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Programme Area: Light Duty Vehicles

Project: Electricity Distribution and Intelligent Infrastructure

Title: Executive Summary

Abstract:

This project was undertaken and delivered prior to 2012, the results of this project were correct at the time of publication and may contain, or be based on, information or assumptions which have subsequently changed. The Electricity Distribution and Intelligent Infrastructure project (TR1002) is comprised of six Work Packages. This Executive Summary covers Work Package 2.4.The purpose of Work Package 2.4 was to develop an open architecture (i.e. system design requirements) for recharging infrastructure to enable the system to be operated and managed effectively while also enabling compatibility between different business models.

Context:

This project looked at the potential impact of electric vehicles on the UK electricity distribution grid.

ETI Executive Summary

Programme: Transport – Plug-in Vehicle Economics and Infrastructure

Project: Electricity Distribution and Intelligent Infrastructure (TR1002)

Work Package(s): 2.4

Final Deliverable(s): TR1002/SP2/IBM/27

Version: *1.0 (11th March 2011)*

Introduction

The Electricity Distribution and Intelligent Infrastructure project (TR1002) is comprised of six Work Packages. This Executive Summary covers Work Package 2.4.

2.1	Network Analysis
2.2	Recharging Network Requirements
2.3	Recharging Infrastructure Cost Driver Analysis
2.4	Intelligent Architecture
2.5	Recharging Infrastructure Implementation
2.6	Consumer Testing Framework

The purpose of Work Package 2.4 was to develop an open architecture (i.e. system design requirements) for recharging infrastructure to enable the system to be operated and managed effectively while also enabling compatibility between different business models.

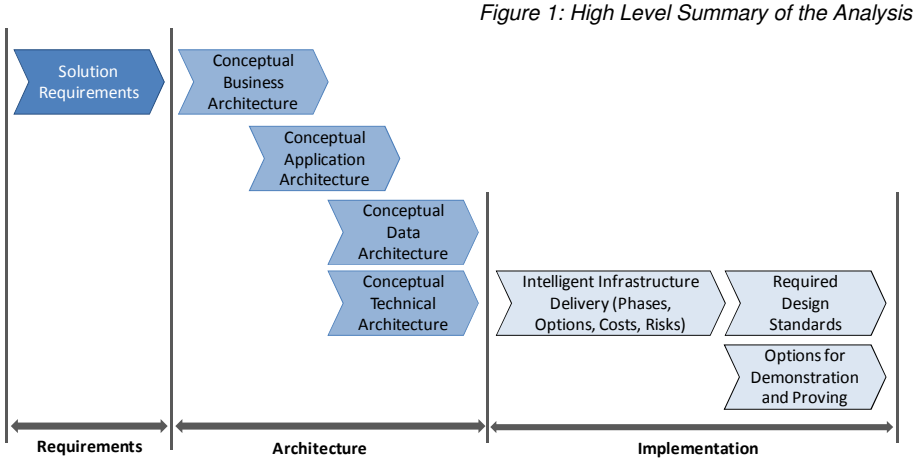
An open architecture will be particularly important for any recharging environment where there is more than one customer per recharge point (such as at workplaces, in communal resident's parking, on streets, etc). The key benefits are:

- Enhancing the consumer experience by providing an integrated approach across a complex space with multiple actors (entities that take actions within the system).
- Encouraging the development of mass market electrification of light vehicles by:
    - Promoting universal services for customers, including ease of payment and access to consolidated data and information.
    - Enabling consistent access to recharging points across the UK and beyond.
    - Enabling common standards within a strategically planned framework.
    - Encouraging competition between recharging point operators and electricity retailers.
- Supporting the electricity industry in mitigating the impact and costs of electricity demand for vehicle recharging on electricity generation and distribution systems.
    - Enabling electricity demand management, including: (a) customer payment linked to time and consumption; (b) variable tariffs; (c) load balancing; (d) real time / dynamic information to users; and (d) physical control of charging locations.
    - Provision of data analytics and information about recharging demand to support control, forecasting and investment decisions.

The structure of the analysis is shown below, starting with an evaluation of the requirements. Interim deliverables were produced at each key step and reviewed by members of the ETI's Strategy Advisory Group (SAG).

