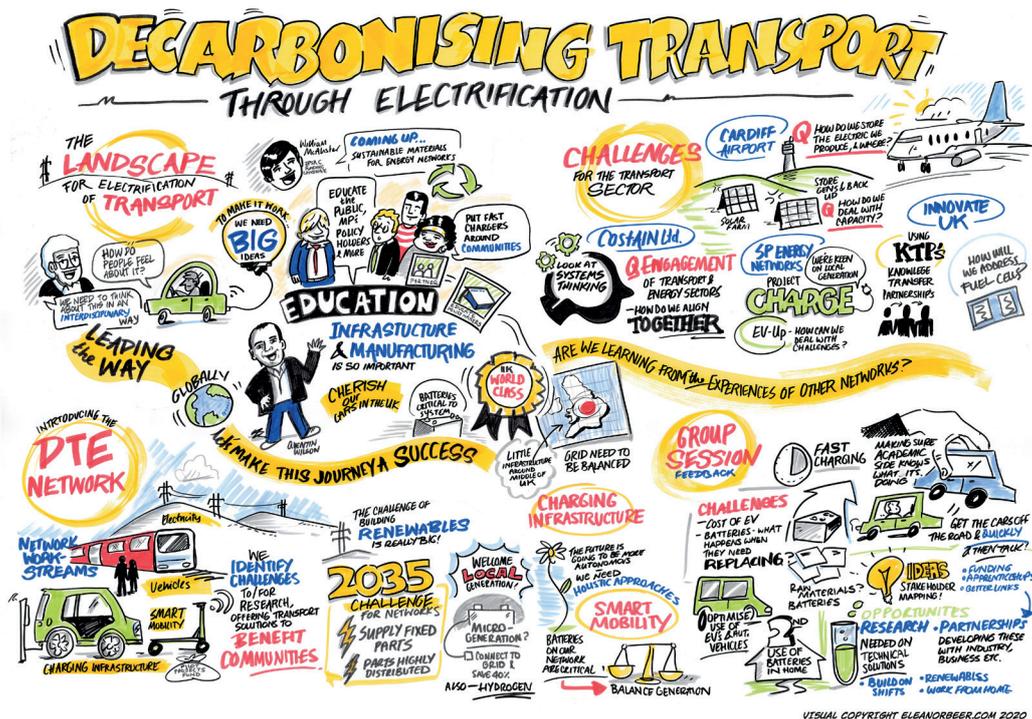


**DTE Network**  
Decarbonising Transport Through Electrification



# DTE Network+

## Framework and Consultation Document



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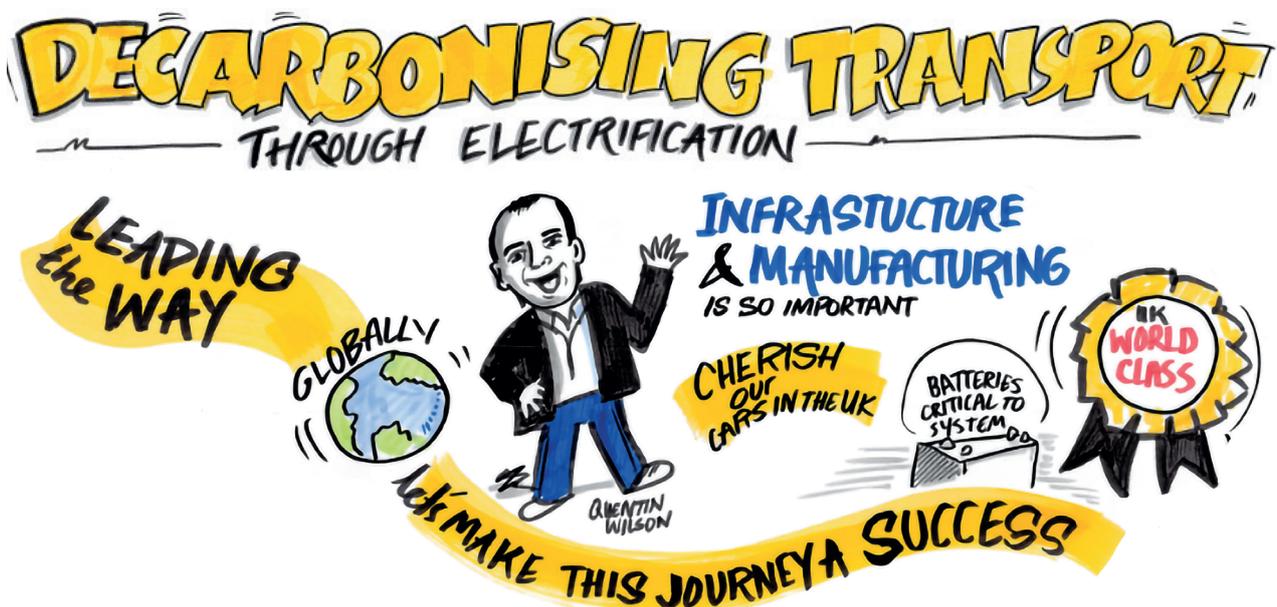
# Introduction

## About the DTE Network+

The Decarbonising Transport through Electrification (DTE) Network+ is a £1M EPSRC funded multidisciplinary project addressing the challenges of implementing an electrified, cost-effective and holistically operating transport sector for the UK.

The network brings together academia, industry and the public sector to work across the major transport divisions of automotive, aerospace, rail and maritime. The integrated, whole system approach of this network will focus on questions over short, medium and long term time-frames within multiple work streams.

Teams will explore drivers for change within the transport system including technological innovation, individual mobility needs and economic requirements for change, alongside environmental and social concerns for sustainability and consider the role, social acceptance and impact of policies and regulations. Multidisciplinary contacts across engineering, psychology, economics and policy are integrated into the network to facilitate detailed investigation of cross cutting subject matters from the role of social acceptance to the impacts of policy and regulation to maximise emission reduction.



# Introduction

## Executive Summary

This document has been produced following the recent DTE Network+ launch event and aims to set out a clear structure surrounding the research to be carried out within this consortium. This will be provided through three key sections of material.

The three sections concern:

- The DTE Network+ Structure: this includes a detailed overview of the holistic work stream based approach to DTE Network+ research and a selection of projects based on our current consortium's expertise.
- Launch Event Stakeholder Consultation – a discussion of the methodology surrounding our recent consultation with stakeholders and the subsequent development of key challenges surrounding transport decarbonisation.
- Challenge Frameworks – five visual representations of key challenges developed by our stakeholders and consortium presented over varying time horizons. These aim to highlight the research and innovation interests to be explored over the coming years to aid in removing emissions from transportation.

The motivation behind the information contained within this document is to provide information on this consortium's efforts, and background for individuals interested in participating in our upcoming funding calls and/or network activities. Work within this consortium aims to provide some additional resource to facilitate the cross disciplinary work towards decarbonising transport through electrification.

# Introduction

## Supporting the Transport Decarbonisation Plan (TDP)

In October 2019, the UK government announced its development of a transport decarbonisation plan (TDP). During March 2020, the Department for Transport (DfT) [published Decarbonising Transport: Setting the Challenge](#) with six strategic priorities identified to build a structure towards the TDP. The DTE Network+ workstreams are aligned with all six. Furthermore, the DTE Network+ has established a presence within the Department for Transport, Transport Research and Innovation Board (TRIB). The report's strategic priorities are listed below and how they align with this networks work streams is explained.



