via an app) and fees are **Pay As You Go**, dependant on the site. The user benefits from the congestion charge exemption, lower Vehicle Excise Duty, and access to (Ultra) Low Emission Zones. *Facts: 50% of vans purchase outright; PAYG is one of the most popular billing models for charging infrastructure*
Private BEV, outright purchase	A private owner uses **Personal Contract Purchase**[5] to acquire an electric vehicle, which allows him/her to pay lower monthly rates than other finance models and provides an opportunity to own the vehicle at the end of the contract. The user has their own charge point at home, and benefits from a **discount in his/her electricity tariff**, provided by Ecotricity. In some cases the discount and the car purchase could be linked (e.g. Tesla cars using free

[3] Is it time? Consumers and time of use tariffs. Trialling the effect of tariff design and marketing on consumer demand for demand-side response tariffs; UCL Energy Institute for Smart Energy GB, 2015
[4] In terms of maintaining acceptable temperature thresholds
[5] Essentially leasing the vehicle over several years before buying outright

	Tesla supercharger network). They also have access to free electricity from Ecotricity's Electric Highway **rapid charge points**, through a swipe card that can also be used in other charge networks. *Facts: Personal Contract Purchase is the most popular access model among private cars (40% of new sales);*
Private BEV, with battery leasing	A private owner uses a **Hybrid access model (battery leasing)**, in which they buy the vehicle but lease the battery from the same entity. The battery is paid for monthly, and rates depend on the length of the contract and on the agreed annual mileage. The OEM offers a battery performance guarantee. The user has registered to the Charge Your Car network, which operates charging points and collects the payments; **billing is done through an application or through a swipe card.** The owner primarily charges at home and overnight, but benefits from cheaper prices through EDF's **Eco20:20 time of use tariff.** Suppliers start to offer tariffs directly tied to EV ownership. *Facts: Battery leasing is offered as the unique access model by some OEMs (i.e. Renault ZOE), or as one access model option by others (i.e. Nissan); In the UK time of use tariffs specific to EVs are not widespread. However, several national ToU trials are being carried out at the moment, and other countries already offer EV-specific ToU tariffs (i.e. Spanish Electric Vehicle Tariff)*
Company car PHEV chosen by user	An employee chooses a Mitsubishi Outlander PHEV as a **Benefit In Kind** from their company, which has acquired the car through **contract hire,** and remains its owner. Being a PHEV, the user benefits from lower **Company Car Tax** rates than petrol and diesel cars, maintenance and insurance are paid for by the company, and the employee benefits from lower Vehicle Excise Duty. The user can charge via the company's **charging infrastructure, located at the workplace, which is leased** on a three-year base and paid for monthly and benefits from access to (Ultra) Low Emission Zones. *Facts: ca. 40% of company car buyers are 'user-choosers'; POD Point launched an option last year to lease fast charging points to businesses*
Electric Car club	A user of **E-car club**, in Milton Keynes, has access to the vehicles through the payment of **a membership fee plus an hourly or daily fee**. The booking is online, and can be done last minute. The car is collected and returned at a central bay *Facts: London is the second largest market for car clubs (ca. 160,000 members), with an industry commitment to include at least 50% ULEVs in fleet by 2025 (London ultra low emission future)*

3.3 Areas for further research and known gaps

WP2 will inform on the attitudes and behaviours of consumers and fleets towards energy demand management through interviews that could potentially also seek evidence on these points. In particular in relation to, **the impact of fuel pricing options** (i.e. Static or Dynamic Time of Use tariffs) **and related charging control options** (e.g. manual, automatic) on the uptake of PiVs.

Gaps identified in the literature include:

- Analysis and demonstrations currently in progress aim to understand the **impact of different billing models (PAYG, subscription)** and how important this is within the Customer Proposition.
- **The relative depreciation of PiVs in comparison with ICEVs** is not well understood and is particularly critical among fleets. Similar aspects include **impact of the battery life and resale value** on the owner experience, the potential impact that the **secondary market** could have on ULEV uptake, and the **potential success of battery leasing** in the UK (which is not well understood).
- The potential penetration of **solutions to provide overnight charging to households without off-street parking** (e.g. socket network/ street furniture connections, shared charge points installed in residential areas) needs to be understood further (i.e. do they have the same value/provide as much certainty of access as 'home charging' for consumers).
- There is uncertainty around the **mass take-up potential of car clubs in cities**.
- **The monetised value attributed by ULEV customers to perks** (e.g. access to bus lanes, free parking, etc.) is not well understood, particularly in terms of the extent to which customers heavily discount these benefits at the point of purchase, particularly where there is the potential for this value to diminish in future with significant ULEV uptake (e.g. the time saved from bus lane access with many users). This could include consumer attitudes to car ownership and the value of 'status' associated with owning a ULEV.
- **The monetised value attributed to having access to a secondary vehicle** (eiher permanently/temporarily) or e.g. via alternative transport services (e.g. longer distance journeys via rail)

3.4 Key focus areas for the Analytical Framework

This section, and the equivalent sections 4.4, 5.4 and 6.4 for other Dimensions, highlights a number of aspects that are important to consider in the Analytical Framework, in some cases with reference to specific Narratives. These are also replicated as section 4 of D1.1, which links the Analytical Framework (WP1) and the BBs that the framework will measure (WP4) – further detail on the application of each specific BB to the framework can be found in section 9 of D1.1.

In the CP, those BBs categorised as high *and medium*[6] materiality are:

- **Purchase methods** in the access model are outright purchase, contract purchase, hybrid - battery leasing only, contract hire, short-term hire/ car clubs and the secondary market.

[6] Medium materiality BBs are italicised

It is therefore important to attempt to reflect the impact of leasing, such as spreading costs over time for contract purchase, or reducing the cost the customer sees together with the vehicle lifetime in for contract hire, as distinct from outright purchase, in the Analytical Framework.

- The secondary market for ULEVs is negligible in the UK currently, but is viewed as an important determinant of the economics of ULEV ownership in fleets. The depreciation of ULEVs may be higher than ICEVs particularly when the battery life is less than the vehicle life and especially in the 'Organic' Narratives (as there is less of coordinated push to standardise around ULEVs).
- *Bundled installation of charging points*, (i.e. provided with the vehicle) is classified as medium materiality. For home and fleet charging points this could be added to the cost of the vehicle; the use of public charging points, together with the bundling of other services such as O&M, insurance and fuel, will be either described qualitatively or as part of the tariffs seen by the consumer in the CVC.

- **Electricity pricing options** such as SToU will be reflected through exogenous charging profile assumptions, adjusted in relation to estimates of consumer response to electricity price shapes from the analytical tools. *Demand Management Payments* should appear in several of the Narratives and under these overall DNO control of charging is assumed and modelled as a payment to consumers. The EV owner benefits indirectly because distribution network reinforcements are not as significant as they would have been without charging control and the EV owner would separately receive a direct payment for providing the DM services (to a DM Aggregator who provides the consolidated service to the DNO).
  - For simplicity, the extent of consumer control will vary depending on whether the customers see flat tariffs, SToU (some load shifting, consumer charges less at peak times but does not transfer power into the grid from the battery), DToU (more load shifting, no transfer to grid), and managed charging (DNO direct load control, including payments for provision of such as service).
  - In the 'Co-ordinated' Narratives, it is assumed that a DNO expands its services to become a DSO, or Distribution System Operation (for instance aggregating individual loads and providing balancing services to the TSO). However, for the purposes of analysis this will likely be represented as a DNO and Aggregator for all Narratives in which Demand Management Payments for the use of automated charging control apply[7]. Note that active network management is assumed to be through network automation algorithms, rather than via instructions to individual users as per a traditional system operator role. V2H may appear qualitatively as part of the OEM Innovation Narrative.
  - **Hydrogen and liquid fossil fuel pricing** will be variable, although to a lesser degree of granularity than electricity, and charged in a PAYG manner, as per current pricing of liquid fossil fuels
- **Recharging availability** should reflect, in particular, private charging (home), workplace and public charging (rapid). For the latter, the access to charging and the extent of the network is important.

[7] As the DSO model is much broader than PiV charging and considers e.g. connection and management of various types of embedded generation

- **The billing models** that the customer sees may vary between Narratives, such as the *subscription model,* and *support for price certainty* (e.g. real time data on current charging costs, at public locations for instance, to allow the consumer to take informed decisions on where it is more economically sensible to charge), may be important. However, there is limited direct evidence on this and it is not practical to model differences directly within the Analytical Framework.
  - The variations in billing models by Narrative will be described qualitatively and could be tested, or simulated, in the Stage 2 Trial.
- The extent of **consumer control:** sole vs. shared, *charging control* (indirectly captured through response to ToU tariffs and V2G provision) and the *vehicle choice.* Shared use is more applicable to the 'Mobility as a Service'-based Narratives and its impact could potentially be captured via the extended use of fleets as opposed to consumer vehicles, assuming that a higher proportion of ULEVs is fleets and consumers hire these hour-by-hour.

Other cost/ subsidy elements that are part of the CP are for instance VED and Company Car Tax. These can be factored-in to the uptake tool and will be discussed further as part of the MPF.

The CP building blocks have been applied in a manner consistent with the description of the Narratives as shown in the summary Table 5, further detail is provided in D4.1 Section 7.

Table 5 Summary of BBs to Narrative mapping for the Customer Proposition

✓	Captured quantitatively
✓	Captured qualitatively
✓	Exists as per BaU

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
1. Outright purchase	✓			✓	✓	
2. Contract Purchase		✓	✓			
3. Hybrid (battery lease)						
4. Contract hire	✓	✓	✓	✓	✓	✓
5. Short-term hire/car club			✓			✓
6. Secondary market	✓	✓	✓	✓	✓	✓
7. Bundled installation of charge points		✓				
8. Maintenance, servicing and insurance	✓	✓	✓	✓	✓	✓
9. Access to other vehicles or forms of transport when ULEV unsuitable						
10. Static ToU		✓	✓			
11. Dynamic ToU			✓	✓		✓
12. Demand Management Payment			✓	✓		✓
13. Flat tariff	✓				✓	
14. Vehicle to Grid/House (V2G/H)						
15. Private charging	✓	✓	✓	✓	✓	
16. Public charging in motorways and A-roads (rapid)	✓	✓		✓	✓	✓
17. Public charging in local points (mid-level)	✓	✓	✓	✓	✓	✓
18. Workplace charging	✓	✓		✓	✓	
19. H_2 refuelling stations	✓	✓	✓	✓	✓	
20. Battery swapping						

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
21. Electrolyte charge						
22. Dynamic charging						
23. Forecourt	✓	✓	✓	✓	✓	✓
24. Subscription model			✓			✓
25. Support for price certainty		✓		✓		
26. Traditional pay per unit model	✓	✓		✓	✓	
27. Multi-modal			✓			✓
28. Own account						
29. Sole vs shared use	✓	✓	✓	✓	✓	✓
30. Charging control			✓	✓		✓
31. Vehicle choice	✓	✓	✓	✓	✓	✓

In terms of building blocks that are not considered explicitly or tackled more qualitatively across the Narratives the rationale for these is as follows:

- CP3 - Hybrid models - these are unlikely to show sufficient variation compared to the other purchase models which span the range from outright purchase, leasing and 'on-demand/hire'
- CP9 – Access to other vehicles – there is limited evidence to quantify the monetised value consumers place on this and it is deemed of secondary importance given that this issue is considered more explicitly in the Analytical Framework via consideration of access to charging infrastructure and physical sufficiency of the ULEVs to meet the desired driving range in their role as the primary vehicle
- CP14 – Whilst dedicated V2G could be used for flexibility services, such as providing power back to the grid during a shortfall, it is assumed that consumers would not normally enact V2G themselves (i.e. as a reaction to price signals for energy arbitrage) without automated controls to facilitate this process. The focus of the literature is also predominantly around DNO/Aggregator led demand management (CP12/CP29), which is considered in a number of Narratives and would restrict the ability of the consumer to manage their own charging or export back to the grid. V2G/H is also dependent on the level of battery degradation that might be experienced under more extensive charging cycles, which will be explored further as part of WP3.
- CP24-28 – there is limited evidence to understand the extent to which consumers value different forms of billing models (as opposed to the actual costs of the energy or transport service) and hence these BBs are more illustrative examples of what might sensibly exist given the broader Narratives, rather than integral part of the success of the each Narrative
- CP20-22 – more novel forms of PIV charging have been excluded either due to early evidence that they are likely to be less effective (e.g. a move away from attempts to commercialise battery swapping) or a high degree of uncertainty over the long-term prospects for others such as electrolyte or dynamic charging (at least for mass market consumers). Given the number of BB permutations associated with more 'standard' charging infrastructure (availability, locations, pricing, etc) these have been the focus for differentiation across the Narratives

4 Physical Supply Chain (PSC)

4.1 Overview

The Physical Supply Chain (PSC) Dimension covers all of the supply chain components relevant to the transport sector and ULEVs in particular, including those associated with the energy supply chain.

The materiality for the Analytical Framework and Research and Development (R&D) needs for each BB have been identified. To support an initial view of materiality, two types of high-level assessment have been carried out:

- *Comparative assessments (e.g. change in Scenario compared to BaU)*: indicative impact of changing key parameters of each BB in terms of the costs or CO_2 emissions (i.e. the difference in battery costs comparing a BaU vs. rapid cost reduction Scenario)
- *Absolute assessments (e.g. stand-alone materiality within Scenario)*: capture the relevance of each BB within its category (e.g. what percentage of the vehicle capex does the battery or the electric motor constitute), or the relevance of the BB at the system level (e.g. investment required by 2050 in distribution network reinforcements).

A summary of key R&D gaps, a specific deliverable requirement for this Dimension, is captured in section 4.3.1, and a summary of the BBs and their materiality is shown in Table 6. A more detailed description of each BB is included within the supporting spreadsheet, with an example in Figure 3.

Table 6 Summary of BBs included in the PSC

Materiality for framework
High
Medium
Low

VEHICLES	ENERGY GENERATION	ENERGY TRANSPORT	ENERGY STORAGE	REFUELLING INFRASTRUCTURE	BACK OFFICE/IT
1. Battery *	8. Electricity generators *	12. Electricity distribution network *	17. Large batteries	21. Private charging *	25. Industry standards
2. Battery Management System *	9. H_2 generation plants *	13. Electricity transmission network *	18, Large underground H_2 storage *	22. Public charging *	26. Assets for settlement (e.g. smart meters)
3. Fuel Cell System (incl. range extenders) *	10. Biofuel plants *	14. H_2 distribution *	19. Oil strategic reserves	23. H_2 refuelling stations *	27. Assets for comms.
4. Generic high technology readiness components (e.g. chassis, engine) *	11. Refineries	15. Trucks for liquid fuels *	20. Natural gas storage	24. Forecourts *	28. Data servers for Big Data
5. Electric motor		16. Gas network			29. Assets for comms. from/ to vehicles
6. Vehicle H_2 tank *					
7. Comms systems					

Figure 3 Example of detailed BB view in the supporting spreadsheet for the PSC

Category		Vehicles
Building block number		**1**
Building block name		**Battery**
Explanation		Electricity storage component in plug-in electric vehicles. Primary influence on the cost and performance of all plug-in vehicles, as well as ability to provide managed charging Scenarios

Currently in the UK?		**Yes**
Explanation/ examples		Most cars in the market have Li-ion batteries (i.e. Nissan Leaf, Mitsubishi Outlander)

Quantification of impact - A1, A2, A3) COMPARATIVE ASSESSMENTS - how does changing the most material(s) state(s) across its different levels affects the analytical framework (i.e. comparing high/low with BaU Scenarios, in terms of costs for the system, CO2 emissions, etc.)	A1) CO2 emissions reduction potential (as % of total 2012 car CO2 emissions; Low: <5%, High: >20%)	
	A2) Cost reduction potential (as % of difference between Scenarios; Low: <5%, High: >20% difference)	High (battery cost differ 15-20% between the 'extreme Scenarios', all along 2020 towards 2050) 'Extreme Scenarios': comparing low battery cost, low range and high battery cost, high range Scenarios. The materiality of changing the state from a low to a high cost case is high, as this could determine whether PiVs are viable or not
	A3) Others (specified when relevant)	High (BEVs premiums over ICEVs differ ca. 10 and 5 % respectively, in 2020 and 2050, between extreme Scenarios) 'Extreme Scenarios': comparing low battery cost, low range and high battery cost, high range Scenarios
B1,B2,B3,B4) ABSOLUTE ASSESSMENTS - what is the importance of a particular state for the analytical framework; i.e. what % of a BEV capex constitutes the battery	B1) Technology development (high: technology development critical for mass deployment and use of ULEVs)	High - battery cost reduction is an important factor underpinning ULEV uptake, among other factors
	B2) Costs (as % of capex; low <10%, high: >20%)	High (BEVs: 25-30% and ca.20% of capex in 2020 and 2050, respectively) Today: 40% of costs *(ca. £9k for a C-segment car; initial modelling with ECCo's cost and performance database)*
	B3) System costs, i.e. associated to infrastructure investment, (cumulative values; Low: <100million; high: >1billion)	
	B4) Others (specified when relevant)	

Overall Materiality		**High** Battery costs and performance are a critical influence on uptake of ULEVs and hence overall opportunity for managed charging

Information Required: States - they are ranked in order of importance. The first(s) one(s) are be used for the quantitative assessment	1	**Battery cost:**- dependant on states below **LOW** (from 160 £/kWh in 2020 to 89 in 2050; 25-35kWh band, 2010£) or **BaU** (from 208 £/kWh in 2020 to 89 in 2050) i.e. cost differences between Scenarios of 25%, 10%, 5% and 0% in 2020, 30, 40 and 50 *(values from ECCo's cost and performance database with HIGH range, LOW energy density, Li-ion batteries)* **This state is based on assumptions on the states below (range, energy density, type of batteries)** Values will be based on Scenarios developed in battery cost modelling in WP3

	2	**Electric range (underlying assumption of battery cost):** - output from WP3 **HIGH** e.g. OEMs 'spend' battery improvements on increasing pack sizes and vehicle range **LOW** e.g. OEMs favour cost reductions rather than significant range increases, reflecting a world where consumers become comfortable with limited range EVs as infrastructure increases
	3	**Battery technology development (energy density) (underlying assumption of battery cost): -** output from WP3 **HIGH** (ca. 0.28kWh/kg, 2050) or **BaU** (0.14kWh/kg, 2050 as per today state-of-the-art); *Values from ECCo's cost and performance database*
	4	**Battery technology development (degradation) (underlying assumption of battery cost):** - output from WP3 **HIGH** e.g. lifetime less than vehicle lifetime, some managed charging configurations increase degradation or **LOW** - e.g. little or no impact of charging configurations on degradation, battery life exceeds vehicle design life
	5	**Battery type (underlying assumption of battery cost):** - output from WP3 Lithium-ion (variants and combinations of LMO, NMC, NCA) or Lithium-sulphur (post 2030)

4.2 Synthesis of evidence and literature

The Physical Supply Chain (PSC) Dimension covers all of the supply chain components relevant to the transport sector and ULEVs in particular, including those associated with the energy supply chain.

The research questions for the literature review have focused primarily on:

- *What is the availability of different technology BBs?*
- *How significant are the BBs expected to be in terms of driving ULEV-related costs both now and in the future?*

In contrast to the Customer Proposition dimension, most PSC BBs exist across multiple narratives, but the extent to which they are used – i.e. their materiality – depends significantly on the uptake and utilisation of different types of vehicles in the analysis of the Narratives. However, key initial insights from the review of literature are:

- *Vehicles*
  - Battery costs will continue to comprise a significant portion of the costs of PIVs in the near term (~40% now ~25-30% in 2020), but they are dropping steadily coupled with more gradual improvements in range. A variety of more novel battery chemistries (e.g. Lithium Sulfur) exist, but their likely cost is subject to significant uncertainty. *A more detailed assessment of battery technologies is being undertaken as part of WP3 and costs/performance data will be included within the Analytical Framework.* In contrast to PIVs there is still significantly higher uncertainty over the long-term costs of Fuel Cell systems vehicles
  - Continued, but more incremental improvements, are expected in conventional vehicle components through weight reduction and improved energy efficiency, but many of these will benefit ULEVs as well as conventional vehicles
- *Energy carriers*
  - Hydrogen production is well established at small and medium scales via existing industrial processes (e.g. SMR). The key challenge moving forwards is production at larger scale for ULEVs in a manner that has low carbon intensity and at reasonable

cost. To reduce carbon intensity sufficiently this is generally dependent on CCS-based production routes (SMR + CCS or coal/biomass gasification + CCS) or large quantities of cheap, low carbon electricity (e.g. from new nuclear). Localised production (e.g. via small scale electrolysers) tends to be more expensive and the value of this route needs to be contrasted with the additional costs of distribution from centralised production

  - Second generation biofuel production routes offer potentially significant CO2 reductions (e.g. 70%+ on a well-to-wheels basis compared to petrol and diesel)

- *Distribution of energy*
  - Management of electrification of vehicles (both scale of supply and balancing) on the wider energy system and associated carbon benefits will benefit from broader activity associated with e.g. integration of increasing levels of intermittent generation and electrification of heat (which are likely to place higher absolute demands on the electricity system than electrification of transport)
  - Individual components of hydrogen distribution technologies are generally already established and the costs of distribution are generally small compared to the overall fuel selling price (potentially <10%). The choice of e.g. pipeline versus truck distribution
- *IT / communications*
  - Technology pre-requisites are required to enable greater management of PIV charging (either by the consumer or more directly by an Aggregator / DNO), such as smart metering and control systems for Active Network Management. But, these are already been driven by other factors of which PIVs are only one aspect (mandated roll-out in the case of smart meters and the requirement for more active management of all supply/demand by DNOs)
  - Interoperability and standards, e.g. with respect to charging infrastructure, are seen as an important enabler of PIVs from the customer perspective and are primarily a matter of coordination as opposed to technology development

4.3 Areas for further research and known gaps

4.3.1 Key R&D needs

For the PSC, key R&D needs for each BB have been identified, a summary of which is presented in Table 7. These will be updated as part of the final version of the Building Blocks in deliverable D4.2.