In addition to SAG review, consultation was undertaken with a broad range of stakeholders through the ETI led Intelligent Architecture Group (IAG). The IAG is comprised of representatives covering recharging point companies, vehicle manufacturers, distribution network operators and system integrators.

Figure 1: High Level Summary of the Analysis



Requirements

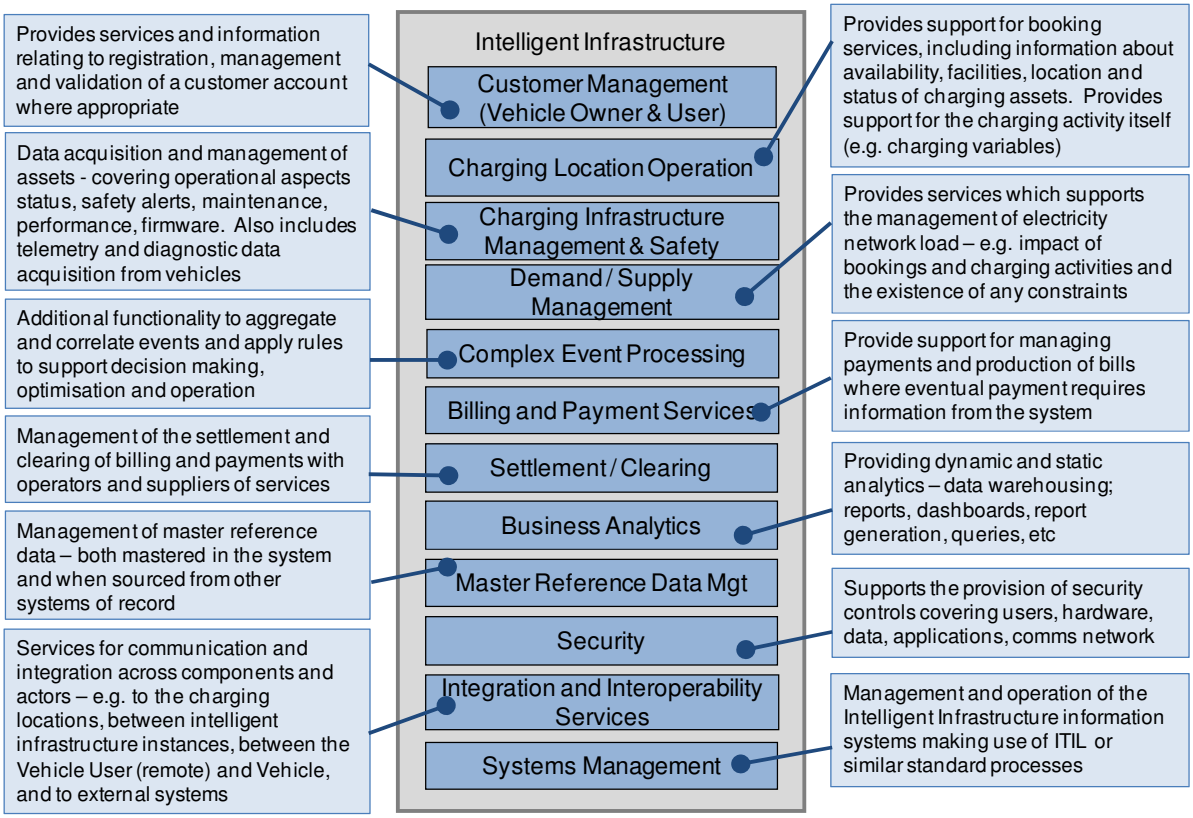
There are six broad categories of actor, each with differing motivations for their interest in the electrification of light vehicles. An expanded list of the types of actor within each category is given in Appendix A.

Government & Regulation	Electric Vehicle Charging Services
• Promote health & environmental improvements in urban areas • Support the electrification of light vehicles as a significant contributor to meeting the commitment to reduce the amount of CO_2 emitted by the UK • Grow the UK's competence in vehicle electrification (as a green technology), with the consequential creation of jobs • Ensure safety, interoperability, quality of services and competition • Ensure the operation of appropriate tax mechanisms to manage road usage	• Opportunity to develop and provide new revenue generating services that can be offered to EV users and EV related businesses • Forge relationships with critical partners (e.g. landlords, electricity retailers, DNOs, charging equipment suppliers, local government, etc) to establish 'core' business • Opportunity to grow the business by vertical expansion into related businesses, products and services to other service providers
Vehicle and Infrastructure Providers	**Other Service Providers**
• Exploit the market opportunity for plug-in vehicles and the associated infrastructure and services • Opportunity to enhance green credentials • Develop affordable plug-in vehicles for the global mass market • Use the provision of plug-in vehicles to the market as a strategy to help meet product portfolio CO_2 emissions (as required under EU Emissions Regulation). • Exploit the opportunity to grow vertically from being an equipment manufacturer and supplier to a service provider	• Opportunity to develop and provide new revenue generating services that can be offered to plug-in vehicle users and related businesses • Target green market segments • Integrate across different intelligent infrastructures