**Accelerating modal shift to public and active transport**

WS1.2 - Connected Autonomous Vehicles

WS4.1 - Human Factors



**Decarbonisation of road vehicles**

WS1.1 - Electric Powertrains

WS2.1 - Extending/building charging infrastructure

WS2.2 - Dynamic charging on the road

WS3 - Supply of electricity as a transport fuel



**Decarbonising how we get our goods**

WS2.2 - Dynamic charging on the road

WS2.3 - Railway feeder stations

WS3 - Supply of electricity as a transport fuel

WS4.2 - Big Data, Cybersecurity



**Place-based solutions**

WS1.3 - Green Taxiing Demonstrator

WS2.3 - Railway feeder stations

WS2.4 - Low carbon generation on the railway electrification network



**UK as a hub for green transport technology and innovation**

WS3 - Electricity as a transport fuel

WS4.3 - Planning, economics, environmental



**Reducing carbon in a global economy**

WS4.3 - Planning, economics, environmental

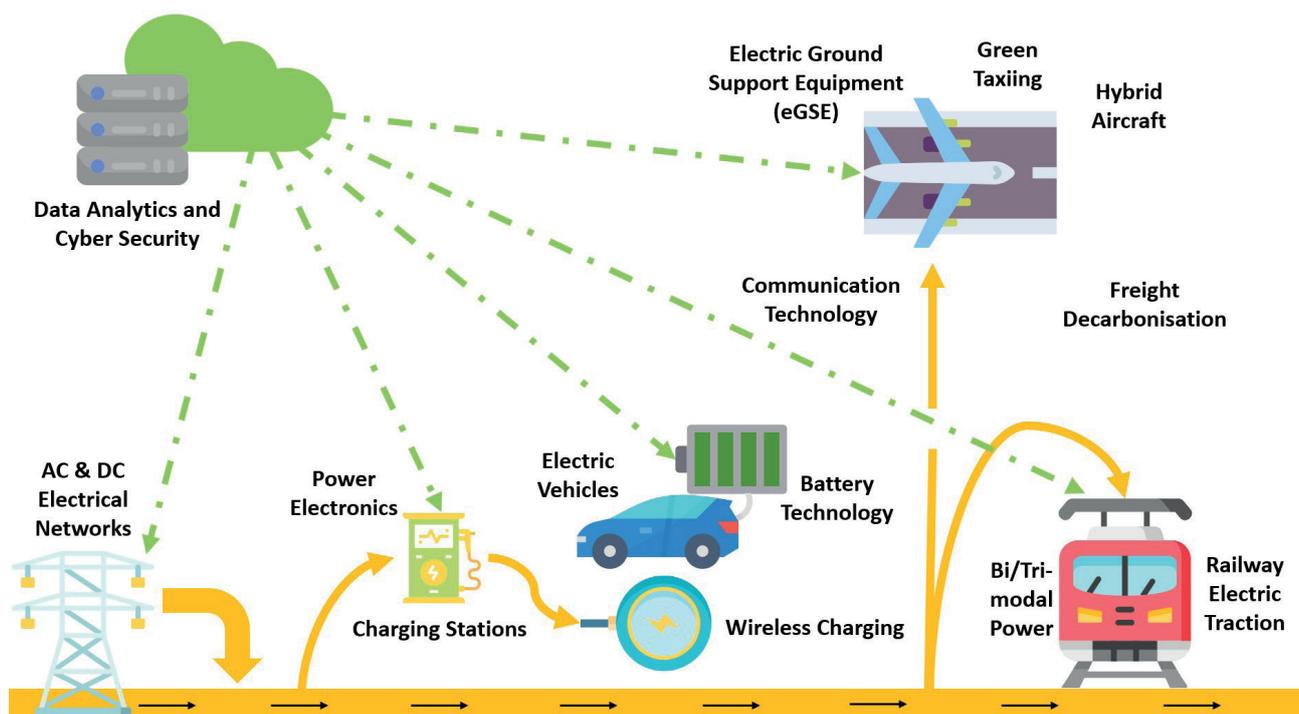
WS4.4 - Policy

# Network Structure

## The Whole System Approach

The interdisciplinary nature of transport decarbonisation requires a whole system approach to maintain a holistic and systemic viewpoint. Therefore, this Network+ has developed, and will sustain, an interdisciplinary team to help solve the challenges surrounding decarbonising transport and will be able to respond quickly to changes in the transport and energy landscape.

The DTE Network+ will pioneer new ways of engaging and participating with industry, government, regulators, and end users. Through the rigour of academic research and consistent stakeholder involvement, the outputs of this Network+ will be successfully applied to the real problems of decarbonising the transport sector which will be critical to ensuring the future deployment of a flexible, open, and multiservice infrastructure. The DTE Network+ also contains mechanisms to support early career researchers and our work stream approach enables us to widen the dissemination of any results.



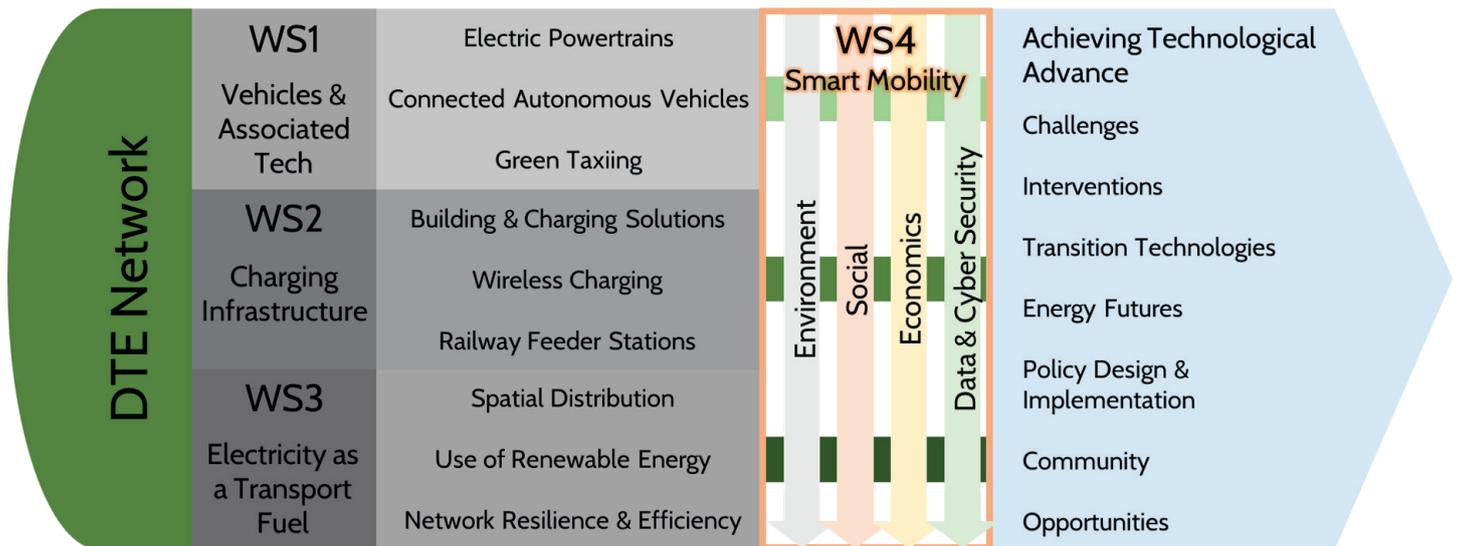
# Network Structure

## The Work Streams

The activity within the DTE Network+ project is distributed across four Work Streams. Using this multidisciplinary work stream approach allows the network to cover a breadth of research topics and spot interdisciplinary synergies where they exist.

The four dedicated work streams are:

- Work Stream 1                      Vehicles and Associated technologies
- Work Stream 2                      Charging Infrastructure
- Work Stream 3                      Supply of electricity as a transport fuel
- Work Stream 4                      Smart Mobility



# Work Stream 1

## Vehicles & Associated Technologies

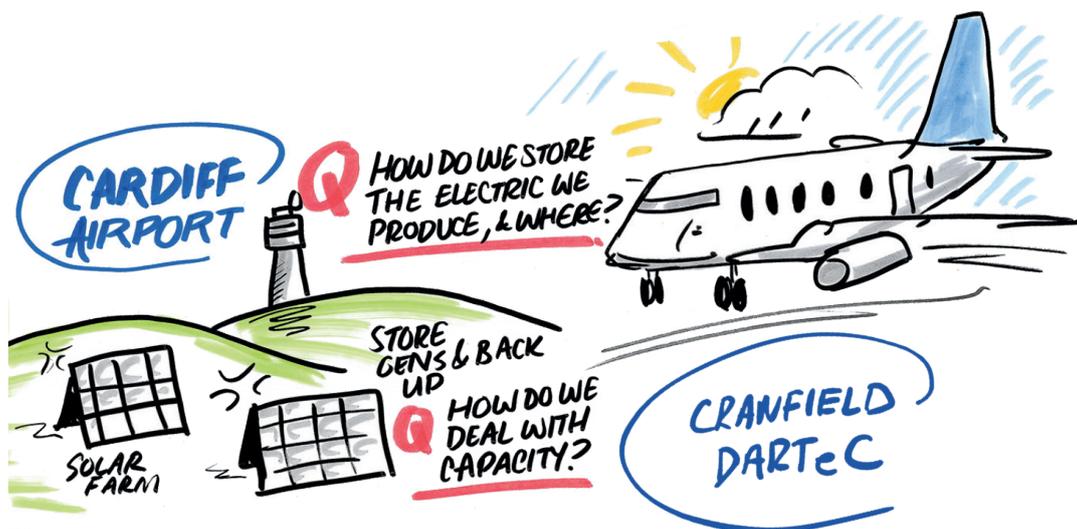
Leader: Professor Patrick Chi-Kwong Luk

Cranfield University

Contact: [p.c.k.luk@cranfield.ac.uk](mailto:p.c.k.luk@cranfield.ac.uk)

Under this stream, research efforts are aimed at advancements in specific transport system modal categories (road, rail, aerospace and maritime). The work stream employs a “cradle to grave approach” when evaluating and developing new technologies and innovations for decarbonising the transport sector.

Energy intensity targets can be achieved by the reduction in gross energy consumption; increase in instantaneous powertrain efficiency; and increase in average powertrain efficiency. On the other hand, power density improvement on propulsion systems must be addressed by exploring new frontiers such as in superconductors and novel materials in order to achieve comparable performance with thermal engines, particularly for aerospace applications with hybrid/full electric propulsion. Advanced wide-bandgap power electronics technologies and new materials and structures for electric machines will be investigated to provide a high-efficiency and high energy density solution. A strategic plan laying out technology integration targets will be developed through investigation of current and future technology offerings.

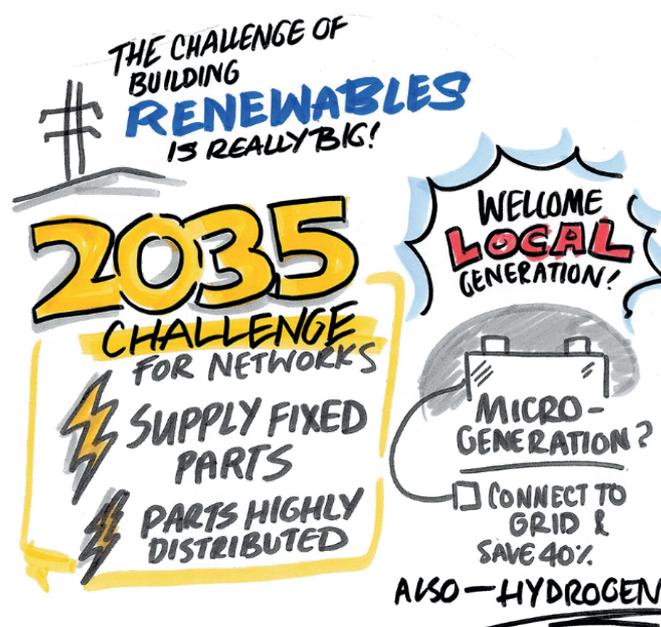


# Stream 1.1

## Electric Powertrains

The Electric Powertrain stream uses a “cradle to grave” approach to evaluate a suite of electric motors optimised for each of the transport sectors, considering user requirements from design to manufacturing, and from vehicle operation to disposal / reuse with the aim to improve efficiencies, increase performance and reduce costs at each stage. This stream will conduct life cycle analysis of competing electric powertrains and explore modular motor design studies on traction/propulsion motors for road, rail and aircraft applications. Dissemination and competition events on electric powertrains are envisioned as outputs of this work.

The modular motor design studies envision a modular motor with a unique toroidal stator which allows for dynamic and flexible electric drivetrain technologies to be deployed. The modular motor can embody different motor technologies from classical (e.g. permanent magnet) to radical (e.g. superconducting) into an integrated motor. This provides a very robust strategy sufficient to meet the supply chain and technical challenges in the automotive, rail, marine and aerospace sectors.



