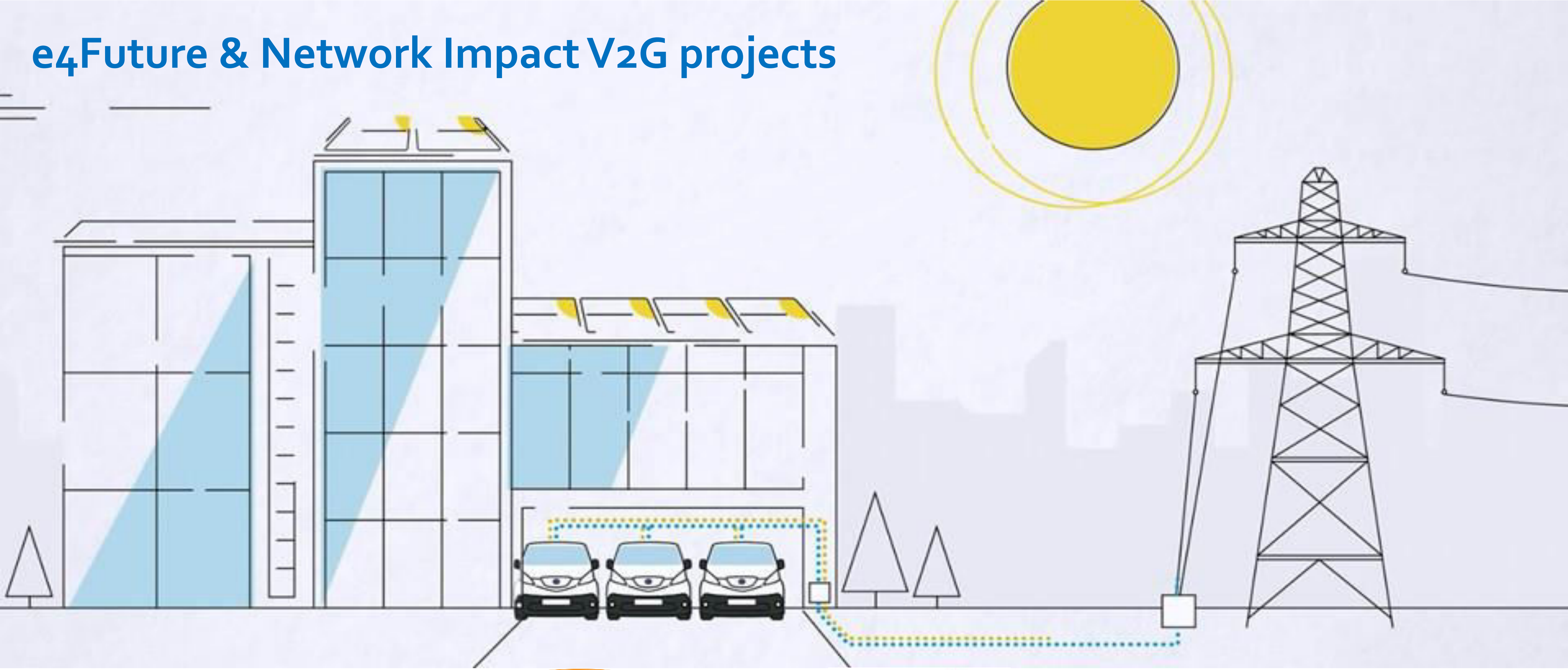
e4Future & Network Impact V2G projects

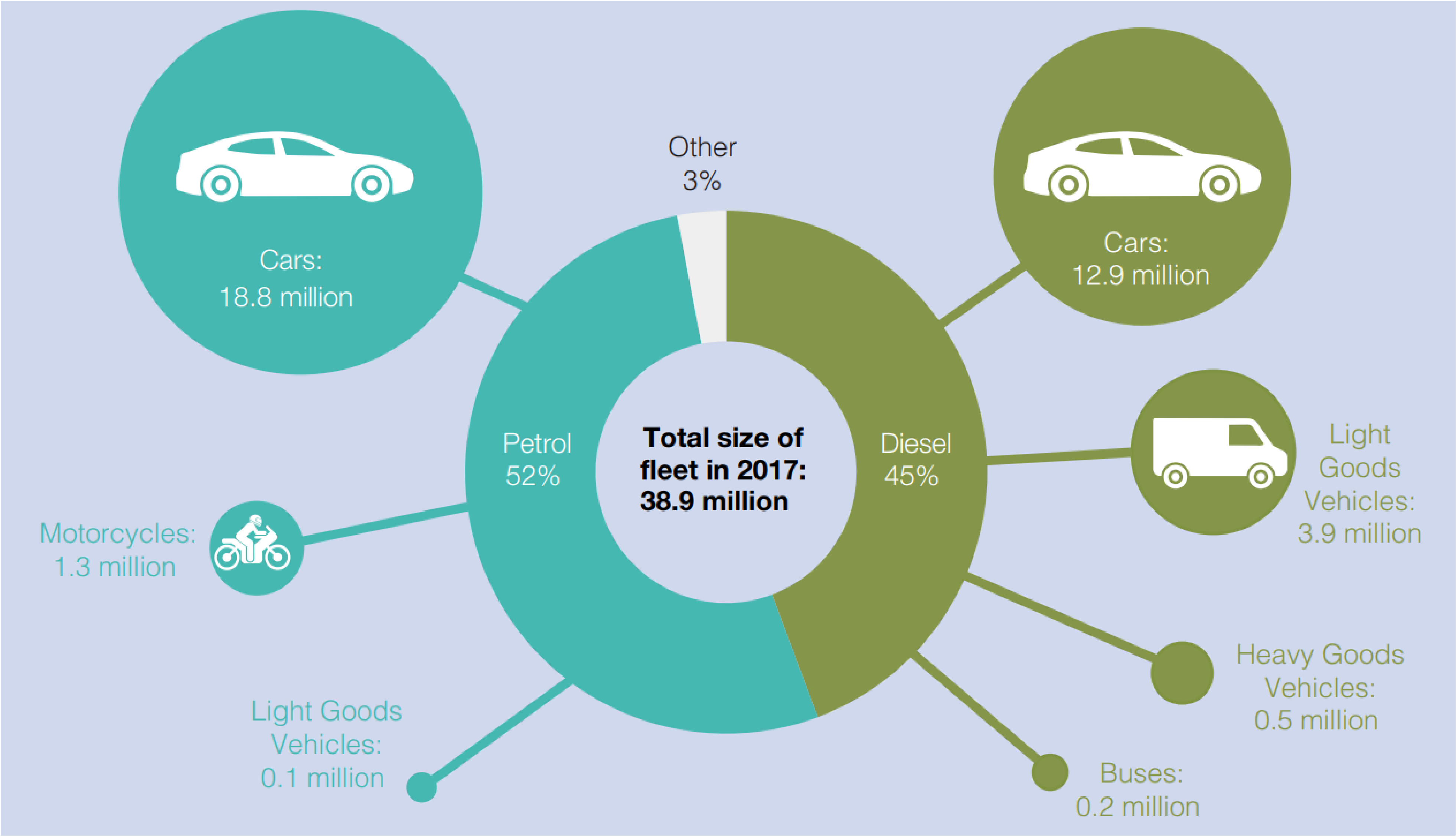


NISSAN | Newcastle University UK | Malaysia | Singapore | Imperial College London | UK Power Networks | Northern Powergrid | e.on UK | nationalgrid

Myriam Neaimeh
PhD, Senior Research Associate
Newcastle University

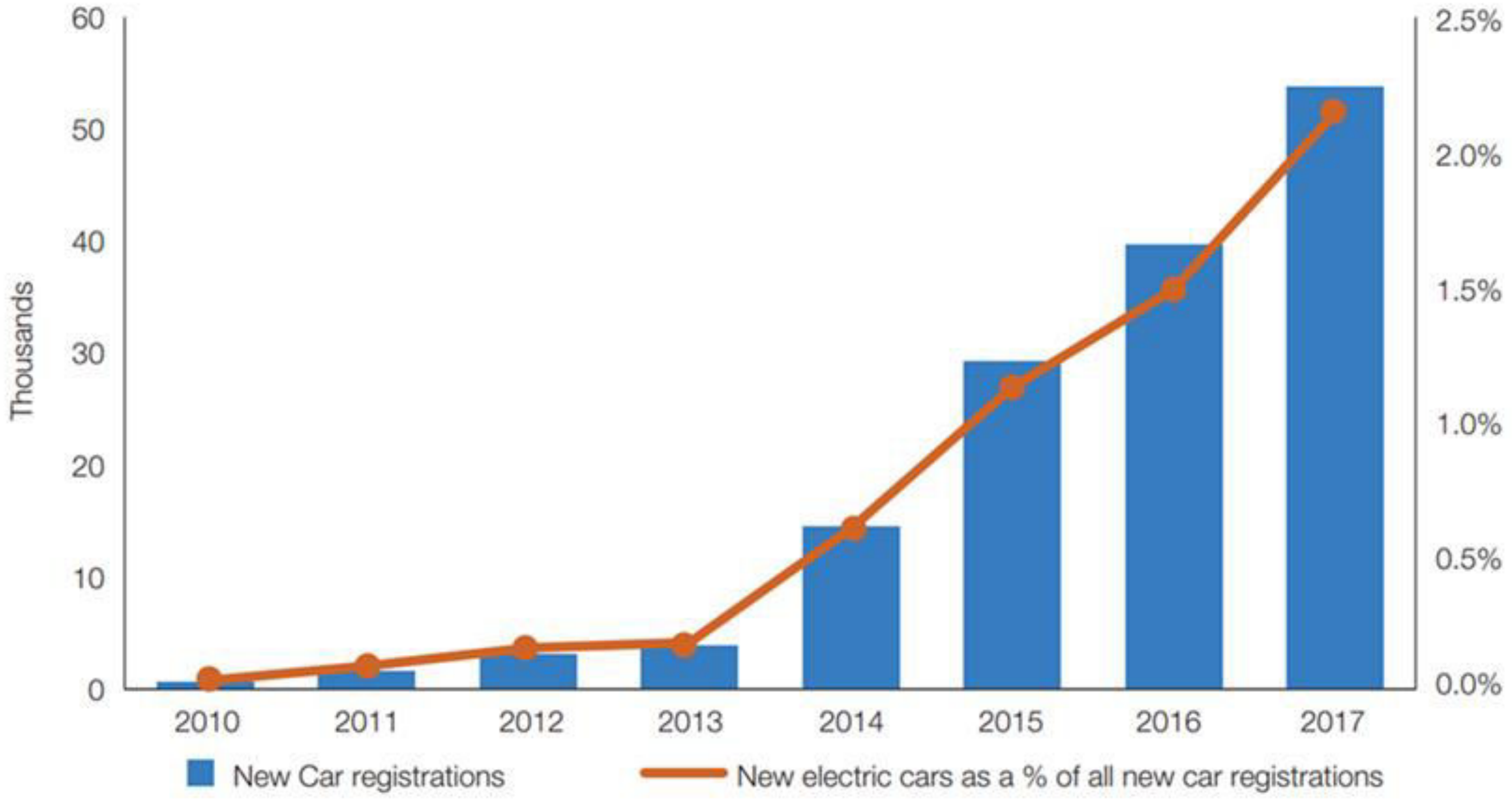
UK Research and Innovation | Department for Business, Energy & Industrial Strategy | Office for Low Emission Vehicles

Existing cars and vans (36 million)



Source: DfT, Road to Zero Strategy

New electric car registration in GB



*Includes plug-in hybrids, 100% electric, range extended electric and fuel cell electric cars

Source: DfT, Vehicle Licensing Statistics, 2018 - table VEH0253.

Source : Road to Zero Strategy

All **new** cars and vans to be effectively zero emission by 2040

2018: 170,000 EVs

22 years to go from just over **2% to 100%** market share.

Can we do it without a ZEV mandate to require automakers to manufacture and sell a lot of EVs?

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Policy Support

Policy paper

The Grand Challenges

Updated 21 May 2018

Contents

The Industrial Strategy sets out Grand Challenges to put the UK at the forefront of the industries of the future, ensuring that the UK takes advantage of major global changes, improving people's lives and the country's productivity.

Put the UK at the forefront of the design and manufacturing of zero emission vehicles and for all new cars and vans to be effectively zero emission by 2040.

HM Government

INDUSTRIAL STRATEGY

The Road to Zero

Next steps towards cleaner road transport and delivering our Industrial Strategy

Setting out government support

Policy paper

Charging Infrastructure Investment Fund

A request for proposals to raise and manage the government's Charging Infrastructure Investment Fund.

Published 23 July 2018
Last updated 14 September 2018 — see all updates
From: HM Treasury and Infrastructure and Projects Authority

Documents

Charging Infrastructure Investment Fund Request for Proposals

PDF, 148KB, 13 pages

This file may not be suitable for users of assistive technology. Request an accessible format.

News story

£30 million investment in revolutionary V2G technologies

Electric vehicles to help power people's homes helped by almost £30 million funding.

Published 12 February 2018
From: Department for Transport, Office for Low Emission Vehicles, Innovate UK, Department for Business, Energy & Industrial Strategy, and Jesse Norman MP

Government support- The Faraday Challenge

FARADAY BATTERY CHALLENGE

The Faraday Institution is the research vehicle for the ISCF Faraday Battery Challenge, which comprises a £246m commitment over the next 4 years to develop, design and manufacture world-leading batteries in the UK. The programme is split into three separate elements, delivered in parallel, to provide connectivity across research and innovation strands.

RESEARCH + INNOVATION + SCALE UP

The Faraday Institution

A new, virtual research institute comprising a headquarters at the Harwell Science and Innovation Campus and a series of research projects carried out in UK universities to accelerate fundamental science and its translation directly related to batteries.

Research and Innovation Projects

An innovation programme to support collaborative research and development with co-investment from industry (led by Innovate UK).