Electricity Supply Chain	Electric Vehicles and Owners / Users
• Maintain security of supply and customer service levels (for distribution networks these are maintained by OfGEM and may require updating for vehicle recharging infrastructure) • Forecast and control demand for power, including techniques like load-shifting to limit stress on localised distribution assets • Provides an opportunity to further demonstrate green credentials • Enhance the stability of the network by using techniques such as local storage, V2G storage, voltage and frequency regulation • Efficiently manage any requirements to renew or update the network due to increasing plug-in vehicle usage (DNO) • Exploit business opportunities through sales of new energy (retailers)	• Attractive Total Cost of Ownership of plug-in vehicles when compared to conventional vehicles and other green technologies • Contribution to environmental cause • Products are safe, desirable and provide sufficient practicality and ease of use, for example: ▪ Removal of range anxiety ▪ Able to charge at home / work so vehicle is ready to use; ▪ Familiar in operation and 'look and feel' ▪ Able to use across different geographies

The information flows between these actors are summarised in Appendix A. From the analysis of the actors' motivations and the necessary information flows, the functional requirements of an open architecture have been determined.

Figure 2: Functional Requirements of an Open Architecture



In addition to the functional requirements, the open architecture is required to:

- Be built using 'open' standards and well defined interfaces so that new users and operators can join the infrastructure and new technologies can be incorporated.
- The design, build, deployment and operation should not constrain vehicle uptake.
- Enable business and operating model innovation as the EV market develops.
- Be expandable in terms of volumes and functionality.
- Meet the current legislation requirements; e.g. data protection, freedom of information, etc.
- Adopt a common classification system for data exchanges to enable interoperability.
- Enable the definition of standards for discrete parts of the system within an overarching interoperability framework.
- Support a mechanism for enabling future trials in terms of being able to provide diagnostic and analytical information on usage, trends, etc.

Architecture

A Component Business Modelling approach (summarised in Figure 3) enabled the components (or competencies) of the business model environment to be defined (summarised in Appendix B).

Not all business model components are required at the outset, and they can be incrementally added as required. Three specific levels of this evolution have been analysed (summarised in Figure 4), although it is likely that different components will need to develop at different rates.