# Stream 1.2

## Connected Autonomous Vehicles

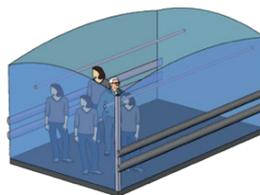
Covers technological (Cranfield) and Human Factors (Cardiff) topics including dynamics & control, guidance & navigation, decision making, sensor fusion, data & information fusion. Since Connected Autonomous Vehicle (CAV) R&D lends itself well to promoting Mobility as a Service (MaaS) and/or shared ownership such that we could see a reduction in road vehicles used for domestic, pleasure and work commute purposes.

Human Factors such as user needs and expectations, attitudes and behaviours associated with MaaS and shared ownership of electric powered CAVs will be developed using Cranfield's Multi-user Environment for Autonomous Vehicle Innovation (MUEAVI) platform, which is a new purpose built experimental facility for developments of on and off highway, ground and airborne autonomous solutions. In addition, questionnaires, interviews and experimental studies (e.g. using driving simulations) will be used to gather data on user needs and experiences. This stream will conduct scenario-based studies on the impacts of technological developments on autonomous & connected vehicles using the MUEAVI platform. It will also investigate the human factors related to the use of CAVs

### Mobility as a Service (MaaS)



Autonomous and Driven Platform



People Mover Capsule



Cargo Capsule

# Stream 1.3

## Green Taxiing

By combining the Electric Powertrain and Connected Autonomous Vehicle, this stream proposes Green Taxiing as a technology demonstrator for a decarbonised transport system. The environmental case for zero emissions taxi of short haul airliners has been demonstrated as feasible using on-board systems retrofitted to current aircraft's main landing gear.

Currently, the powered taxi solution is a wheel tug. There are concerns that this nose-wheel driven solution lacks traction for wet runway operations. Safran and Airbus have announced commercialisation of a main-gear-wheel driven solution. However, since it uses aircraft's auxiliary power unit, this is not the long-term zero emission solution required by future targets. TaxiBot is the most advanced and environmentally friendly electric taxiing system, and involves a semi-robotic pilot-controlled electric vehicle for dispatch towing. It has some key drawbacks such as ground operator involvement and potential long delays due to connecting and disconnecting. It also lacks agility and manoeuvrability. This stream will develop a design study of the concept of green taxiing by exploiting the team's expertise on electric drives, autonomous vehicles, airframe design and modular design & manufacture.

This stream will look at:

- A design study of the concept of an autonomous modular green taxiing system
- Formulating a simulation of the Green Taxiing within Cranfield's Digital Aviation Research Technology Centre (DARTeC)

# Work Stream 2

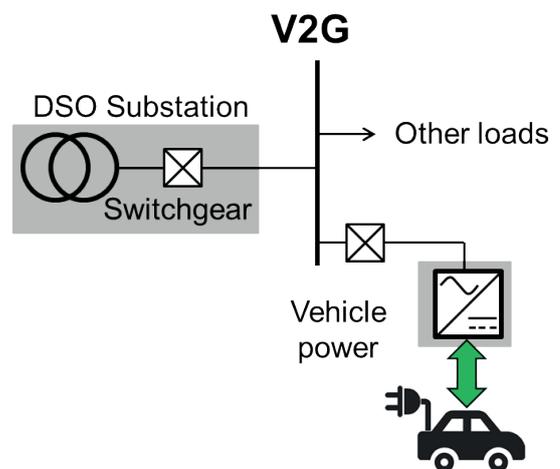
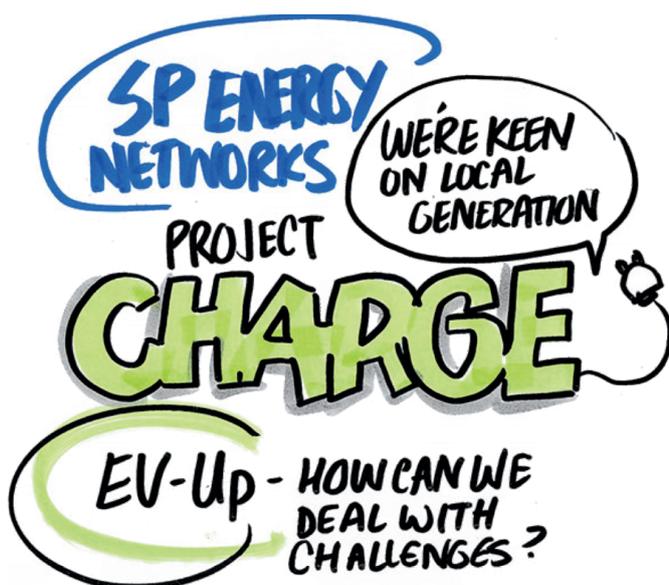
## Charging Infrastructure

Leader: Dr. Pietro Tricoli

Birmingham University

Contact: [p.tricoli@bham.ac.uk](mailto:p.tricoli@bham.ac.uk)

The decarbonisation of transport through electrification relies on the parallel development of charging and electrical infrastructure. The network will consider the current status of various technologies and physical infrastructures as well as the impact of emerging technologies e.g. wireless charging and dynamic charging. It will consider the current status of technologies and physical infrastructures as well as the impact of emerging technologies, including wireless charging. Working with the other work streams, a whole systems approach will be adopted for exploring the implications of radical transformations in energy and transport systems. Close cooperation with cities, regions, road operators, public transport operators and other relevant stakeholders will be established as many of the proposed measures do not need new legislation and can be adopted with local support. Stakeholder involvement will be critical to ensure the deployment of a flexible, open, multi-service infrastructure. Finally, the transitional role of the technologies used to achieve emission reduction goals will be assessed.



# Stream 2.1

## Extending & Building Charging Infrastructure

This stream will look at the development of charging and/or fuelling infrastructure for EVs, including the development of (smart) integration of these vehicles with grid capacity, flexible demand and energy storage. It will also look at how to enable the integration of autonomous land and air vehicles and the analysis of regional disparity for charging infrastructure (spatial urban planning versus rural, population density).

# Stream 2.2

## Dynamic Charging on the road and its applicability

This stream will look at the distribution and transmission network requirements for dynamic charging. The magnetic circuit designs for this application and their relative performances; how demand patterns for dynamic charging would manifest and any installation's impact on the grid; safety issues surrounding successful implementation of high power magnetic field systems. The stream builds on an existing collaboration with National Grid.

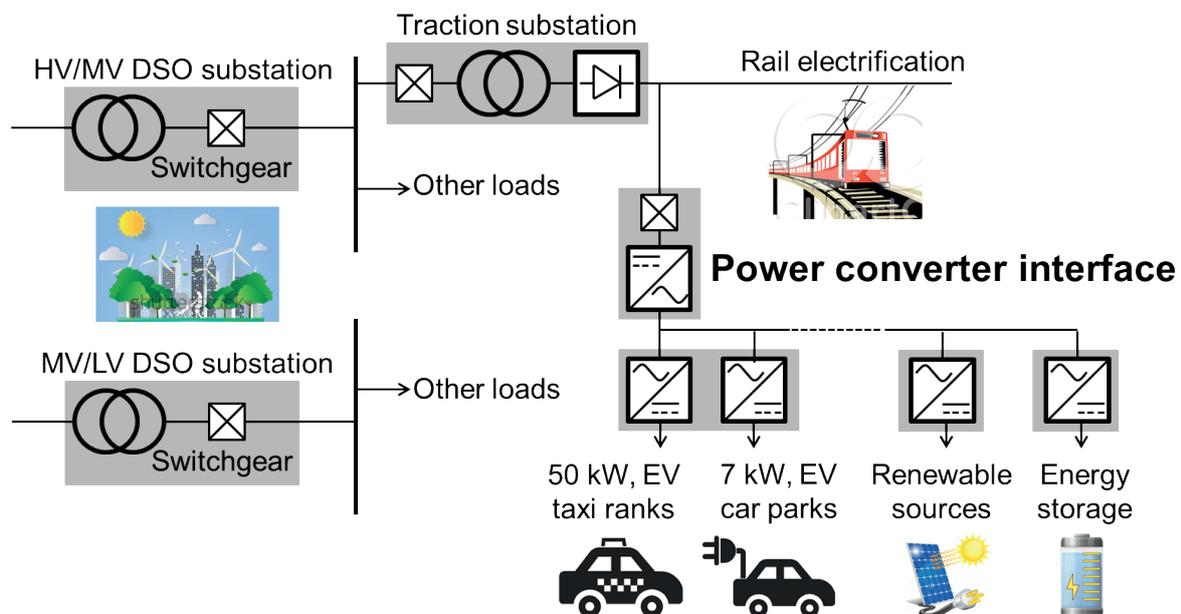
# Stream 2.3

## Railway Feeder Stations

This stream will consider the use of railway feeder stations in an integrated mobility concept (e.g. railway stations fitted with EV charging, combined tickets for rail transport and charging)

Railway feeder stations as a key component of smart grids to aid the storage and optimised use of electricity.

For this objective the Southampton National Infrastructure Systems model for transport can be used. This model can forecast the use of rail stations up to 2100, using a combination of external scenarios and internal strategies, along with energy/electricity requirements. Additional modelling could determine the use of access and egress modes and the resultant energy/electricity requirements. A rolling programme of hub development could then be determined.