Table 7 Summary of R&D needs for the Physical Supply Chain

VEHICLES	ENERGY GENERATION	ENERGY TRANSPORT	ENERGY STORAGE	REFUELLING INFRASTRUCTURE	BACK OFFICE/ IT
Battery*: Li-on energy density, Li-S and Li-air batteries, degradation rates, battery pack manufacture	**Electricity generators:** conventional, mature. R&D for most renewables	**Electricity distribution network:** low voltage control technology (i.e. solid state transformer)	**Large batteries:** technically proven. R&D specific to technology type	**Private charging:** inductive charging, cost and performance (i.e. higher power ratings)	**Industry standards:** several under development

BMS*: state-of-charge, state-of-health and control algorithms for central management	**H_2 generation:** 'Brown H_2' production roll-out ready	**Electricity transmission network:** HVDC cables, better deep-water foundations	**Large underground H_2 storage:** large scale salt caverns, interaction with intermittent renewables	**Public charging:** inductive & dynamic charge, street furniture, electrolyte refuelling	**Assets for settlement:** Smart meters - capabilities, data exchange protocols
Fuel Cell System: industrialisation of initial FCEV volume manufacturing processes	**Biofuel plants:** next generation fuels e.g. from gasification of solid biomass	**H_2 distribution:** mature. Increase mass stored per truck	**Oil strategic reserves** mature	**H_2 refuelling stations (HRS):** demonstrate 'roll-out ready' HRS, compressor reliability, maintenance cost	**Assets for comms.:** demonstration of Active Network Management
Generic high technology readiness level components: novel materials and efficiency measures	**Refineries:** mature. Introduction of drop-in biofuels (Hydrotreated Vegetable Oil)	**Trucks for liquid fuels:** mature. Improved efficiency	**Natural gas storage** mature	**Forecourts** mature	**Assets for comms. from/to vehicles:** navigation software, apps
Electric motor: low voltage and cheap, no rare earth metal motors		**Gas network:** mature			**Data servers for Big Data:** mature
Vehicle H_2 tank: novel materials for lower costs, higher capacity-to-weight and capacity-to-volume					
Communication systems: standards					

Note: *A literature review will be conducted in WP3 for these BBs

Table 8 summarises the main sources used to address the R&D needs within each BB, where a more detailed description can be found. Those where the technology is fully mature, have been excluded from Table 8.

Table 8 Summary of sources for key R&D needs

Source	Battery	BMS	Fuel Cell	Generic High TRL comp.	Elec. motor	H2 tank	Comms	Elect. generation	H2 generation	Elect. Transmission	Elec. Distribution	H2 distribution	Large batteries	Large und. H2 storage	Private charging	Public charging	H2 refuelling stations	Industry standards	Assets for settlement	Assets for comms	Comms from/to
1				x	x		x							x	X	x		x	x	x	x
2	x	x																			
3			x			x			x			x					x				
4							x														x

5								x													
6								x													
7								x													
8								X													
9										x	x		x								

Sources:

1) Website (indicated as a comment in 'Level of technology development', in the workbook)
2) Cost and performance of EV batteries. Element Energy for the Committee on Climate Change, March 2012
3) Technology Innovation Needs Assessment (TINA) Hydrogen for Transport Summary Report, Low Carbon Innovation Coordination Group, November 2014
4) Intelligent Mobility Technology Roadmap, Automotive Council, 2013
5) Technology Innovation Needs Assessment (TINA) Offshore wind Power Summary Report, Low Carbon Innovation Coordination Group, February 2012
6) Technology Innovation Needs Assessment (TINA) Bioenergy Summary Report, Low Carbon Innovation Coordination Group, September 2012 (covered under 'biopower')
7) Technology Innovation Needs Assessment (TINA) Marine energy Summary Report, Low Carbon Innovation Coordination Group, August 2012
8) Technology Innovation Needs Assessment (TINA) Carbon Capture and Storage in the Power sector Report, Low Carbon Innovation Coordination Group, August 2012
9) Technology Innovation Needs Assessment (TINA) Electricity Networks and Storage (EN&S) Summary Report, Low Carbon Innovation Coordination Group, August 2012

4.3.2 Outputs of other Work Packages for the Analytical Framework

Information about the **battery and battery management system** will be provided as part of WP3 and incorporated into the Analytical Framework (e.g. in terms of updated cost and performance data).

4.3.3 Gaps in the literature

Gaps identified in the literature include:

- More research may be required on the potential role **of low voltage motors for PiVs** and to quantify the impact on the total cost (e.g. there may be a trade-off between cheaper batteries and more expensive motor/electronics controls), however, this is currently considered to be a low materiality BB based on the low R&D impetus vs. improvement of high voltage battery packs.
- **Industry standards:** a more detailed understanding of the impact of different levels of industry standards (e.g. strict standards to guarantee the interoperability of ULEVs with the charging infrastructure)

4.4 Key focus areas for the Analytical Framework

The high/medium materiality Building Blocks in the PSC are discussed below:

- For the **vehicles** the material components are the battery and battery management system (which will be part of the focus of WP3) and the fuel cell system.
- The electricity generators and H_2 generation plants are an important part of the **energy generation** category and will be accounted for in the system modelling. The price of electricity and H_2 will vary under different Narratives depending on the generation mix

(including types and capacities of H_2 generation technology deployed). A distinction will need to be made between localised H_2 generation (e.g. on-site via electrolysis) and centralised generation and the cost differences between these.

- **Energy carrier transport** needs to be considered, in particular the electricity distribution network, *H_2 distribution network* and to a lesser extent the electricity transmission network. The investment requirements for the networks depend on demand for energy vectors which varies by Narrative. In most Narratives it is assumed that H_2 distribution is carried out by trailers as this is generally more cost effective at lower volumes, however, the H_2 Push Narrative may include pipelines in the longer-term (to forecourts)
- The focus of the **recharging/ refuelling infrastructure** should be on private charging, public charging, H_2 refuelling stations and *petrol/ diesel forecourts* – the demand for infrastructure will vary between the Narratives[8]

The PSC building blocks have been applied in a manner consistent with the description of the Narratives as shown in the summary in Table 9, further detail is provided in D4.1 Section 7.

Table 9 Summary of BBs to Narrative mapping for the Physical Supply Chain

✓	Captured quantitatively
✓	Captured qualitatively
✓	Exists as per BaU

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
1. Battery	✓	✓	✓	✓	✓	✓
2. Battery Management System	✓	✓	✓	✓	✓	✓
3. Fuel Cell System	✓	✓	✓	✓	✓	✓
4. Generic high technology readiness components (e.g. chassis, engine)	✓	✓	✓	✓	✓	✓
5. Electric motor	✓	✓	✓	✓	✓	✓
6. Vehicle H_2 tank	✓	✓	✓	✓	✓	
7. Communication systems						✓
8. Electricity generators	✓	✓	✓	✓	✓	✓
9. H_2 generation plants	✓	✓	✓	✓	✓	
10. Biofuel plants	✓	✓	✓	✓	✓	✓
11. Refineries	✓	✓	✓	✓	✓	✓
12. Electricity distribution network	✓	✓	✓	✓	✓	✓
13. Electricity transmission network	✓	✓	✓	✓	✓	✓
14. H_2 distribution	✓	✓	✓	✓	✓	
15. Trucks for liquid fuels	✓	✓	✓	✓	✓	✓
16. Gas network						
17. Large batteries	✓	✓	✓	✓	✓	✓
18, Large underground H_2 storage	✓	✓	✓	✓	✓	
19. Oil strategic reserves						
20. Natural gas storage						
21. Private charging	✓	✓	✓	✓	✓	

[8] E.g. less demand in Narratives without FCVs due to a lack of H2 stations that would otherwise have been sited at petrol/ diesel forecourts. In this situation fossil forecourt retailers would likely require Government subsidies to remain commercially viable given the same number of overall forecourts.

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
22. Public charging	✓	✓	✓	✓	✓	✓
23. H_2 refuelling stations	✓	✓	✓	✓	✓	
24. Forecourts	✓	✓	✓	✓	✓	✓
25. Industry standards						✓
26. Assets for settlement (e.g. smart meters)	✓	✓	✓	✓	✓	✓
27. Assets for comms.			✓	✓		✓
28. Data servers for Big Data						✓
29. Assets for comms. from/ to vehicles (e.g. autonomous vehicles)						✓

In contrast to the Customer Proposition dimension, most PSC BBs exist across multiple narratives, but it is the extent to which they are used which will depend on the uptake and utilisation of different types of vehicles in the analysis of the Narratives. The rationale for excluding specific BBs or treating them more qualitatively is as follows:

- PSC7/25/26/27/29 - Measures such as industry standards should form a part of the relevant overarching Narrative but their impact cannot be quantified explicitly and hence they can only be explored more qualitatively
- PSC10/11/17 are included in the Analytical Framework as part of the existing tools used, but are modelled only at a relatively high level (e.g. large scale batteries in the ESME model) or treated as a boundary condition (e.g. Refineries via exogenous assumptions for petrol/diesel wholesale costs)
- PSC16/19/20 are not modelled explicitly as part of the Analytical Framework tools, but their direct impact on ULEV uptake is deemed to be very limited (as they have limited impact on the cost of availability of infrastructure from the perspective of the ULEV owner) and hence there is negligible value to including them in the analysis

5 Commercial Value Chain (CVC)

5.1 Overview

The CVC consists of the entities that exist in the value chain, together with the underlying business models that define how each of these creates value.

Given the myriad of potential commercial entities across the value chain these have been simplified to focus on generic commercial entities (and variants of these), which are closest to the consumer or more material in terms of ULEV specific investments. This section describes the approach taken in doing so and the final list of entities that will be incorporated within the Analytical Framework, whereas the logic for how the 'commercial viability' of the entities will be assessed is described within the separate deliverable D1.1, as part of the discussion on the tools used in the Analytical Framework.

5.2 Synthesis of evidence and literature

The approach taken was to first identify all entities on the value chain, categorised in a matrix by:

1. **Category:** e.g. transport (Vehicles, Batteries, Fuel Cells) or Fuel & Infrastructure (Electricity & Charging Points, Hydrogen & Pipelines/ Trucks/ Trailers, Liquid Fuels & Trailers)
2. **Position:** along the value chain, in terms of 'classic' business models (Manufacturer, Broker/ Exchange Operator, Installer, Site Developer, Owner, Operator, Distributor, Retailer, Service Provider and Secondary Services)

An initial assessment of materiality for the Analytical Framework was undertaken and partnerships/ mergers already in existence were noted, together with those that may make commercial sense in the future. This raised several key challenges that commercial entities might need to meet in order to efficiently achieve high ULEV uptake (aside from the commercially viability of the business model, which will be assessed using the Analytical Framework):

- **How can the impact of plug-in vehicles on electricity distribution networks be managed?**
  - How can network management be structured? How can efficient reinforcement be incentivised?
- **How would hydrogen be delivered to the consumer?**
  - How could a hydrogen network be financed?
  - What drives the viability of pipeline versus truck-based distribution?
- **How might integration of vehicle provision, energy provision and other bundled services be achieved?**
  - What constructs efficiently achieve this integration?
- **How can fossil fuel business models be sustained?**
  - As volumes decline, can a fossil fuel distribution business be made viable?
- **How will deployment of charging infrastructure be financed?**
  - Public finance, private businesses, individual installation?

Targeted research was undertaken by E3 and Baringa, to provide information on how these questions might be answered by the CVC, and to understand the roles of each entity and relevant business models already in existence in the UK and elsewhere (this information has been incorporated into the descriptions of the business models in the supporting spreadsheet). Key insights include:

- *Vehicle-related propositions*
  - Vehicle manufacturers/retailers are already beginning to offer a range of financing/leasing packages to PIV consumers mirroring the Customer Proposition Building Blocks and this is expected to increase in future helping to overcome the barrier of high upfront cost of ownership for ULEVs
  - PIV-based car hire/sharing is still in its relative infancy, particularly in the UK. There are however, more developed examples in other countries, such as Car2Go in the US, which also includes bundling of additional services including energy. This is facilitated via free charging at a number of points in San Diego owned by partner charging point operator ECOtality
- *Charging infrastructure and propositions*
  - A wide range of entities are involved in the development of non-home charging point infrastructure from dedicated charging point providers (e.g. Chargemaster), OEMs such as Tesla to retail suppliers such as Ecotricity in the UK. However, the deployment of such infrastructure is still at relatively small scale and many charging points are either free or heavily cross-subsidised to serve other purposes (e.g. promote customer loyalty, advertising) and a question mark remains of the viability of these approaches at larger levels of infrastructure deployment and use.
  - Other more novel forms of charging infrastructure have proven less successful commercially. 'Better Places' battery swapping business in Denmark/Israel went into administration in 2013 and Tesla have recently dropped plans to commercialise battery swapping stations, instead focusing on their rapid charging network
- *Enabling demand management*
  - Demand management of PIV charging in the UK has been delivered through DNO-led innovation trials under Ofgem's Low Carbon Network Fund, such as SSEPD's My Electric Avenue project and UKPN's Low Carbon London project. To date the focus has been on been on the technical and economic issues associated with managed charging at the DNO level and less on new commercial arrangements.
  - Whilst aggregators could at present monetise PIV demand management services and sell these to the TSO (e.g. as part of National Grid's Short Term Operating Reserve programme) commercial routes to monetise these services at the DNO level are still in their relative infancy. This is driven in large part by the clear separation of network ownership from supply of energy in the GB market, which does not exist in many other countries (e.g. some utilities in California) and hence these markets are often more developed in terms of their commercial structures to facilitate demand management
  - At the distribution level active management of PIV demand is closely tied into the broader evolution of the DNO in the UK to more actively manage both supply (e.g. distributed generation) and demand as part of a move to a DSO (Distribution System Operator model).

- *Facilitating new hydrogen infrastructure*
  - Large-scale hydrogen network development for transport is not necessarily contingent on significant Government intervention and bodies of work such as the H2Mobility project in the UK have illustrated how such a network could be developed organically through coordinated private sector activity.
  - This does have implications for how such infrastructure may be developed as it tends to favour e.g. truck and trailer distribution to facilitate more incremental roll-out and avoid the potential for significant lumpy investments in larger scale pipeline infrastructure. These could be more economic with larger volumes of hydrogen in later years, but have a higher risk of asset stranding

Using the targeted research, the long list of entities (defined by their position and category) was condensed to a short list of generic entities that are considered to be material, and variations to these that are novel, or that could be particularly important for ULEVs. The specific entities (BBs) on the CVC will vary by Narrative.

5.2.1 Framing the business models

Using the short list of commercial entities, the business models have been defined using a framework. This gives high-level information about the elements that collectively represent each specific model: Partner Network, Key Activities and Resources, Offer, Customer Relationships and Distribution Channels, Customer Segments, and Revenues and Costs.

'Generic' models have been used as a basis, either drawing on traditional models, or existing examples (in the UK or elsewhere) that are starting to gain traction. **Variations to these generic models are included** on each framework as either:

- **Changes to the activities assumed within one model**, e.g.
  - a **Charging Point Operator** may vary through its use or not of distributed generation on-site, tariffs used for cost recovery, payment to host (e.g. host sites the stations for free or a fee/ rent), and ownership models (charging points owned by Charging Point Operator itself, by an OEM, a utility, or the host)
  - **Vehicle Sharing Schemes** might provide different offerings to their customers; for instance, manufacturer or third-party led (BMW DriveNow uses BMW cars, whereas Car2Go buys cars from local dealerships), the range of operation (ZipCar uses range extender vehicles, whereas other operators may be city-led and offer BEVs only), incentivised charging, cost of parking, and the extent of associated apps/ digital offerings
- **Closely-linked or very similar types of business models that can be described on the same framework**, e.g.
  - a **Hydrogen Network Operator** may typically operate at least in the short-medium term by delivering hydrogen gas in high pressure tube trailers/ cannisters; variants may be building new pipelines, re-purposing using existing gas pipelines (through injection and recovery of hydrogen in the natural gas stream) or delivery as a liquid in tankers
  - a **Vehicle Leaser** is described as the generic business model; a Battery Leaser is similar enough to be described as a variant to this and would likely combined with

the Vehicle Leaser. Vehicle Sharing Schemes have been described separately as their focus is on shorter-term mobility and in some cases these could also be used as an advertising tool to encourage uptake of ULEVs

Appendix A shows the business model examples using the framework. Detailed descriptions of the business models for the short listed commercial entities are provided in the supporting spreadsheet.

These entities are represented on the Analytical Framework in deliverable D1.1, section 8.1.1 – Focus of CPAT Tool.

5.2.2 Example business model

An example of the business model on the framework for the Vehicle Manufacturer is shown in Figure 4. Table 10 provides the detailed description of this example, taken from the supporting spreadsheet.