Figure 3: Component Business Modelling Approach

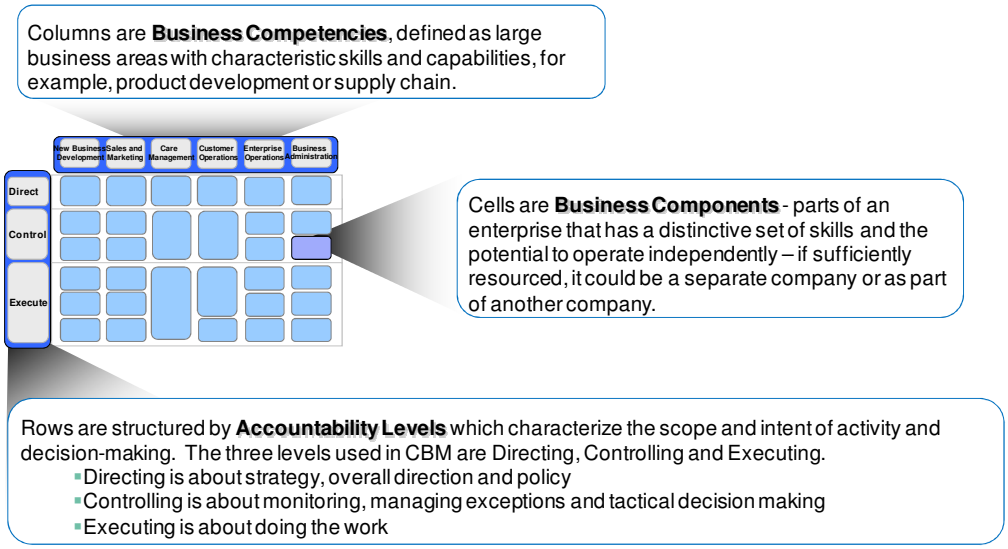
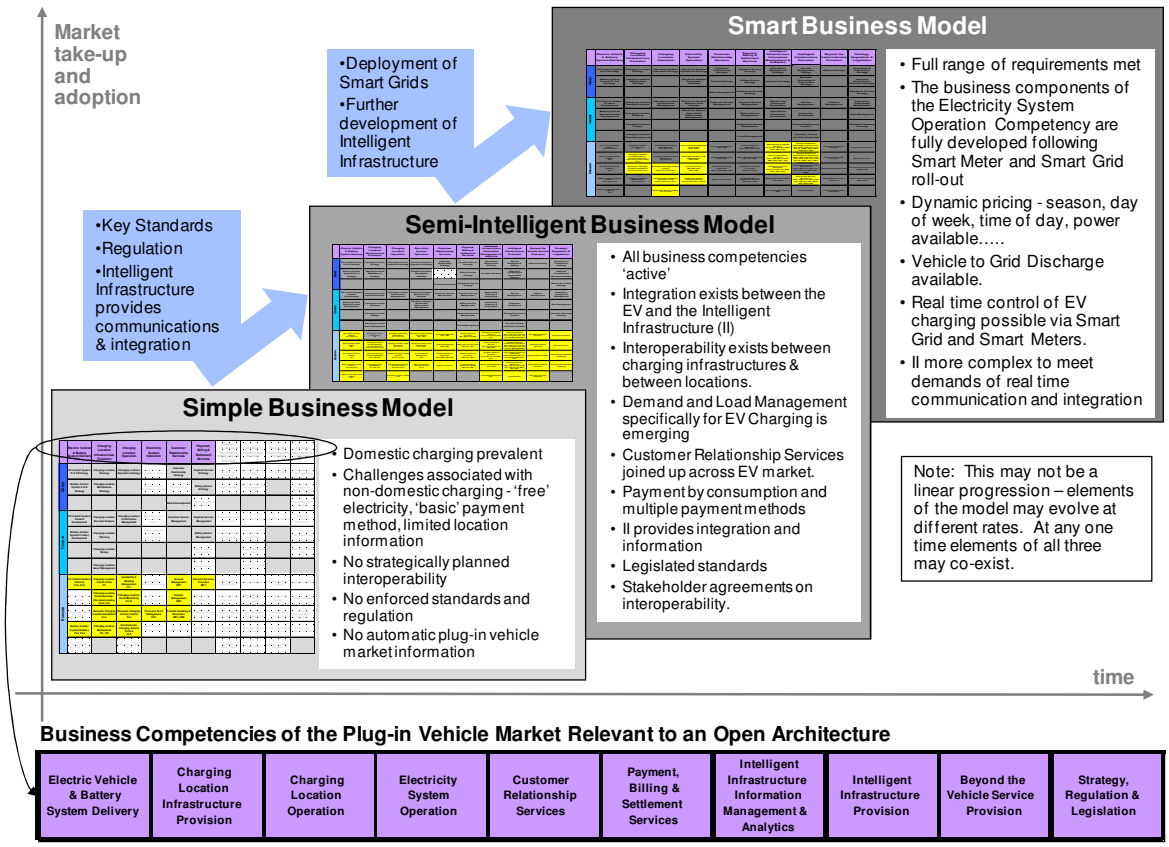


Figure 4: Roadmap for the Incremental Implementation of the System Architecture



The 'Simple Business Model' is akin to the activities under the Office for Low Emission Vehicles (OLEV) Plugged-in-Places (PiP) scheme. Recharging infrastructure providers and operators, heavily subsidised by the public sector, are focused on raw recharging capability, a simple method of payment and the minimum element of customer relationship services. Due to limited integration, vehicle users may have to join multiple recharging operator schemes. This is unlikely to present a viable commercial operating model.