UK Battery Industrialisation Centre

An open access facility with technology scale-up capabilities to ensure solutions are ready for manufacturing technologies at high volume (led by APC).

Extending Battery Life

Led by the University of Cambridge, this project will examine how environmental and internal battery stresses (such as high temperatures, charging and discharging rates) damage electric vehicle (EV) batteries over time.

Battery System Modelling

Imperial College London (ICL) will lead a consortium to equip industry and academia with new software tools to understand and predict battery performance, by connecting understanding of battery materials at the atomic level all the way up to an assembled battery pack.

Recycling and Reuse

A project led by the University of Birmingham will determine the ways in which spent lithium batteries can be recycled. With the aim to recycle 100% of the battery, the project will look how to reuse the batteries and their materials, to make better use of global resources.

Next Generation Solid State Batteries

The University of Oxford will lead an effort to break down the barriers that are preventing the progression to market of solid-state batteries, that should be lighter and safer, meaning cost savings and less reliance on cooling systems.

FOUNDING UNIVERSITIES

The Faraday Institution unites the expertise and insight from its 7 founding partner universities, along with industry partners and other academic institutions, to accelerate fundamental research to develop battery technologies.

University of Oxford · UCL · Warwick · University of Cambridge · Imperial College London · Newcastle University · University of Southampton

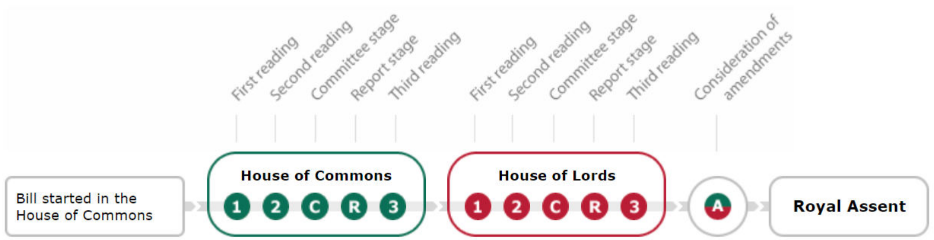
Policy Support- The Automated and EV Act 2018

Automated and Electric Vehicles Act 2018

Type of Bill: Government Bill

Sponsors: Chris Grayling, Transport; Baroness Sugg, Transport

Progress of the Bill



Last events

- RA Royal Assent (Hansard) 19 July, 2018 | 19.07.2018
- RA Royal Assent (Minutes of Proceedings) 19 July, 2018 | 19.07.2018

Read debates on all stages of the Automated and Electric Vehicles Act 2018

Act of Parliament

House	Act	Date
O	Automated and Electric Vehicles Act 2018 (c. 18)	19.07.2018

Stay up to date

Keep up to date with the progress of Bills going through Parliament. Sign up for email alerts or use our RSS feeds.

RSS feed for this Bill

PART 2 Electric vehicles: charging

Introductory

9. Definitions

Requirements and prohibitions

10. Public charging or refuelling points: access, standards and connection
11. Large fuel retailers etc: provision of public charging or refuelling points
12. Duty to consider making regulations under section 11(1)(a) on request by elected mayor
13. Information for users of public charging or refuelling points
14. Transmission of data relating to charge points
15. Smart charge points

15 Smart charge points

(1) Regulations may provide that a person must not sell or install a charge point unless it complies with prescribed requirements.

(2) The requirements that may be imposed under subsection (1) include requirements relating to the technical specifications for a charge point, including for example the ability of a charge point—

(a) to receive and process information provided by a prescribed person,

(b) to react to information of a kind mentioned in paragraph (a) (for example, by adjusting the rate of charging or discharging),

(c) to transmit information (including geographical information) to a prescribed person,

(d) to monitor and record energy consumption,

(e) to comply with requirements relating to security,

(f) to achieve energy efficiency, and

(g) to be accessed remotely.

(3) Regulations under subsection (1) may also prescribe requirements to be met in relation to the sale or installation of a charge point.

(4) In this section—

(a) "sell" includes let on hire, lend or give;

(b) references to a prescribed person include references to—

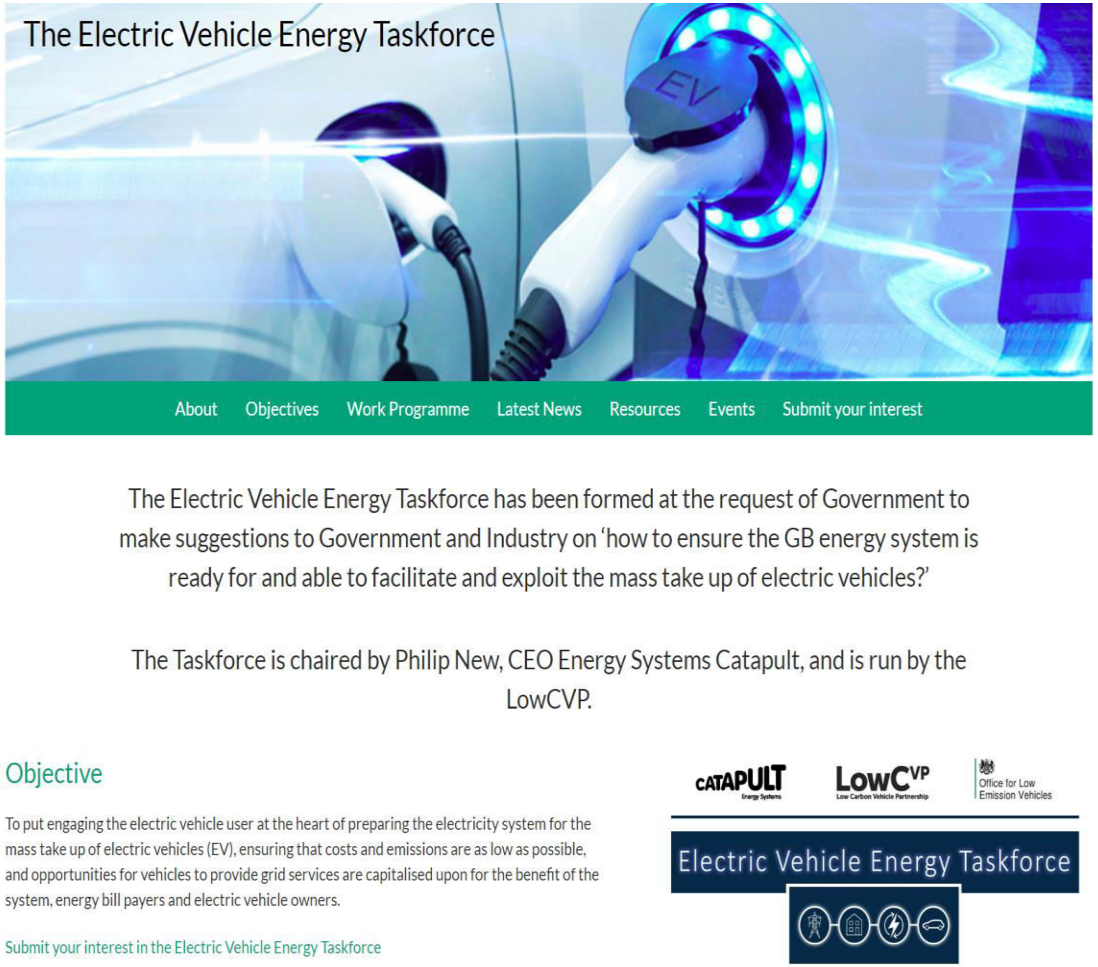
(i) a person of a prescribed description, and

(ii) a device operated by one or more prescribed persons.

Empower the government to set standards and to regulate some aspects of the EV industry if necessary in future year- Smart Charging

The EV Energy Taskforce

- Formed at the request of Government to make suggestions to Government and Industry on ‘how to ensure the GB energy system is ready for and able to facilitate and exploit the mass take up of electric vehicles?’
- The EV Energy Taskforce is due to report in 2019.
- Government and Ofgem will continue to work with the taskforce and will consider its recommendations.
- 4 WPs:
    - Strategic understanding of the requirements of the energy system to support mass uptake of EVs.
    - Engaging EV users in smart charging and energy services
    - Smart charging technical requirements
    - Accessible data for decision making



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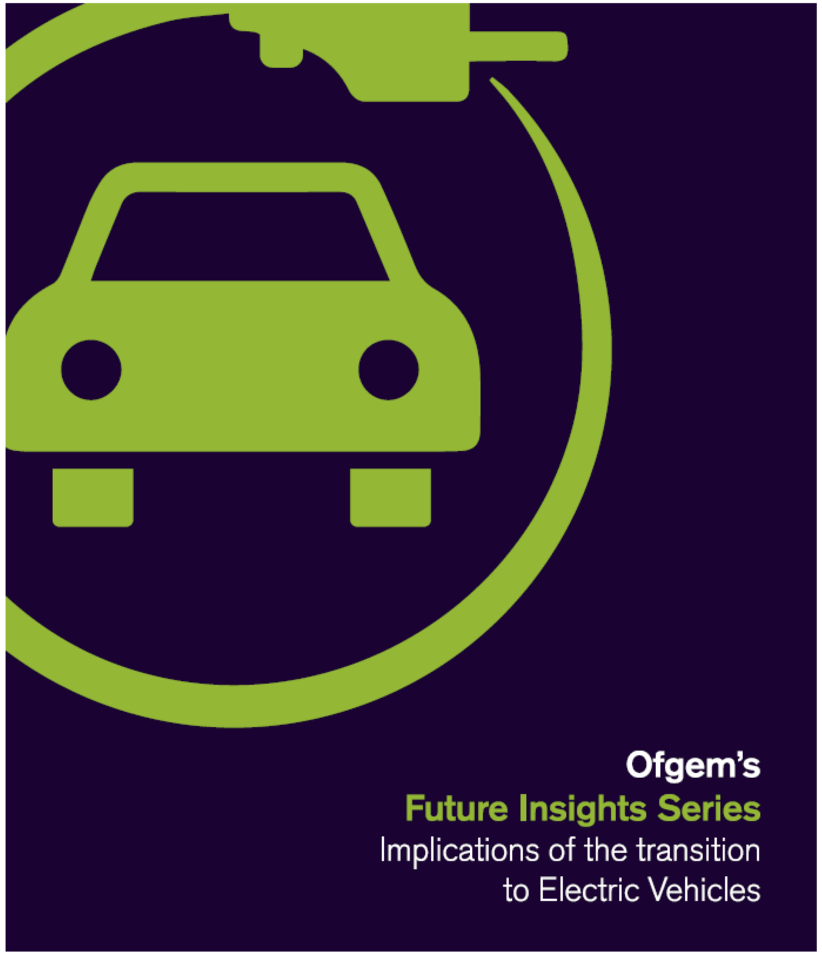
Government Regulator- Office of Gas and Electricity Markets (OFGEM)

ofgem | future insights



"Regulation will need to adapt to provide predictability to the EV market and protection to EV users."

"Industry should focus on minimising overall system costs for all consumers (including non- EV users), by seeking to make more efficient use of our existing assets, before considering reinforcement. The development of new markets that provide flexibility will play a key role here, by incentivising or automating the shifting of load away from peak demand, even if total demand increases.

<u>This means that network companies should not expect to be remunerated for reinforcement alone when more cost-effective solutions exist.</u>"

EV Innovation Research at Newcastle University

EV Innovation Research at Newcastle University

Vehicle

Charging Infrastructure

Power System

Electric Vehicles Usage Patterns

EV Network Impact Assessment

Fast Charge

Wireless Charge

Bi-directional Charge (V2G)

Energy Storage for EVs

Second Life EV Batteries

Motor and Drive Design

Power Electronics

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Real world demonstrators of EVs and charging infrastructure

Electric Vehicles Usage Patterns

Fast Charge

EV Network Impact Assessment

- SwitchEV- TSB' ULCVDP. Early EV demonstrtor
- RCN- Fast chargers
- CLNR- Access to data from 9,000 smart meters+ validated network models.