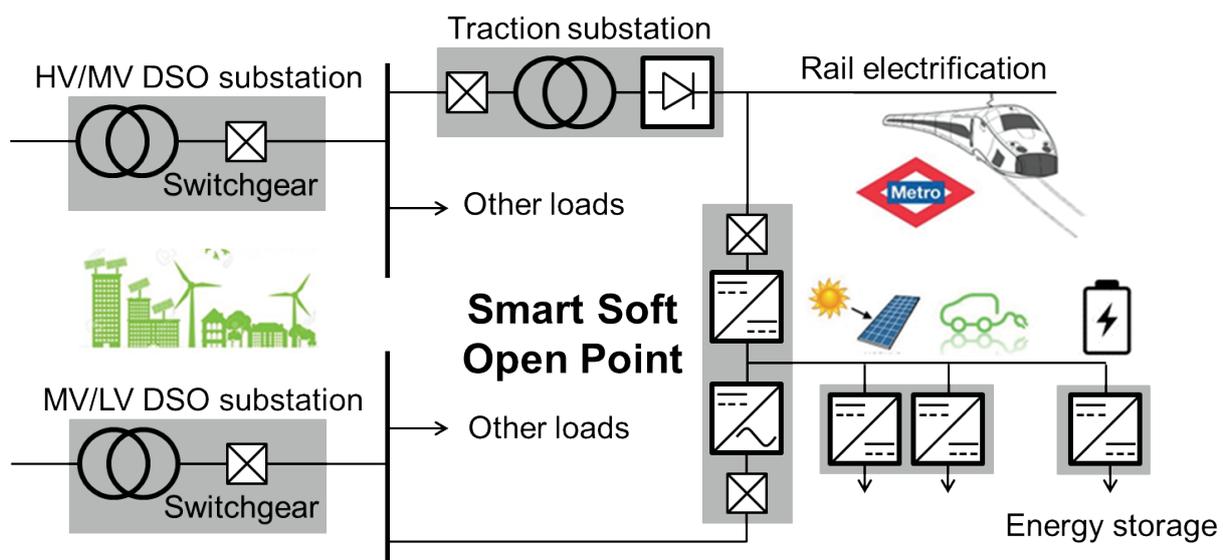
# Stream 2.4

## Low Carbon Generation on the Railway Network

Attractive opportunities are offered by the integration of low carbon generation on the railway electrification network using the smart grids concept, although this is rather challenging for the railway as off-the-shelf solutions do not currently exist.

This research stream will be focussed on:

- Technologies using Smart Soft Open Points for the reduction of power losses based on a better control of the power flow with energy storage and power distribution grids
- Medium voltage DC traction power supply systems to reduce the cost of the railway electrical infrastructure by increasing the distance between railway substations, eliminating neutral sections and negative phase sequence currents, and allowing connection to the power distribution grid rather than the sub-transmission network



# Work Stream 3

## Supply of electricity as a Transport Fuel

Leader: Professor Manu Haddad

Cardiff University

Contact: [Haddad@cardiff.ac.uk](mailto:Haddad@cardiff.ac.uk)

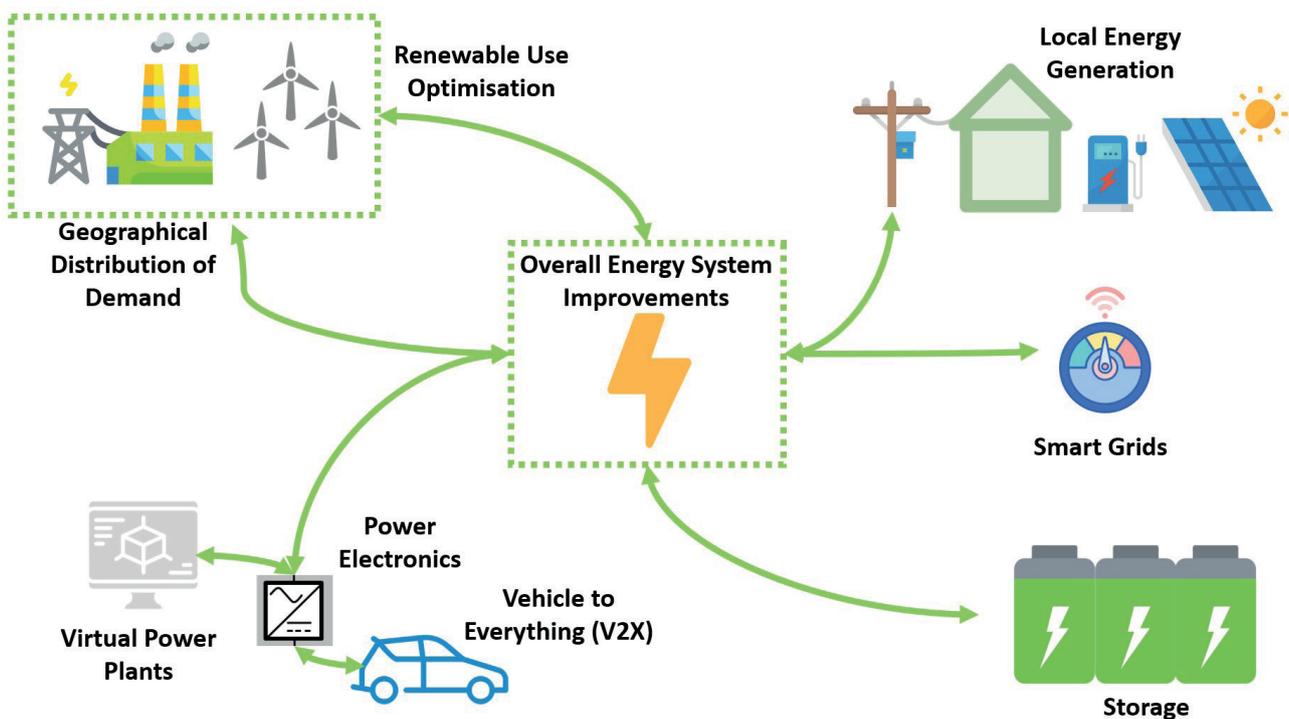
The effectiveness of decarbonising the transport sector is largely dependent on the extent to which the power sector is decarbonised. In order to fully achieve the decarbonisation of transport we need to reinforce both sectors and make these systems smarter. Electricity networks and transport are increasingly interacting in an unprecedented manner with the potential to give rise to a new merged industry.

This research stream will look at the short, medium and long-term challenges associated with electricity as an energy carrier for different low-carbon transport modes and carbon intensive services (cars, trains and electric aircraft). Mapping this with planned electricity generation mixes in the UK up to 2040 is key to future proofing supply.

This work stream will closely collaborate with WS1 and WS2 to identify the technological, infrastructural, and regulatory changes needed to deliver energy demand reduction. In addition to modelling the supply of electricity as a transport fuel, the electricity demand for transport will also be taken into account, and made dependent on different market / business scenarios, resulting from different levels of demand-side and supply-side incentives to accelerate the market take-up of low carbon transport modes. The whole-system framework across sectors will allow the cost-effectiveness of decarbonisation to be assessed more holistically.

Areas of focus for this work stream are:

- Analysis of geographical distribution of demand as a result of low-carbon transport modes
- Optimising the use of renewables
- Studying the cost of, and interaction between demand-side and supply-side measures.
- Investigating the carbon footprint reduction of low-carbon transport modes by considering synergies and interaction with renewable energy sources, local energy generation, storage and management systems
- Exploring synergies between power grids and rail electrification lines with power electronics technologies
- Analysing charging infrastructure deployment in combination with grid edge technologies (decentralized generation, microgrids, storage, and smart buildings) & integration with smart grids
- Increased reliability, resilience, efficiency, and asset utilization of the overall system using grid edge devices
- EVs as a source of flexibility, vehicle-to-everything (V2X)



# Work Stream 4

## Smart Mobility

Leader: Professor Carol Featherston

Cardiff University

Contact: [FeatherstonCA@cardiff.ac.uk](mailto:FeatherstonCA@cardiff.ac.uk)

Smart Mobility is based around delivering a system which is:

- Flexible: multiple transportation modes allow travellers to choose which works best for a given situation
- Efficient: the traveller gets to their destination with minimal disruption and in as little time as possible
- Integrated: the full route is planned door-to-door, regardless of modes of transport used.
- Clean: transportation moves away from pollution-causing vehicles to zero-emission ones.
- Safe: fatalities and injuries are drastically reduced

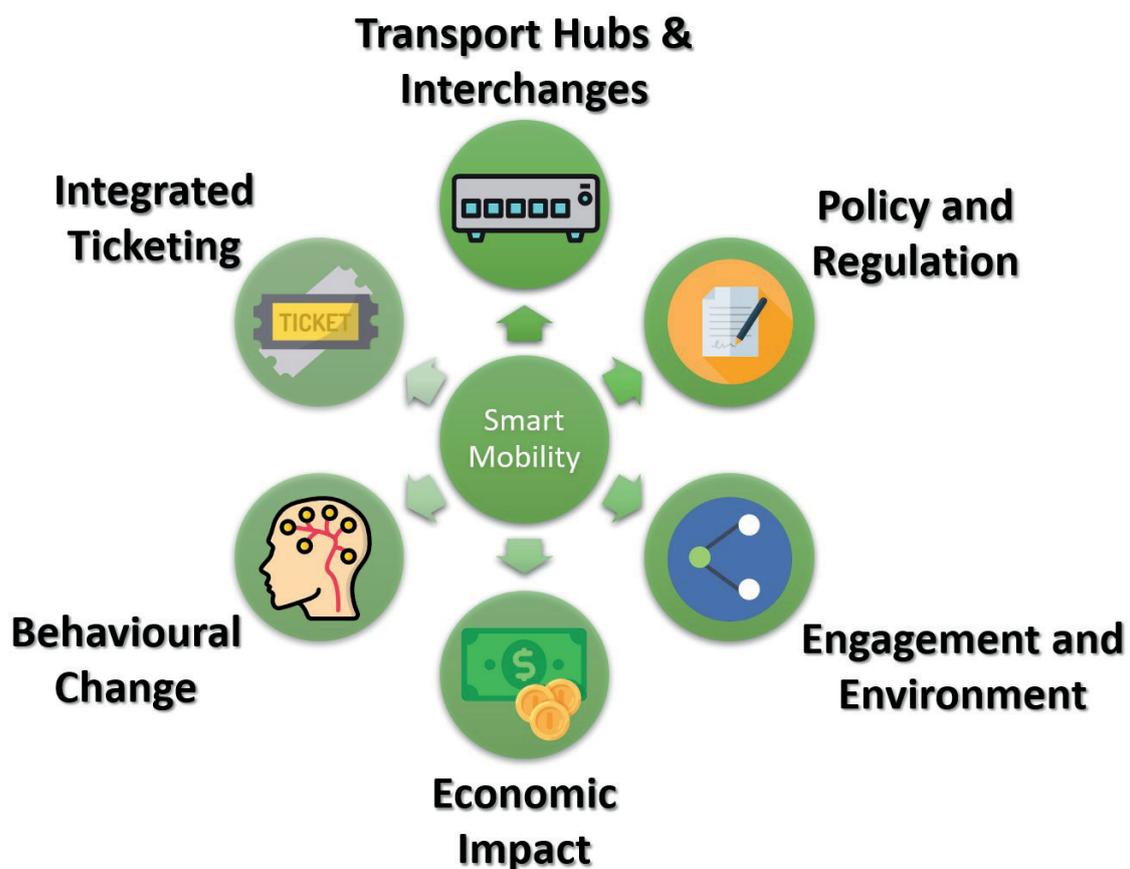
To deliver this we need to make significant changes, but this shift has already begun. New business models inspired by the sharing economy and disruptive technologies are ushering in an exciting new age in transportation: the era of smart mobility. The arrival of on-demand ride services like Uber, real-time ride-sharing services, car-sharing and bike sharing programs, and thousands of miles of urban bike lanes are all changing how people get around. Commuters no longer need to own a car to have one at their disposal. They don't have to pre-arrange carpools to share a ride with others headed in the same direction. They needn't wait for a ride home when it's pouring down rain and there's not an empty cab in sight.