The 'Semi-intelligent Business Model' implements the core components of a viable commercial operating model. All of the business model components are required to exist to one degree or another. The key actions required to achieve this level of integration are the implementation of a minimum set of standards and the deployment of the basic communication and integration services. The timing is dependent on vehicle uptake.

The 'Smart Business Model' implements the full set of business model components, building on external developments such as a full Smart Grid. This model is characterised by a much higher level of information flow and greater potential for actively controlling vehicle recharging demand. The key actions required to achieve this level of integration are the implementation of Smart Meter and Smart Grid technologies and the deployment of communication and integration services capable of handling more sophisticated and extensive real-time communications and management. The timing is dependent on vehicle uptake and specifically the need to control the demand for electricity due to generation or distribution constraints.

Implementation

There are two fundamental options for the structural solution of the system architecture to enable the necessary transactions to take place between actors within the plug-in vehicle ecosystem:

a) '**Organic**' (Figure 5a), which requires interconnect agreements to be independently negotiated and implemented directly between all actors

b) **'Strategically Planned'** (Figure 5b), which has a central body and defined standard interfaces

Figure 5a: Options for the Structure of the System Architecture – 'Organic' Model

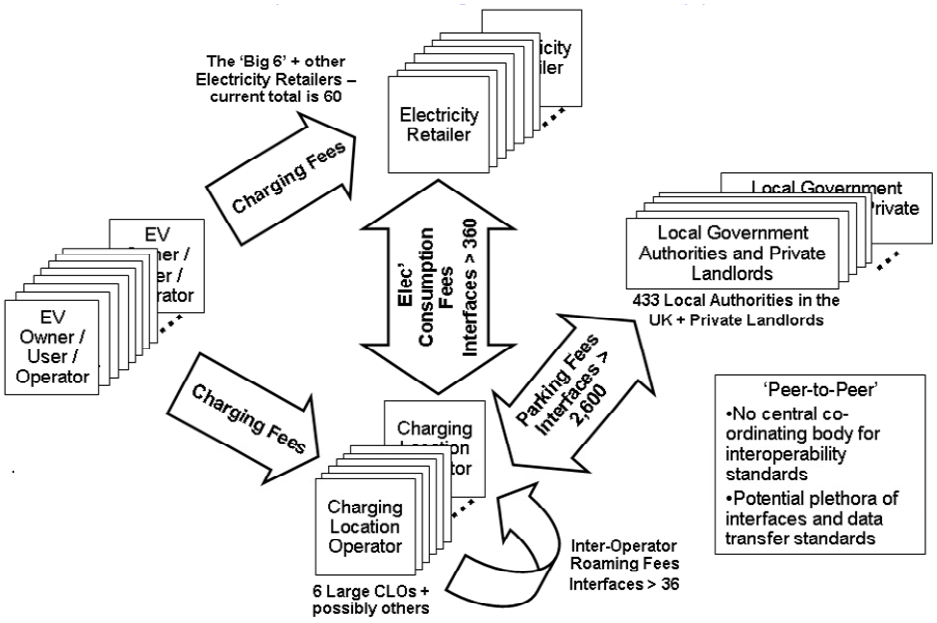
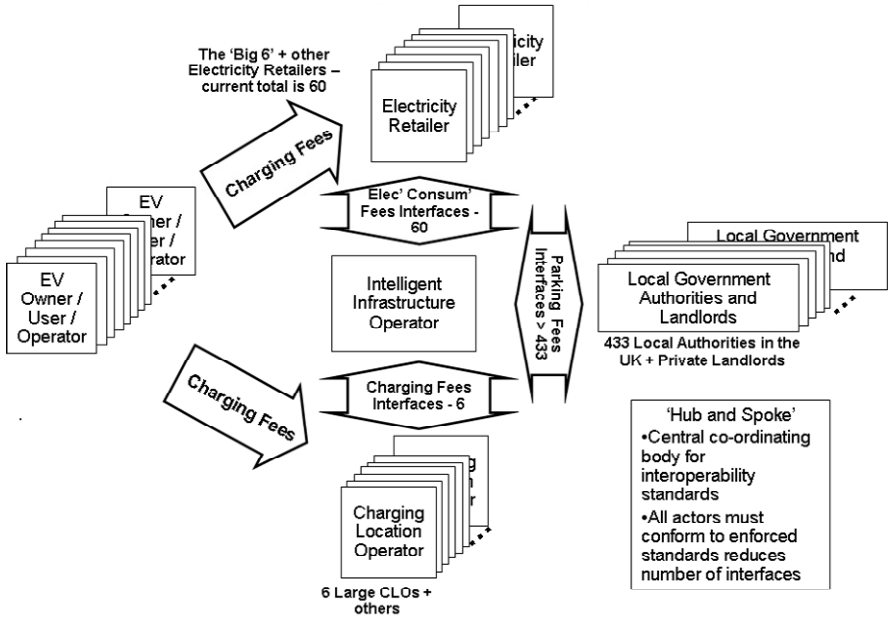