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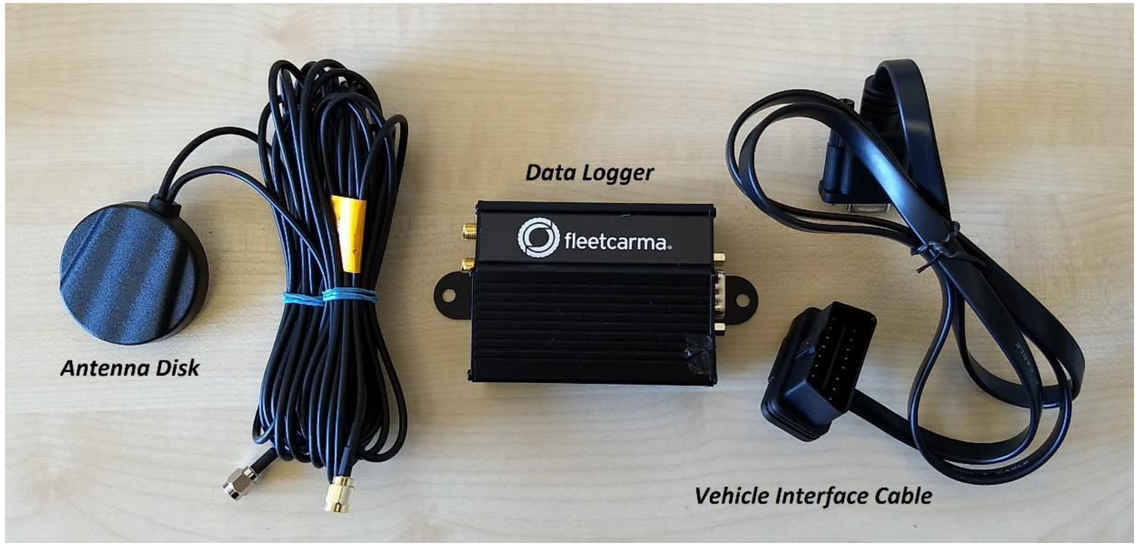
BEV Data Collection



Renault ZOE installation

Nissan e-NV 200 installation

Nissan LEAF installations

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BEV data collection

Data logger provider server → FTP → University server → Data Processing → Data Analysis

- Over 140,000 trips and 40,000 charging events.
  - ✓ With 1.1 million kilometres driven in over 121,000 trips and 25,000 associated charging events from 84 private passenger BEVs participating
- Mix of private and fleet drivers. Up to 18 month data collection per BEV user.
- Some drivers residing in rural areas
- Home, work, public including fast chargers
- High resolution data-Time, GPS, SoC, Temperature, etc…

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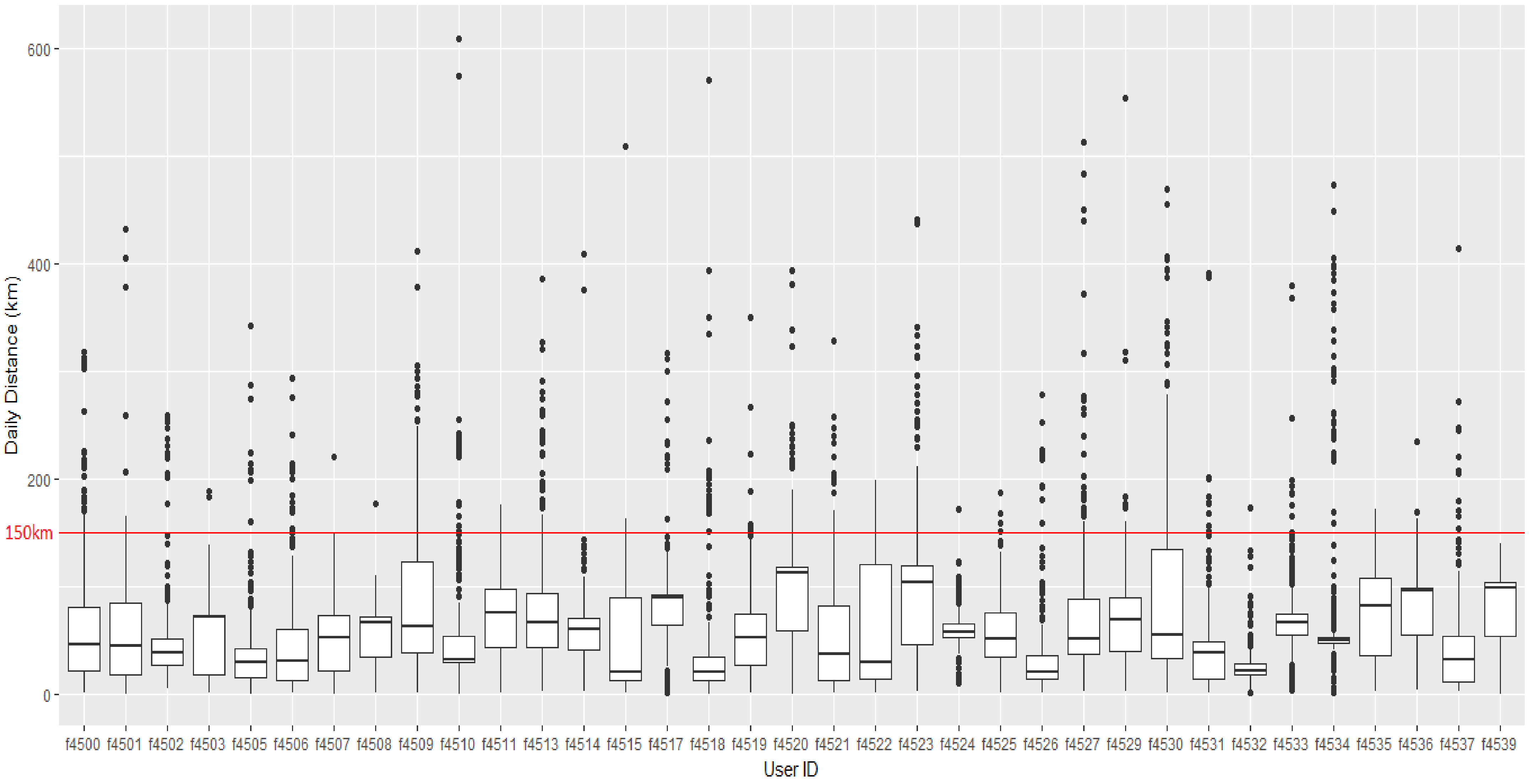
Driving Behaviour



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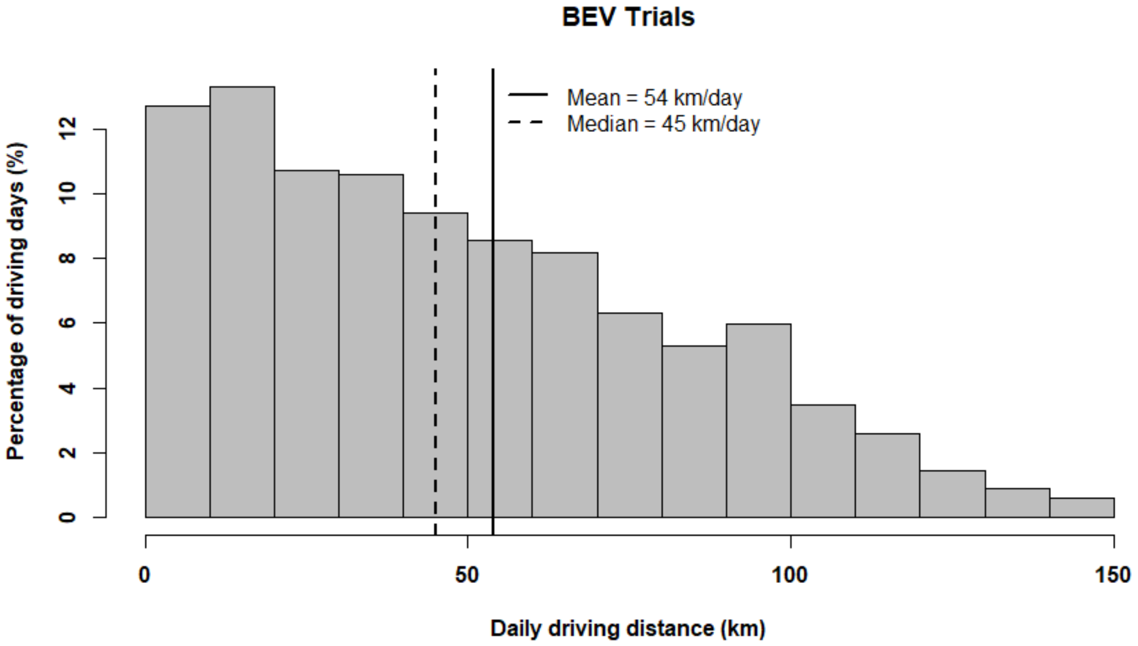
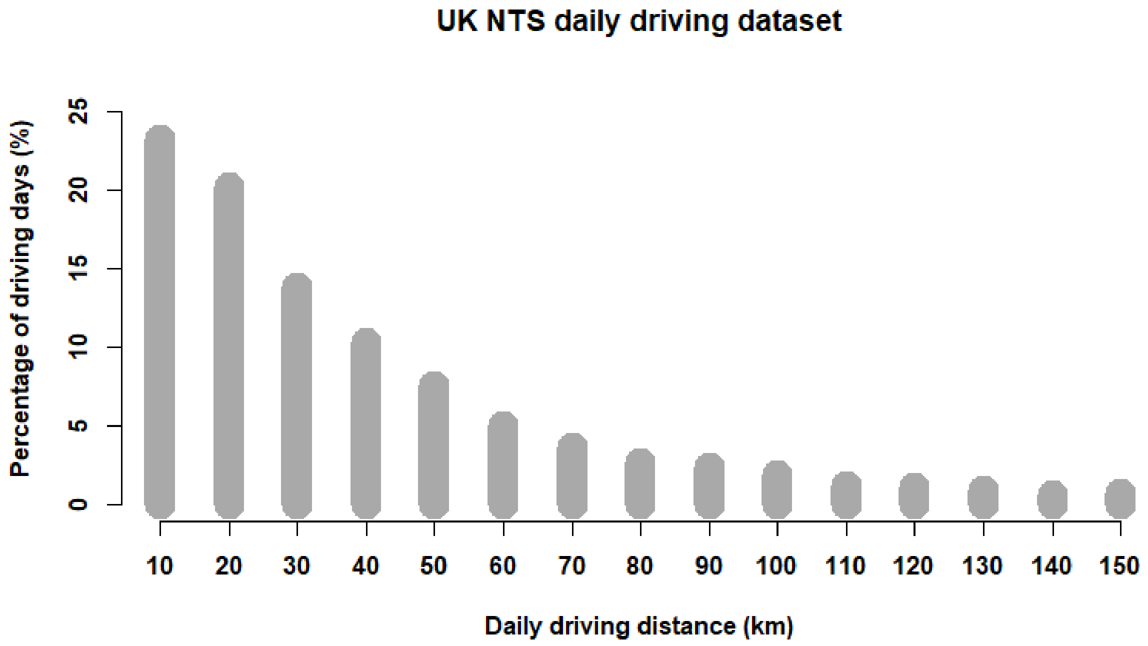
Driving Behaviour