Figure 4 Business model of the Vehicle Manufacturer described using the framework

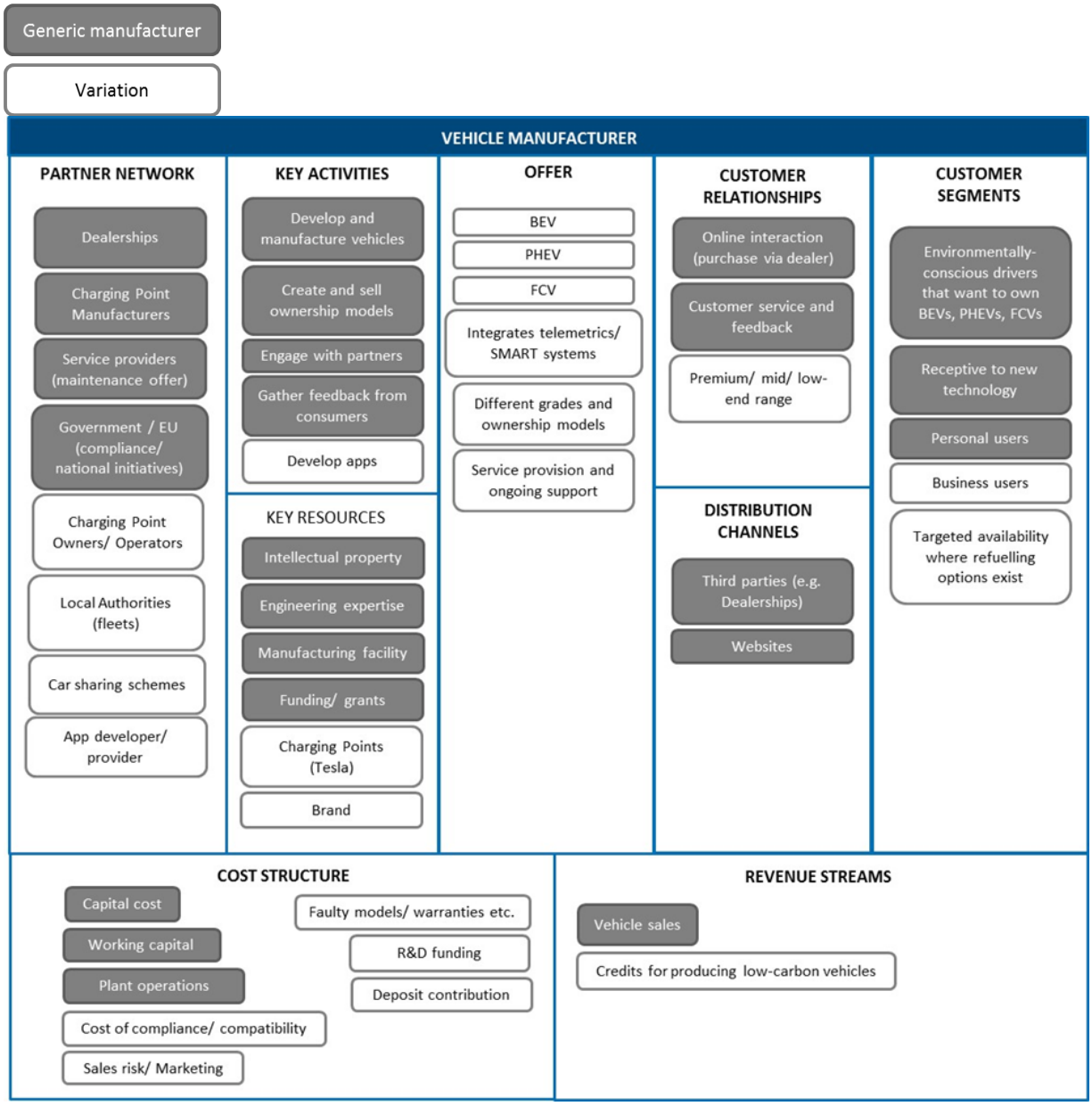


Table 10 Business model of the Vehicle Manufacturer described in detail

Vehicle Manufacturer	
Known examples	Nissan LEAF, Mitsubishi Outlander PHEV, Tesla Model S, Chevrolet Volt, Toyota Prius Honda FCV Concept (US, 2017), Toyota FCV Mirai (US 2015-16), Hyundai FCV Tucson (US, 2014)

Generic Vehicle Manufacturer (e.g. Nissan LEAF)

Proposition Offer	• **Manufacture of ultra low-emissions vehicles (<75 gCO2/km) at cost appropriate to the target market, once accounting for any tax exemptions and credits.** Ideally cost-competitive with conventional vehicles. • **Service provision and ongoing support** (providing warranties e.g. 3-year or 60,000-miles vehicle warranty/ 5-year warranty on the battery) • **Information about mobility/ ChargePoint Partners/ Smart systems:** Nissan provides tools to manage range: 'Eco' driving mode option, option to specify reaching certain internal car temperature during car charging, and option to maximise range by choosing the most energy-efficient route • **Lower maintenance cost for EVs:** engines have less moving parts, which translates to fewer visits to a garage for repairs over the life of the car. Servicing costs of an EV are about £350 less than a petrol or diesel car. • **Range of mileage depending on model but in general low relative to conventional vehicles** (Nissan LEAF = 95-155 miles depending on Scenario, Tesla Model S = 330miles) • **Optional add-ons for high-end ULEVS:** such as acceleration upgrades, packages for sub-zero weather package or towing
Who is the customer? Customer segments etc.	• **Consumer is typically environmentally-conscious** (or corporate fleet user that wishes to improve their brand) • **Mid-range user** (Nissan c.£20,000); **low-end** (Toyota Prius); **high-end** (Tesla £95,000 Model X, GM, Fiat-Chrysler).
How is value creation organized? Activities/ Resources/ Partners/ Costs	**Activities**: • **Develop and manufacture low-emissions vehicles** at various grades (entry level, mid, top-of-the-range) and **create ownership models** (outright purchase, battery leasing based on three different annual mileages), **recommends charging options** [1) cable allowing recharging using a standard household socket, which can also be used at many public charging stations throughout the UK, 2) manufacturer's home chargers], **manage risk** (mitigate problem around stranding risk by focusing all engineering efforts on using the same basic parts in multiple cars), **marketing** (branding at charge stations, other advertising materials, cross-country excursions, partner with car-sharing scheme so consumers essentially test drive the cars without realising) **Resources:** • **IP, engineering skills**, **manufacturing facilities,** as well as **credits** for manufacturing ULEVs (super credits from EU), **grants/ funding** (Nissan LEAF factory supported by a £21m Grant for Business Investment from the UK Government and a proposed finance package from the European Investment Bank of up to £197m), **brand** (increased take-up has only happened with more well-known brands and models, sales only began to increase significantly with the availability of 4-5 seaters as there were concerns around safety of 2 seater models) **Partners:** • **Government/ EU** (lobbying/ influencing and compliance - in 2009, technology-neutral CO2 emission sales targets for new passenger cars were adopted, each manufacturer required to achieve at least a fleet-average CO2 target of 130g/km by 2015 and 95g/km by 2020 and, for vans, the corresponding CO2 target is 175g/km from 2016 and provisionally 147g/km from 2020) • **Industry bodies** (with the objective of supporting UK production of ULEVs, five key agencies have been established by the UK government and DECC established Local Carbon Economic Areas across the UK to support low carbon specialisation within the UK economy; the North East is designated as the provider of EV expertise, while the Midlands region is linked more generally to advanced automotive technology, which includes EV design) • **Dealerships** to display and sell cars on forecourts • **Charging Point Manufacturers and owners** **Costs:** • Manufacturing (Nissan shifted production from Japan to the UK to reduce retail prices). GM and Fiat were reporting losses on EVs as over-engineered and over-priced.

Variation: Vehicle Manufacturer and Charging Point Owner/ Operator (Partnership or Merger)	
What makes this business model similar?	Vehicle Manufacturer as per stand-alone manufacturer, partnered or merged with charging point owners/ operators
What makes this business model different?	In the stand-alone model the vehicle manufacturer may provide some information about the availability of charging point (e.g. this could be incorporated into the dashboard), however, there are extended options in a partnership/ merger arrangement: • **Charging points installed in dealerships associated with the manufacturer** (rapid charging in Nissan Dealerships; charging in Toyota dealerships in US) • **Partnerships with charging point owners** (Nissan recommend the use of the Ecotricity Electric Highway as it's currently free, in the USA they offer complimentary charging for 2 years, estimating the value at 500 $ p.a., and Toyota offer free fuel on their FCV for the first 3 years, estimating the value at 1250 $ p.a) • **Roll-out of own charging point stations to incentivise take-up of cars:** Tesla US and European Supercharger network – its Supercharger stations are free to use for Tesla owners, and by using a hugely powerful 120kW DC supply they can take the Model S from empty to 50% in 20 minutes. The 120kW DC supply only works with the Model S for now, but Tesla has said that if rivals build electric cars that can handle this current, it will help develop an adapter – so long as these makers agree to let their customers use the Supercharger network for free, too. • **Only make ULEVs available where refuelling stations exist:** e.g. targeted roll-out in the USA of the Honda FCV, which is only available to customers who live in Southern California where fast-fill hydrogen stations are available

5.3 Areas for further research and known gaps

Many of the business models on the CVC are traditional and therefore well-understood. There is less information available on the potential success and commercial viability of novel business models, such as those that do not yet exist at scale, including:

- The **DNO becoming a DSO**, which is at the early stages of discussion within the GB market and covers a wide range of potential roles[9] including more active management of both supply and demand – the latter is of more direct relevance in terms of demand management of PIVs, potentially via aggregators.
  - For example UKPN's Low Carbon London trials focused primarily on the technical and economic implications of integrating a range of low carbon technologies at the distribution level, with some initial exploration of possible commercial arrangements[10]
- **battery leasing** models,
- **battery swapping** (this has been trialled internationally but not in the UK),
- and the **IT/ data provider** (especially the appetite of the consumer for smart, consumer-oriented apps and bundling).

5.4 Key focus areas for the Analytical Framework

The short list of commercial entities on the CVC is shown in Table 11, and can broadly be categorised into

- **Electricity:** retail suppliers, network operators, aggregators and charging point operators
- **Liquid fossil:** distributers (to forecourt) and retailer (to forecourt)
- **Hydrogen**: retailers (either forecourt or to home/depot[11]), distribution (road, pipeline network, gas distribution network repurposing), localised H2 producers
- **Vehicles:** retailers, leasers, sharing business models (e.g. car clubs)

[9] https://www.ofgem.gov.uk/sites/default/files/docs/2014/02/role_of_the_dso_slides.pdf

[10] Such as contract templates for the provision of demand management from direct customers or via aggregators http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Low-Carbon-London-(LCL)/Project-Documents/LCL%20Learning%20Report%20-%20D1%20-%20Development%20of%20new%20network%20design%20and%20operation%20practices.pdf

[11] I.e. via pipeline network and potentially separating ownership and operation of the network to sale of the product flowing through it; analogous to the overarching market structure for gas and electricity today.

Table 11 also identifies those commercial entities that are stand-alone (i.e. represented as a single entity on the Analytical Framework) and those that are a merger of two or more commercial entities (i.e. where a combined offering creates value, represented on the Analytical Framework via a shared P&L belonging to this 'multiple-entity company'). Partnerships between entities are used in some Narratives, although there is no intent to quantify the value associated with partnerships via the Analytical Framework.

Table 11 Summary of BBs included in the CVC

Described by business model framework
Described as variant on framework
Not described/ limited notes in supporting spreadsheet

Category	Business model	Stand-alone Entity	Building Block Name	Sheet with Further Information
Vehicles	Manufacturer	×	1. Vehicle Manufacturer	Vehicle Manufacturer
		×	2. Vehicle Manufacturer and Charging Point Owner/ Operator	Vehicle Manufacturer
	Retailer	✓	3. Vehicle Retailer (retail arm of manufacturer)	Vehicle Sales
	Leaser	✓	4. Vehicle Leaser	Vehicle Sales
		×	5. Battery Leaser	Vehicle Sales
		✓	6. Vehicle Sharing Scheme	Vehicle Sharing
Electricity	Retailer	✓	7. Electricity Supplier	Electricity Supplier
		×	8. Electricity Supplier with Vehicle Manufacturer	Electricity Supplier
	Distribution Network Operator	✓	9. Electricity DNO	Electricity Network Operator
		×	10. Electricity DNO as DSO	Electricity Network Operator
		✓	11. Electricity DNO/ DSO with Charging Point Network	Electricity Network Operator
	Charging Point Owner	✓	12. Charging Point Operator / Network/ Owner	Charging Point Operator
		×	13. Charging Point Operator/ Network/ Owner with Electricity Supplier	Charging Point Operator
		×	14. Battery Swapping	Charging Point Operator
	Aggregator	✓	15. DM Aggregator	Aggregator & Digital
		✓	16. IT/ Data Provider	Aggregator & Digital
Liquid Fuel	Retailer	✓	17. Liquid Forecourt Retailer	Liquid Fuel & H2 Retailer
	Distribution Network Operator	✓	18. Liquid Fuel Road Distributor	Liquid Fuel & H2 Network Operator
Hydrogen	Retailer	✓	19. Hydrogen Retailer (at Forecourt)	Liquid Fuel & H2 Retailer

	Producer	✓	20. Localised Hydrogen Producer	Liquid Fuel & H2 Retailer
		×	21. Localised Hydrogen Producer with Forecourt Retailer	Liquid Fuel & H2 Retailer
	Distribution Network Operator	✓	22. Hydrogen Network Operator (Pipe)	Liquid Fuel & H2 Network Operator
		✓	23. Hydrogen Road Distributor	Liquid Fuel & H2 Network Operator
	Centralised Producer	✓	24. Centralised Hydrogen Producer	Not described – boundary condition

The entities in Table 11 are the Building Blocks that will be represented on the Analytical Framework and are, by definition, the focus for the framework.

The CVC building blocks have been applied in a manner consistent with the description of the Narratives as shown in the summary in Table 12, further detail is provided in D4.1 Section 7.

Table 12 Summary of BBs to Narrative mapping for the Commercial Value Chain

✓	Captured quantitatively
✓	Captured qualitatively
✓	Exists as per BaU

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
1. Vehicle Manufacturer	✓	✓	✓	✓	✓	✓
2. Vehicle Manufacturer and Charging Point Owner/ Operator		✓				
3. Vehicle Retailer (retail arm of manufacturer)	✓ (private)	✓ (private)		✓ (private)	✓ (private)	
4. Vehicle Leaser	✓ (fleet)	✓ (fleet)	✓	✓ (fleet)	✓ (fleet)	✓
5. Battery Leaser	As per vehicle model					
6. Vehicle Sharing Scheme			✓			✓
7. Electricity Supplier	✓	✓	✓	✓	✓	✓
8. Electricity Supplier with Vehicle Manufacturer		Partnered				
9. Electricity DNO	✓	✓	✓		✓	
10. Electricity DNO as DSO						
11. Electricity DNO/ DSO with Charging Point Network				✓		✓
12. Charging Point Operator / Network/ Owner	✓	✓ (vehicle OEM)	✓			
13. Charging Point Operator/ Network/ Owner with Electricity Supplier						
14. Battery Swapping						
15. DM Aggregator			✓			
16. IT/ Data Provider			✓			✓
17. Liquid Fuel Forecourt Retailer	✓	✓	✓	✓	✓	✓
18. Liquid Fuel Road Distributor	✓	✓	✓	✓	✓	✓
19. Hydrogen Retailer (at Forecourt)	✓	✓	✓	✓	✓	
20. Localised Hydrogen Producer			✓ (depots)			
21. Localised Hydrogen Producer with Forecourt Retailer						
22. Hydrogen Network Operator (Pipe)				✓ (LT)	✓ (pipes)	
23. Hydrogen Road Distributor	✓	✓	✓	✓ (ST)		
34. Centralised Hydrogen Producer	✓	✓	✓	✓	✓	

There are, however, several simplifying assumptions that have been made, including putting in place defined boundary conditions (these conditions are described in Deliverable D1.1 Section 8) as part of the way the CVC BBs have been applied to the Narratives. These are described below for each of the categories.

- **Electricity:**
  - **Large-scale generation and transmission are treated as part of the boundary conditions reflecting a "wholesale price".**
  - **Potential changes to the risk premium and hedging strategies, or differences due to economies of scale, for the Electricity Supplier in different Narratives will not be modelled**[12], therefore changes are likely to be described qualitatively. Similarly it is assumed that in general, Electricity Suppliers continue to exist in their current format.
  - **The DNO model for electricity is assumed to be a regulated 'natural monopoly' model**; independent DNOs could exist but for simplicity these are only reflected for hydrogen where multiple private distribution network operators could distribute hydrogen via high-pressure trailers, as opposed to a pipeline network.
  - **The DSO model is "very broadly**[13]**" considered to be equivalent to a DNO together with a DM Aggregator.** The Aggregator is assumed to provide DM and/or ancillary services from control of ULEV charging directly to the distribution network[14]. The use of managed ULEV charging/discharging for energy arbitrage revenues is considered to be less material and should be described qualitatively.
  - **There are various permutations of the Charging Point Operator/ Network/ Owner in existence today, however, in general the Charging Point Operator/ Network/ Owner will be set up in a 'generic' specified configuration.** Exceptions are the Charging Point Operator/ Network/ Owner may partner with an Electricity Supplier and provide discounted tariffs for EV use; or the DNO may also form a merger or partnership with a Charging Point Network (for instance, with Government guaranteeing a regulated return to the DNO for rolling out the network), capturing the cost of the network through distribution network charges as a regulated entity.
- **Liquid fossil:**
  - **Production and supply is treated as part of the boundary conditions reflecting a "wholesale price"** – the forecourt retailer and distributor are accounted for because any changes to ULEV uptake will naturally have an impact on the liquid fuel value chain in terms of its ongoing commercial viability.
- **Hydrogen**:
  - **Large-scale generation and transmission are treated as part of the boundary conditions reflecting a "wholesale price".**

[12] Consistent with the key simplifying assumptions in D1.1

[13] As the focus is not on exploring the wider set of issues around commercial management of e.g. different forms of distributed and intermittent generation at the distribution level, which are somewhat removed from the benefit of directly manage PiV charging to minimise network investments

[14] As opposed to current forms of aggregation which tend to be based around I&C customers with services provided directly to the TSO.

- **Repurposing of the gas network for H2 delivered direct to the household / depot is not currently considered as part of any of the core Narratives, but may be tested as a sensitivity.** The business case for doing so would not be ULEV specific and as such would need to include the costs of e.g. repurposing all heat, cooking and small scale industrial appliances to either hydrogen or electricity. The options for distribution and production have been somewhat simplified and it is the timescales of transition that are particularly important (e.g. from trailers to potentially pipeline distribution, from localised methane reforming to electrolysis or large scale hydrogen production).

- **Vehicles:**
  - **Manufacturers and the secondary vehicle market for ULEVs are treated as part of the boundary conditions,** however the price of the vehicles from the vehicle retailer contains the margin required by both the manufacturer and retailer themself**.**
  - **For simplification, the Battery Leaser is only used in instances when the Vehicle Leaser applies.**
  - **Battery Swapping may be described qualitatively where applicable**. It is not clear how successful this would be in the UK – Denmark and China are examples of countries that have battery swapping stations, however, these also have a relatively low EV market share for a relatively high degree of incentives. Battery swapping relies on a high degree of standardisation and hence may be more suited to fleets that use standardised battery packs.

- **The IT/ Data Provider will be described qualitatively where applicable.** This entity collects data and converts it into products, such as apps showing charging station locations, apps giving the ability to choose, reserve and locate the vehicle, remote temperature control, state of charge monitoring, advanced services such as modelling the battery life, and information provision on the electricity prices/ tariffs to encourage smart charging

6 Market and Policy Framework (MPF)

6.1 Overview

The MPF has been divided into various BBs, grouped into: Financial Measures (Fixed Cost), Financial Measures (Running Cost), Non-Financial Incentives, Limits, Information, Investment, and Regulation. Across these categories it is important to note that the distinction between:

- The **market framework** that provides an overarching set of rules by which *all* commercial entities and/or consumers must operate. This includes energy sector regulation in general, i.e. one of the most significant examples in the UK is the clear separation of monopoly ownership of electricity and gas network assets (via regulated return business models) and the supply of energy through them.
  - This separation is not mandated for liquid fossil road distribution to forecourts (as there exists the potential for meaningful competition), but it is not yet clear what the long term market structure might be for pipeline (as opposed to road-based) hydrogen networks[15]
- **Policy options** which are specific interventions enacted within the overarching market framework, such as a tax or subsidy, and which may be targeted or differentiated by entities operating in the same part of the market

Each category has defined BBs within it that are either currently in use in the UK, in use elsewhere, or have not yet been implemented but could be used as a new method to incentivise ULEV uptake or dis-incentivise the use of conventional vehicles.

A level of materiality is assigned to each BB, either high, medium or low, and this defines its relative importance in the Analytical Framework. For the MPF, the materiality is dependent on three underlying factors; approximate value to the end consumer (absolute £, % of vehicle cost or qualitative assessment), buyers covered (all vehicle buyers including fleets and individual users, cars and vans vs. specific target customers) and importance to the consumer (i.e. widely reported as a primary or secondary reason to buy a ULEV). A summary of the BBs is provided in Table 13.

A more detailed description of each BB is included within the supporting spreadsheet, and Figure 5 provides an example for one of the BBs. For each BB, its use and success in the UK and elsewhere has been documented and is another factor used in defining the overall level of materiality. As per the PSC and CP, an initial assessment of the information that will most likely be required to quantify the BB is also incorporated.

[15] And similarly district heat networks who can currently exist on a merchant basis vertically integrated with supply to the point of the consumer.

Table 13 Summary of BBs included in the MPF

Materiality for framework
High
Medium
Low

FINANCIAL MEASURES: FIXED COST	FINANCIAL MEASURES: RUNNING COST	NON-FINANCIAL INCENTIVES	LIMITS	INFORMATION	INVESTMENT	REGULATION
1. Gov. grants to consumers *	7. Fuel price subsidies *	18. Increased mobility	22. Direct CO2 tax *	26. Education/ marketing	28. Government funding/ investment	33. Adequate access to infrastructure *
2. Private grants to consumers	8. Vehicle excise duty (annual road tax) *	19. Simplification	23. Direct emissions limit inc. EC car/van regulation*	27. Mandatory/ voluntary reporting	29. Leveraging Private investment *	34. Other laws/ wider energy sector regulations including EC*
3. VAT on assets *	9. Company car tax *	20. Status	24. Emissions cap and trade scheme		30. Investment in R&D	35. Commitment
4. Purchase/ registration tax *	10. Fuel duty *	21. Increased access to parking	25. Emissions credits scheme		31. Capital allowances	36. Role of local authorities
5. Refund schemes	11. VAT on fuel *				32. Government guarantees	37. Standard-isation
6. Subsidies for other fixed costs	12. Cheaper mobility *					38. Co-ordination/ National initiatives
	13. Cheaper access to parking					39. Planning regulations
	14. National insurance					
	15. Subsidies for other running costs					
	16. Road pricing – congestion / CO2 / revenue objectives *					
	17. Weight tax					

Figure 5 Example of detailed BB view in the supporting spreadsheet for the MPF

Category	Financial Measures: Fixed Cost
Building block number	**1**
Building block name	**Direct Grants to Consumers**
Explanation	• Upfront payment given to the consumer towards the cost of the vehicles/ infrastructure.