Figure 5b: Options for the Structure of the System Architecture – 'Strategically Planned' Model



The ‘Organic’ model (Figure 5a) would require a large number of independent agreements to be put in place between actors to enable interoperability across the system. Consequently, proprietary interfaces and agreements are likely to emerge limiting future competition and accessibility within the market. This is the current position.

The ‘Strategically Planned’ model (Figure 5b) would require a central service to be implemented. The actors within the ecosystem would need to comply with the interface standards of this central service. This is anticipated to be the most appropriate solution, as it has potential to encourage competition within the market and is comparable to similar industry approaches:

- Electricity markets: ELEXON, Electralink, DCC
- Retail Banking ATM networks: Link
- Bankers’ clearing services: BACS and CLS.

Since the industry will develop around this system, it will be very difficult to retrospectively move toward a ‘Strategically Planned’ model after a market is established (as found with the US mobile telecoms industry). It would therefore be prudent to implement it sooner than later.

Governance of the central service will be critical to ensure that it stimulates market growth, rather than stifling it or attempting to create a monopoly.

The analysis has established that plug-in vehicles and the infrastructure will exist in a highly disaggregated and complex ecosystem. The efficient exchange of data and information between many disparate locations and systems is therefore essential to effective operation. Accordingly, the development and adoption of specific standards for discrete parts of the ecosystem will be critical. The specific interfaces requiring development, agreement and adoption of standards have been identified and prioritised. The highest priority specific interfaces are:

- Vehicle user to / from the recharge point to ensure consistent access to different vehicles and consumers.
- Recharge point to / from the recharging location operator to ensure interoperability between different recharge points and operators.
- Charging location operator to / from the central service (assuming that the ‘Strategically Planned’ model is adopted) to ensure open access.

The table below summarises the opportunities for investment in the creation of the central service to enable the 'Strategically Planned' model to be realised.

Opportunity	Viability	
Private company investment	R	The market uptake rate is anticipated to be too slow to deliver a viable return on investment as an independent business. It would be inappropriate for a business with a vested interest within the ecosystem, due to the governance issues highlighted above.
Private sector consortium investment	R	Joint funding makes private investment more viable, but the desire of individual organisations to seek advantageous positioning makes it unlikely that the necessary consensus will emerge in an appropriate timeframe.
Government funded body	A	While viable, it appears unlikely that the public sector will be in a position to make this investment in the near to medium term.
Regulatory framework	G	In a similar manner to the existing systems operated within the electricity industry, a regulated body could be created to: (a) undertake the appropriate consultation; (b) develop and maintain the interface standards; and (c) commission and maintain the central service. The investment costs could be recovered through charges to electricity consumers.

Recommendations on Next Steps

Further work is required to understand the business case (justification and timing) for investment in the central service proposed above. This is largely dependent on vehicle uptake and relative economics, which are being analysed within the ETI's Consumers and Vehicles project and Economics and Carbon Benefits project.

Key to realising an open system architecture will be:

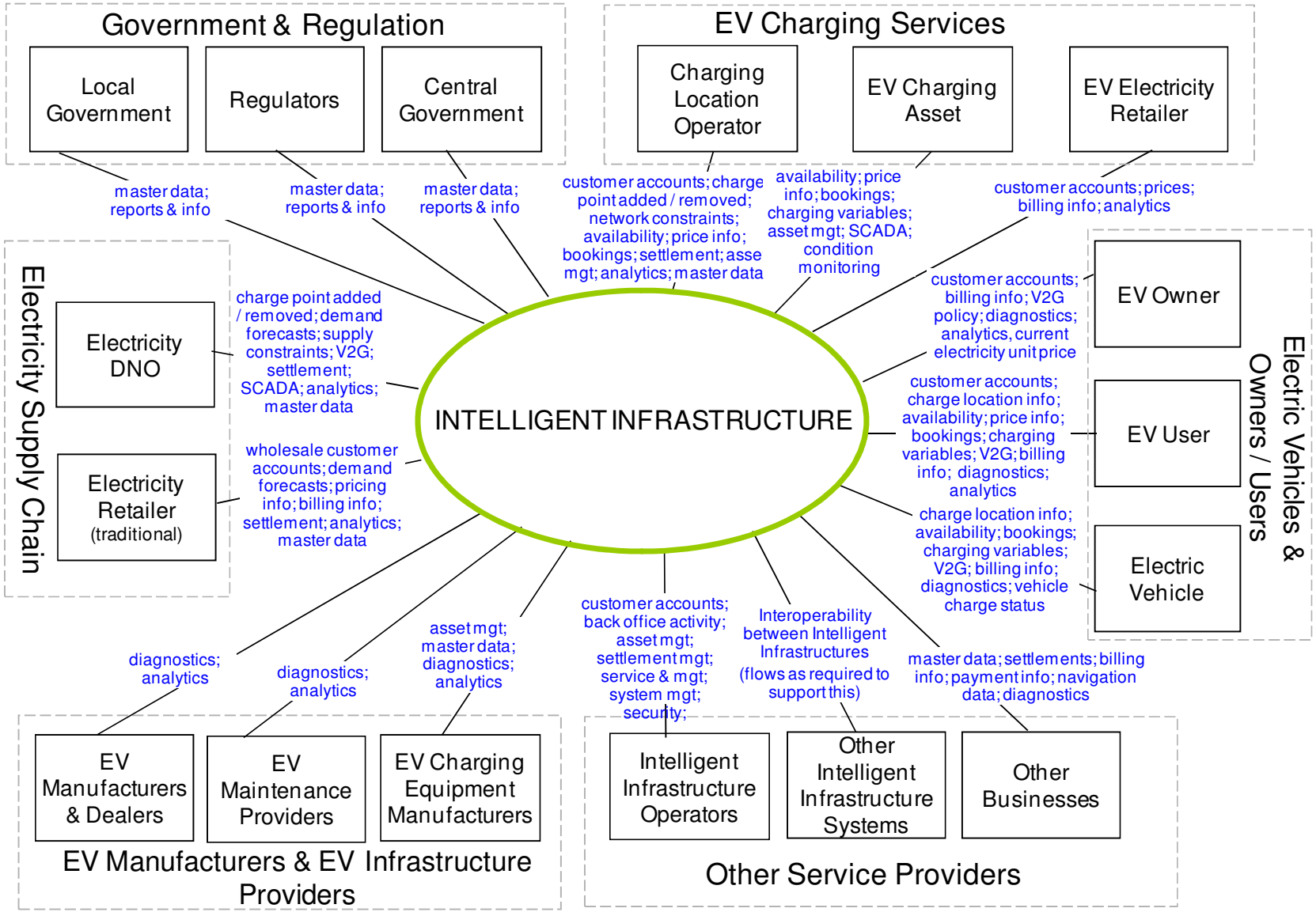
- The development, agreement and adoption of the necessary specific standards for vehicles, recharge points, electricity networks and payment systems.
- Demonstration and proving of the functionality and benefits that a central service would offer. The options for a trial to achieve this are summarised at Appendix C.
- Investment in the deployment of the central service.

The following next steps are therefore recommended:

- Publication and wide dissemination of the proposed system architecture.
- Ongoing engagement of a broad range of stakeholders through the ETI led Intelligent Architecture Group to stimulate the development of the necessary specific standards.

  It is recommended that this group is extended to include representatives of the key UK, EU and international standards bodies identified for the various specific interfaces.
- Investment in a demonstration project, with key work packages to demonstrate the functionality and benefits of the central service and associated interfaces.
- Engagement of key stakeholders in the Government and regulatory space to inform decisions on enabling investment in a central service in support of realising the 'Strategically Planned' model.