19,518 driving days



570,000 driving days

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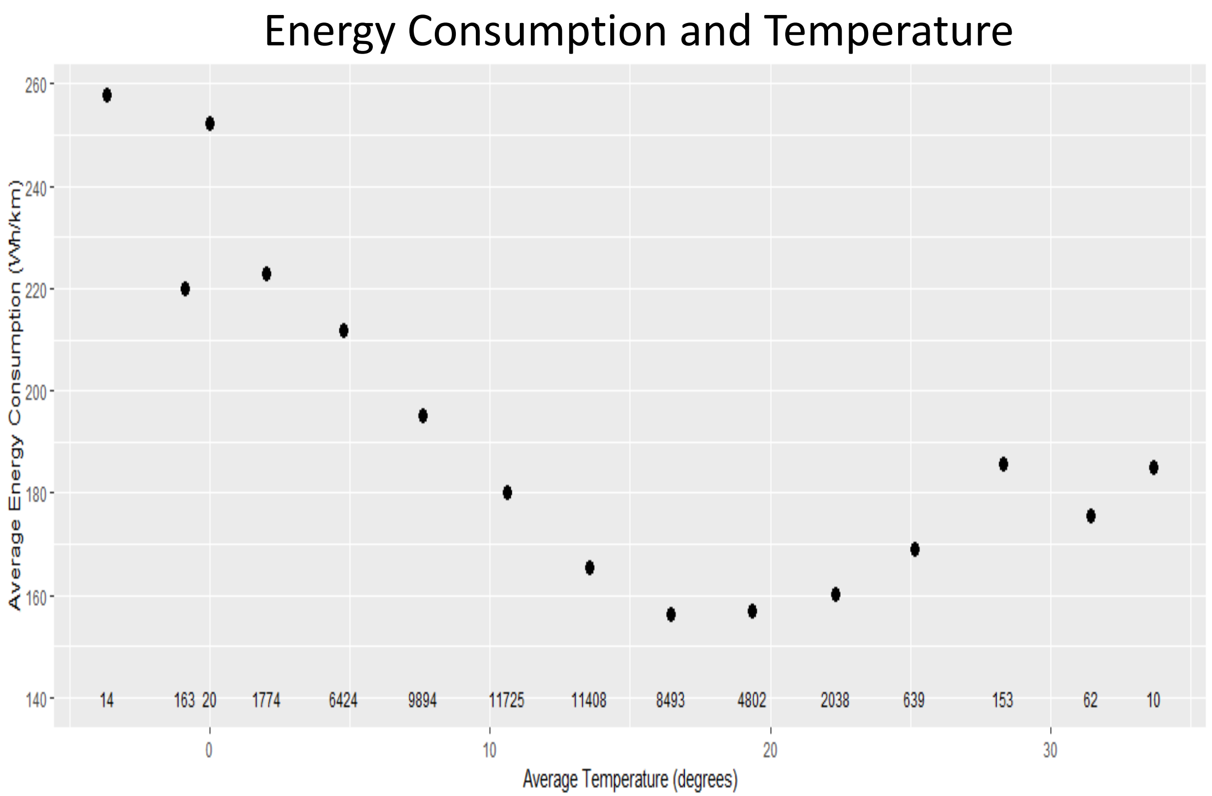
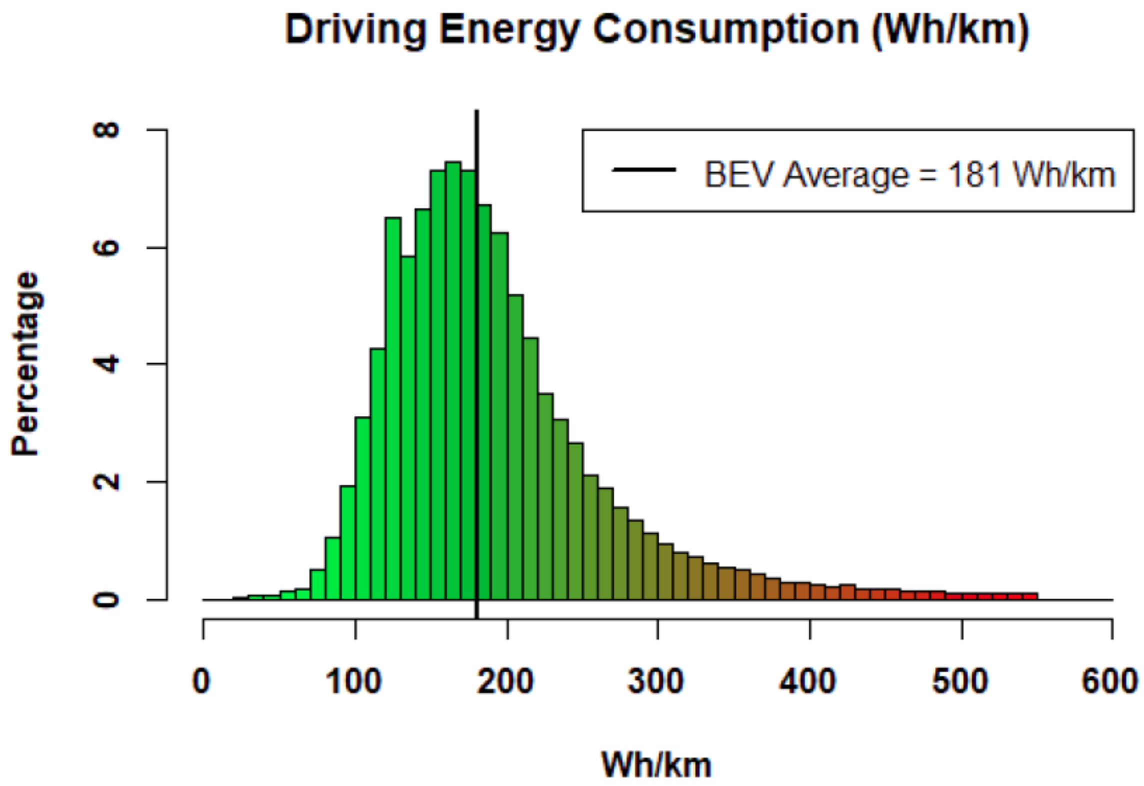
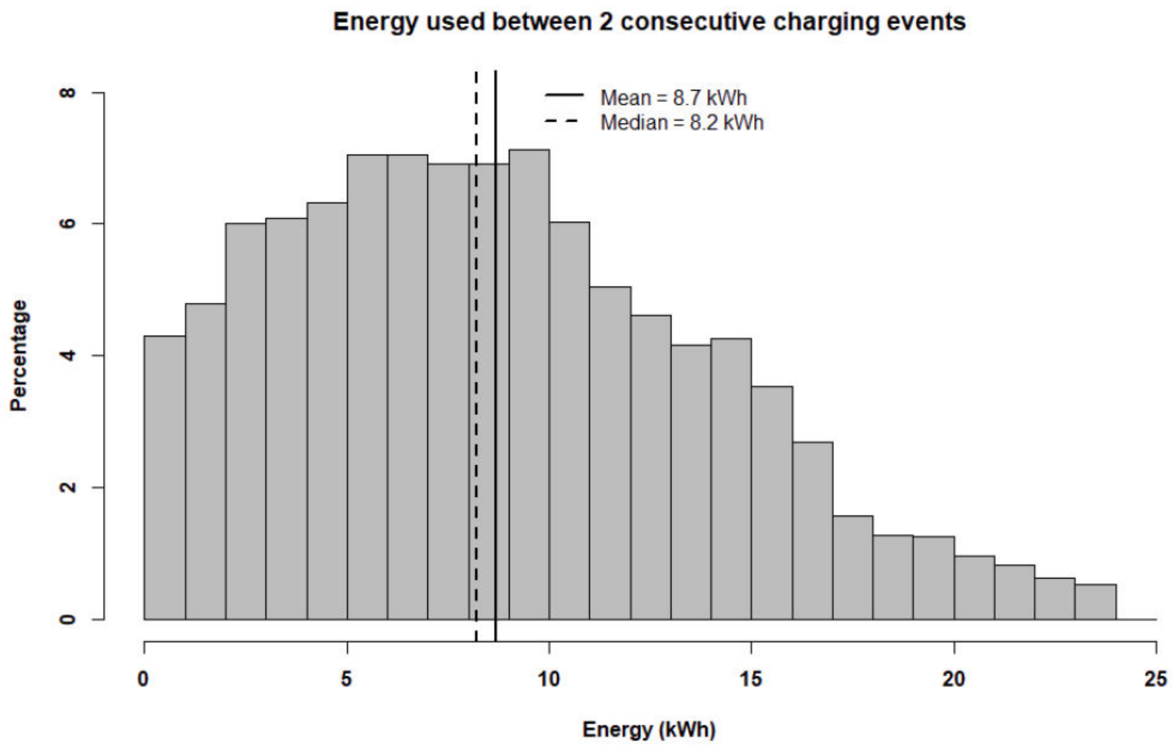
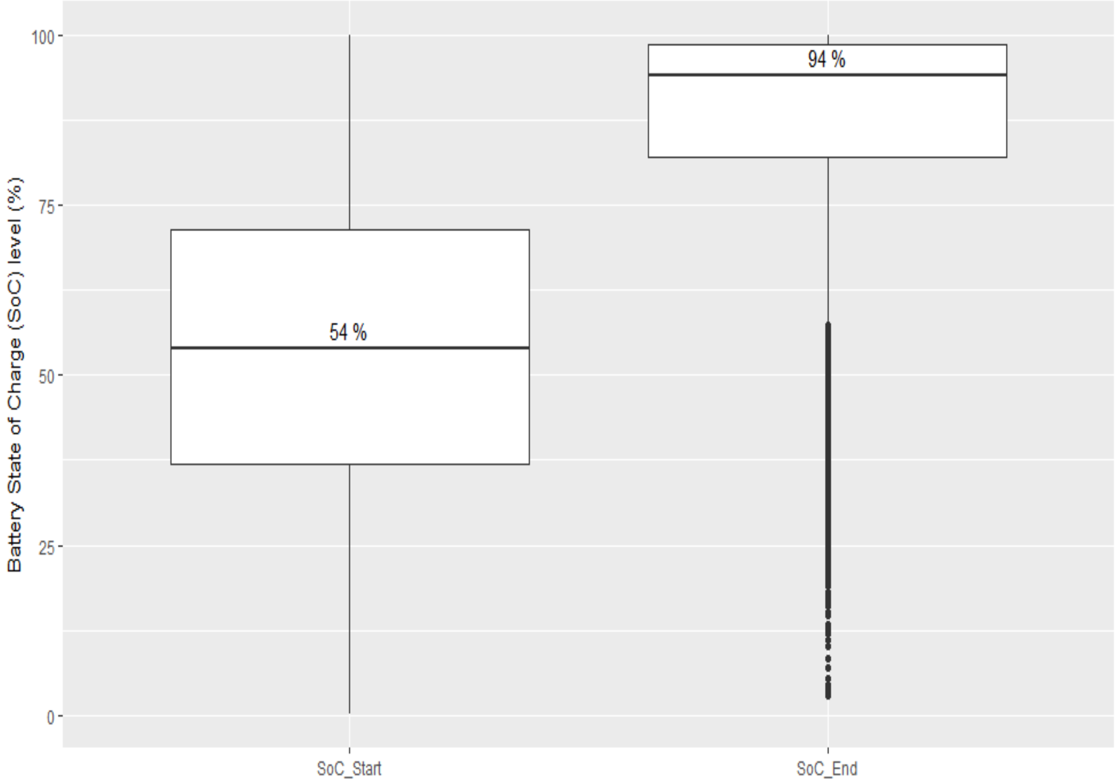
Driving energy consumption





Charging Behaviour





25,000 charging events

A case for workplace charging?

- More than just a top-up charging location
- But a key location to enable BEV charging demand management strategies.
- Preliminary demand management strategy to create diversity in charging demand.
  - Distribution of charging demand in space and time could alleviate network impacts.
- … but also this would create more DSR opportunities if the car is plugged to the electricity network most of the time
  - Participation in V2G services
  - inc. integration of more solar power.

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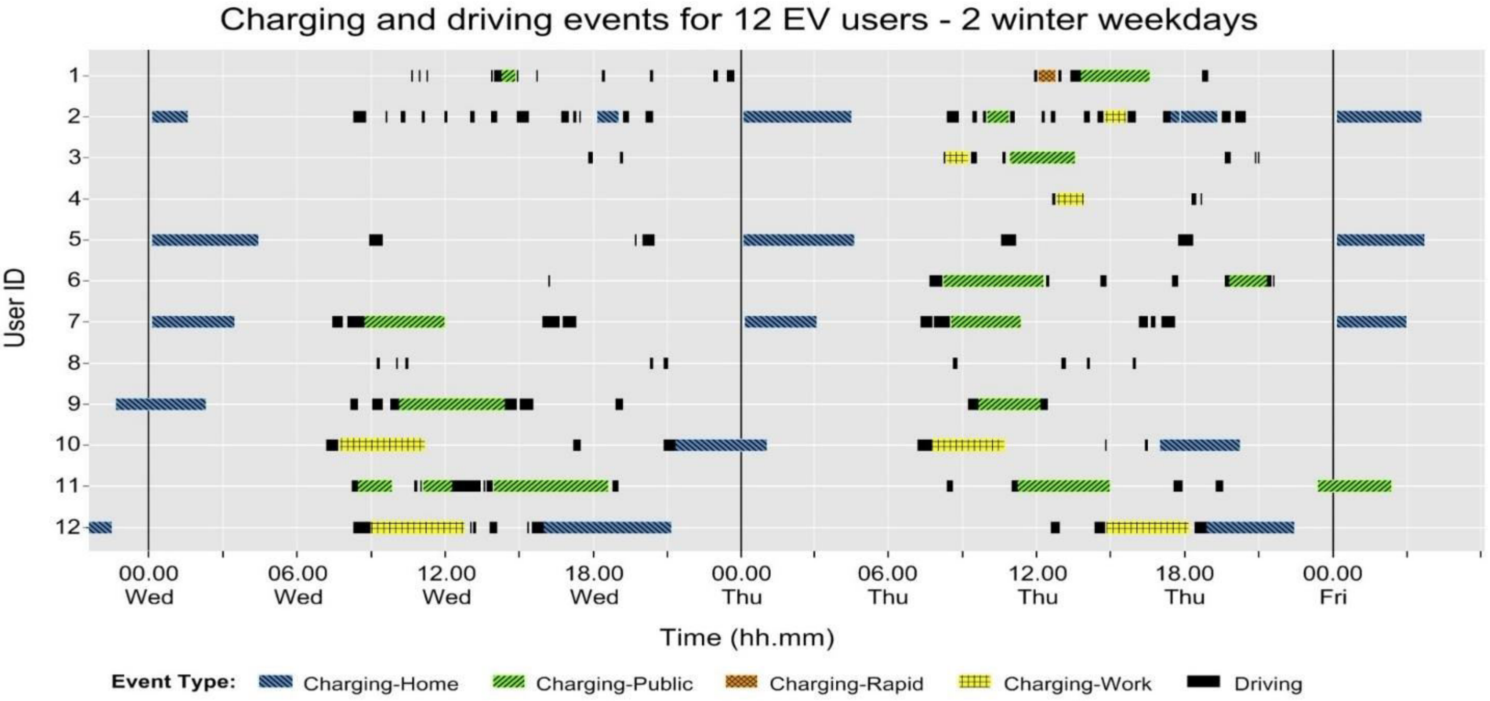
Distribution Network Impact Assessment

CLNR- 2011-2014, £53m -LCNF funding. In collaboration with NPg.

Domestic load profiles of half-hourly power consumption from 2000 smart meters.

Urban and rural charging profile data.

A probabilistic method is used to combine both datasets.



Distribution Network Impact Assessment

Applied Energy 157 (2015) 688–698

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

A probabilistic approach to combining smart meter and electric vehicle charging data to investigate distribution network impacts ☆

Myriam Neaimeh [a,*], Robin Wardle [b], Andrew M. Jenkins [c], Jialiang Yi [c], Graeme Hill [a], Padraig F. Lyons [c], Yvonne Hübner [a], Phil T. Blythe [a], Phil C. Taylor [c]

[a] Transport Operations Research Group, Newcastle University, United Kingdom
[b] School of Engineering and Computing Sciences, Durham University, United Kingdom
[c] School of Electrical and Electronic Engineering, Newcastle University, United Kingdom

HIGHLIGHTS

- Working with unique datasets of EV charging and smart meter load demand.
- Distribution networks are not a homogenous group with more capabilities to accommodate EVs than previously suggested.
- Spatial and temporal diversity of EV charging demand alleviate the impacts on networks.
- An extensive recharging infrastructure could enable connection of additional EVs on constrained distribution networks.
- Electric utilities could increase the network capability to accommodate EVs by investing in recharging infrastructure.