Currently used in UK	**Yes**
Explanation/ examples	• Plug-in Car Grant. This was introduced in 2011. From 1st April 2015, the grant was raised from 25% to 35% of the vehicle's RRP, (maximum of £5,000) and three grant categories introduced. This level will remain until at least 50,000 cars have been sold or until 2017, whichever is the sooner. Governmentcommitted to providing at least £200m in the period 2015-2020 to bridge the additional cost of ultra low emission cars. • Plug-in Van Grant. • The Electric Vehicle Homecharge scheme. This was introduced in 2013 to enable ULEV owners to receive a grant towards the installation of a domestic charge point of 75% (maximum £1000 including VAT) and the Gov. has seen that a number of vehicle manufacturers and chargepoint suppliers will supply the remaining 25%. • Public Sector Workplace Grant.
How successful have these been in UK?	• Over 90% of responses to 2013 OLEV CfE suggested Government should continue to provide upfront consumer grants for cars and vans and reduce emisssion threshold from 75 gCO2/km (other definitions suggest 50 gCO2/km more appropriate). • The Plug-in Van Grant has had low uptake due to limited product availability so Government stated in 2014 it would consider whether to widen the scope.
Approximate value (abs) Rule of thumb: Low (~<£1000)/ Med (~£1000-3000,~10%)/ High (~>£3000,>10%)	• Up to £5000 per car (max £200m to 2020) or 35% RRP • Up to £8000 per van (max £30m) or 20% RRP
Buyers covered Rule of thumb: All (Fleet, Private, Car, Van)/ Most (some focus)/ Min (very targeted, e.g. ~<25% market) **(or otherwise other parties)**	• Private and fleet, car and van
Importance to consumer Rule of thumb: High (key reason) Med (considered a reason) Low (not important) **(or otherwise to parties involved)**	• UK fleets account for 75% of those that have claimed PiCG. • The Plug-in Car Grant was considered an important factor in the purchase decision of 85% of ULEV purchasers. • 89% of respondents to one survey said that the Plug-in Car Grant was very/fairly important in their decision to buy an EV.

Current policies elsewhere	• Direct grants and feebates
Estonia	• The deal between Government and Mitsubishi included subsidies from Mitsuibishi for the first 500 private buyers of any electric car approved by the European Union
Norway	• Government set up a £5.6m fund allowing municipalities and companies to apply for grants to cover the installation costs up to around £4000 per charging point.
Japan	• EV purchasers in Japan are given a grant on the purchase of a new EV, capped at about €6,300. Representative BEV would receive €4600 and PHEV €3400. • The current formula is complicated but is basically: two thirds of the price difference between the EV and a comparable gasoline car.
Netherlands	• Subsidy for vans c.€3000 plus local grant (€2000 in cities for companies). • Home charging has also been supported, with some local municipalities giving grants of up to €1,000 towards the installation of home charging points. • Furthermore, some EVs were sold with one or more charging stations included, mostly free of charge including installation at home or office locations. • The city of Amsterdam will also grant up to €1,000 towards the cost of a charging point in a public parking space.

France	• A feebate on the purchase of new cars, the "Bonus/Malus", was introduced in France in 2008. The system was neutral for cars emitting between 130 and 160 g/km. The less polluting cars benefited from a price reduction of up to €1,000, while the most polluting ones were subject to a taxation of €2,600. • Bonus cannot exceed 30% of purchase price. €7000 for BEV, €5000 for representative PHEV. • The policy appears to enhance the total sales of new cars by around 13%, despite the slowing down of the economy observed at this period. Planned to be neutral for the State budget, the measure turned out to cost €285m in 2008 because of its overwhelming success. • Buyers shifted their purchase option to cars benefiting from rebates but with hardly lower emissions. For more notes about effectiveness of feebates see 'Pathways to high penetration of EVs', p97
US	• Representative BEV: $7,500 federal (~€5400) and $2,500 (~€1800) state rebate. • Representative PHEV: $5,400 federal (~€3900) and $1,500 (~€1100) state rebate.
Germany - example for FCVs	
Denmark - example of unsuccessful MPF	• The case of Denmark, where tax exemptions lead to significant rebate, is an example showing that addressing the cost barrier does not necessarily lead to high uptake. • Despite a more generous tax exemption for BEVs in Denmark as compared to Norway, the uptake was only 0.3% in 2012 (vs.3.3% in Norway)
China - example of unsuccessful MPF	• China is another example of high purchase incentive not delivering uptake in comparison to the results obtained in leading countries (grant of 60,000 yuan [ca. £6.3k] in 2012 and 0.08% uptake) • One time bonus €4200-7200 for BEVs based on battery range and around €4200 for PHEVs.
How successful have these been?	• Feebates have been very successful in France, appearing to enhance the total sales of new cars by around 13%. However, buyers shifted their purchase option to cars benefiting from rebates but with hardly lower emissions. A self-financing feebate scheme may not be sustainable beyond when EV sales match or exceed ICEV sales. • Upfront incentives are very important; but alone they may not lead to significant uptake (as was the case in Denmark and China)

Overall Materiality	**High:** • Upfront incentives viewed as important - likely to be a barrier until ~2030 • Often supplemented by local authorities and manufacturers/ vehicles suppliers (in the case of charging points). • Are not enough alone to result in significant uptake (as was the case in Denmark and China). • In Norway, the aim is to make ULEVs competitive or near-competitive with conventional vehicles; in Japan, roughly two-thirds of the price difference is captured.

Information Required	Car type, Van type, Charging Point type, H2 infrastructure type
	Total value
	Absolute or % of total cost
	Payment frequency
	Capped
	National or locational
	Differences for private users, leasing, and business users
	Differences for fleets/ non-fleet company cars
	Changes with emissions rate
	Difference for new vs. retrofit
	Forecast changes over time

6.2 Synthesis of evidence and literature

The Market and Policy Framework (MPF) Dimension covers all market and policy components relevant to the transport sector and ULEVs in particular. The literature review focussed on understanding the current market for ULEVs in the UK and for other targeted countries, the strategies taken in different countries together with the government policies that underpin these, and the use of incentives, dis-incentives and laws/ regulations. The review aimed to address the following questions:

- ***Which market and policy instruments have been applied,*** *either currently or historically, and how successful have these been at promoting high ULEV uptake?*
  - *In the UK, and for targeted countries (those that have been particularly successful or unsuccessful)*
  - *Have pre-determined **strategies** been developed and used? What did these contain? Do these address the primary concerns of the consumer e.g. range anxiety?*
- *Are there are **novel instruments** that have not yet been implemented in the UK or have had limited use elsewhere but that have the potential to be particularly effective?*
- *What value does the consumer place on **financial measures** targeting fixed costs compared to those targeting running costs, **or non-financial incentives**?*
  - *How can these be grouped effectively into a suite of complementary measures?*
- *How can **regulation be targeted at entities on the supply chain** to incentivise the production, marketing and sale of ULEVs?*
  - *For instance, enforced limits on emissions, requirements to provide and disseminate information, common standards for equipment and planning regulations*
- *Who should invest in ULEVs and supporting infrastructure?*
  - *What is the **role of the government and local authorities in both investing** in the physical supply chain directly **and in providing information** and educating others?*
  - *How can **private financing** be supported?*

The **market framework** that provides an overarching set of rules by which *all* commercial entities and/or consumers must operate. This includes energy sector regulation in general, i.e. one of the most significant examples in the UK is the clear separation of monopoly ownership of electricity and gas network assets (via regulated return business models) and the supply of energy through them.

Policy options which are specific interventions enacted within the overarching market framework, such as a tax or subsidy, and which may be targeted or differentiated by entities operating in the same part of the market

For the MPF it is both the value and the combination of measures (BBs) that is important. An equivalent level of subsidy or value to the consumer can be established using various combinations of different BBs. Key initial insights from the review of literature are:

- *Current measures*
  - In the UK, most of the instruments identified are already used, or have been used to varying extents.
  - The Government's current activities are aimed at supporting the early market, shaping the required infrastructure, securing the right regulatory and fiscal measures (strong, clear, lasting tax incentives to at least 2020 and making funding available to cities that commit to supporting a step change in ULEV adoption), investing in UK automotive capability and preparing the energy sector (e.g. ensure smart meters support charging).
- *Strategies*

- Different countries have aimed to encourage high uptake of ULEVs in different ways and further detail is given on the specific approaches that countries have taken in the supporting D4.1 spreadsheet.
- In delivering its current vision for the ULEV sector in the UK, the Government's goals are: helping support the purchase of ULEVs through direct grants, incentives and advice; facilitating the provision of recharging infrastructure through provision where consumers would use it most (primarily homes and workplaces), with some provision of public recharging where needed; preparing for hydrogen fuel cell electric vehicles in the UK following Government's technology neutral approach; encouraging and investing in R&D; lowering emissions from other vehicles.
- The primary barriers to purchasing an electric vehicle are range, certainty of access, cost and lack of knowledge, and for a hydrogen vehicle are availability of hydrogen, cost and supply of FCVs.

- *Financial incentives versus 'perks'*
  - Upfront incentives are viewed as important and likely to be a barrier until at least 2030, however, these may not be enough alone to result in significant uptake (e.g. as was the case in China). It is primarily the overall value of the upfront incentives that is important; these have been applied as tax exemptions in the Netherlands, grants in Norway and fee-bates in France, whereby vehicles with low emissions are rewarded whilst those with higher emissions are penalised[16].
  - Refund/ buyback schemes may also be material; particularly for fleet users, which may be more concerned about residual value and battery replacement (Nissan is addressing these concerns by last year introducing a scheme through which buyers will receive cashback for their old battery).
  - Access to HOV lanes is also considered to be important in California, and in Norway bus lane access is considered to be as important in EV uptake as main financial incentives in regions with high rush-hour traffic.
- *Combining measures*
  - A country that has been particularly successful in incentivising ULEV uptake through a combination of measures is Norway. Incentives in Norway are focused on tax exemptions rather than subsidies, and making the electric car purchase price competitive with, or at a small premium to, conventional cars. Growth in the market has been organic and sales increased significantly once models were available from major OEMs. Incentives such as road toll exemptions and access to bus lanes are viewed as important. Many incentives either have no cost, or are covered by those who pay more or over a longer period, and support measures are guaranteed for relatively long periods of time. Commitment is demonstrated by public procurement for municipal vehicles and the provision of public charge points with free charging and parking, and awareness of ULEVs is raised via the Norwegian Electric Vehicle Association.
- *Role of government and local authorities in investment*

[16] A fee-bate on the purchase of new cars, the "Bonus/Malus", was introduced in France in 2008. The system was neutral for cars emitting between 130 and 160 g/km. The less polluting cars benefited from a price reduction of up to €1,000, while the most polluting ones were subject to a taxation of €2,600.

- The importance of anticipatory investment is still an unknown. It is argued that in Norway, growth in EVs was organic and did not require anticipatory investment in a public charging network. However, it has been shown that high proportions of some consumer segments believe a rapid public charging infrastructure needs to be in place before they would adopt vehicles.
- In the UK, the Government intends to make up to £35m available to the 2 to 4 cities that commit to supporting a step change in ULEV adoption in their areas through measures and £20m available to local authorities who commit to introducing ULEV taxis.

- *Information and education*
  - Measures such as *education/ marketing,* and *mandatory/ voluntary reporting* may increase awareness and, consequently, uptake. Other than range concerns and purchase price, lack of knowledge/ familiarity with EVs is one of the most commonly cited barriers to uptake; various schemes have been used in the past, currently or are planned to try and meet this need – the Go Ultra Low Government website, various trials such as the Ultra Low Carbon Vehicle Demonstrator Programme, the Green Bus Fund, Plugged-in-Places and Plugged-in-Fleets initiatives, a National Consumer Campaign with manufacturers and various apps. In particular, it is thought that direct user experience (e.g. test drives for fleet users) is important

6.3 Areas for further research and known gaps

The majority of the market and policy instruments identified have been applied either in the UK or internationally, and studies have assessed the success of some of these measures.

Aspects that are less well understood and that have a direct impact on the consumer are:

- market and policy instruments used to introduce 'perks', such as **cheaper mobility** (road tolls) and **cheaper access to parking**,
- the impact of **resale value and the secondary market** on ULEV uptake is unclear; measures that support the secondary market and maximise the residual value may therefore be interesting to explore
- the impact of novel taxation/ incentive schemes such **as road pricing** which can be designed to address a combination of congestion, CO2, Air Quality and tax revenue objectives. The most complicated aspects are the quantifiable impact on driving patterns/modal shift as a result of different forms of road pricing and their subsequent effect on congestion/CO2/Air Quality

6.4 Key focus areas for the Analytical Framework

This section focuses on those BBs that have been identified as high and medium materiality for the MPF. Materiality has been primarily determined based on the approximate value of the measure (typically for the consumer), the extent of buyers covered (i.e. individual or fleet specific, targeted at specific powertrains), and the perceived importance of that measure to the consumer.

The high *and medium* materiality Building Blocks for the MPF are considered to be:

- Financial measures aimed at reducing fixed costs are **direct *and private* grants to consumers** (e.g. for cars, vans and home charging points)**, VAT on assets** (e.g. reclaimable if used for business, or can reclaim part if leasing) and ***purchase/ registration taxes*** (these are particularly low in the UK).
- BBs targeted at running costs and considered material are **fuel price, *VED*** ('road tax', currently varies in the UK according to emissions), ***fuel duty*** (electricity and hydrogen are currently exempt)***, VAT on fuel*** (electricity has a reduced rate).
    - ***Company car tax*** is currently lower for ULEVs than for petrol/ diesel cars and means that the individual user benefits from paying less tax; this could be important – low uptake of ULEVs in Denmark is thought to be due to lower incentives for company cars vs. individual purchase.
    - Differentiated **road pricing** could be used to recover loss of revenue from fuel duty due to the reduction in the proportion of cars that are fossil-fuelled decreases as the uptake of ULEVs increases.
- 'Perks' such as ***cheaper mobility*** (e.g. congestion charge exemptions for ULEVs in the near term) and ***cheaper access to parking*** could be important, although likely to be valued more in urban areas, affecting a smaller number of overall users. Currently in the UK, Local Authorities operate a range of schemes to provide discounted or free parking or resident's parking permits.
- Potentially important non-financial incentives are focused on ***increased mobility*** (e.g. local low-emissions zones in cities) and intangible measures such as ***simplification*** (e.g. of taxes for ULEV users, badge schemes to simplify the identification of ULEVs, interoperability, removal of Vehicle Special Orders for hydrogen vehicles) and ***status*** (i.e. in Norway users have reserved number plates, and in France eco-labels) – whilst they are difficult to quantify these measures should be described qualitatively.

- A **direct CO_2 tax** will be applied in the MPF to account for the cost of meeting EU and national carbon targets. The level of carbon tax will be informed by the whole energy system element of the Analytical Framework and importantly reflects the most cost-effective level of abatement from transport as part of the system as a whole. This will be applied as a price on emissions in transport (e.g. as fuel duty to ICEV users) and will be used to offset the implementation of 'subsidy' BBs when tracking an acceptable level of Government spending applied to transport abatement.
- ***Direct emissions limits,*** on manufacturers - currently there are limits imposed on vehicle manufacturers at EU level, requiring them to achieve specific fleet-average emissions targets by 2015 and 2020/21 for cars and vans[17] and, for instance, car manufacturers in California need to sell a set number of EVs each year. As part of the EU regulation there are also various adjustments applied to calculating compliance with these targets, including super-credits for ULEVs with CO_2 emissions of 50g or less, aimed at encouraging the development of breakthrough technologies.
    - There are also other potential measures that could be applied which focus directly on emissions such as emissions cap-and-trade schemes (Vehicle Owners/ Fuel Suppliers get certificates depending on emissions rate of vehicle/ emissions of fuel and can trade these)

[17] Fleet average values for new sales of cars of 95gCO2/km by 2021 and 147gCO2/km by 2020 for vans.

- Measures such as ***education/ marketing,*** and ***mandatory/ voluntary reporting*** may increase awareness and, consequently, uptake. Other than range concerns and purchase price, lack of knowledge/ familiarity with EVs is one of the most commonly cited barriers to uptake; various schemes have been used in the past, currently or are planned to try and meet this need – the Go Ultra Low Government website, various trials such as the Ultra Low Carbon Vehicle Demonstrator Programme, the Green Bus Fund, Plugged-in-Places and Plugged-in-Fleets initiatives, a National Consumer Campaign with manufacturers and various apps.
- Direct investment BBs considered particularly material are:
    - **Government funding** (e.g. funding to local authorities, to public-private partnerships such as match funding, and to private companies such as funding of charging infrastructure and vehicle manufacturing facilities)**,**
    - **Private investment** leveraged by direct or indirect Government 'support' (e.g. low interest loans versus guaranteed/regulated returns), particularly with respect to network infrastructure (including charging points).
    - ***Capital allowances*** (for instance write-downs in the first year for ULEVs, which Element Energy has previously estimated to be worth around 7-10% of the value of the vehicle over four years), are also thought to be important. Note that this benefit no longer applies to rental companies, including car clubs; it has been suggested that it would be highly advantageous to re-instate enhanced capital allowances for leased and rental fleets to support ULEV uptake.
    - ***Investment in R&D*** could also be important; the current focus is on improving the range of the battery, battery management systems and novel technologies such as dynamic charging
- More **novel taxation/ incentive schemes** for transport such as **road pricing**, which are not necessarily ULEV specific, but can be designed to address multiple policy objectives simultaneously. For example, road pricing designed primarily to address congestion (via static or dynamic pricing strategies), but with secondary objectives to replace lost revenue from liquid fuel duty and/or reduce CO2/Air Quality emissions (e.g. via more efficient driving patterns or modal shift). In addition, congestion charging could alter PIV charging patterns indirectly by shifting the pattern of when vehicles need to be charged

Aside from this, there are highly material elements of the overarching policy framework such as **other laws and regulations** (e.g. compliance with EU directives) and adequate **access to infrastructure** (extent of coverage, whether investment is anticipatory vs. organic, led by public authorities or private companies, perceived vs. actual access requirements). Organic investment can be reflected in the 'Organic' Narratives, whereas investing somewhat more ahead of need (in order to increase consumer awareness or reduce perceived barriers such as lack of access to refuelling infrastructure) could be reflected in the 'Co-ordinated' Narratives.

There are other aspects of the overarching policy framework for which it is harder to quantify the impact but that are still important, such as:

- ***Commitment*** (e.g. Government commitment to a strategy – for instance leading by example by using ULEVs in Government fleets, and Government commitment to

industry – for instance through grandfathering of subsidies and timely announcements of changes),

- The ***role of local authorities*** (e.g. mandates for a certain number of charging points or parking spaces),
- ***Standardisation*** (e.g. Government only funding public charge points with a certain type of sockets, standards for autonomous vehicles), all of which are likely to be described qualitatively rather than quantitatively.

The CP building blocks have been applied in a manner consistent with the description of the Narratives as shown in the summary Table 14, further detail is provided in D4.1 Section 7.