Appendix A: System Architecture Actors and Information Flows



Appendix B: Component Business Model for the Open Architecture

	Electric Vehicle & Battery System Delivery	Charging Location Infrastructure Provision	Charging Location Operation	Electricity System Operation	Customer Relationship Services	Payment, Billing & Settlement Services	Intelligent Infrastructure Information Management & Analytics	Intelligent Infrastructure Provision	Beyond the Vehicle Service Provision	Strategy, Regulation & Legislation
Direct	EV Control System R & D Strategy	Charging Location Strategy	Charging Location Operation Strategy	Electricity System Operations Strategy	Customer Relationship Strategy	Payment Service Strategy	Information Management Strategy	Service Management Stategy	Alliance Strategy	Regulatory & Compliance Strategy
	Battery Control System R & D Strategy	Charging location Maintenance Strategy		Electricity System Emergency Planning	Channel Strategy	Billing Service Strategy	Analytics Strategy	Business Technology & Governance Strategy		Inteligent Infrastructure Business Strategy
					Market Development	Settlements Service Strategy				Standards & Policy Strategy
Control	EV Control System Product Development	Charging Location Demand Analysis	Charging Location Performance Management	Electricity System Network Load Analysis	Customer Service Management	Payment Service Management	Master Data Planning & Governance	Service Management	Alliance Management	Regulatory Compliance Management
	Battery Control System Product Development	Charging Location Planning		Electricty System Operational Performance Management		Billing Service Management	Information Planning & Governance	Enterprise Architecture		Risk Management
		Charging Location Design				Settlements Service Management		Change Deployment Control		Standards Roadmap Planning
		Charging Location Asset Management				Fraud Management		Security, Privacy and Data Protection		
Execute	EV Control System Delivery	Charging Location Construction	Availability & Booking Management	Electricty System Demand Forecasting	Account Management	Payment Services Provision	Data Extract & Upload Services	Service Integration	Roadside Assistance Provision	Regulator Interaction
	EV In-Life Operations Support	Charging Location Commissioning / Decommissioning	Charging Location Asset Monitoring	Electricity System Load Management	Contact Management	Billing Services Provision	Query & Reporting Services	System, Network & Infrastructure Operations	Information Service Provision	Market Research
	EV Communications Delivery	Domestic Charging Location Installation	Domestic Charging Activity Control	Price and Tarrif Management	Problem Handling & Resolution	Settlement Services Provision	Analytics Services Provision	User Identity and Access Processing	Navigation Data Provision	Standards Development & Publishing
	Battery Control System Delivery	Charging location Maintenance	Non Domestic Charging Activity Control	Electricity System Charging Control	Sales & Promotions	Fraud Detection & Revenue Protection	Master Data Management	End to End Service Monitoring	Entertainment Service Provision	Environmental Legislation Reporting
	Battery In-Life Operations Support		Discharge Activity Control				Knowledge Management	Project Delivery	Emergency Services Integration	

Appendix C: Options on the Scope for Demonstration and Proving in a Future Project

Broad Feature	Basic Trial	Advanced Trial
Customer Management	Register users, create accounts, handle basic contact; simple customer relationship management functionality.	Extended customer relationship management functionality .
Charge Point Information and Management	Static location information; snapshot status information no consolidated asset view.	Real time status information; consolidated asset view across all factors (supplier, operator, location, etc).
Charging Activity Management	Basic charging variable selection (e.g. charge after 2300, charge for 4 hours, etc).	Extended charging variables and parameters selectable (such as recharge based on price, recharge as fast as possible, recharge until xx% then stop until time = xx, etc); booking services, calendars, etc.
Payment Management	Basic payment methods supported (account based, fee based, pay on use)	Extended payment method support, including full ability of users to 'roam' between different systems
Settlement	No settlement in a basic trial.	Settlement supported to allocate payments across different providers and operators.
Integration	No external real time integration required.; updates batch based or periodic polling type (such as for charging assets)	Real time integration between systems, including simulated and real-world external systems (e.g. pricing, demand, payment)
Analytics & Reporting	Mainly static reports; some basic analytics.	Extended analytics and moving towards optimisation.
Demand Management	Not part of a basic trial.	Information and analytical functionality available for demand management.
Vehicle Interaction	No vehicle interaction; standard and standalone vehicle diagnostics.	Extensive vehicle interaction (e.g. with recharge point), external information source, etc); potential integration of vehicle diagnostics with analytics.
Trial Specific Data Capture Infrastructure	As required (e.g. for consumer research).	As required (e.g. for consumer research).