ARTICLE INFO

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Keywords:
Electric Vehicle (EV)
Smart meter
Load profiles
Spatial–temporal data
Distribution network
User behaviour

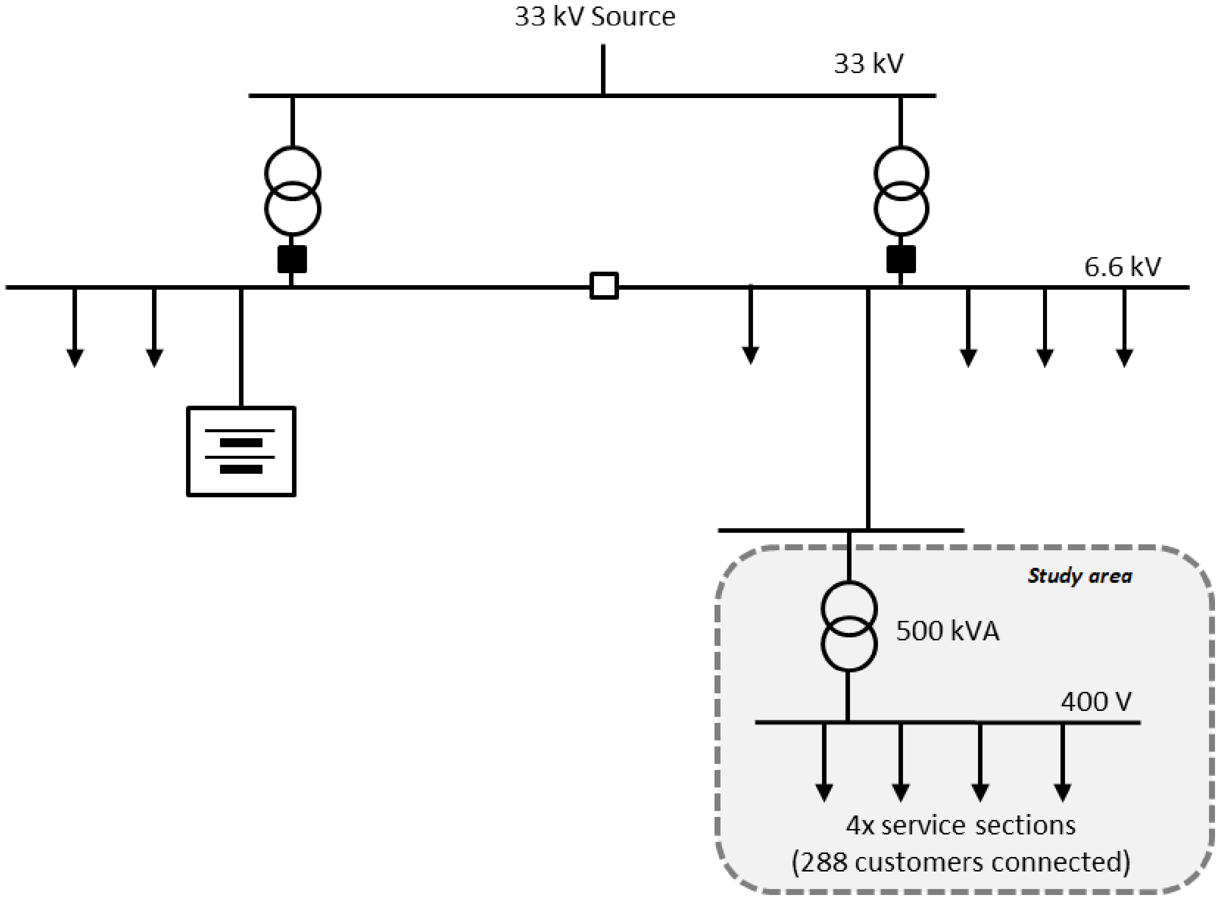
ABSTRACT

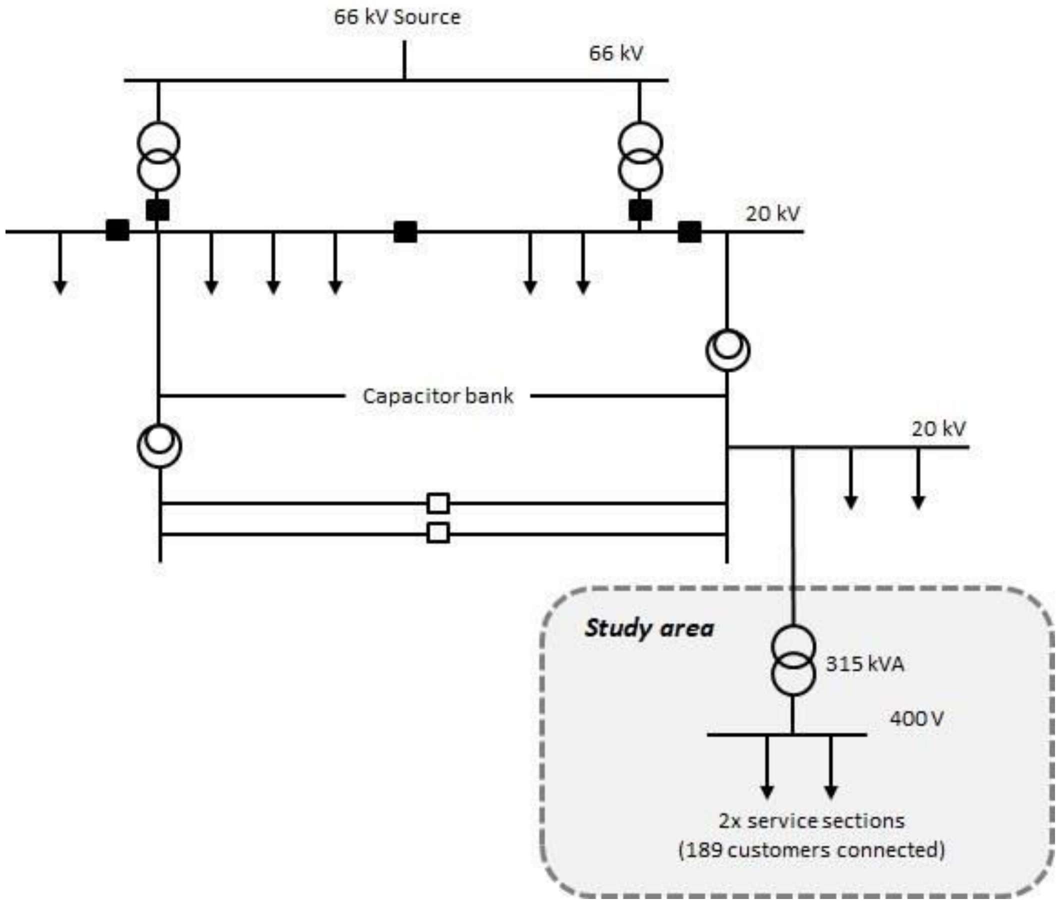
This work uses a probabilistic method to combine two unique datasets of real world electric vehicle charging profiles and residential smart meter load demand. The data was used to study the impact of the uptake of Electric Vehicles (EVs) on electricity distribution networks. Two real networks representing an urban and rural area, and a generic network representative of a heavily loaded UK distribution network were used. The findings show that distribution networks are not a homogeneous group with a variation of capabilities to accommodate EVs and there is a greater capability than previous studies have suggested. Consideration of the spatial and temporal diversity of EV charging demand has been demonstrated to reduce the estimated impacts on the distribution networks. It is suggested that distribution network operators could collaborate with new market players, such as charging infrastructure operators, to support the roll out of an extensive charging infrastructure in a way that makes the network more robust; create more opportunities for demand side management; and reduce planning uncertainties associated with the stochastic nature of EV charging demand.

To assess the additional impact of BEVs during an existing peak loading event, a single peak load test day corresponding to the DNO’s system peak load day in January is studied.

2 real networks representing an urban and rural area, and a generic network representative of a heavily loaded UK distribution network were used for the impact assessment.

Urban and Rural network models

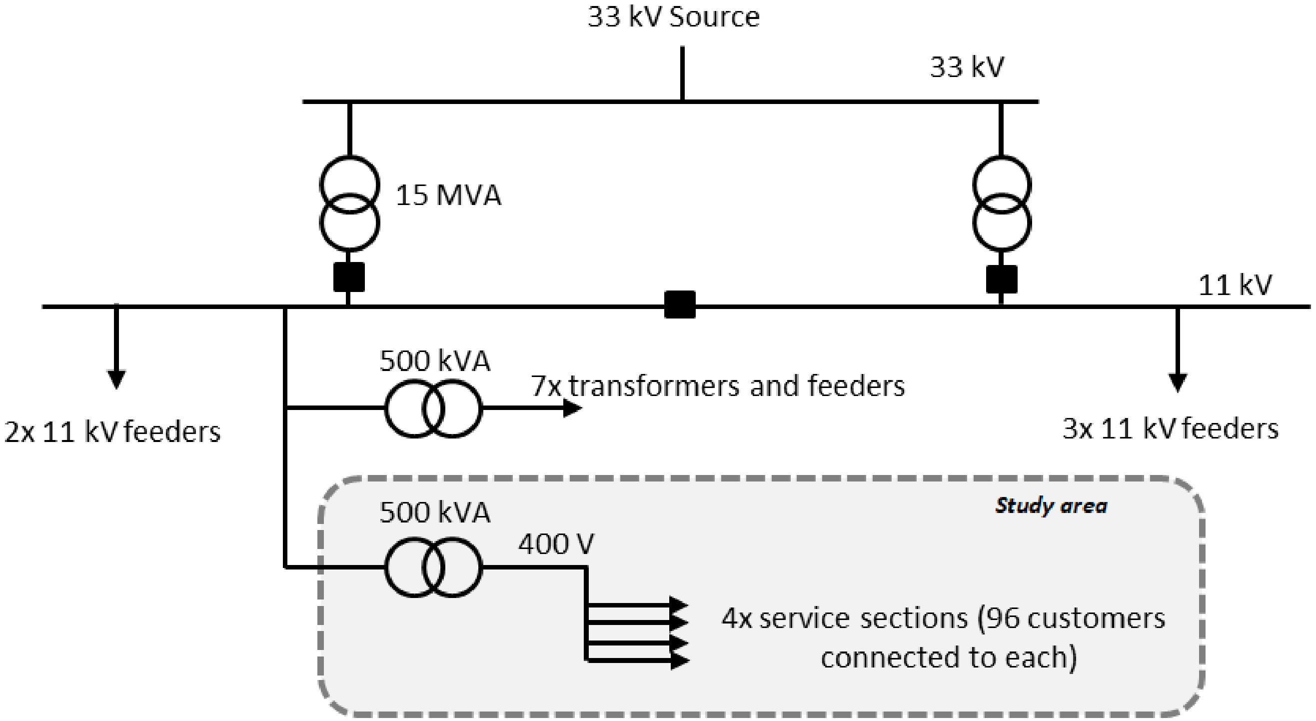




6.6kV network supplying approximately 6,000 customers. One particular HV/LV substation supplying 288 customers via a 500kVA transformer and 4 LV feeders has been studied.
288 customers and a vehicle ownership of 86%; 60% penetration (149 EVs)

20kV feeder, approximately 40 km long, supplying a number of towns in Northumberland in northern England. Three HV/LV substations supply one of these towns;
work focuses on one of these substations which supplies 189 residential properties.

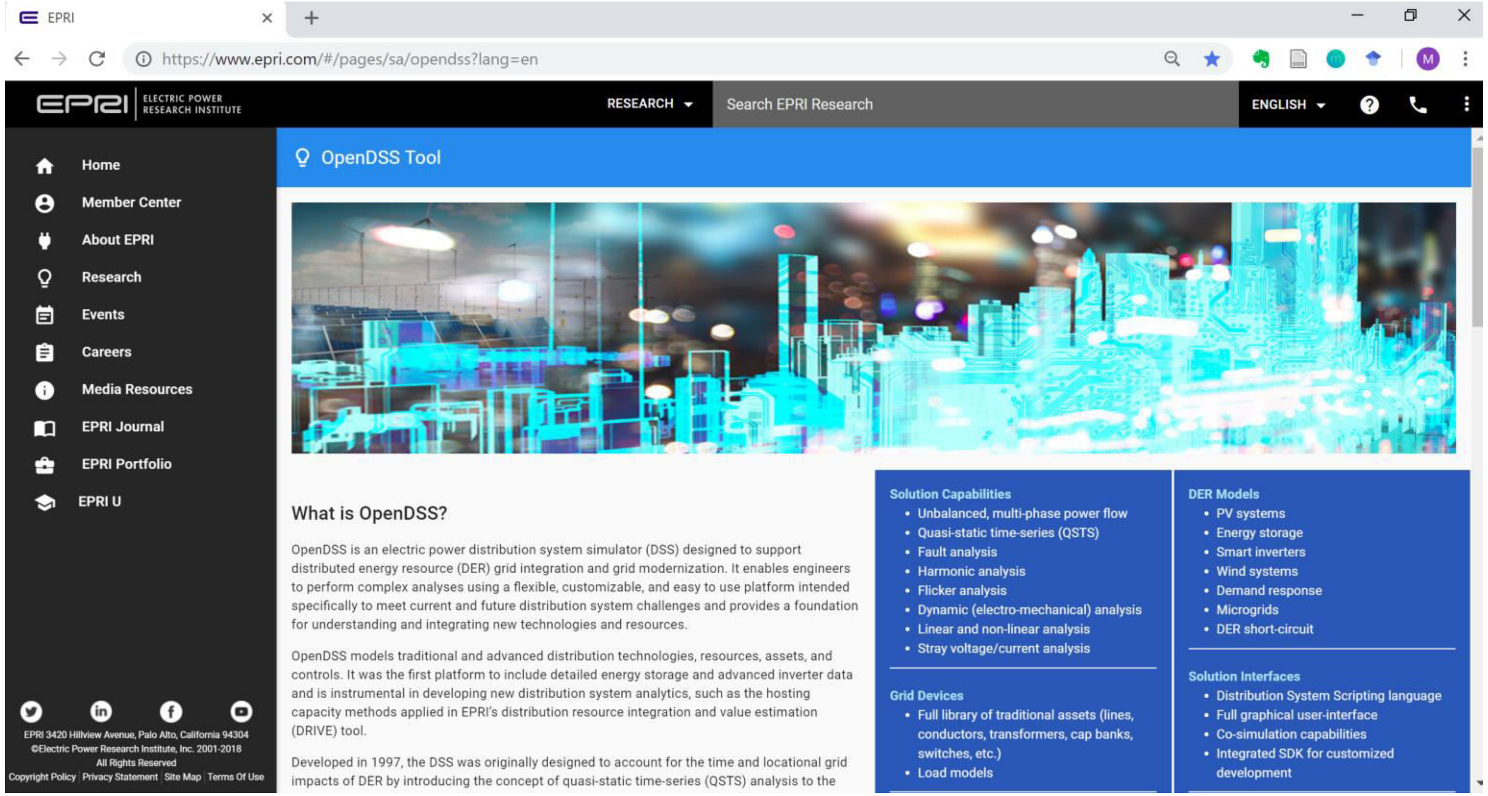
Generic network model



384 domestic single-phase loads are distributed equally between the four feeders, resulting in 96 loads per feeder.