Table 14 Summary of BBs to Narrative mapping for the Market and Policy Framework

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
1. Gov. grants to consumers	✓			✓	✓	
2. Private grants to consumers	✓					
3. VAT on assets	✓	✓		✓	✓	
4. Purchase/ registration tax	✓	✓	✓	✓	✓	✓
5. Refund schemes	✓	✓		✓	✓	
6. Subsidies for other fixed costs						
7. Fuel price subsidies				✓		✓
8. Vehicle excise duty	✓	✓	✓	✓	✓	✓
9. Company car tax	✓	✓	✓	✓	✓	✓
10. Fuel duty	✓	✓	✓	✓	✓	✓
11. VAT on fuel	✓	✓	✓	✓	✓	✓
12. Cheaper mobility	✓		✓			
13. Cheaper access to parking			✓			
14. National insurance	✓					
15. Subsidies for other running costs						
16. Road pricing						✓
17. Weight tax						
18. Increased mobility	✓		✓			
19. Simplification						
20. Status						
21. Increased access to parking			✓			
22. Direct CO2 tax	✓	✓	✓	✓	✓	✓
23. Direct emissions limit	✓	✓	✓	✓	✓	✓
24. Emissions cap and trade scheme						
25. Emissions credits scheme						
26. Education/ marketing	✓	✓	✓	✓	✓	✓
27. Mandatory/ voluntary reporting	✓	✓	✓	✓	✓	✓
28. Government funding/ investment	✓					
29. Private investment	✓	✓	✓	✓	✓	✓
30. Investment in R&D	✓	✓	✓	✓	✓	✓
31. Capital allowances	✓					
32. Government guarantees	✓					
33. Adequate access to infrastructure					✓	✓
34. Other laws/ wider energy sector regulations	✓	✓	✓	✓	✓	✓
35. Commitment	✓					

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
36. Role of local authorities	✓		✓			
37. Standardisation	✓					✓
38. Co-ordination/ National initiatives	✓			✓		✓
39. Planning regulations	✓		✓	✓		

In terms of building blocks that are not considered explicitly or tackled more qualitatively across the Narratives the rationale for these is as follows:

- MPF2 – private grants are not considered directly as one of the key simplifying assumptions within the Commercial and Policy Accounting Tool (CPAT) – see Deliverable D1.1 Section 8 - is that commercial entities set prices to be as reflective of underlying costs as possible rather than undertake strategic pricing or use cross-subsidies in a wider business to achieve market share
- MPF6/15 – subsidies for other fixed/ running costs are likely to have limited impact in relation to the upfront vehicle grants for example
- MPF13 – cheaper access to parking could particularly valuable in urban areas, however, this may have limited influence on the total number of EVs unless parking spaces are converted to EV parking on a larger scale
- MPF17 – weight tax does not differentiate between ULEVs and conventional vehicles and the value of including it in the analysis is thought to be negligible
- MPF19/20 – simplification (e.g. of all taxes for ULEVs or of access methods for charging points) and status (e.g. different number plates or status symbols for ULEVs) can be assessed qualitatively if needed, however, the value of including them in the analysis is thought to be negligible
- MPF24/25 – other emission schemes are not modelled because a carbon tax is already accounted for in defining the overall amount of tax that is recovered by Government and can be distributed through subsidies

7 Mapping Building Blocks to Narratives

7.1 Introduction and rationale

Section 3 in Deliverable D1.1 and sections 2 to 6 in this deliverable D4.1 describe the process by which Scenarios and Narratives have been developed, and presents at a high level the distinguishing characteristics of each. This section provides a finer level of detail, recording how the themes of the Scenarios, which describe each Dimension of the Narratives, have been translated into individual Building Blocks. This is the result of a process of rationalisation and cross-referencing to ensure that each Narrative is distinct, and that all material Building Blocks are considered somewhere. A summary of the rationale for allocation of Building Blocks for each Scenario is provided in Table 15, ordered by Dimension. The following sections enumerate the individual Building Blocks envisaged for each Narrative.

The Customer Proposition describes the consumer experience in using ULEVs. To a large extent defining this Dimension drives the configuration of other Dimensions, as they combine to deliver the Customer Proposition.

Table 15 Customer Proposition Building Blocks rationale

Narrative	Scenario	Comment
Business as Usual	BaU	▸ *Access mode:* upfront purchase of cars ▸ *Fuel pricing:* flat tariffs, as per usual domestic supply contract ▸ *Billing model:* separation of vehicle / services / energy ▸ *Fuelling availability:* existing access to overnight charging, very limited rapid charging ▸ *Consumer control:* full control
OEM innovation	BaU +	▸ *Access mode:* financing of car purchase to overcome cost barrier ▸ *Fuel pricing:* static ToU tariffs with separately metered charge point ▸ *Billing model:* bundling of payments to OEM for vehicle plus data and insurance / maintenance / break down services ▸ *Fuelling availability:* existing access to overnight charging, limited rapid charging ▸ *Consumer control:* consumer response to static ToU tariff

Narrative	Scenario	Comment
City led	Opt-in sharing	▸ *Access mode:* car club sharing in urban areas, long term leasing in rural areas as ownership is less common ▸ *Fuel pricing:* dynamic ToU driven by fleet operators looking to optimise costs, including Demand Management Payments for automated control, enabled by concentrated hubs ▸ *Billing model:* subscription based car clubs and multi modal tickets ▸ *Fuelling availability:* depot charging and some public charging, no rapid charging between cities ▸ *Consumer control:* automated DM
ULEV enabled	BaU ++	▸ *Access mode:* upfront purchase as government subsidies diminish cost barrier ▸ *Fuel pricing:* dynamic ToU for charging due to central charging network operator, price per unit for hydrogen ▸ *Billing model:* separation of vehicle / services / energy, information support for cost effective charging ▸ *Fuelling availability:* high degree of access to overnight charging and widespread rapid charging on trunk roads ▸ *Consumer control:* EV charging with automated DM
Hydrogen push	Indirect restriction	▸ *Access mode:* upfront purchase as government subsidies diminish cost barrier ▸ *Fuel pricing:* price per unit for hydrogen, akin to liquid fuels ▸ *Billing model:* separation of vehicle / services / energy ▸ *Fuelling availability:* dense hydrogen filling station network ▸ *Consumer control:* freedom in hydrogen refuelling
Transport on demand	On demand	▸ *Access mode:* short term hire ▸ *Fuel pricing:* dynamic ToU driven by fleet operators looking to optimise costs ▸ *Billing model:* all in one PAYG fee for vehicle / services / energy ▸ *Fuelling availability:* extensive public and rapid charging ▸ *Consumer control:* automated DM

In the case of the Market and Policy Framework, the identification of Building Blocks that deliver the themes of the selected Scenarios is relatively intuitive in the context of the Narrative thematic axes:

- **Mobility as an asset / Mobility as a service:** the former is associated with addressing upfront barriers to ULEV adoptions, the later to ongoing barriers to ULEV adoptions
- **Organic action / Co-ordinated action:** the former is associated with disincentivisation of conventional vehicles whilst remaining neutral between ULEV technologies, with actions

focussed on consumers and at a regional level. The latter is associated with active incentivisation of ULEVs, potentially to the extent of particular ULEV technologies. Interventions encompass both the supply side and the consumer, and are implemented at a national level to drive towards a chosen outcome.

Table 16 Market and Policy Framework Building Blocks rationale

Narrative	Scenario	Comment
Business as Usual	BaU	▸ Modest grant programme and VED advantage for ULEVs
OEM innovation	Market driven	▸ Purchase tax disadvantage and scrappage refund scheme for non-ULEVs. Carbon price reflected in fossil fuel costs
City led	Regionally led	▸ Local benefits to increase mobility for ULEVs, such as access to bus lanes or low emission zones. VED disadvantage for non-ULEVs
ULEV enabled	Infrastructure focus	▸ Government led deployment of charging and hydrogen networks. Grants for ULEVs in addition to disincentives for non-ULEVs
Hydrogen push	Centrally planned	▸ Government led deployment of dense hydrogen infrastructure, with disincentives for non-ULEVs and incentives for FCV purchase
Transport on demand	On demand	▸ Government led deployment of dense public charging network, with subsidies for electricity for transport ▸ Application of basic road pricing to alleviate lost liquid revenue, and deliver congestion/CO2 benefits[18].

A relatively large number of Building Blocks have been identified in the Market and Policy Framework. In many instances there are multiple suitable Building Blocks that could achieve the Market and Policy Framework envisaged. Furthermore, when implemented in the Analytical Framework, many Building Blocks will effectively be indistinguishable from each other, as they will be represented as either an increase or decrease in the cost of owning, operating or using a vehicle. In mapping specific Market and Policy Framework Building Blocks to the Narratives the focus has been on a few core Building Blocks to deliver the necessary environment. In practice, the same outcome could be delivered by other Building Blocks, or the other Building Blocks included qualitatively.

The properties of the Physical Supply Chain largely mirror those of the Customer Proposition.

[18] It is only proposed to explore the congestion and CO_2 benefits qualitatively, as it is not possible within the scope of this project to model this directly.

Table 17 Physical Supply Chain Building Blocks rationale

Narrative	Scenario	Comment
Business as Usual	BaU	▸ *Vehicles:* full range of choices, PiV and hydrogen ▸ *Hydrogen:* centralised production with road distribution, forecourts co-located with fossil fuels ▸ *Charging:* overnight home charging and limited rapid charging
OEM innovation	ANM / manual DM / fast charging	▸ *Vehicles:* full range of choices ▸ *Hydrogen:* centralised production with road distribution, forecourts co-located with fossil fuels ▸ *Charging:* overnight home charging
City led	Depot charging	▸ *Vehicles:* smaller PiVs and hydrogen in cities, PHEVs in rural areas ▸ *Hydrogen:* distributed production at urban fuelling hubs ▸ *Charging:* concentrated at hubs allowing ANM and Automated Control of Charging
ULEV enabled	Smart grid / FCV role	▸ *Vehicles:* full range of choices, PiV and hydrogen ▸ *Hydrogen:* centralised production and road distribution, later pipes, to skeleton network co-located with liquid fuels ▸ *Charging:* high degree of access to overnight charging, widespread rapid charging, with ANM
Hydrogen push	High FCV	▸ *Vehicles:* ULEV choice limited to hydrogen vehicles ▸ *Hydrogen:* centralised production and pipe distribution ▸ *Charging:* not relevant
Transport on demand	On demand	▸ *Vehicles:* PiVs, becoming autonomous, with variation for intra- and inter-city trips ▸ *Hydrogen:* not relevant ▸ *Electricity networks:* widespread charging in public areas and rapid charging with ANM

The Commercial Value Chain will be shaped within the Market and Policy Framework so as deliver the Customer Proposition.

Table 18 Commercial Value Chain Building Blocks rationale

Narrative	Scenario	Comment
Business as Usual	BaU	▸ *Vehicles:* Vehicle Leaser and Battery Leaser applies for fleets, and Retailer (including batteries) for private users ▸ *Electricity:* DNO exists, no DM Aggregator. Charging Point Operator / Network / Owner exists in generic set-up ▸ *Hydrogen:* Retailer (via forecourts only), hydrogen production is centralised (production technology transitions from SMR to bio-gasification / electrolysis), partnered with forecourt Retailers, Road Distributor (no pipelines)
OEM innovation	Smart cars	▸ *Vehicles:* Vehicle Leaser and Battery Leaser applies for fleets, and Retailer (including batteries) for private users Retailer (retail arm of the manufacturer) merges with the Charging Point Owner / Operator (as per the Tesla model) ▸ *Electricity:* Supplier forms a partnership with the Vehicle Manufacturer (no impact on modelling). DM Aggregator provides services to the DNO. Charging Point Operator / Network / Owner forms a partnership / merger with the Electricity Supplier (providing discounts to electricity tariffs for EV charging) ▸ *Hydrogen:* Retailer (via forecourts only), hydrogen production is centralised as per BaU, partnered with forecourt Retailers, Road Distributor (no pipelines)
City led	Final mile	▸ *Vehicles:* Mobility as a Service - Vehicle and Battery Leaser applies for private and fleet vehicles. Vehicle Sharing Scheme entity should be modelled for fleets ▸ *Electricity:* DM Aggregator provides services to the DNO. Charging Point Operator / Network / Owner as per BaU. IT / Data provider 'added services' more relevant to Mobility as a Service – qualitative entity ▸ *Hydrogen:* Localised Hydrogen Producers, producing hydrogen at car club depots

Narrative	Scenario	Comment
ULEV enabled	Regulated infra	▸ *Vehicles:* Vehicle Leaser and Battery Leaser applies for fleets, and Retailer (incl. batteries) for private users Subsidies targeted at the manufacturers in the MPF should be seen by the Vehicle Leaser or Retailer ▸ *Electricity:* Co-ordinated action - DNO becomes DSO, and expands activities to be Charging Point Network Operator/ Owner ▸ *Liquid fuel:* Forecourt Retailer and Road Distributor entities apply but more asset stranding in this high EV world ▸ *Hydrogen:* Retailer (via forecourts only), partnered with liquid fuel forecourt Retailers. Production is centralised, with Road Distributor in the short-term only and transition to Pipeline Operator in the longer term (no re-purposing of the existing gas network)
Hydrogen push	Hydrogen	▸ *Vehicles:* Vehicle Leaser and Battery Leaser applies for fleets, and Retailer (including batteries) for private users ▸ *Electricity:* DNO exists, no DM Aggregator, no Charging Point Operator / Network / Owner (no ULEVs) ▸ *Hydrogen:* Retailer (via forecourts only), hydrogen producers is centralised. Pipeline Operator to forecourts (no re-purposing of the existing gas network) exist
Transport on demand	On demand	▸ *Vehicles:* Mobility as a Service, 100% EVs and fleets - Vehicle and Battery Leaser applies for private and fleet vehicles. Vehicle Sharing Schemes entity should be modelled for fleets ▸ *Electricity:* co-ordinated action - DNO becomes DSO, and expands activities to be Charging Point Network Operator / Owner. IT / Data provider 'added services' more relevant to Mobility as a Service – qualitative entity. Battery swapping may be applied qualitatively ▸ *Hydrogen:* no entities exist as this is a 100% EV world

7.2 Factors common to all Narratives

A number of Building Blocks will be common to all the Narratives, describing the following features.

- **Liquid fuel system:** the system of production of liquid fuels and its distribution to forecourts (i.e. the current dominant system of providing energy for automotive use), will exist in all Narratives. In general volumes in this system will be expected to decline, though the forecourt system may be partially sustained through providing hydrogen.
- **Conventional vehicles:** conventional vehicles will continue to be used and be available for at least part of the modelled horizon, in all Narratives. Existing regulations applying to conventional vehicles are assumed to continue.

- **Policy programmes in related energy systems:** known programmes elsewhere in the energy system with relevance to ULEV deployment and use, for example smart meter roll out, will also be assumed.
- **Impact of EU vehicle standards:** proposed to reflect a linear improvement in the current EU targets from 2020/21 to 2030, of 75 gCO2/km for cars and 120gCO2/km for vans, but hold these constant from 2030 to 2050.

In addition, some themes, as identified in deliverable D1.1, are independent and will be relevant to all Narratives.

- **Timing:** the rate at which ULEV deployment and use occurs, and the extent of ULEV deployment earlier in the time horizon. This will be largely a function of the Market and Policy Framework, and the budget available.
- **Urban-rural split:** the drivers determining vehicle choice for consumers will differ depending on whether they live in an urban or rural area. In some Narratives, for example City Led, this difference will be more pronounced than in others. In general where different drivers exist, the Building Blocks will accommodate different choices.

7.3 Business as Usual

Table 19 enumerates the Building Blocks to be used in the Business as Usual Narrative.

Table 19 Business as Usual Building Blocks

BB code	BB name	State, value or commentary
Customer Proposition		
CP1	Outright purchase	For private users
CP4	Contract hire	For fleets
CP6	Secondary market	Current increased rate of depreciation vs ICEVs is maintained
CP8	Maintenance, servicing and insurance	Unbundled, users source separately
CP13	Flat tariff	No price signals to modulate charging
CP15	Private charging	Current levels of access
CP16	Public charging (rapid)	Network as today (~1,500 points in total)
CP17	Public charging (local)	Limited evolution of network today
CP18	Workplace charging	Limited evolution of network today
CP19	Hydrogen refuelling stations	Very limited number, co-located with liquid fuels
CP23	Forecourt	Current numbers initially, expected to decline
CP29	Sole vs shared use	Sole use
CP30	Charging control	User has full control of charging

BB code	BB name	State, value or commentary
CP31	Vehicle choice	Full choice of vehicles available
Physical Supply Chain		
PSC1	Battery	For PiVs
PSC2	Battery Management System	For PiVs
PSC3	Fuel Cell System	For FCVs
PSC4	Generic components	For all ULEVs
PSC5	Electric motor	For PiVs
PSC6	Vehicle hydrogen tank	For FCVs
PSC8	Electricity generation	Centralised generation, common to all Narratives
PSC9	Hydrogen generation	Centralised production on a small scale
PSC12	Electricity distribution network	As current
PSC13	Electricity transmission network	As current
PSC14	Hydrogen distribution	Road distribution
PSC21	Private charging	Current levels of access, main mode of charging
PSC22	Public charging	Very limited network of rapid chargers on trunk roads
PSC23	Hydrogen refuelling stations	Very limited density
PSC24	Diesel / petrol forecourts	Current numbers initially, expected to decline
Commercial Value Chain		
CVC1	Vehicle manufacturer	Boundary condition
CVC3	Vehicle retailer (retail arm of OEM)	Selling vehicles to private consumers
CVC4	Vehicle leaser	Leasing vehicles to fleets
CVC5	Battery leaser	Leasing batteries to fleets (combined with vehicle)
CVC7	Electricity supplier	As current
CVC9	Electricity DNO	As current
CVC12	Charging point operator / network / owner	Commercial operators of rapid charging network
CVC17	Liquid fuel forecourt retailer	Selling liquid fuels to end consumers
CVC18	Liquid fuel road distributor	Transporting liquid fuels from refineries

BB code	BB name	State, value or commentary
CVC19	Hydrogen retailer	Selling hydrogen to end consumers at liquid fuel forecourts
CVC23	Hydrogen road distributor	Transporting hydrogen by truck from centralised production to forecourt
CVC24	Centralised hydrogen producer	Boundary condition
Market and Policy Framework		
MPF1	Gov. grants to consumers	At a level similar to today's scheme
MPF3	VAT on assets	At today's levels
MPF4	Purchase / registration tax	At today's levels
MPF8	Vehicle excise duty	Zero rate for ULEVs
MPF9	Company car tax	Reduced rates for ULEVs, as current policy
MPF10	Fuel duty	Electricity and hydrogen exempt from fuel duty, fossil fuels as today
MPF11	VAT on fuel	As today
MPF12	Cheaper mobility	Exemption from congestion zones
MPF14	National insurance	Reduction in NICs for employers providing company ULEVs (qualitative)
MPF18	Increased mobility	Access to low emission zones (qualitative)
MPF22	Direct CO_2 tax	Electricity includes carbon price
MPF23	Direct emissions limit	EU regulations on vehicle emissions
MPF26	Education / marketing	Government ULEV information services (qualitative)
MPF27	Mandatory / voluntary reporting	Reporting of vehicle emission levels (qualitative)
MPF28	Government funding / investment	Government provision of funds to enable local authorities to enable ULEVs (qualitative)
MPF29	Private investment	Private investment in rapid charging networks
MPF30	Investment in R&D	Government investment in ULEV research (qualitative)
MPF31	Capital allowances	Enhanced writing down allowances on ULEV investments (qualitative)
MPF32	Government guarantees	Government guarantees on loans for ULEV related investments (qualitative)
MPF34	Other laws/ wider energy sector regulations	For example EU emissions laws (qualitative)
MPF35	Commitment	Government commitment to promoting ULEV deployment (qualitative)

BB code	BB name	State, value or commentary
MPF36	Role of local authorities	Implementation of local measures such as installing charge points (qualitative)
MPF37	Standardisation	Government creation of standards for information and infrastructure (qualitative)
MPF38	Co-ordination / national initiatives	Centrally coordinated schemes involving multiple entities (qualitative)
MPF39	Planning regulations	Facilitating charging point deployment (qualitative)

7.4 OEM Innovation

Table 20 enumerates the Building Blocks to be used in the OEM innovation Narrative.