Automakers increasingly see themselves as both product manufacturers and mobility services companies. In addition to developing next-generation connected and autonomous vehicles that will improve traffic flows and safety, automakers are investing in a wide swath of new mobility services—everything from car-sharing and rental services to multi-modal trip-planning applications.

There's no question that consumers have been the primary beneficiaries of new mobility services. The question facing urban planners is how today's expanded mobility ecosystem can help advance public policy goals such as encouraging higher productivity and reducing congestion, while bringing related benefits such as fewer traffic accidents, better air quality, and a smaller urban footprint for parking.

We need to look at the feasibility of using alternative transportation modes to help metropolitan areas reduce traffic congestion without spending tens of billions of pounds on new roads, tunnels, and light rail. What are the most promising strategies? Which approaches work best in which cities? How can automakers and transportation officials work together to address changing mobility needs?

In this workstream we look at how four cross cutting themes can be used to deliver this vision:



# Stream 4.1

## Human Factors

How we change our relationship with the use of vehicles?

The move to this autonomous, shared transport systems will require a transition in how we view our relationship and use of vehicles. Factors such as handover and handback of manual controls within highly automated vehicles, designing human-machine interfaces for fully autonomous vehicles and trust in automated vehicles when negotiating junctions, other traffic, pedestrians and cyclists. Issues related to shared travel, exploring the human motivations and decision-making considering physical mobility, in relation to the ability to use a mode of transport, user perceptions, expectations, knowledge and social factors, including perceptions of trust, communication and collaboration.

# Stream 4.2

## Big Data and Cyber Security

How do we foster balanced development of all transport modes?

One of the frustrations of urban transport systems is the lack of co-ordination between different transport providers. We want to know how to get from A to B as easily as possible, whether that's on foot, by bicycle, electric scooter, metro, bus, train, hire car or taxi – or a mixture. In the past we didn't have enough data to know. Now we do, and we have the connected smartphones to help us visualise it all.

# Stream 4.3

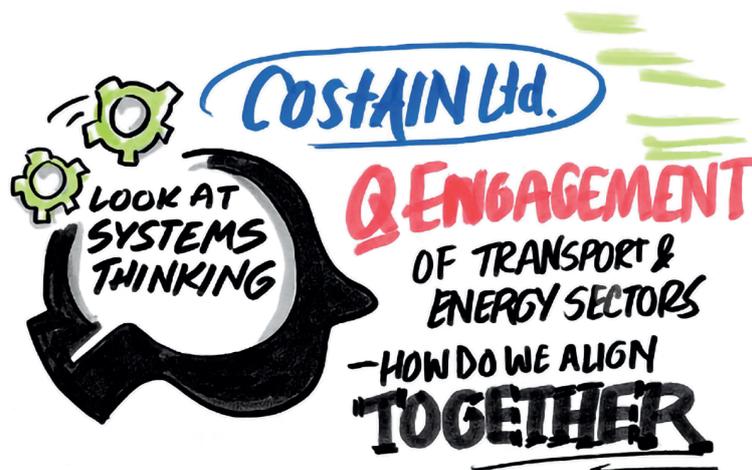
## Planning, Economics and the Environment

How do we get from A to B as easily as possible?

A Sustainable Urban Mobility Plan fosters a balanced development of all relevant transport modes, while encouraging a shift towards more sustainable modes.

Considering:

- Public transport: provide a strategy to enhance the quality, security, integration and accessibility of public transport services
- Non-motorised transport: raising the attractiveness, safety and security of walking and cycling
- Inter-modality: contributing to a better integration of the different modes
- Urban road safety: improving road safety based on an analysis of the main road safety problems and risk areas in the concerned urban area
- Road transport: optimising the use of existing road infrastructure considering reallocating road space to other modes of transport
- Urban logistics: including urban freight delivery, while reducing related externalities like emissions of GHG, pollutants and noise
- Mobility management: fostering change towards more sustainable mobility patterns

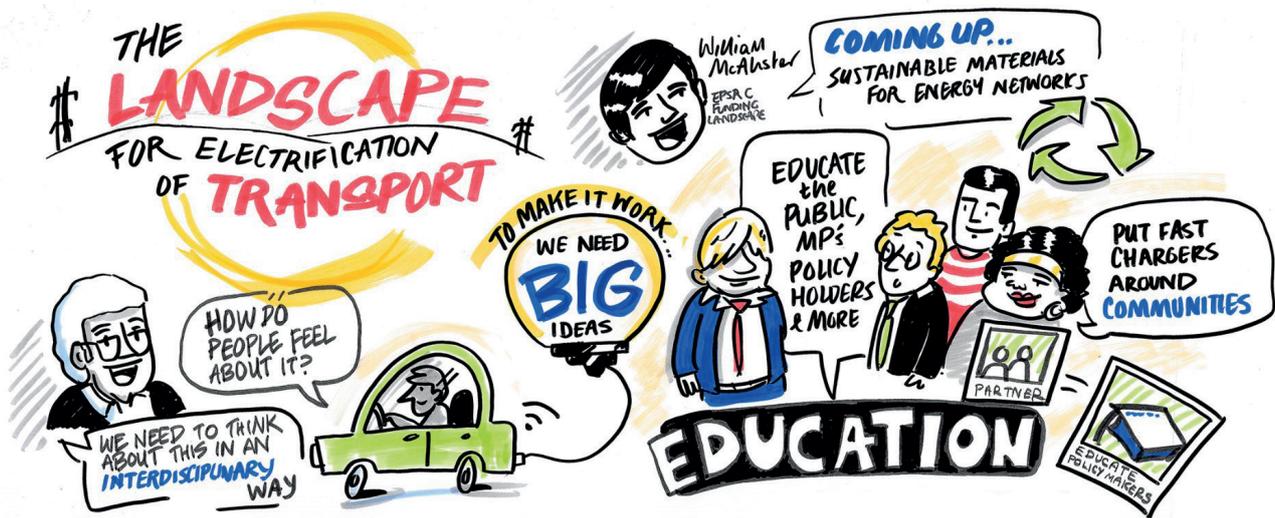


# Stream 4.4

## Policy

How do we implement sustainable governance?

This stream aims to explore fully the role of transport policy, infrastructure planning, energy infrastructure deployment and policy making at national, regional and local level on transport decarbonisation. Sustainable governance and regulatory appraisal of the interdependencies between infrastructure plans (road, rail and airborne) is essential for effective carbon reduction.