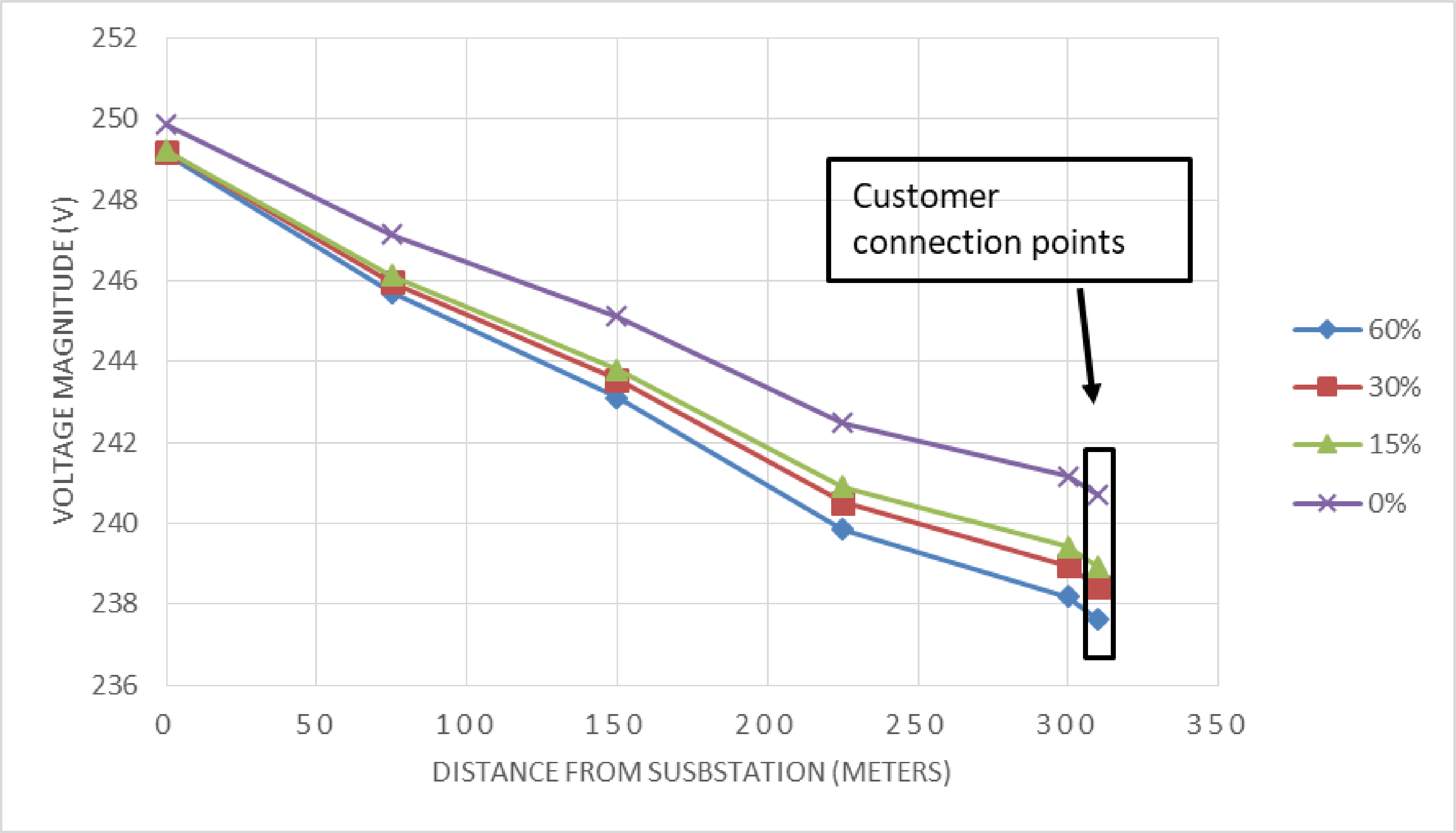
Voltage study one feeder

Open power distribution system simulator- OpenDSS



- OpenDSS is an open-source steady-state electric distribution systems' simulation tool developed by the Electric Power Research Institute (EPRI).
- It is designed for the unbalanced multi-phase distribution systems. It uses a 3-phase 4-wire representation of the network and this would capture phase unbalance.
- It has been used to co-simulate power and ICT networks

Distribution Network Impact Assessment- Voltage study



Voltage levels at 19:00 for different BEV % - voltage drop.
The minimum voltage magnitude occurring at the customer connection point (237.6 V) is well above the minimum statutory limit (216.2 V).

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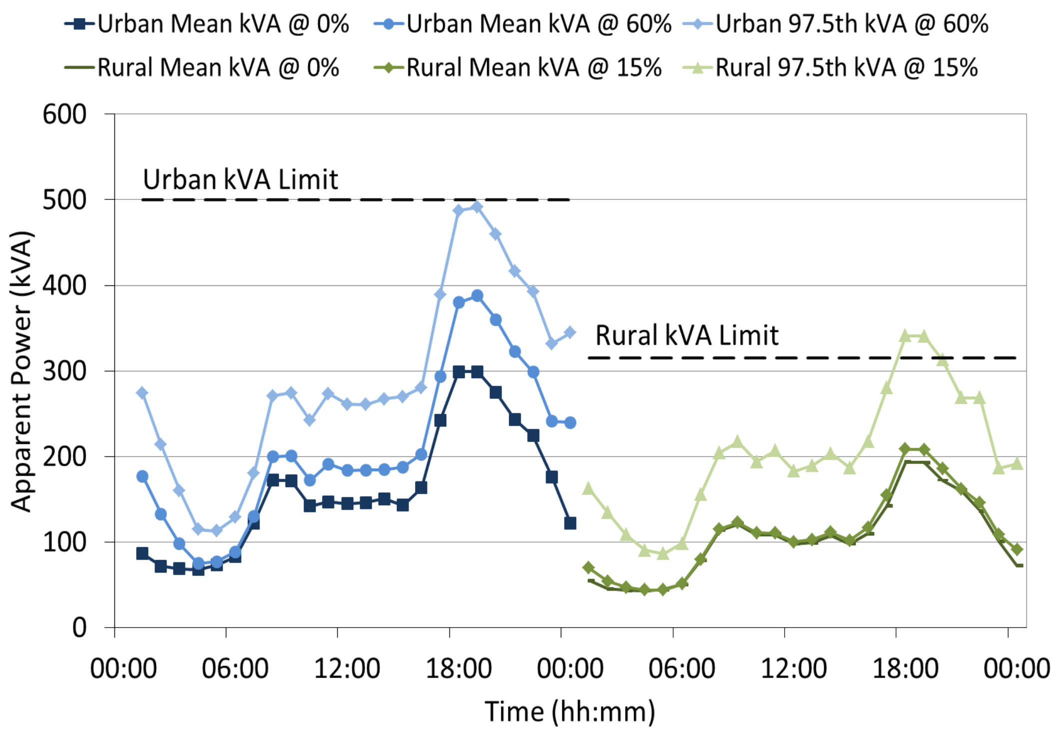
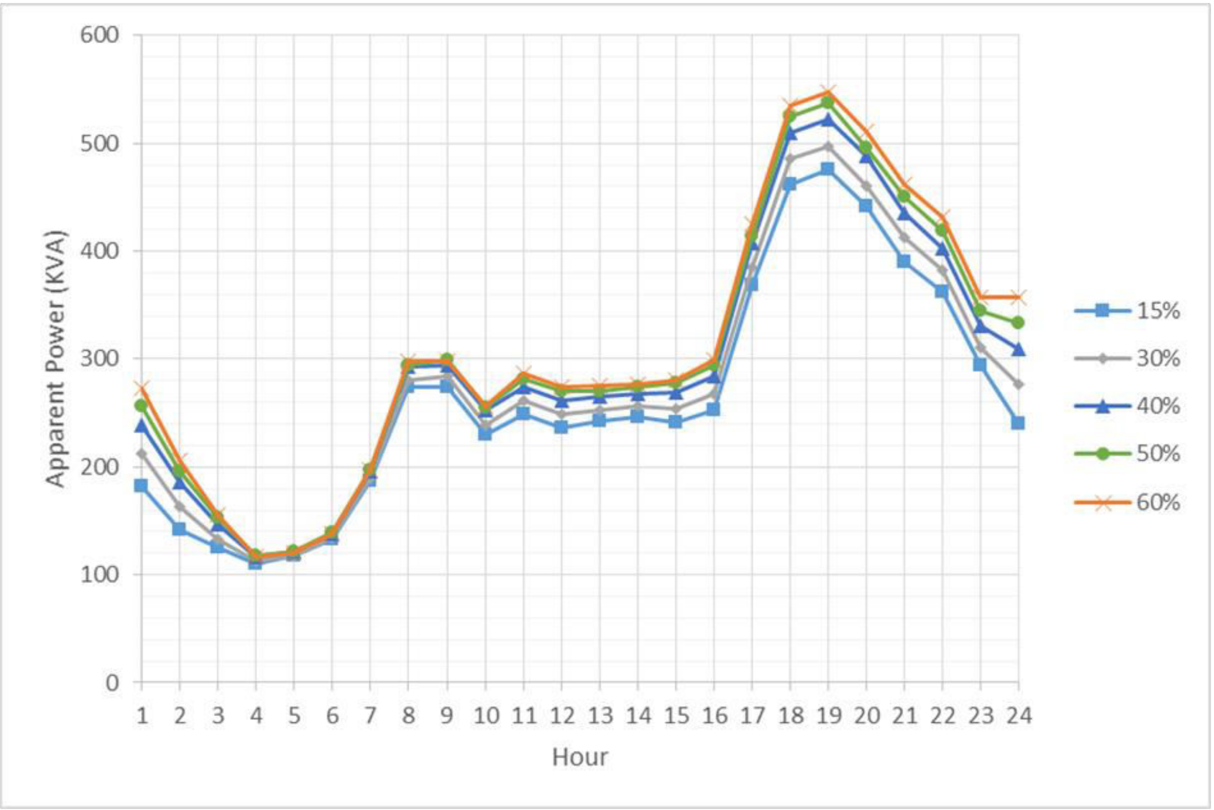
Transformer loading



Using the 97.5th upper bound load data, the urban network was not compromised even at 60% BEV penetration, although at this point the load was approaching the transformer rating (500kVA). The rural network was compromised at 15% penetration.



Using the 97.5% upper demand limit, the loading exceeded the transformer rating capacity (500kVA) at 30% BEV penetration.

Results/Implications

- LV networks are not a homogenous group and have different characteristics, sets of parameters and customer behaviour, which illustrates the importance of bespoke studies.

E.g. Urban vs Rural: Differences in BEV charging profiles, network topologies and impedances between the urban and rural areas.

- Spatial and Temporal diversity of charging demand alleviated the impact on distribution networks.

A preliminary demand management strategy: support the roll-out of charging infrastructure at workplace locations?

Network Innovation Allowance (NIA) V2G project

DNO funding; 250K; 2018-2020
16 chargers in 7 locations on NPg premises

Initial testing of V2G chargers technical characteristics
Network modelling, simulation and assessment
Connection procedure

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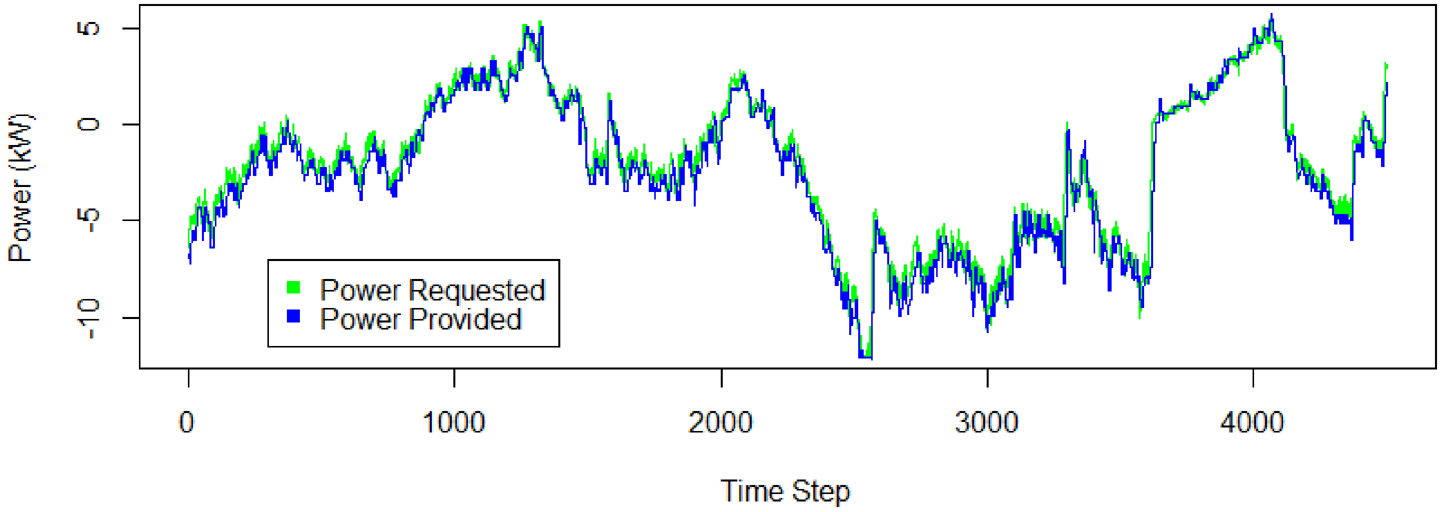
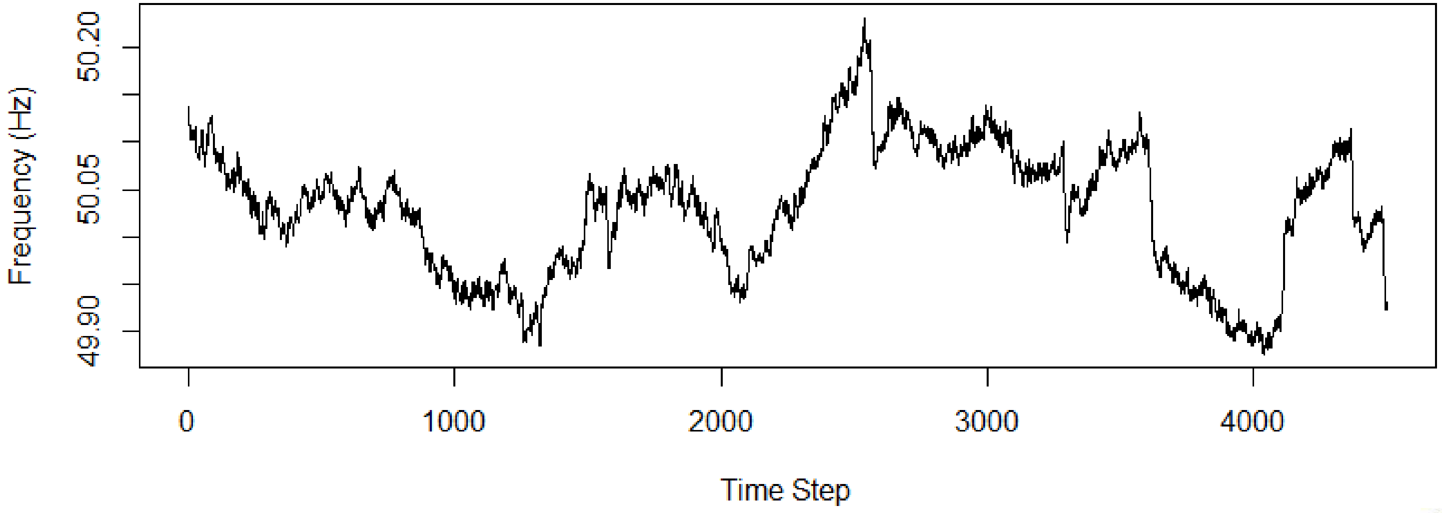
Last week of February 2018 (plot showing first 75 minutes)





Emulating the participation in frequency response

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e4Future- Large Scale Demonstrator on V2G

Deploying 1000 V2G chargers to business customers, providing grid services with E.ON aggregation, overseen by UKPN, Northern Powergrid and National Grid

Data collection from cars, users, charging infrastructure and the electricity networks.