Table 20 OEM innovation Building Blocks

BB code	BB name	State, value or commentary
Customer Proposition		
CP2	Contract purchase	For private users
CP4	Contract hire	For fleets
CP6	Secondary market	Current increased rate of depreciation vs ICEVs is maintained
CP7	Bundled installation of charging point	Provided by vehicle OEM
CP8	Maintenance, servicing and insurance	Bundled into vehicle OEM service
CP10	Static ToU	All private charging is on static ToU basis
CP14	Vehicle to house	V2H enhances user energy security (qualitative)
CP15	Private charging	Access at current levels (as BaU)
CP16	Public charging (rapid)	Limited deployment, greater than BaU
CP17	Public charging (local)	Some evolution of network today, greater than BaU
CP18	Workplace charging	Some evolution of network today, greater than BaU
CP19	Hydrogen refuelling stations	Limited number (greater than BaU)
CP23	Forecourt	Current numbers initially, expected to decline
CP25	Support for price certainty	Support for users to understand available charging locations and prices given ToU tariffs
CP26	Traditional pay per unit	For fuel (qualitative)
CP29	Sole vs shared use	Sole use

BB code	BB name	State, value or commentary
CP30	Charging control	User has full control of charging
CP31	Vehicle choice	Full choice of vehicles available
Physical Supply Chain		
PSC1	Battery	For PiVs
PSC2	Battery Management System	For PiVs
PSC3	Fuel Cell System	For FCVs
PSC4	Generic components	For all ULEVs
PSC5	Electric motor	For PiVs
PSC6	Vehicle hydrogen tank	For FCVs
PSC8	Electricity generators	Centralised generation, common to all Narratives
PSC9	Hydrogen generation	Centralised production on a small scale
PSC12	Electricity distribution network	As current
PSC13	Electricity transmission network	As current
PSC14	Hydrogen distribution	Road distribution
PSC21	Private charging	Current levels of access (same availability as BaU), main mode of charging
PSC22	Public charging	Limited rapid charging on trunk roads (greater than BaU)
PSC23	Hydrogen refuelling stations	Limited density (greater than BaU)
PSC24	Diesel / petrol forecourts	Current numbers initially, expected to decline
Commercial Value Chain		
CVC1	Vehicle manufacturer	Boundary condition
CVC2	Vehicle manufacturer and charging point owner/ operator	Vehicle OEM operates network of rapid chargers
CVC3	Vehicle retailer (retail arm of OEM)	Selling vehicles to private consumers
CVC4	Vehicle leaser	Leasing vehicles to fleets
CVC5	Battery leaser	Leasing batteries to fleets (combined with vehicles)
CVC7	Electricity supplier	As today
CVC8	Electricity supplier partnered with vehicle manufacturer	Vehicle OEMs may partner with electricity supplier to offer tariff

BB code	BB name	State, value or commentary
CVC9	Electricity DNO	As current
CVC17	Liquid fuel forecourt retailer	Selling liquid fuels to end consumers
CVC18	Liquid fuel road distributor	Transporting liquid fuels from refineries
CVC19	Hydrogen retailer	Selling hydrogen to end consumers at liquid fuel forecourts
CVC23	Hydrogen road distributor	Transporting hydrogen by truck from centralised production to forecourt
CVC24	Centralised hydrogen producer	Boundary condition
Market and Policy Framework		
MPF1	Gov. grants to consumers	At a level similar to today's scheme (as BaU)
MPF3	VAT on assets	Higher for non ULEVs
MPF4	Purchase / registration tax	As today
MPF5	Refund schemes	For scrappage of non-ULEVs
MPF8	Vehicle Excise Duty	Zero rate for ULEVs
MPF9	Company car tax	Reduced rates for ULEVs, as current policy
MPF10	Fuel duty	Electricity and hydrogen exempt from fuel duty, fossil fuels as today
MPF11	VAT on fuel	As today
MPF12	Cheaper mobility	Exemption from congestion zones
MPF22	Direct CO_2 tax	Electricity and liquid fuels include carbon price
MPF23	Direct emissions limit	EU regulations on vehicle emissions (as BaU)
MPF26	Education / marketing	Government ULEV information services (qualitative)
MPF27	Mandatory / voluntary reporting	Display of vehicle emission levels (qualitative)
MPF30	Investment in R&D	Government investment in ULEV research (qualitative)
MPF34	Other laws/ wider energy sector regulations	For example EU emissions laws (qualitative)

7.5 City Led

Table 21 enumerates the Building Blocks to be used in the City led Narrative.

Table 21 City led Building Blocks

BB code	BB name	State, value or commentary
Customer Proposition		
CP2	Contract purchase for rural consumers	I.e. for those outside of car sharing clubs (in CP5), who increasingly provide services to consumers in urban areas
CP4	Contract hire for fleets,	For fleets
CP5	Short term hire / car club	Short term hire from hubs for urban consumers
CP6	Secondary market	Current increased rate of depreciation vs ICEVs is maintained
CP8	Maintenance, servicing and insurance	Bundled into lease payments (with energy for city car clubs)
CP10	Static ToU	For rural users
CP11	Dynamic ToU	Seen by car club fleet operators
CP12	Demand Management Payment	Payment for direct DNO control of charging under CP29
CP15	Private charging	At hubs for car club fleets, at home for rural users
CP17	Public charging (loca)	Some intermediate power charging at public hubs (supermarkets etc.), greater than BaU
CP18	Workplace charging	Limited evolution of network today, same as BaU
CP19	Hydrogen refuelling stations	Some car club fleet depots may be hydrogen based
CP23	Forecourt	Current numbers initially, expected to decline
CP24	Subscription model	For car club membership (qualitative)
CP27	Multi-modal	Combined tickets across transport modes (qualitative)
CP29	Sole vs shared use	Shared use
CP30	Charging control	Aggregators have control of depot charging
CP31	Vehicle choice	Rural users' choice of vehicles weighted towards PHEVs, some choice available for urban users
Physical Supply Chain		
PSC1	Battery	For PiVs
PSC2	Battery Management System	For PiVs
PSC3	Fuel Cell System	For FCVs
PSC4	Generic components	For all vehicles

BB code	BB name	State, value or commentary
PSC5	Electric motor	For ULEVs
PSC6	Vehicle hydrogen tank	For FCVs
PSC8	Electricity generators	Centralised generation, common to all Narratives
PSC9	Hydrogen generation	Distributed generation at depots
PSC12	Electricity distribution network	As today, with procurement of services from DM aggregators
PSC13	Electricity transmission network	As current
PSC21	Private charging	At depots, main mode of charging
PSC22	Public charging	Some intermediate power charging at public hubs (supermarkets etc.)
PSC24	Diesel / petrol forecourts	Current numbers initially, expected to decline
PSC27	Assets needed for comms	To enable control, Automated Control of Charging by the DNO/aggregators
Commercial Value Chain		
CVC1	Vehicle manufacturer	Boundary condition
CVC4	Vehicle leaser	For rural users and leasing vehicles to fleets (including car club fleets)
CVC5	Battery leaser	For rural users and leasing to fleets (including car club fleets), combined with vehicle
CVC6	Vehicle sharing scheme	Car clubs
CVC7	Electricity supplier	As current
CVC9	Electricity DNO	As current, with procurement of services from DM aggregator
CVC12	Charging point operator / network / owner	Owner / operator of intermediate power public charging points
CVC15	DM aggregator	Pays car club depot operators for providing network services, and sells services on to DNO
CVC16	IT / data Provider	Providing digital services for car clubs
CVC17	Liquid fuel forecourt retailer	Selling liquid fuels to end consumers
CVC18	Liquid fuel road distributor	Transporting liquid fuels from refineries
CVC19	Hydrogen retailer	Selling hydrogen to end consumers at liquid fuel forecourts
CVC20	Localised hydrogen producer	At depots
CVC23	Hydrogen road distributor	In short term, transporting hydrogen by truck from centralised production to forecourt
CVC24	Centralised hydrogen producer	Boundary condition

BB code	BB name	State, value or commentary
Market and Policy Framework		
MPF1	Gov. grants to consumers	At a level similar to today's scheme (as BaU)
MPF4	Purchase / registration tax	As today
MPF5	Refund schemes	For scrappage of non-ULEVs
MPF8	Vehicle excise duty	Zero rate for ULEVs
MPF9	Company car tax	Reduced rates for ULEVs, as current policy
MPF10	Fuel duty	Electricity and hydrogen exempt from fuel duty, fossil fuels as today
MPF11	VAT on fuel	As today
MPF12	Cheaper mobility	Exemption from congestion zones in short term, removed in longer term as ULEV penetration increases
MPF13	Cheaper access to parking	ULEVs receive cheaper parking (qualitative)
MPF18	Increased mobility	Bus lane access, access to low emission zone (qualitative)
MPF21	Increased access to parking	Car club reserved parking (qualitative)
MPF22	Direct CO_2 tax	Electricity and liquid fuels include carbon price
MPF23	Direct emissions limit	EU regulations on vehicle emissions
MPF26	Education / marketing	Government ULEV information services (qualitative)
MPF27	Mandatory / voluntary reporting	Display of vehicle emission levels (qualitative)
MPF30	Investment in R&D	Government investment in ULEV research (qualitative)
MPF34	Other laws/ wider energy sector regulations	For example EU emissions laws (qualitative)
MPF36	Role of local authorities	Implementation of local measures such as installing charge points (qualitative)
MPF39	Planning regulations	Facilitating charging point deployment (qualitative)

7.6 ULEV Enabled

Table 22 enumerates the Building Blocks to be used in the ULEV enabled Narrative.

Table 22 ULEV enabled Building Blocks

BB code	BB name	State, value or commentary
Customer Proposition		

BB code	BB name	State, value or commentary
CP1	Outright purchase	For private users
CP4	Contract Hire	For fleets
CP6	Secondary market	ULEV depreciation same as ICEVs
CP8	Maintenance, servicing and insurance	Unbundled (sourced separately)
CP11	Dynamic ToU	Seen at charging network
CP12	Demand Management Payment	Payment for direct DNO control of charging under CP29
CP15	Private charging	High degree of availability outside of offstreet
CP16	Public charging (rapid)	Broad deployment (greater than OEM innovation, same as Transport on demand)
CP17	Public charging (local)	Some intermediate power charging at public hubs (supermarkets etc.), greater than BaU
CP18	Workplace charging	Significant development of network greater than OEM innovation
CP19	Hydrogen refuelling stations	Reasonable national network (greater than OEM innovation)
CP23	Forecourt	Current numbers initially, expected to decline
CP25	Support for price certainty	Support for users to understand available charging locations and prices given ToU tariffs
CP29	Sole vs shared use	Sole use
CP30	Charging control	DSO has control of charging network
CP31	Vehicle choice	Full choice of vehicles available
Physical Supply Chain		
PSC1	Battery	For PiVs
PSC2	Battery Management System	For PiVs
PSC3	Fuel Cell System	For FCVs
PSC4	Generic components	For all vehicles
PSC5	Electric motor	For all ULEVs
PSC6	Vehicle hydrogen tank	For FCVs
PSC8	Electricity generators	Centralised generation, common to all Narratives
PSC9	Hydrogen generation	Centralised generation, becoming large scale as demand justifies it
PSC12	Electricity distribution network	DNO capabilities expand to include ANM technologies, making use of automated charging control services

BB code	BB name	State, value or commentary
PSC13	Electricity transmission network	As current
PSC14	Hydrogen distribution	By road initially moving to pipes in longer term where economically viable
PSC21	Private charging	High degree of availability outside of off-street, main mode of charging
PSC22	Public charging	Reasonable rapid charging on trunk roads (greater than OEM innovation)
PSC23	Hydrogen fuelling stations	Reasonable national network (greater than OEM innovation), co-located with liquid fuel stations
PSC24	Diesel / petrol forecourts	Current numbers initially, expected to decline compared to BaU / OEM innovation, but to be explored further in analysis
PSC27	Assets needed for comms.	To enable ANM
Commercial Value Chain		
CVC1	Vehicle manufacturer	Boundary condition
CVC3	Vehicle retailer	Selling vehicles to private users
CVC4	Vehicle leaser	Leasing vehicles to fleets
CVC5	Battery leaser	Leasing batteries to fleets (combined with fleets)
CVC7	Electricity supplier	Electricity suppliers supply electricity to PiV users through DNO's charging point network, paying DNO for use of network
CVC11	Electricity DNO as DSO with charging point network	DNO builds and owns charging point network. DNO pays electricity suppliers for providing network services, and reduces its investment in reinforcement. Electricity suppliers pass savings on to charge point users
CVC17	Liquid fuel forecourt retailer	Selling liquid fuels to end consumers
CVC18	Liquid fuel road distributor	Transporting liquid fuels from refineries
CVC19	Hydrogen retailer	Selling hydrogen to end consumers at liquid fuel forecourts
CVC22	Hydrogen network operator	In longer term
CVC23	Hydrogen road distributor	In short term, transporting hydrogen by truck from centralised production to forecourt
CVC24	Centralised hydrogen producer	Boundary condition
Market and Policy Framework		
MPF1	Direct grants to consumers	For ULEVs

BB code	BB name	State, value or commentary
MPF3	VAT on assets	Higher for non-ULEVs
MPF4	Purchase / registration tax	As per BaU
MPF8	Vehicle Excise Duty	Zero rate for ULEVs
MPF9	Company car tax	Reduced rates for ULEVs, as current policy
MPF10	Fuel duty	Electricity and hydrogen exempt from fuel duty, fossil fuels as today
MPF11	VAT on fuel	Reduced VAT on hydrogen as per Electricity
MPF12	Cheaper mobility	Exemption from congestion zones
MPF22	Direct CO_2 tax	Electricity and liquid fuels include carbon price
MPF23	Direct emissions limit	EU regulations on vehicle emissions
MPF26	Education / marketing	Government ULEV information services (qualitative)
MPF27	Mandatory / voluntary reporting	Display of vehicle emission levels (qualitative)
MPF29	Private investment	In charging and hydrogen networks for regulated return
MPF30	Investment in R&D	Government investment in ULEV research (qualitative)
MPF34	Other laws/ wider energy sector regulations	For example EU emissions laws (qualitative)
MPF38	Coordination / national initiatives	Centrally coordinated network roll out (qualitative)
MPF39	Planning regulations	Facilitating charging point deployment (qualitative)

7.7 Hydrogen Push

Table 23 enumerates the Building Blocks to be used in the ULEV enabled Narrative.

Table 23 Hydrogen push Building Blocks

BB code	BB name	State, value or commentary
Customer Proposition		
CP1	Outright purchase	For private users
CP4	Contract purchase	For fleets
CP6	Secondary market	ULEV depreciation same as ICEVs
CP8	Maintenance, servicing and insurance	Unbundled (sourced separately)

BB code	BB name	State, value or commentary
CP17	Public charging (local)	Limited development beyond current network, capped at BaU level ~2020
CP18	Workplace charging	Limited development beyond current network, capped at BaU level ~2020
CP19	Hydrogen refuelling stations	Dense national network (greater than ULEV enabled)
CP23	Forecourt	Current numbers initially, expected to decline
CP26	Traditional pay per unit	For fuel (qualitative)
CP29	Sole vs shared use	Sole use
CP31	Vehicle choice	Restriction on availability of PiVs
Physical Supply Chain		
PSC3	Fuel Cell System	For FCVs
PSC4	Generic components	For all vehicles
PSC5	Electric motor	For all ULEVs
PSC6	Vehicle hydrogen tank	For FCVs
PSC8	Electricity generators	Centralised generation, common to all Narratives
PSC9	Hydrogen generation	Centralised generation at large scale
PSC12	Electricity distribution network	As current
PSC13	Electricity transmission network	As current
PSC14	Hydrogen distribution	Pipeline based
PSC23	Hydrogen fuelling stations	Dense national network (greater than ULEV enabled)
PSC24	Diesel / petrol forecourts	Current numbers initially, expected to decline
Commercial Value Chain		
CVC1	Vehicle manufacturer	Boundary condition
CVC3	Vehicle retailer	Selling vehicles to private users
CVC4	Vehicle leaser	Leasing vehicles to fleets
CVC7	Electricity supplier	As current
CVC9	Electricity DNO	As current
CVC17	Liquid fuel forecourt retailer	Selling liquid fuels to end consumers
CVC18	Liquid fuel road distributer	Transporting liquid fuels from refineries

BB code	BB name	State, value or commentary
CVC19	Hydrogen retailer	Selling hydrogen to end consumers at liquid fuel forecourts
CVC22	Hydrogen network operator	Owner operator of hydrogen pipelines
CVC24	Centralised hydrogen producer	Boundary condition
Market and Policy Framework		
MPF1	Direct grants to consumers	For FCVs
MPF3	VAT on assets	Higher for non- FCVs
MPF4	Purchase / registration tax	As per BaU
MPF8	Vehicle Excise Duty	Zero rate for FCVs
MPF9	Company car tax	Reduced rates for ULEVs, as current policy
MPF10	Fuel duty	Fossil fuels as today, hydrogen initially exempt from fuel duty, becoming liable in longer term to counteract decline in fuel duty
MPF11	VAT on fuel	As today
MPF12	Cheaper mobility	Exemption from congestion zones
MPF22	Direct CO_2 tax	Liquid fuels include carbon price
MPF23	Private investment	EU regulations on vehicle emissions
MPF26	Education / marketing	Government FCVs information services (qualitative)
MPF27	Mandatory / voluntary reporting	Display of vehicle emission levels (qualitative)
MPF29	Private investment	In hydrogen networks for regulated return
MPF30	Investment in R&D	Government investment in FCVs research (qualitative)
MPF33	Adequate access to infrastructure	Significant anticipatory investment in infrastructure
MPF34	Other laws/ wider energy sector regulations	For example EU emissions laws (qualitative)

7.8 Transport on demand

Table 24 enumerates the Building Blocks to be used in the Transport on demand Narrative.

Table 24 Transport on demand Building Blocks

BB code	BB name	State, value or commentary
Customer Proposition		

BB code	BB name	State, value or commentary
CP4	Contract hire	For fleets
CP5	Short term hire / car club	Short term hire for on demand consumers
CP6	Secondary market	ULEV depreciation same as ICEVs
CP8	Maintenance, servicing and insurance	Bundled in to single fee (with energy cost)
CP11	Dynamic ToU	Seen by fleet operators
CP12	Demand Management Payment	Payment for direct DNO control of charging under CP29
CP16	Public charging (rapid)	Broad deployment (greater than OEM innovation, greater than ULEV enabled)
CP17	Public charging (local)	Broad deployment (greater than OEM innovation and ULEV enabled)
CP18	Workplace charging	Limited development of current network, same as BaU
CP23	Forecourt	Current numbers initially, expected to decline
CP26	Traditional pay per unit	For transport service (qualitative)
CP29	Sole vs shared use	Shared use
CP30	Charging control	DNO has control of charging
CP31	Vehicle choice	More limited choice of vehicles
Physical Supply Chain		
PSC1	Battery	For PiVs
PSC2	Battery Management System	For PiVs
PSC4	Generic components	For all vehicles
PSC5	Electric motor	For all ULEVs
PSC7	Comms systems	To enable autonomous vehicles
PSC8	Electricity generators	Centralised generation, common to all Narratives
PSC12	Electricity distribution network	DNO capabilities expand to include ANM technologies, making use of automated charging control services
PSC13	Electricity transmission network	As current
PSC22	Public charging	Dense rapid charging network on trunk roads (greater than ULEV enabled) and dense intermediate charging at public points (main mode of charging)

BB code	BB name	State, value or commentary
PSC24	Diesel / petrol forecourts	Current numbers initially, expected to decline compared to BaU / OEM innovation, but to be explored further in analysis
PSC25	Industry standards	For charging and data interoperability
PSC27	Assets for comms	To enable ANM
PSC29	Assets for comms from / to vehicles	To enable autonomous vehicles (qualitative)
Commercial Value Chain		
CVC1	Vehicle manufacturer	Boundary condition
CVC4	Vehicle leaser	Leasing vehicles to fleets
CVC5	Battery leaser	Leasing batteries to fleets (combined with vehicles)
CVC6	Vehicle sharing scheme	Operators of on-demand service
CVC7	Electricity supplier	Electricity suppliers supply electricity to vehicle fleet operators through DSO's charging point network, paying DSO for use of network
CVC11	Electricity DNO as DSO with charging point network	DSO builds and owns charging point network. DSO pays electricity suppliers for providing network services, and reduces its investment in reinforcement. Electricity suppliers pass savings on to vehicle fleet operators.
CVC16	IT / data provider	Providing digital services for on-demand vehicle fleets
CVC17	Liquid fuel forecourt retailer	Selling liquid fuels to end consumers
CVC18	Liquid fuel road distributer	Transporting liquid fuels from refineries
Market and Policy Framework		
MPF3	VAT on assets	Higher for non- PiVs
MPF4	Purchase / registration tax	As per BaU
MPF7	Fuel price subsidies	Subsidy / price reduction for electricity for transport
MPF8	Vehicle excise duty	Zero rate for ULEVs (as BaU)
MPF9	Company car tax	Reduced rates for ULEVs (as BaU)
MPF10	Fuel duty	Fossil fuels as today, electricity exempt
MPF11	VAT on fuel	As today
MPF12	Cheaper mobility	Exemption from congestion zones

BB code	BB name	State, value or commentary
MPF16	Road pricing	Static road pricing replaces lost tax revenues from fuel duty in longer term, also delivers congestion/CO2 benefits
MPF22	Direct CO_2 tax	Electricity and liquid fuels include carbon price
MPF23	Direct emissions limit	EU regulations on vehicle emissions
MPF26	Education / marketing	Government ULEV information services (qualitative)
MPF27	Mandatory / voluntary reporting	Display of vehicle emission levels (qualitative)
MPF29	Private investment	In charging networks for regulated returns
MPF30	Investment in R&D	Government investment in ULEV research (qualitative)
MPF33	Adequate access to infrastructure	Significant anticipatory investment in infrastructure
MPF34	Other laws/ wider energy sector regulations	As per BaU
MPF37	Standardisation	Charging and data standards
MPF38	Coordination / national initiatives	Charging network deployment