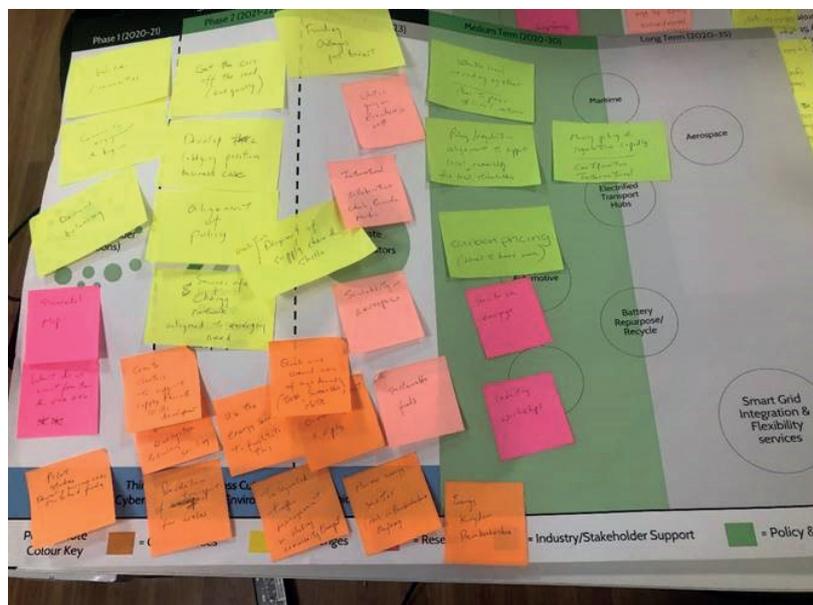
# Stakeholder Consult

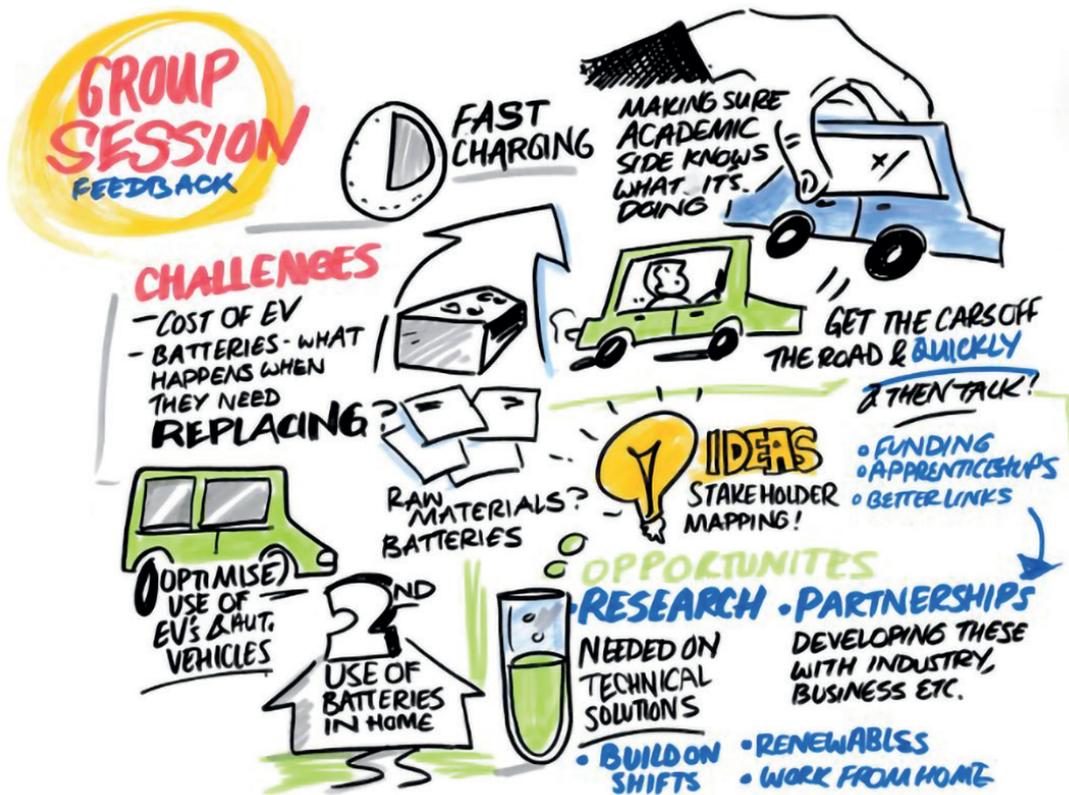
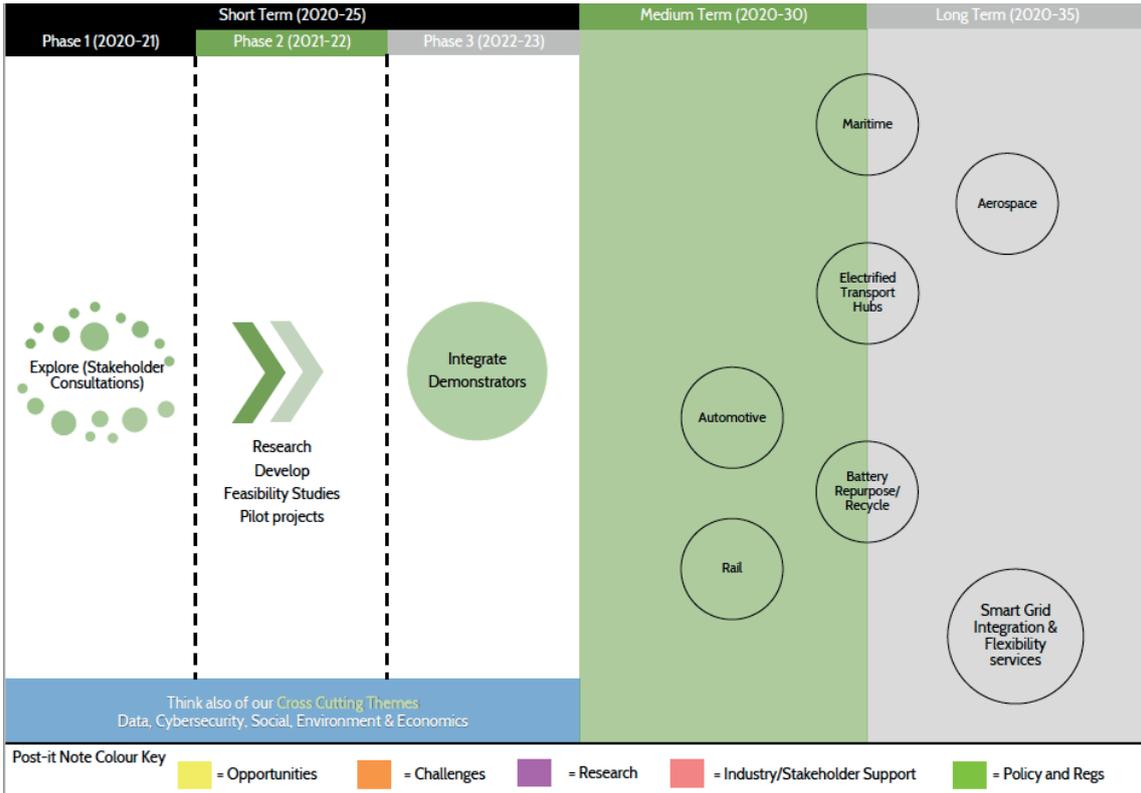
## Consultation Methodology

During the DTE Network+ launch event a consultation was conducted to identify the key challenges and priorities for this consortium's efforts as well as to identify the medium and long term challenges surrounding transport decarbonisation.

Over 200 individuals participated in the consultation activity and many unique ideas and challenges were identified. Participants represented many different industries and thus formed a very diverse group. Ideas were categorised and fitted to the appropriate work streams and key opportunities were identified. These will be considered in the feasibility and pilot projects within this network over the medium to long-term. It is our intention to organise workshops and sandpit events that will focus entirely on medium and long term goals. The questions asked in the roadmap exercise were:

- What are the challenges to be addressed by the network?
- What are the short-term, medium term and long-term priority issues?
- How the industry could engage with the researchers?
- How the DTE Network+ research could benefit your industry/sector?
- What are the other sectors / themes to be addressed to achieve the whole system approach and integration?

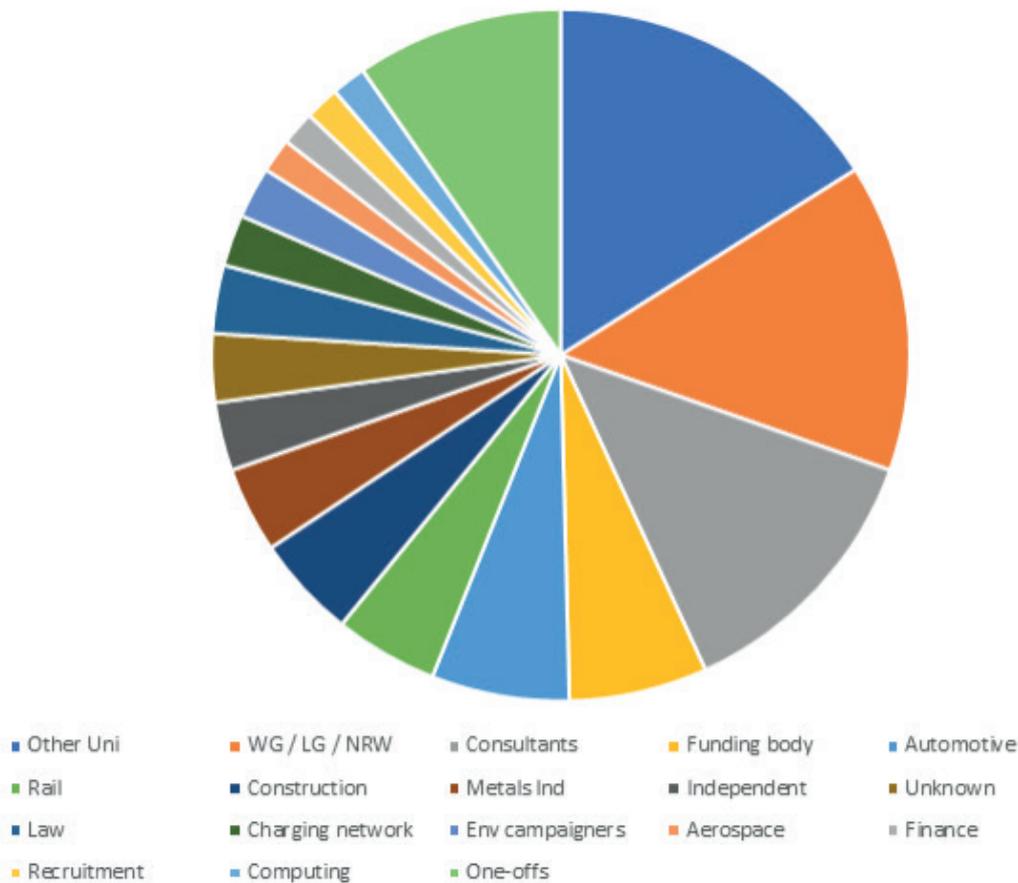




# Stakeholder Consult

## Participants

During our launch event we were delighted to see 200+ participants covering a wide range of stakeholders from various sectors.