£10 million; 36 months between 2018 and 2021

Significance: scale, OEMs/energy industries; TSO/DNOs.

e4Future- Large Scale Demonstrator on V2G

Topics addressed

- Define and refine of customer offer
- Customer acceptance and willingness to use this technology.
- Impacts and benefits to DNOs and whole system.
- Additional testing & approval to ensure commercial warranties remain intact
- Establish the business case for V2G from providing multiple local and system services.
- Identify market and regulatory barriers.
- Ensure the security and resilience of the V2G system infrastructure against cyber attacks.
- Ensure privacy of the users' personal data (Data protection regulation enforced in 2018).

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e4Future- Large Scale Demonstrator on V2G

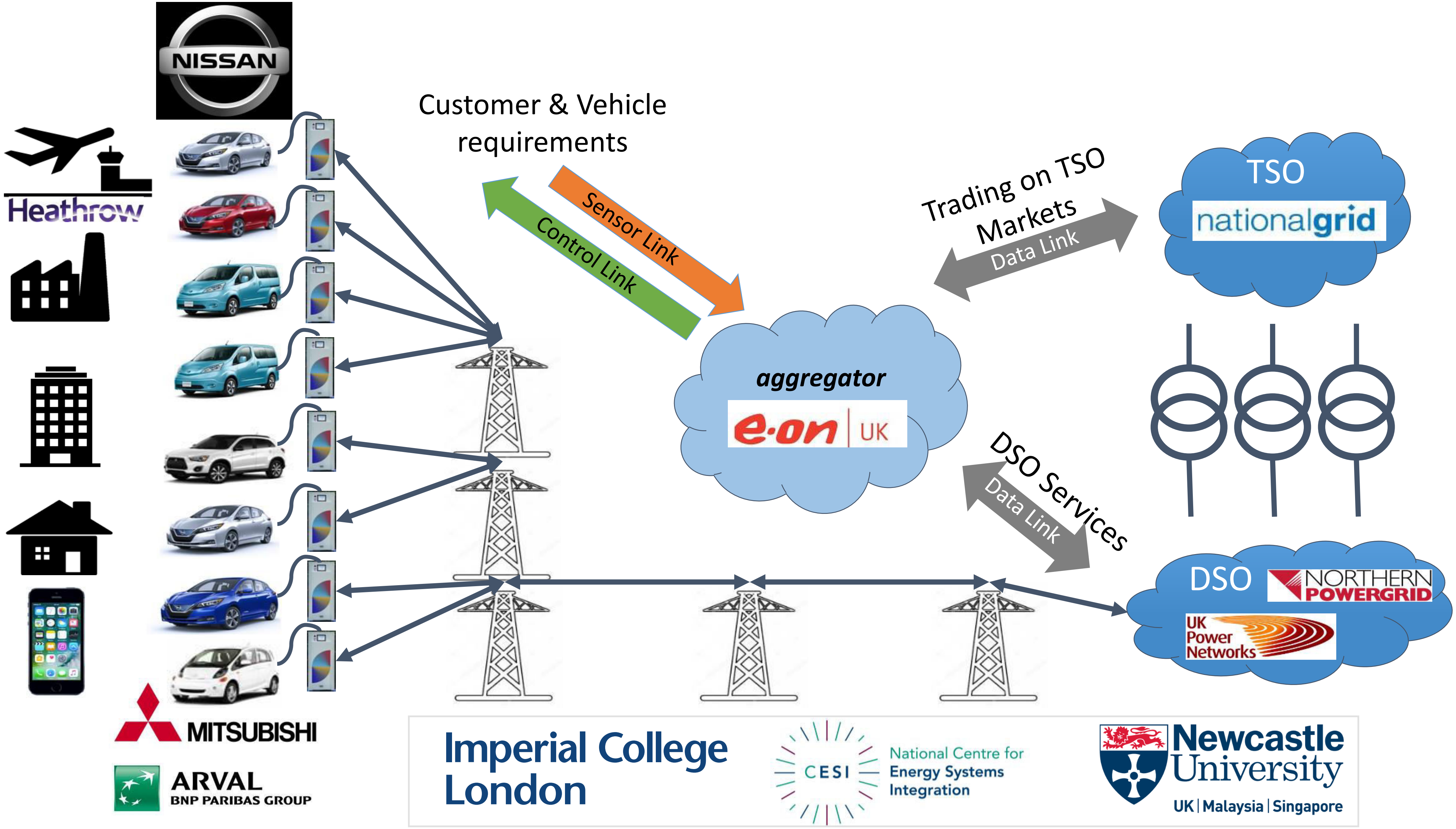
Topics not addressed:

- End to end modelling: molecules to markets

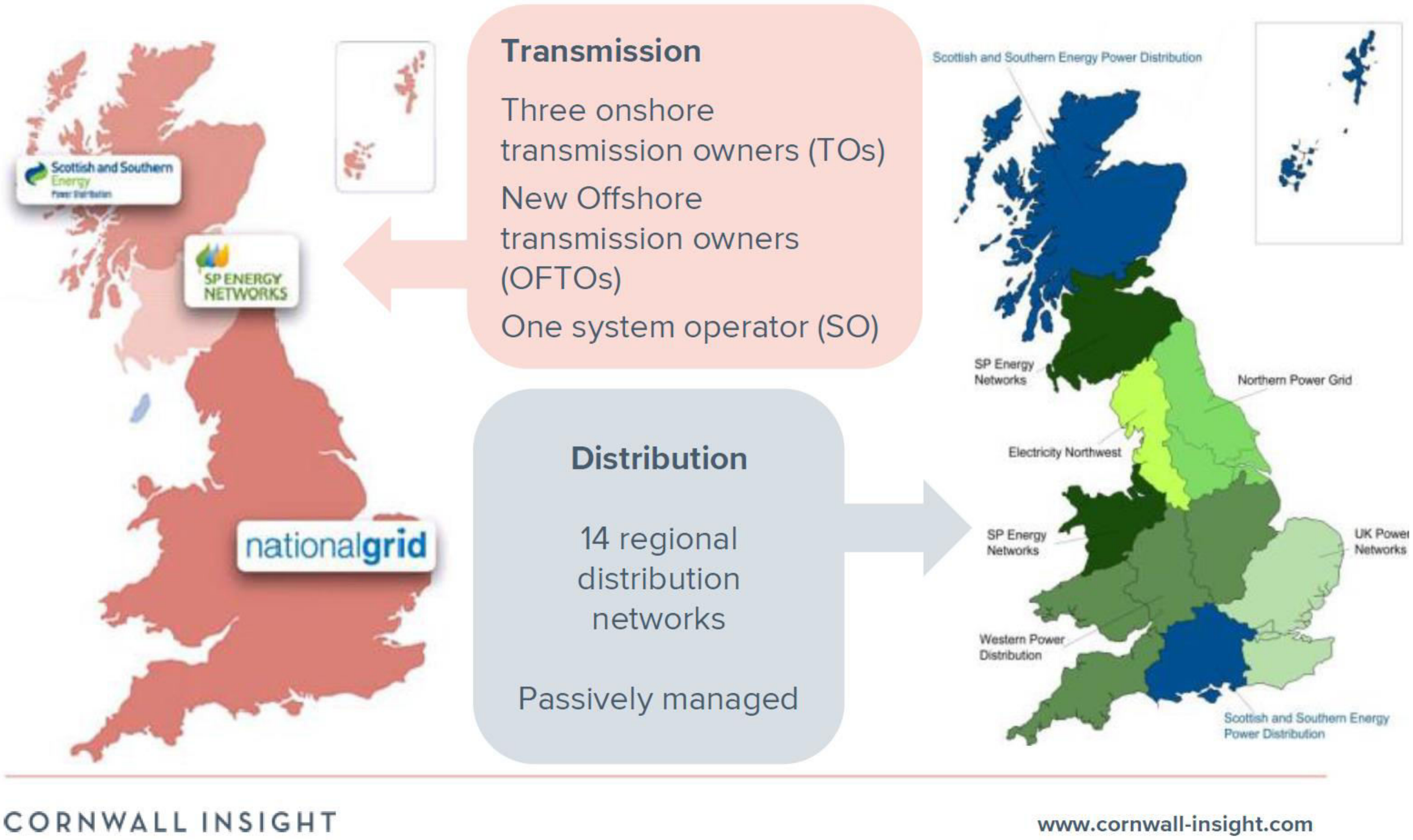
Some risks:

- Recruitment risk with consumer confidence
- Users don’t routinely plug the cars

e4Future consortium



GB Electricity Networks



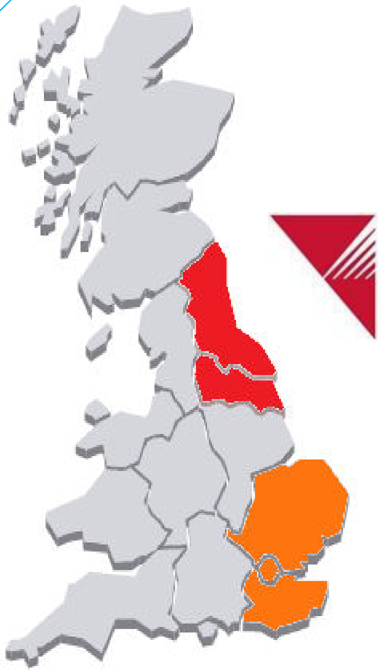
1 ESO

14 licensed distribution network operators (DNOs) each is responsible for a regional distribution services area.

The 14 DNOs are owned by six different groups.

Source: Corwall Insight; ENA

e4Future – System as a whole



NORTHERN POWERGRID

nationalgrid

UK Power Networks Delivering your electricity

- From the densest UK urban network in UKPN's London to amongst the most rural in Northern Powergrid's north Northumberland the two DNOs provide a full spectrum of UK distribution networks.
- 2 DNOS representing 40% of the distribution activities in UK, aiming to a transition to system operator

- National Grid are responsible for transmission throughout GB

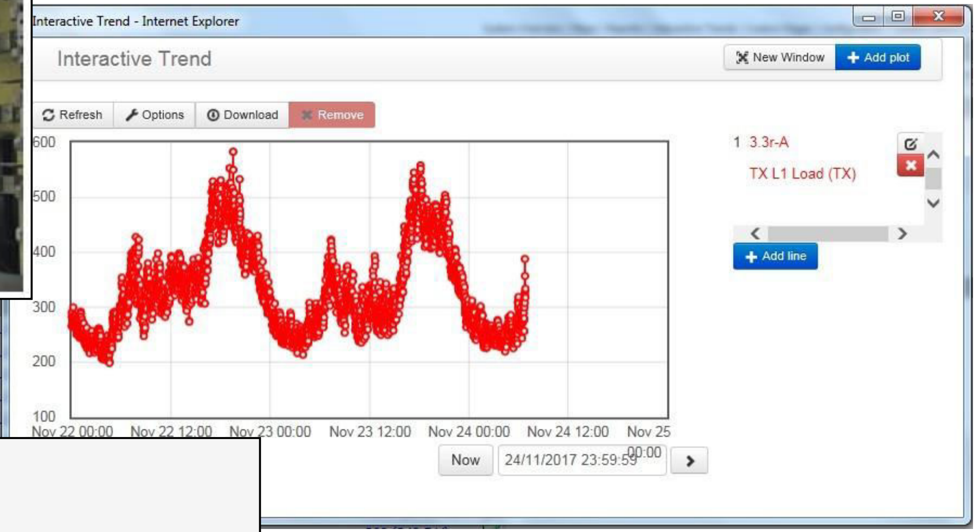
e4Future- System as a whole

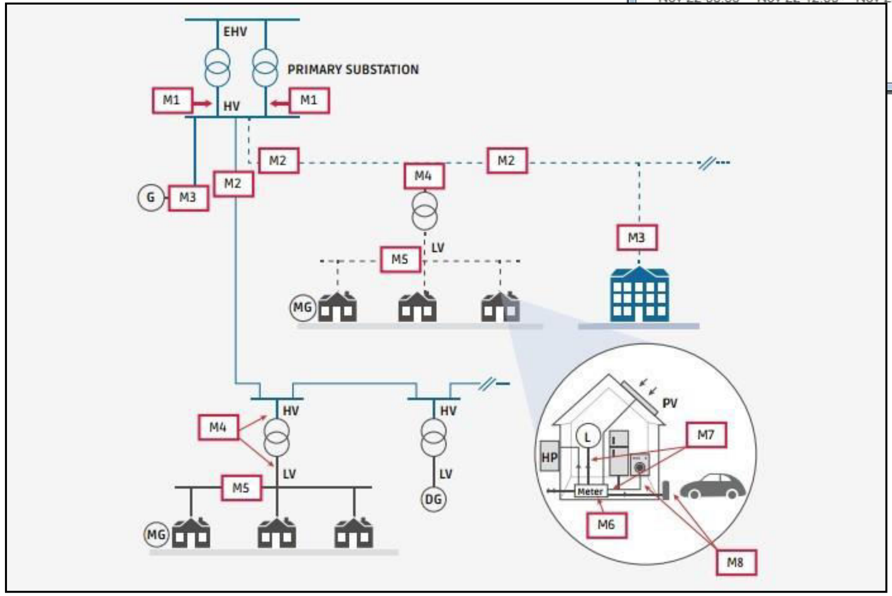
- Test and assess V2G technical characteristics (e.g. response time, durability, etc.)
- Conduct prequalification tests for balancing services provision
- Coordination between TSO and DNOs
- Response, reserve
- Voltage control, mitigate thermal overloading of cables and transformers
- Stacking of services
- Investigate the conflicts and synergies in meeting local and global requirements.