7.9 Summary of Building Block use

✓	Captured quantitatively
✓	Captured qualitatively
✓	Exists as per BaU

Table 25 Summary of BBs to Narrative mapping for the Customer Proposition

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
1. Outright purchase	✓			✓	✓	
2. Contract Purchase		✓	✓			
3. Hybrid (battery lease)						
4. Contract hire	✓	✓	✓	✓	✓	✓
5. Short-term hire/car club			✓			✓
6. Secondary market	✓	✓	✓	✓	✓	✓
7. Bundled installation of charge points		✓				
8. Maintenance, servicing and insurance	✓	✓	✓	✓	✓	✓
9. Access to other vehicles or forms of transport when ULEV unsuitable						
10. Static ToU		✓	✓			
11. Dynamic ToU			✓	✓		✓
12. Demand Management Payment			✓	✓		✓
13. Flat tariff	✓				✓	
14. Vehicle to Grid/House (V2G/H)						
15. Private charging	✓	✓	✓	✓	✓	
16. Public charging in motorways and A-roads (rapid)	✓	✓		✓	✓	✓
17. Public charging in local points (mid-level)	✓	✓	✓	✓	✓	✓
18. Workplace charging	✓	✓		✓	✓	
19. H_2 refuelling stations	✓	✓	✓	✓	✓	
20. Battery swapping						
21. Electrolyte charge						
22. Dynamic charging						
23. Forecourt	✓	✓	✓	✓	✓	✓
24. Subscription model			✓			✓
25. Support for price certainty		✓		✓		
26. Traditional pay per unit model	✓	✓		✓	✓	
27. Multi-modal			✓			✓
28. Own account						
29. Sole vs shared use	✓	✓	✓	✓	✓	✓
30. Charging control			✓	✓		✓
31. Vehicle choice	✓	✓	✓	✓	✓	✓

Table 26 Summary of BBs to Narrative mapping for the Physical Supply Chain

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
1. Battery	✓	✓	✓	✓	✓	✓
2. Battery Management System	✓	✓	✓	✓	✓	✓
3. Fuel Cell System	✓	✓	✓	✓	✓	✓
4. Generic high technology readiness components (e.g. chassis, engine)	✓	✓	✓	✓	✓	✓

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
5. Electric motor	✓	✓	✓	✓	✓	✓
6. Vehicle H_2 tank	✓	✓	✓	✓	✓	
7. Communication systems						✓
8. Electricity generators	✓	✓	✓	✓	✓	✓
9. H_2 generation plants	✓	✓	✓	✓	✓	
10. Biofuel plants	✓	✓	✓	✓	✓	✓
11. Refineries	✓	✓	✓	✓	✓	✓
12. Electricity distribution network	✓	✓	✓	✓	✓	✓
13. Electricity transmission network	✓	✓	✓	✓	✓	✓
14. H_2 distribution	✓	✓	✓	✓	✓	
15. Trucks for liquid fuels	✓	✓	✓	✓	✓	✓
16. Gas network						
17. Large batteries	✓	✓	✓	✓	✓	✓
18, Large underground H_2 storage	✓	✓	✓	✓	✓	
19. Oil strategic reserves						
20. Natural gas storage						
21. Private charging	✓	✓	✓	✓	✓	
22. Public charging	✓	✓	✓	✓	✓	✓
23. H_2 refuelling stations	✓	✓	✓	✓	✓	
24. Forecourts	✓	✓	✓	✓	✓	✓
25. Industry standards						✓
26. Assets for settlement (e.g. smart meters)	✓	✓	✓	✓	✓	✓
27. Assets for comms.			✓	✓		✓
28. Data servers for Big Data						✓
29. Assets for comms. from/ to vehicles (e.g. autonomous vehicles)						✓

Table 27 Summary of BBs to Narrative mapping for the Commercial Value Chain

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
1. Vehicle Manufacturer	✓	✓	✓	✓	✓	✓
2. Vehicle Manufacturer and Charging Point Owner/ Operator		✓				
3. Vehicle Retailer (retail arm of manufacturer)	✓ (private)	✓ (private)		✓ (private)	✓ (private)	
4. Vehicle Leaser	✓ (fleet)	✓ (fleet)	✓	✓ (fleet)	✓ (fleet)	✓
5. Battery Leaser	As per vehicle model					
6. Vehicle Sharing Scheme			✓			✓
7. Electricity Supplier	✓	✓	✓	✓	✓	✓
8. Electricity Supplier with Vehicle Manufacturer		Partnered				
9. Electricity DNO	✓	✓	✓		✓	
10. Electricity DNO as DSO						
11. Electricity DNO/ DSO with Charging Point Network				✓		✓
12. Charging Point Operator / Network/ Owner	✓	✓ (vehicle OEM)	✓			
13. Charging Point Operator/ Network/ Owner with Electricity Supplier						
14. Battery Swapping						
15. DM Aggregator			✓			
16. IT/ Data Provider			✓			✓

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
17. Liquid Fuel Forecourt Retailer	✓	✓	✓	✓	✓	✓
18. Liquid Fuel Road Distributor	✓	✓	✓	✓	✓	✓
19. Hydrogen Retailer (at Forecourt)	✓	✓	✓	✓	✓	
20. Localised Hydrogen Producer			✓ (depots)			
21. Localised Hydrogen Producer with Forecourt Retailer						
22. Hydrogen Network Operator (Pipe)				✓ (LT)	✓ (pipes)	
23. Hydrogen Road Distributor	✓	✓		✓ (ST)		
34. Centralised Hydrogen Producer	✓	✓		✓	✓	

Table 28 Summary of BBs to Narrative mapping for the Market and Policy Framework

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
1. Gov. grants to consumers	✓	✓	✓	✓	✓	✓
2. Private grants to consumers	✓					
3. VAT on assets	✓	✓	✓	✓	✓	✓
4. Purchase/ registration tax	✓	✓	✓	✓	✓	✓
5. Refund schemes		✓	✓			
6. Subsidies for other fixed costs						
7. Fuel price subsidies						✓
8. Vehicle excise duty	✓	✓	✓	✓	✓	✓
9. Company car tax	✓	✓	✓	✓	✓	✓
10. Fuel duty	✓	✓	✓	✓	✓	✓
11. VAT on fuel	✓	✓	✓	✓	✓	✓
12. Cheaper mobility	✓	✓	✓	✓	✓	✓
13. Cheaper access to parking			✓			
14. National insurance	✓					
15. Subsidies for other running costs						
16. Road pricing						✓
17. Weight tax						
18. Increased mobility	✓		✓			
19. Simplification						
20. Status						
21. Increased access to parking			✓			
22. Direct CO2 tax	✓	✓	✓	✓	✓	✓
23. Direct emissions limit	✓	✓	✓	✓	✓	✓
24. Emissions cap and trade scheme						
25. Emissions credits scheme						
26. Education/ marketing	✓	✓	✓	✓	✓	✓
27. Mandatory/ voluntary reporting	✓	✓	✓	✓	✓	✓
28. Government funding/ investment	✓					
29. Private investment	✓	✓	✓	✓	✓	✓
30. Investment in R&D	✓	✓	✓	✓	✓	✓
31. Capital allowances	✓					
32. Government guarantees	✓					
33. Adequate access to infrastructure					✓	✓
34. Other laws/ wider energy sector regulations	✓	✓	✓	✓	✓	✓
35. Commitment	✓					
36. Role of local authorities	✓		✓			

Building Block Name	BaU	OEM innovation	City led	ULEV enabled	Hydrogen push	Transport on demand
37. Standardisation	✓					✓
38. Co-ordination/ National initiatives	✓			✓		✓
39. Planning regulations	✓		✓	✓		

Appendix A Business model overview

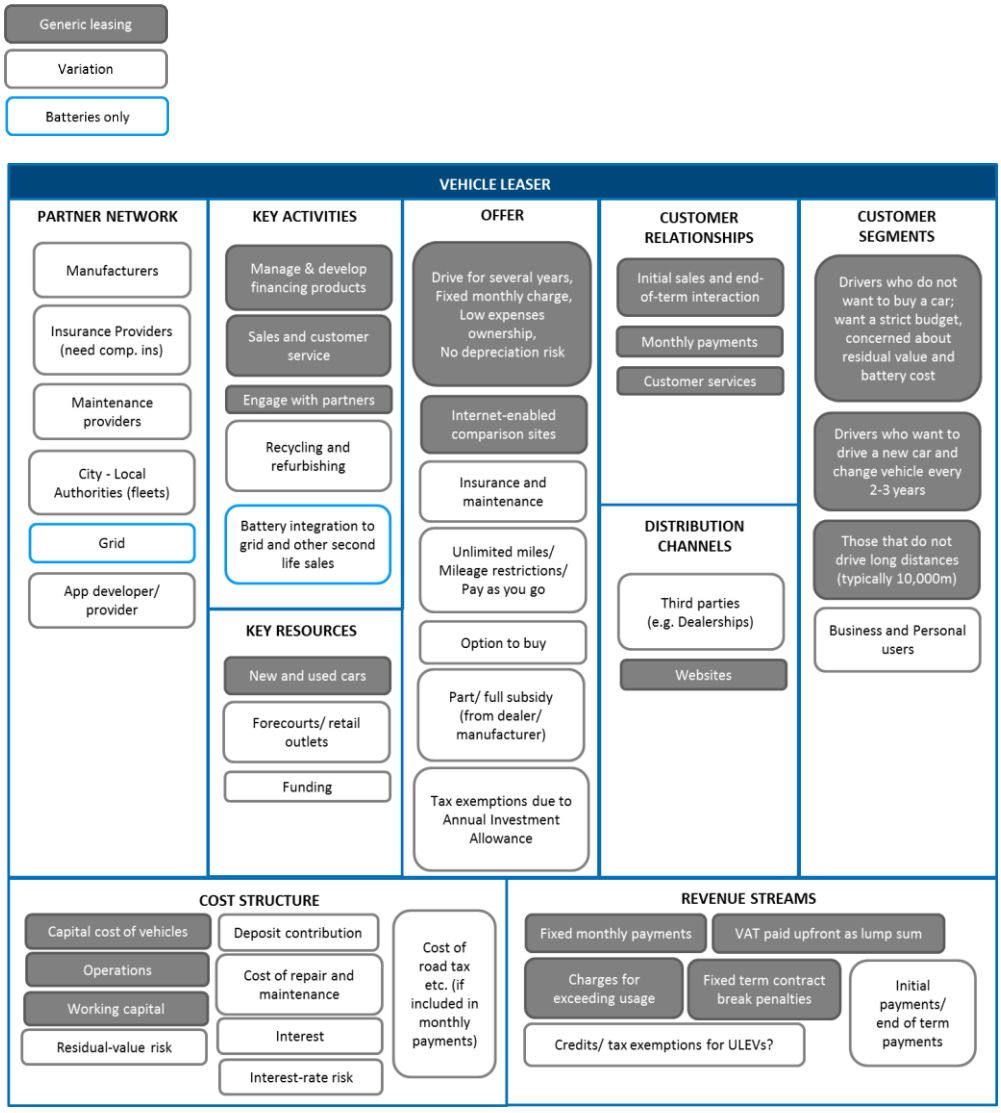
This section describes the key business model elements for each generic commercial entity on the value chain using the business model framework.

A.1 Vehicles

A.1.1 Vehicle Leaser

The Vehicle Leasing model is used to describe the Vehicle Leaser, Battery Leaser (typically combined with the Vehicle Leaser). The Vehicle Retailer is a similar business model, with the exception that the customer purchases the vehicle outright, rather than delaying purchase until the end of the contract (e.g. via a contract purchase scheme) or not purchasing at all (contract hire).

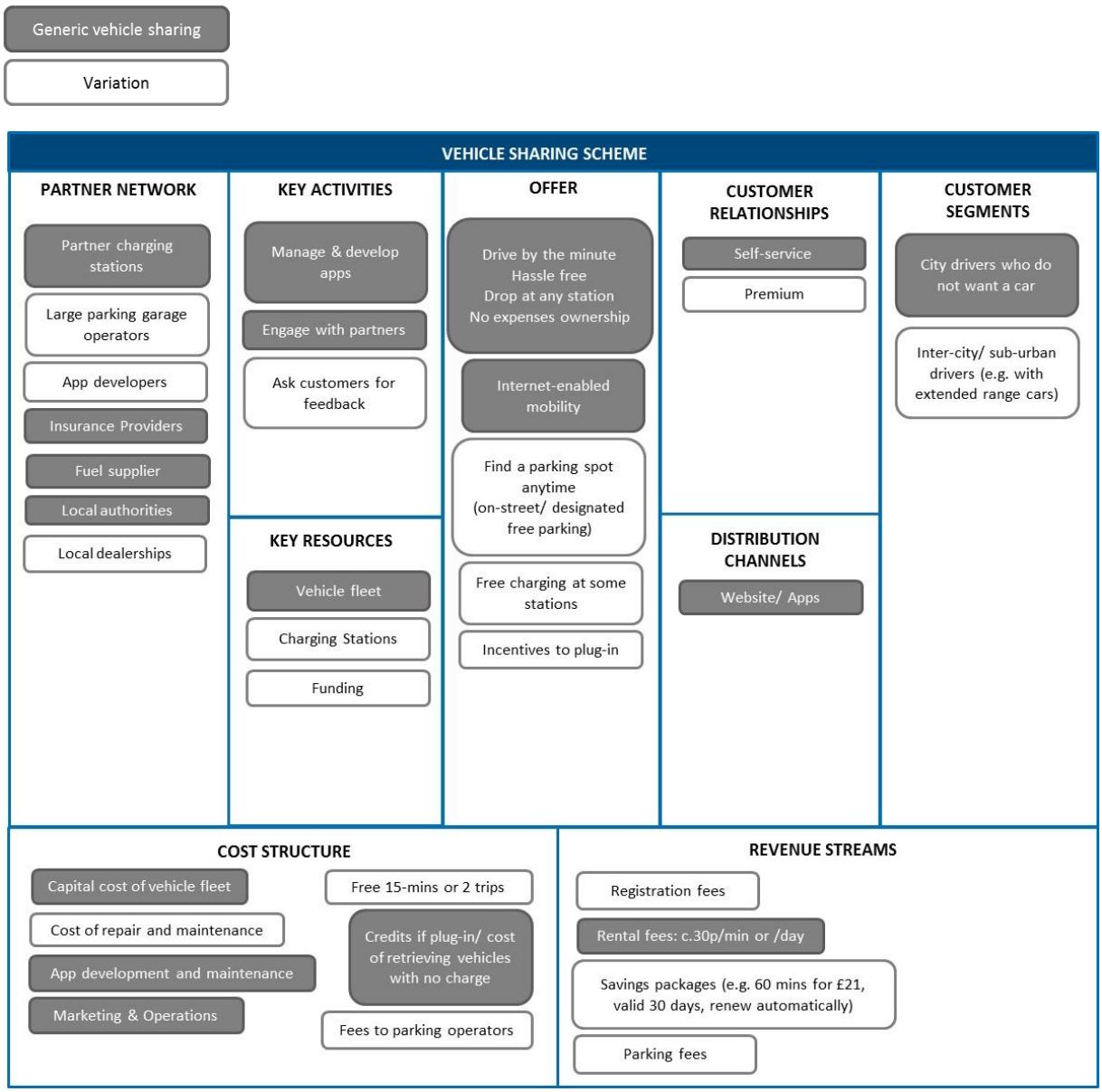
Figure 6 Business model of the Vehicle Leaser described using the framework



A.1.2 Vehicle Sharing

Vehicle Sharing is a scheme whereby there is never an intent that the customer will own the car; instead it is rented on a short-term per-minute or per-day basis. Three examples of these schemes are described in the supporting spreadsheet.

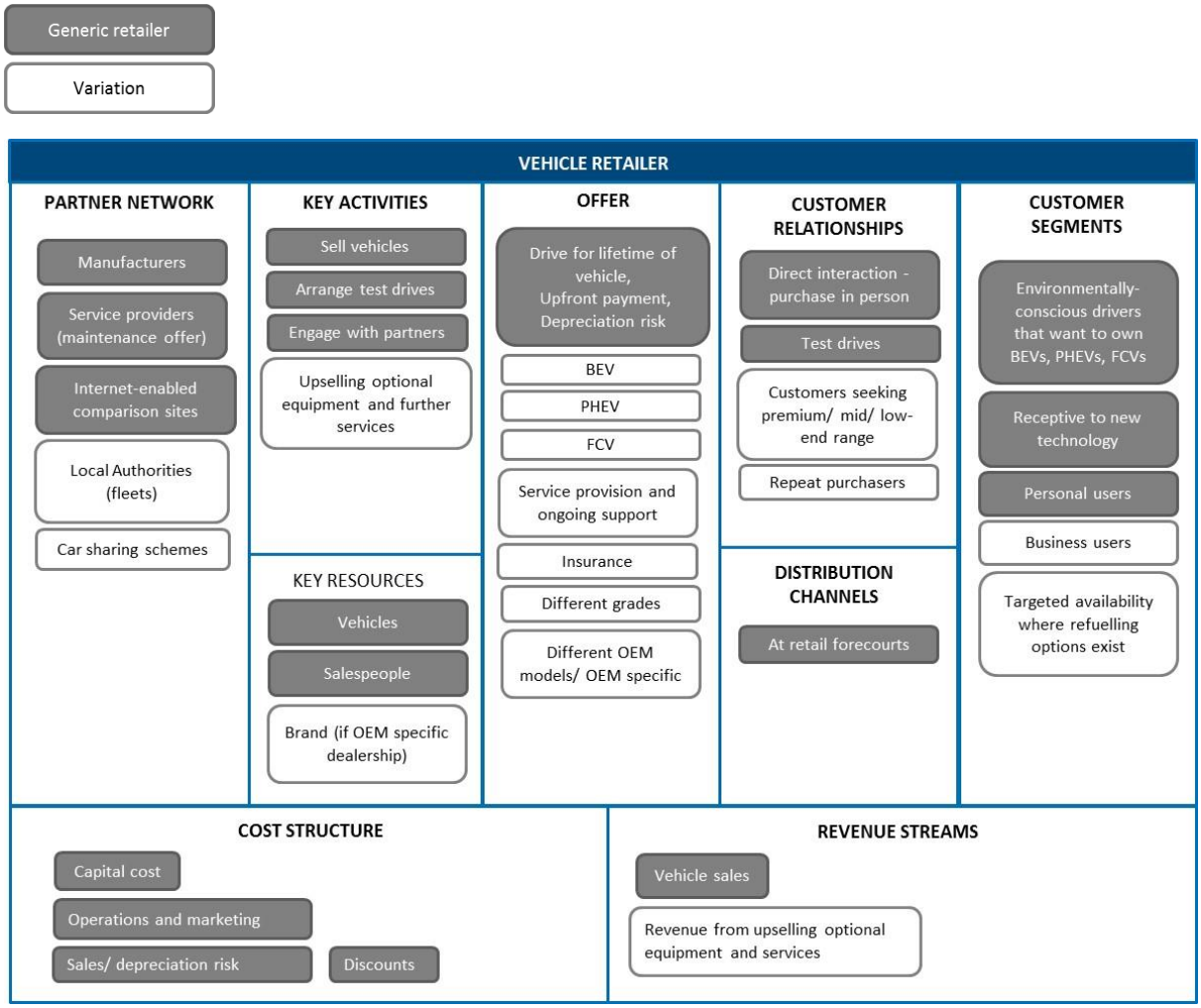
Figure 7 Business model of the Vehicle Sharing Scheme Co. described using the framework



A.1.3 Vehicle Retailer

The Vehicle Retailer is a traditional commercial entity, with variations captured in the framework in Figure 8.