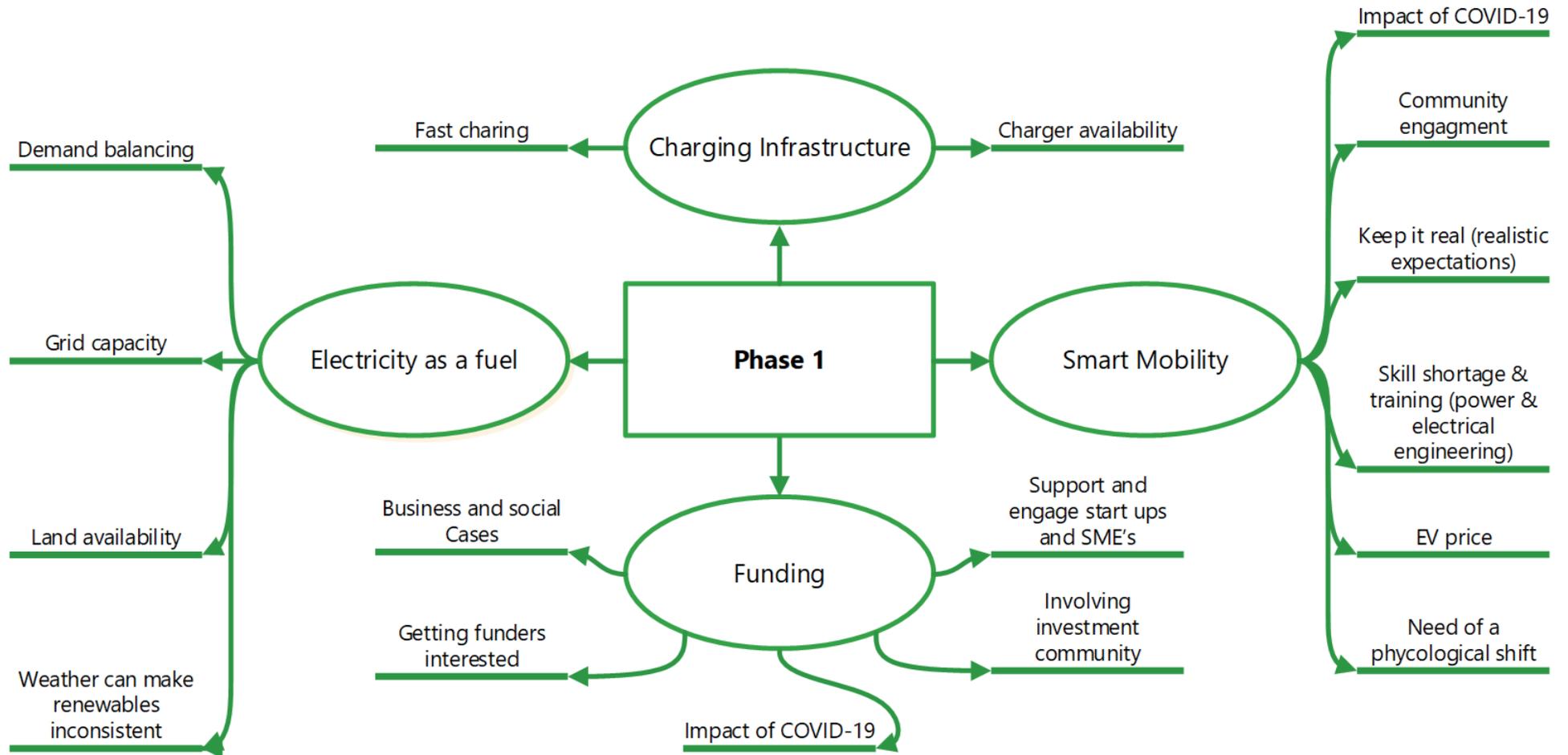


We would like to thank those listed for their contribution to the report. We welcome all feedback and encourage you to communicate any ideas you may have with us. We would like you to be part of the DTE Network+ as an enormous amount of effort is required to tackle decarbonisation of transport through electrification.

Admiral Group  
Aerospace Wales  
Amey Consulting  
Apex Transport Planning Ltd  
B J Seals Limited  
Birmingham University  
Cardiff City Council  
Carmarthenshire Energy  
Cardiff University  
Celtic Innovation Solutions Limited  
Cenin Renewables Ltd.  
Costain  
Cranfield University  
CSA Catapult  
Deregallera  
Dragon Executive Management Ltd  
Energy Service Wales  
Engenie  
EPSRC  
European Recycling Platform  
FSEW - International Freight  
Geldards LLP  
Industry Wales  
Innovate UK  
IPFT  
Maple Consulting  
Meritor  
Microchip  
Mott McDonald  
National Grid  
Natural Resources Wales  
Neath Port Talbot Council  
NPL  
Quercus Investment Partners  
Renewable UK  
Ricardo  
River Simple  
Riding Sunbeams  
Safran  
Set Squared  
SP Energy Networks  
Spectrum Technologies Brigend  
Swansea University  
TATA  
Transport for Wales  
Turbo Power Systems  
UDL Intellectual Property  
United Plastics Group  
University of Derby  
University of Exeter  
University of South Wales  
Vibe Recruit  
Welsh Government