e4Future – distribution network monitoring and modelling

- Monitor the present load characteristics

- Network modelling, validation, and simulation of pilot sites
- Experiment with various scenarios that are not practical or possible to test in real life (e.g. Scenarios for future load and generation such as heat pumps and photovoltaics).





e4Future – Customer experience and acceptance

- Conduct surveys through online questionnaires tools (e.g. Survey Monkey)
- Assess user preference and attitudes to V2G at different stages of the project.
  - Before the start of the trial
  - During the trial as users get a real experience.
  - A couple of months after the trial is completed, as a follow up is strongly recommended.
- Link with data collection on actual customer usage.
- What's needed to incentivise/ increase EV owner participation in V2G programmes?
  - Monetary incentives, reliability, safety, easiness of use, attitudes toward environment
  - Monitor different types of users. We might find that different type of users need different incentives.

e4Future – Privacy and Security

Security Context- Connected infrastructure is target to cyber attacks

WannaCry Ransomware: all the updates on the cyberattack

Contributors: Jacob Kastrenakes, Russell Brandom, Colin Lecher, and 3 others

SHARE TWEET LINKEDIN

On Friday afternoon, NHS hospitals in the UK were infected with a ransomware strain known as WannaCry. Since then, it has continued to spread across the world, infecting computers in over 150 countries. Follow along for the latest updates.

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NEWS

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echnology

Hackers behind Ukraine power cuts, says US report

26 February 2016 | Technology

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Ukraine has been forced to turn to back-up power sources in recent months following a spate of power cuts

Hackers were behind an attack that cut power to 225,000 people in Ukraine, a US report has concluded.

ico. Information Commissioner's Office

The UK's independent authority set up to uphold information rights in the public interest, promoting openness by public bodies and data privacy for individuals.

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TalkTalk gets record £400,000 fine for failing to prevent October 2015 attack

Date 05 October 2016
Type News

Telecoms company TalkTalk has been issued with a record £400,000 fine by the ICO for security failings that allowed a cyber attacker to access customer data "with ease".

The ICO's in-depth investigation found that an attack on the company last October could have been prevented if TalkTalk had taken basic steps to protect customers' information.

ICO's largest fine, a penalty of £400,000 to TalkTalk after the telecoms company failed to properly protect customer data from a cyber attack

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Security Context- Possible attacks?

- Attack causing all the chargers to charge or discharge at full power at the same time? This would likely cause a serious network problem if we are talking about hundreds of thousands of 7 to 10 kW chargers.
- Attack propagating malware/ransomware on vehicles?
- Denial of service attacks on the network? This would prevent communication between chargers and operators.
- Data injection/spoofing against state estimation?
- Data leakage? This would cause users to mistrust, and not to engage with the service.

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Trust and Privacy Context-End-users do not always trust “smart” systems

Nouvelle fronde contre le compteur électrique Linky

Jean-Claude Bourbon, le 16/05/2017 à 18h45

Des avocats veulent lancer une action collective contre le compteur de consommation électrique d’Enedis. Selon eux, un abonné doit avoir le droit de refuser son installation.

www.nydailynews.com/news/national/houston-woman-thelma-taormina-pulls-gun-electric-company-worker-install-smart-meter-article-1.1118051

Crime U.S. World Politics

Houston woman Thelma Taormina pulls gun on electric company worker for trying to install ‘smart meter’

Fifty-five year-old Thelma Taormina pulled out a gun on a CenterPoint Energy employee who arrived at her Houston-area home to install a

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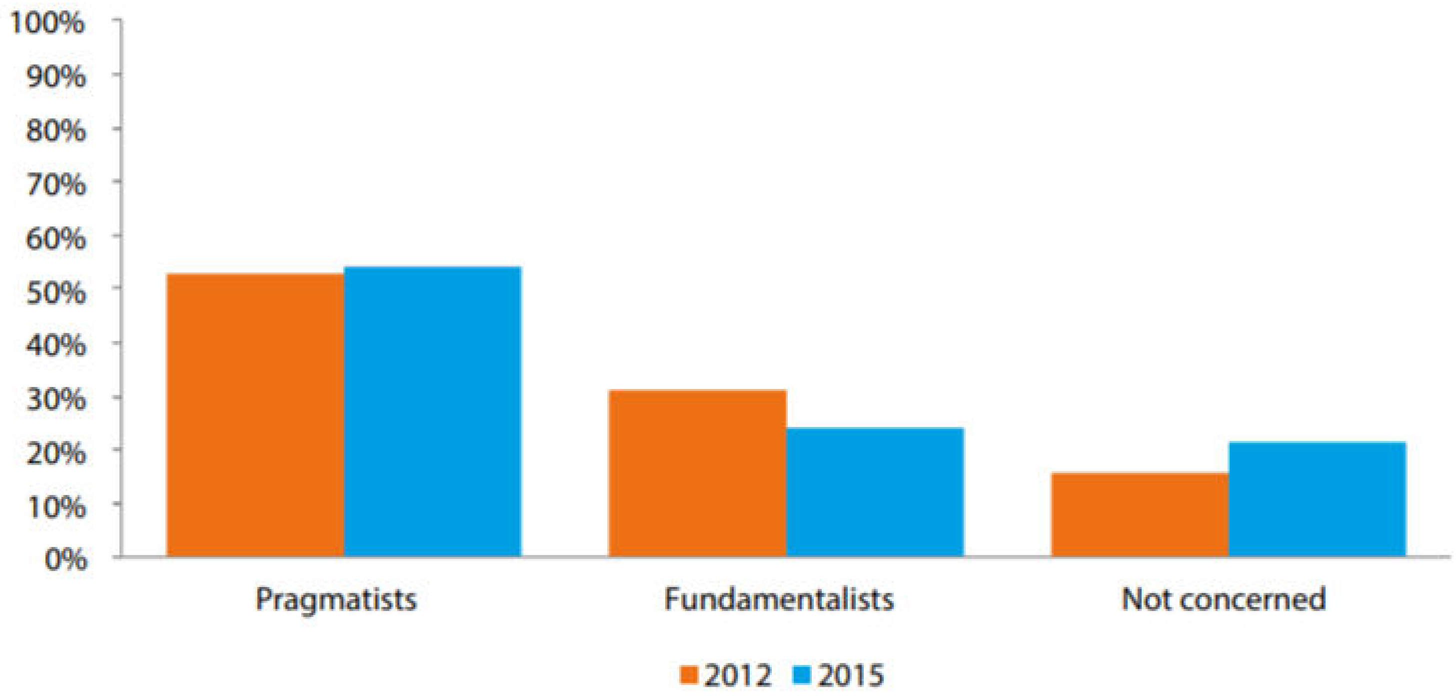
Trust and Privacy Context-Sharing by default without engaging the user is risky because you might end up with no one wanting to participate.

A segmentation of attitudes towards privacy in the UK (2012 vs. 2015)



- **Data pragmatists**: those who will make trade-offs on a case-by-case basis as to whether the service or enhancement of service offered is worth the information requested
- **Data fundamentalists**: those who are unwilling to provide personal information even in return for service enhancement
- **Data unconcerned**: those who are unconcerned about the collection and use of personal information about them

https://dma.org.uk/uploads/ckeditor/Data-privacy-2015-what-consumers-really-thinks_final.pdf

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Government Support- GDPR (General Data Protection Regulation) enforced May 2018, with potential stronger rights for end-users with respect to their personal data.

- The right to be informed
- The right of access
- The right to rectification
- The right to erasure
- The right to restrict processing
- The right to data portability
- The right to object
- Rights related to automated decision making and profiling

https://ico.org.uk/for-organisations/data-protection-reform/overview-of-the-gdpr/

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Government Support- 8 key principles of vehicle cyber security for connected and automated vehicles

Principles give an overview for obtaining good cyber security within the automotive sector. Created by DfT and the Centre for the Protection of National Infrastructure (CPNI).

- Principle 1 - organisational security is owned, governed and promoted at board level
- Principle 2 - security risks are assessed and managed appropriately and proportionately, including those specific to the supply chain
- Principle 3 - organisations need product aftercare and incident response to ensure systems are secure over their lifetime
- Principle 4 - all organisations, including sub-contractors, suppliers and potential 3rd parties, work together to enhance the security of the system
- Principle 5 - systems are designed using a defence-in-depth approach
- Principle 6 - the security of all software is managed throughout its lifetime
- Principle 7 - the storage and transmission of data is secure and can be controlled
- Principle 8 - the system is designed to be resilient to attacks and respond appropriately when its defences or sensors fail

https://www.gov.uk/government/publications/principles-of-cyber-security-for-connected-and-automated-vehicles

e4Future – Privacy and Security proposed work

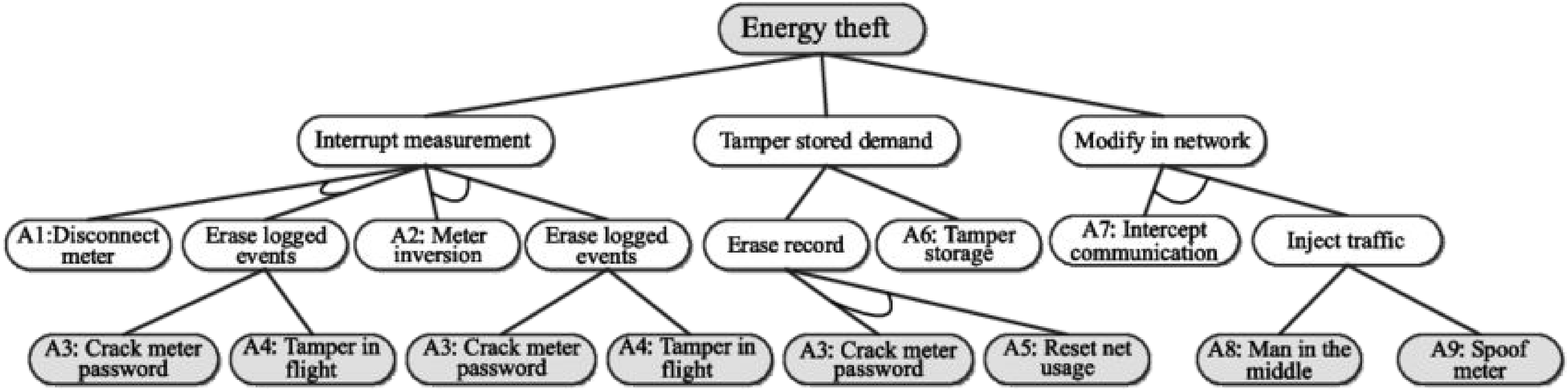
Conduct cyber-security research for the V2G infrastructure, to ensure the security and privacy of the users personal data, and to ensure the security and resilience of the V2G system infrastructure.

Three overlapping tasks:

- Task-1: Privacy and Access Control: Elicit the requirements in terms of privacy and access control for users over their data: which data can be shared or not? which data matters? which data can be aggregated? how should users control data? Implement a privacy preserving communication protocol, thus enforcing Principle 7.
- Task-2: Security Analysis: Compile threats and possible vulnerability into a dedicated Attack Tree (a standard attack description technique in security). The Attack Tree will include hardware, software and social aspect.
- Task-3: Incident responses: Elicit the response deployed when an incident is detected, which is included in Principle 3. First, create a controlled environment for attack simulation (i.e., ensuring that no effective damage can be done). Then, run some attack simulations using the Attack Trees designed in the previous task, in order to ensure that these attacks are effectively detected by the existing infrastructure, and to elaborate the required incident responses accordingly.

e4Future – Privacy and Security Task2– Security Analysis

- Jiang, Rong, et al. "Energy-theft detection issues for advanced metering infrastructure in smart grid." *Tsinghua Science and Technology* 19.2 (2014): 105-120.



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Research Assistant/Associate in **Data Analysis and Machine Learning** for Vehicle-Grid Integration *(24 months).*

Research Assistant/Associate in **Power Systems Analysis** for Vehicle-Grid Integration *(24 months)* [e4future project].

Research Assistant/Associate in **Power Systems Analysis** for Vehicle-Grid Integration *(12 months)* [NIA project].

Research Assistant/Associate in **Privacy and Security** for Vehicle-Grid Integration *(24 months).*

Research Assistant/Associate in Data Collection and **Analysis of Customers' Experience** in Vehicle-Grid Integration *(12 months).*

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