Figure 8 Business model of the Vehicle Retailer described using the framework



A.2 Electricity

A.2.1 Charging Point Operator and Variants

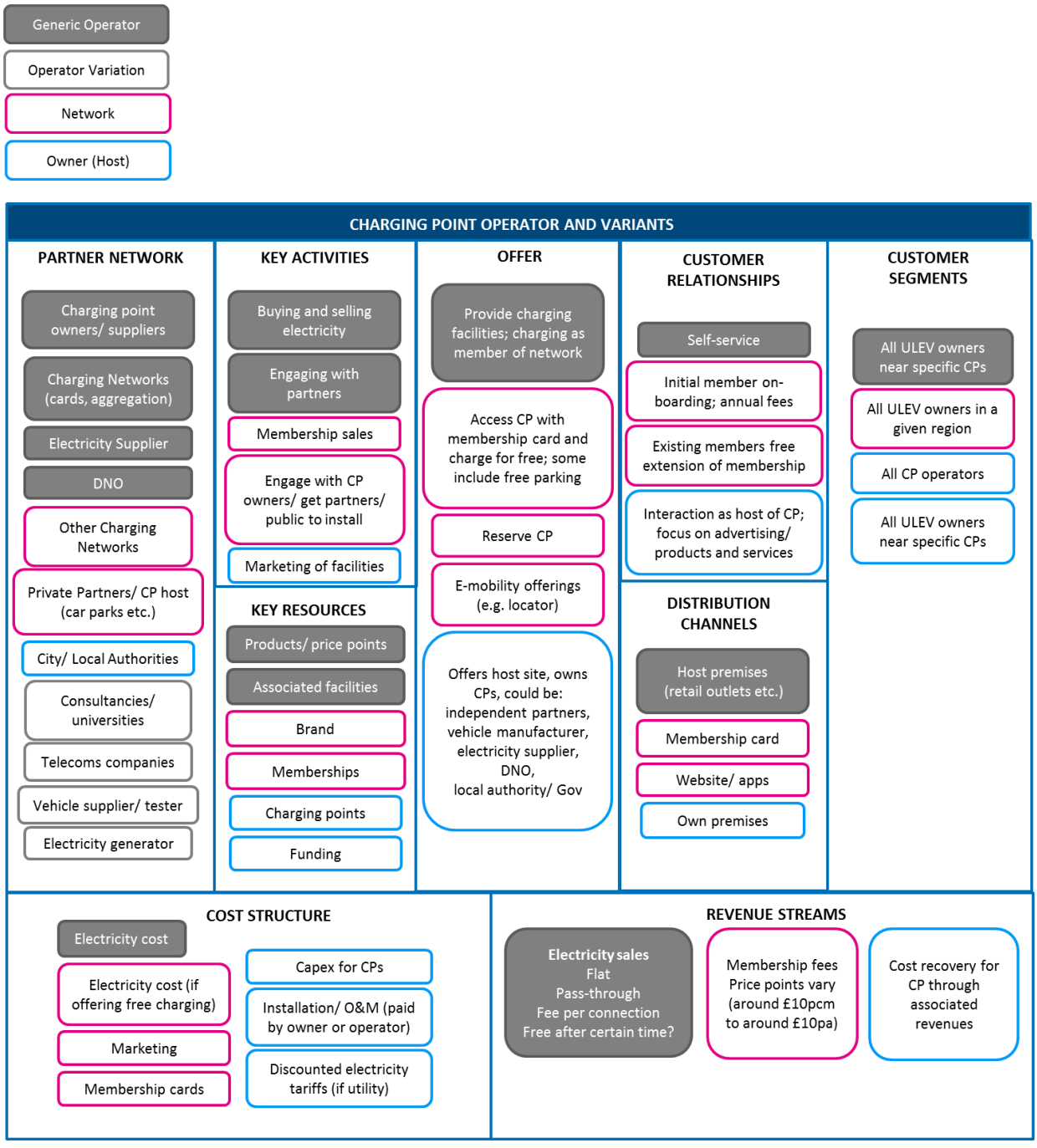
As Charging Point infrastructure is currently being installed, a number of business models and combinations are being tested. The entities can be separately defined as:

- **Operator:** buys and sells electricity - focuses on making margin from electricity. May/ may not own charging points. E.g. Source London, Source East, Plugged in Midlands, Charge Your Car, ChargeMaster
- **Network Operator:** aggregator of charging points - focuses on membership fees. May/ may not own charging points. Can be network owner, or independent private partners
- **Owner:** host of charging points - focuses on associated revenues. May/ may not be the operator also. Retail outlets, home owners etc.

The 'generic' Charging Point Network Operator is described in the detailed supporting spreadsheet (as SourceLondon), and other known UK examples are set out, in addition to US examples.

Partnerships/ mergers of the Electricity Supplier with the Charging Point Owner/ Operator have occurred (e.g. Ecotricity, British Gas, RWE). Battery swapping is another form of charging network and has been tested (e.g. BetterPlace in the US, Tesla). Both of these are depicted qualitatively in the supporting spreadsheet.

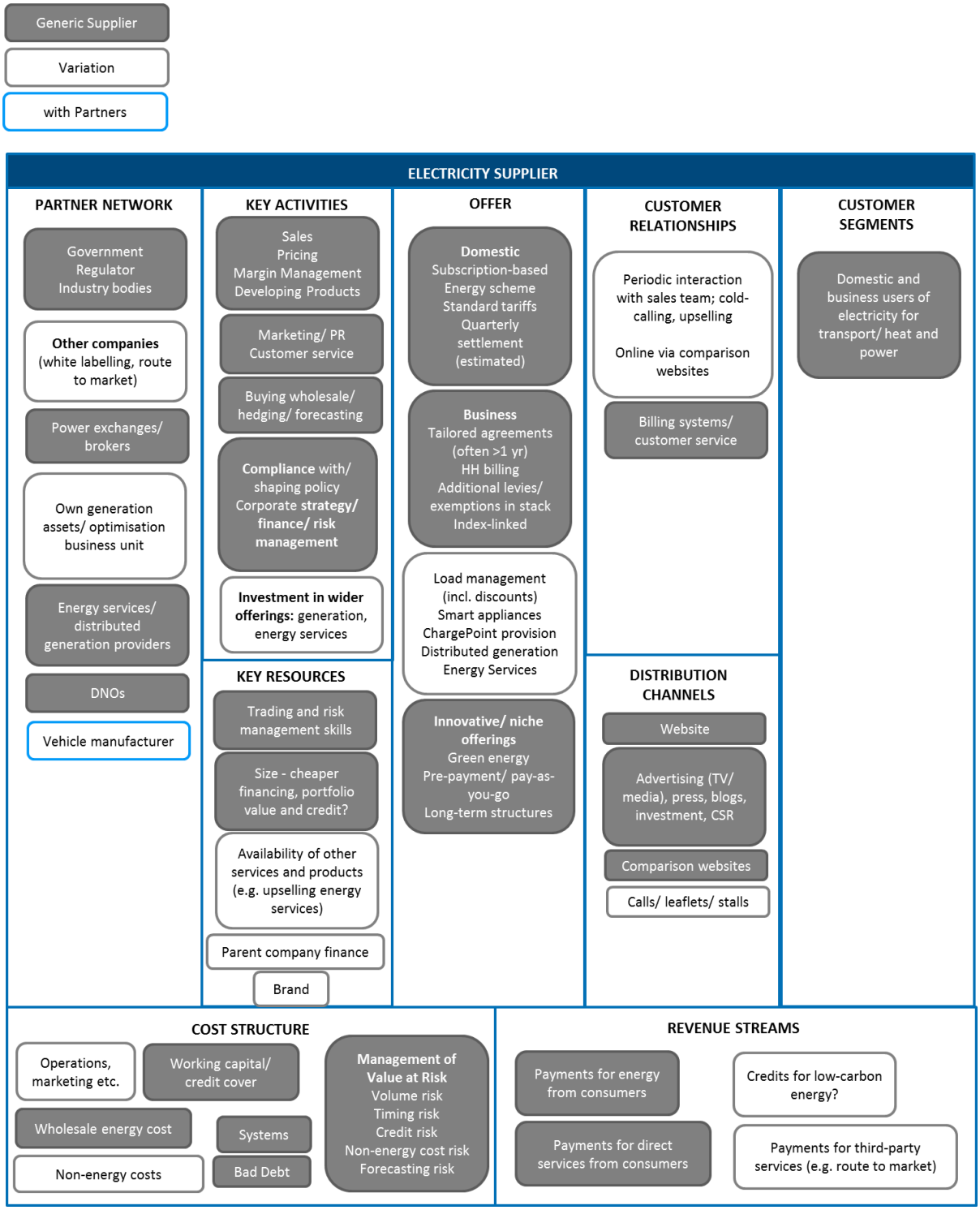
Figure 9 Business model of the Charging Point Operator/ Owner/ Network described using the framework



A.2.2 Supplier

The Electricity Supplier is a well-established business model. In the UK, Electricity Suppliers have partnered with Vehicle Manufacturers (British Gas, Ecotricity and RWE); shown on the framework.

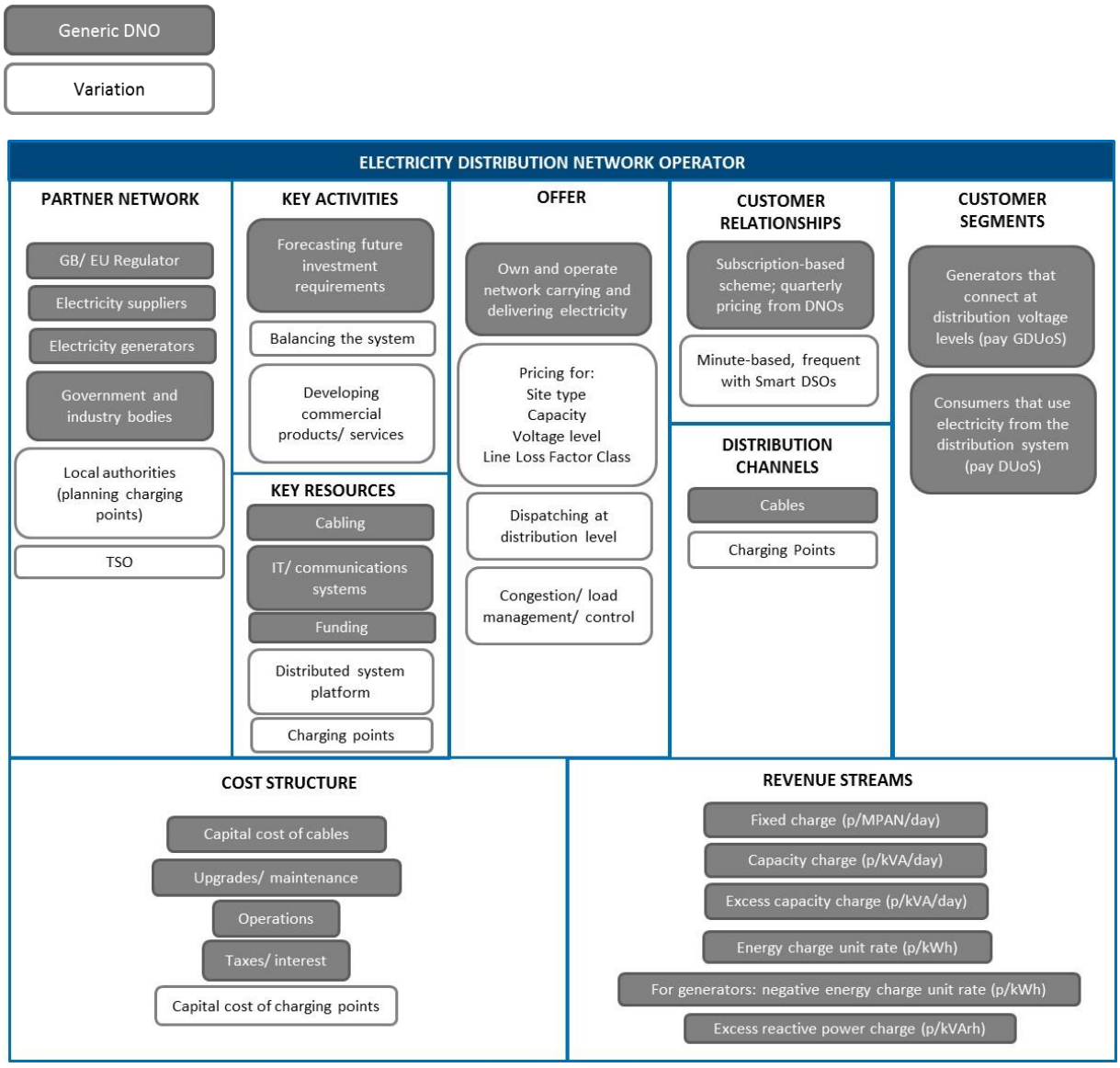
Figure 10 Business model of the Electricity Supplier described using the framework



A.2.3 Distribution Network Operator

The role of the Distribution Network Operator will likely need to evolve as the deployment and use ULEVs increases. An account of the traditional business model is provided, and the associated changes were the Distribution Network Operator ('building and connecting') to transition to a Distribution System Operator ('connecting and managing'). Another existing model is the Network Operator also owning the charging point network (e.g. ESB Networks). These have been described as variations.

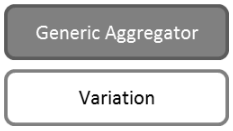
Figure 11 Business model of the Electricity Distribution Network Operator described using the framework

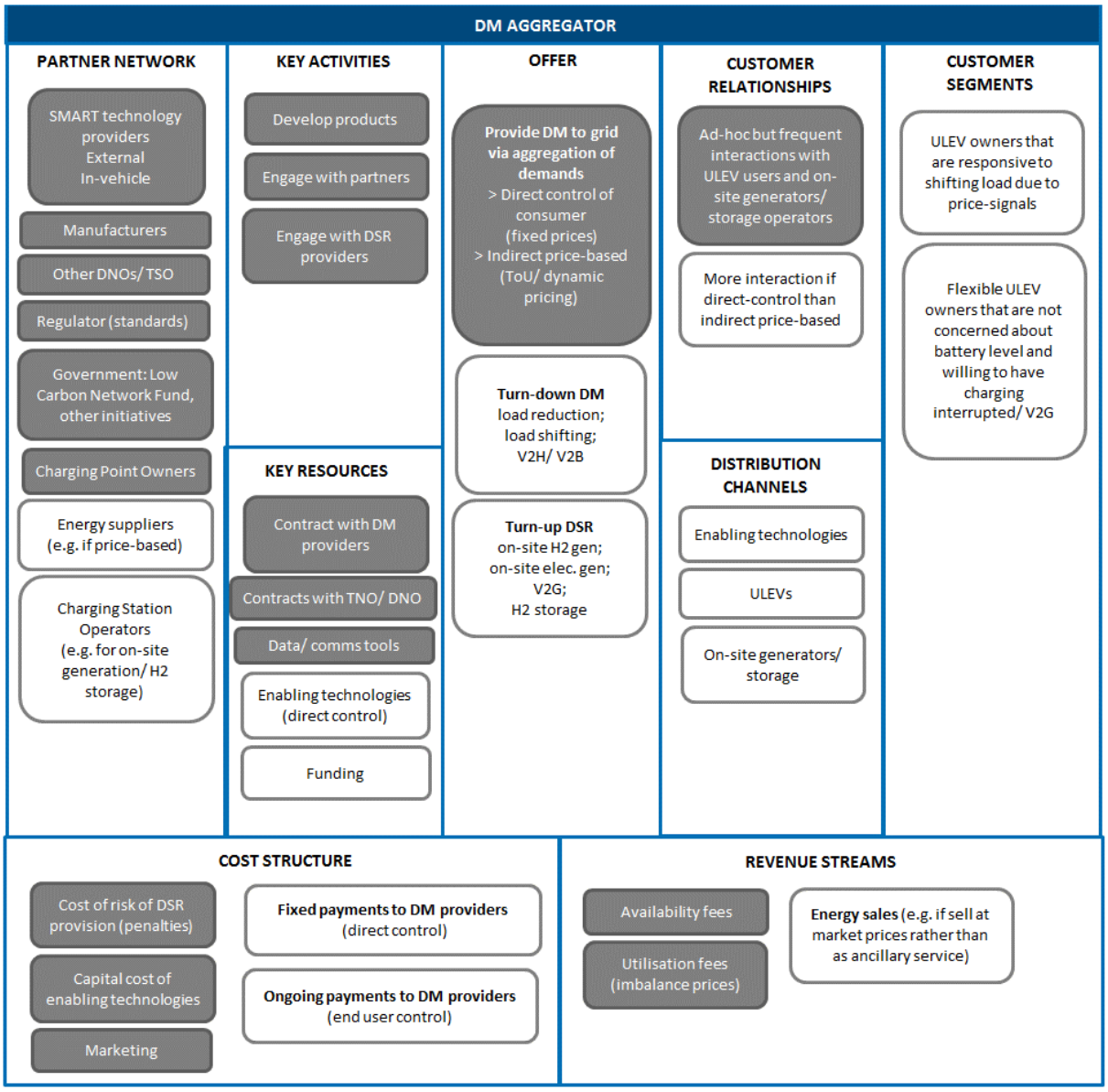


A.2.4 DM Aggregator

As ULEV uptake increases there will be more of a role for an entity that aggregates the load of the ULEVs and provides DM to the grid. The role of IT/ Data/ SMART services is similar in the sense that is requires a collection of data from individual users/ value chain entities and analyses it to produce useful insights or to optimise/ simplify a process. This is discussed in the supporting spreadsheet.

Figure 12 Business model of the DM Aggregator described using the framework





A.3 Liquid fossil / biofuel

A.3.1 Retailer

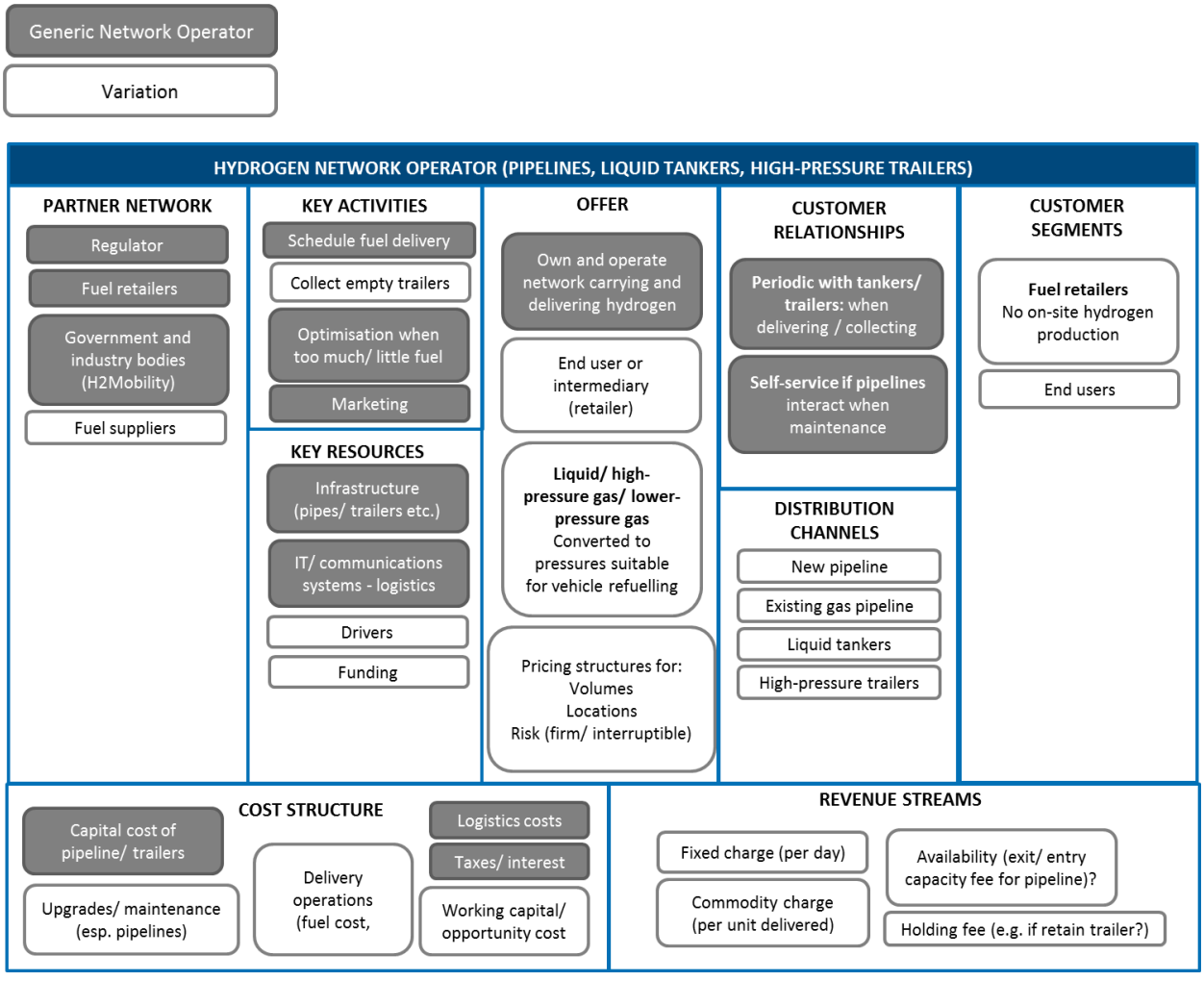
Liquid fuel retailer described as a variant in A.4.2.

A.4 Hydrogen

A.4.1 Network Operator

There are various ways that the Hydrogen Network might evolve; in a more flexible way through high-pressure trailers, liquid tankers or through the use of static pipelines, either by re-purposing the existing gas pipelines or laying new pipelines. These are shown on the framework in Figure 13.

Figure 13 Business model of the Hydrogen Network Operator described using the framework



A.4.2 Hydrogen Retailer

The generic Hydrogen Retailer sells hydrogen to drivers of FCVs, via forecourts. Examples of this are Air Products, First Element, Air Liquide and LindeAir. This is in early stage development at the moment the hydrogen is primarily delivered as a gas in Tankers. A variation is the use of on-site generation (water electrolysis) such as ITM Power and Shell.

Figure 14 Business model of the Liquid Fuel/ Hydrogen Retailer described using the framework