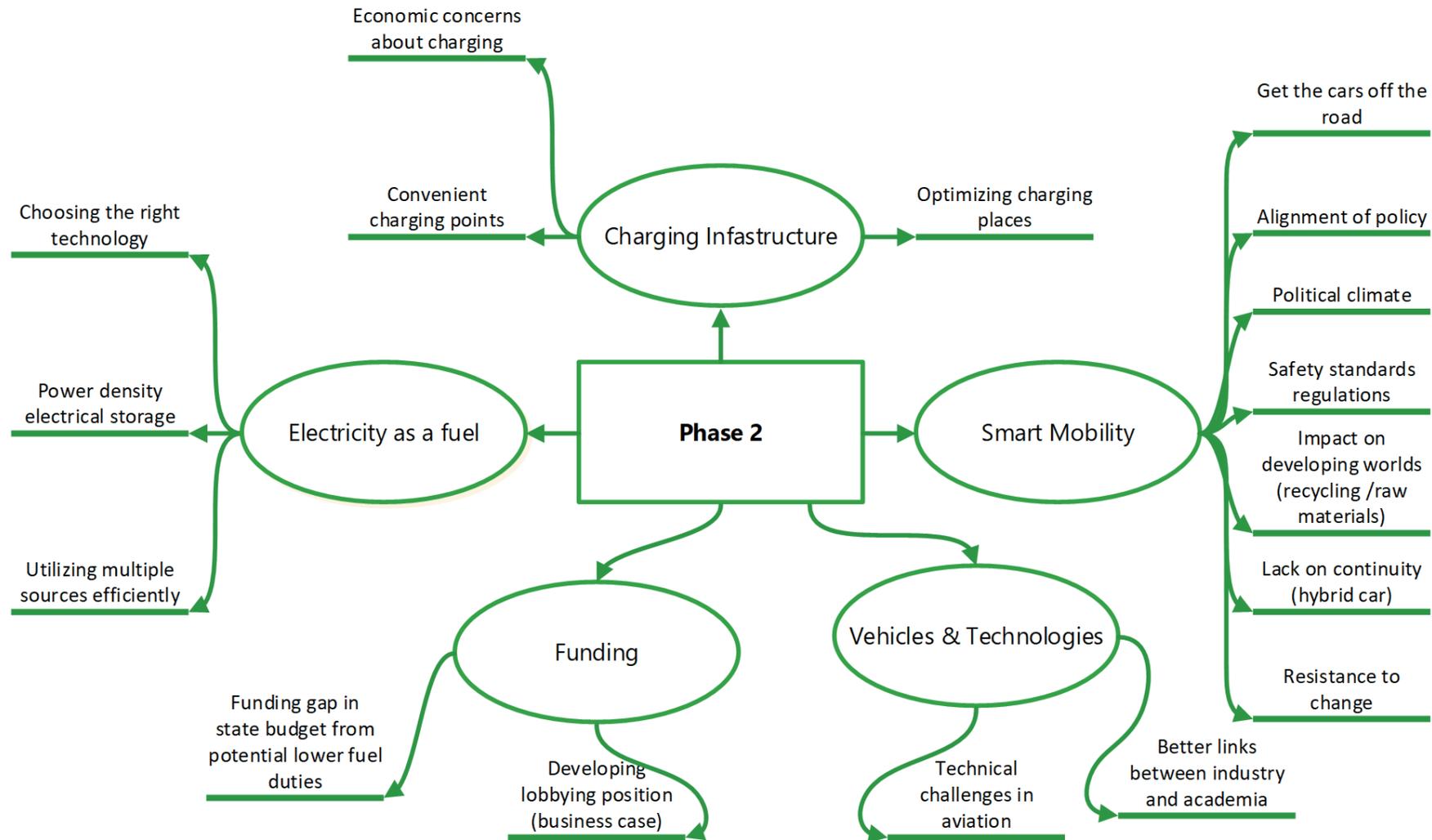
# Frameworks

## DTE Network+ Phase 1 (2020-2021)



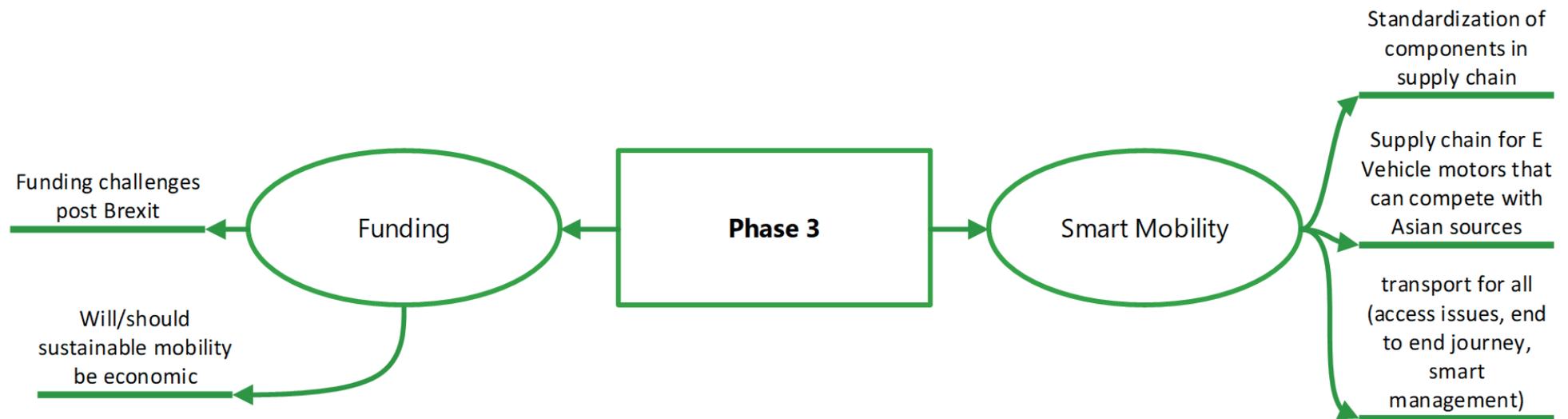
# Frameworks

## DTE Network+ Phase 2 (2021-2022)



# Frameworks

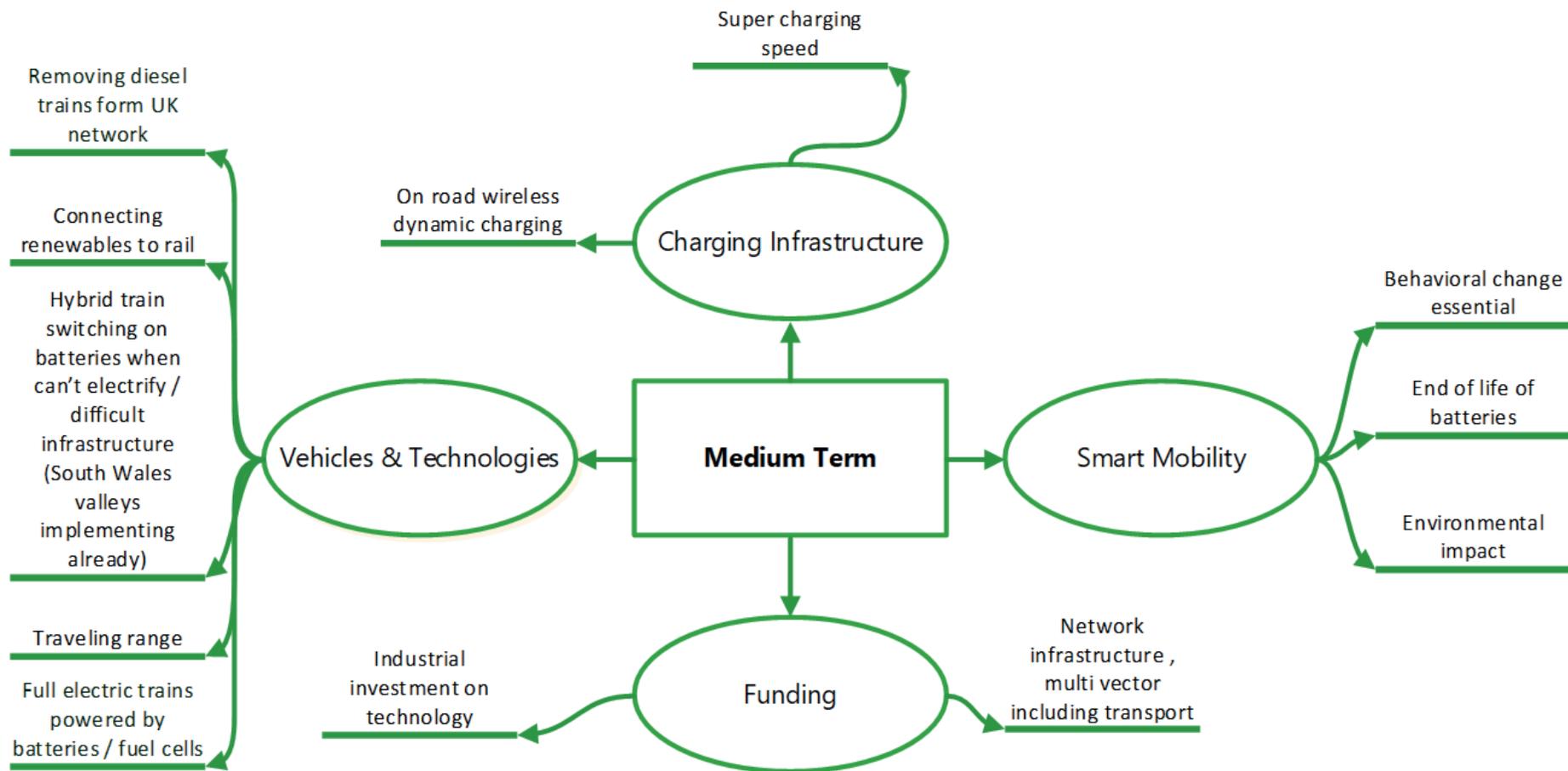
DTE Network+ Phase 3 (2022-2023)



# Frameworks

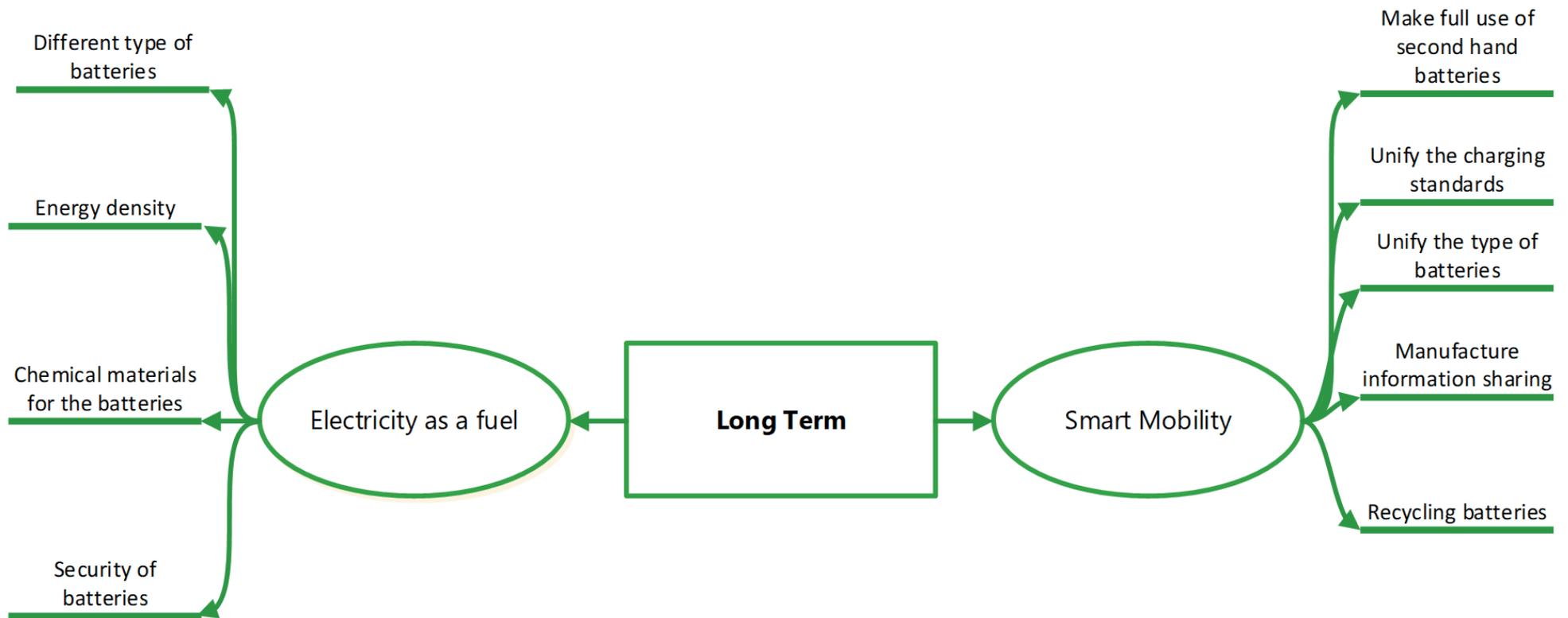
## DTE Network+ Medium Term (2020-2030)

Medium and long term challenges can be harder to identify but there were several interesting ideas received. It is important to note that there will be further development of the medium and long term challenges as the DTE Network+ project progresses.



# Frameworks

DTE Network+ Long Term (2030-2040)



# Contact Information

Register to be a member of the network using the contact form on our website at [dte.network](http://dte.network)

Please send all enquiries to [transport@dte.network](mailto:transport@dte.network)

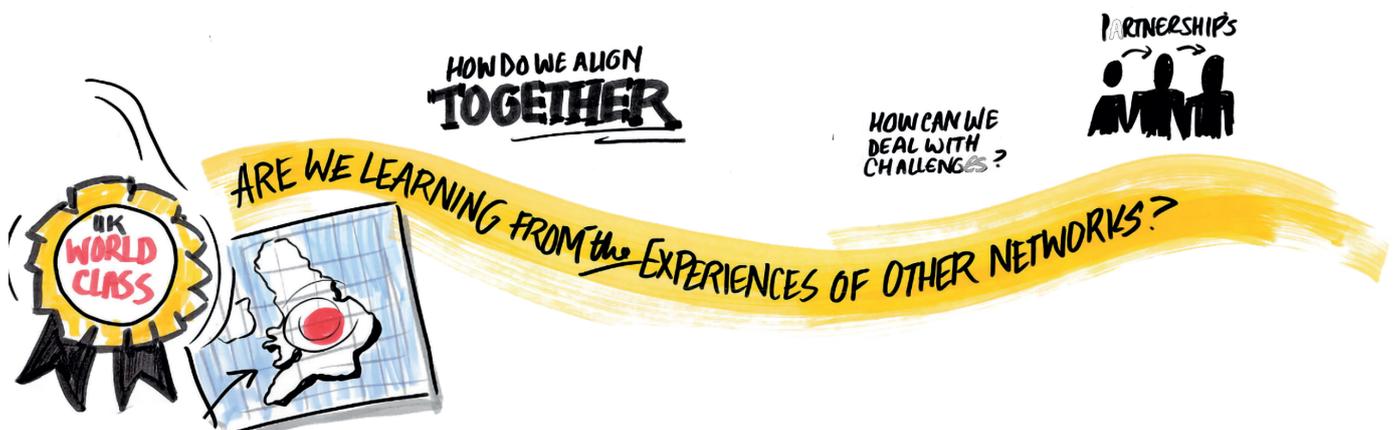
Network Principal Investigator:

**Professor Liana Cipcigan**

School of Engineering  
Cardiff University  
Queens Buildings  
The Parade  
Cardiff  
CF24 3AA

+44 (0) 2920 870 665

[cipciganlm@cardiff.ac.uk](mailto:cipciganlm@cardiff.ac.uk)



Engineering and  
Physical Sciences  
Research Council



UNIVERSITY OF  
Southampton

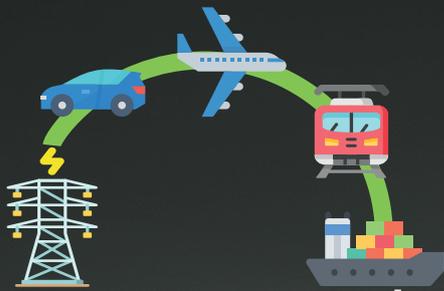


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# DTE Network

Decarbonising Transport Through Electrification



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