DELTA
Energy & Environment

MADE PROJECT
FOR PASSIVSYSTEMS

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Executive summary
MADE – Multi Asset Demand Execution

The MADE project is the only one of its kind – covering a suite of domestic low carbon technologies. The deployment of these technologies is set to grow rapidly.

The MADE concept is unique
Homes of the future will increasingly have multiple energy assets such as electric vehicles (EVs), hybrid heating systems, solar PV and battery storage systems. The MADE (Multi Asset Demand Execution) project is all about understanding how to manage these multiple energy assets in a way that is both beneficial to the homeowner and the energy networks. Whilst previous projects have looked at optimisation of single assets, none have attempted to optimise across multiple assets.

A review of UK network innovation projects as well as a global scan of innovative companies acting in the domestic low carbon technology space has evidenced the fact that the MADE concept is unique. No innovation project or company currently covers the range of technologies being focussed on in this project.

The deployment of low carbon technologies will grow rapidly out to 2050
Strong growth in the sales of all low carbon heating technologies is expected in the medium to long-term. Under almost any scenario the number of air source heat pumps and hybrid heating systems installed in UK homes will be well into the millions by 2030. The uptake of EVs will also be rapid from the late 2020 in to the early 2030s with over 10 million on the roads by the mid 2030s in all scenarios.

Domestic solar PV installations will also see a significant increase with anywhere from 2x to 5x more installations than today by 2050.

Understanding how to optimise these technologies in mature market conditions will be essential to maximise value and limit network and system impacts.

Executive summary

MADE – Multi Asset Demand Execution

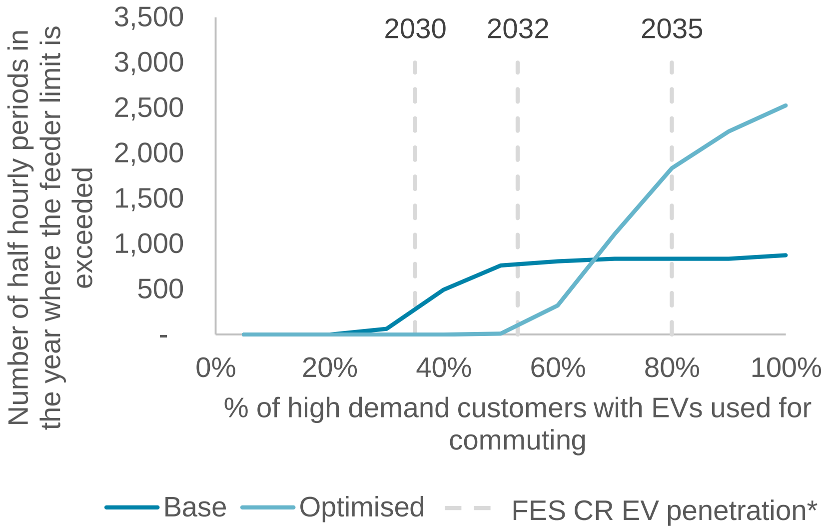
Increased electrification of heating and mobility combined with decentralised generation and storage will require optimisation to limit network impacts.

Deployment of the MADE concept will have a significant impact on the low voltage grid
The demands and exports from the rapid increase in domestic low carbon technologies will place significant additional strain on the electricity networks though increased peak loads. Our modelling has shown that the deployment of these technologies will result in serious impacts on the low voltage network once more than approximately 30% of high demand homes on a feeder adopt these technologies in an unoptimized manner.

In many cases, optimisation of household energy demand and export based on current electricity market price signals will reduce the load on the network. At technology penetration levels of less than 50%, optimisation at the household level using existing price signals reduces occurrences of feeders being overloaded.

Beyond this point, price signals will need to be altered to incentivise behaviour and load shifting, and increase diversity, which is beneficial to networks.

Proportion of high demand customers with EVs used for commuting versus the number of half hourly periods per year the low voltage network limit is breached



*National Grid Future Energy Scenarios 2019 – Community Renewables

Executive summary

MADE – Multi Asset Demand Execution

The key non-financial barriers to deploying the MADE concept will centre around technology awareness, third party control and having an easy to use interface.

Homeowners are largely unengaged with their current heating technologies
Our customer research has shown the majority of homeowners do not engage with their current heating system. There is also fairly low awareness of low carbon heating technologies among the general UK population.

Our research also indicated a majority of homeowners are concerned about third party control of their devices. If third party management of assets is to be accepted, homeowners still want to feel as if they are ultimately in control. It is also important to recognise that saving money is the main driver behind UK homeowner's decisions related to their heating system.

Homeowners, especially those under the age of 45, indicated that the way they interface with their heating systems is an important factor as well.

MADE will require unique business models to be developed
A review of new energy companies active in this space revealed that no company currently has a business model that incorporates all aspects of the MADE project.

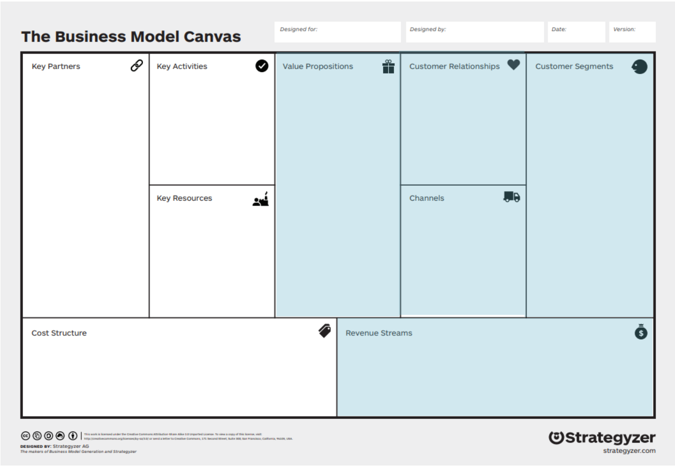
Building on the technology forecasts, the customer research, the modelling work and the analysis of relevant existing business models three new business model propositions were constructed.

Executive summary

MADE – Multi Asset Demand Execution

Engaging customers to optimise will require the development of new business models and propositions which unlock new values and are simple to understand.

Developing MADE business models
Our findings indicate that the propositions need to be simple for homeowners to understand, provide the appropriate platform for the different energy assets to be optimised, and share the value streams unlocked through optimisation. Using these findings along with a business model canvass (below) we designed the propositions.



The three propositions developed for the MADE concept are:

- All energy services (heating, personal transport and other energy needs) provided for single monthly fee.
- Company optimises energy demand across technologies and pays income to customer.
- Balancing electricity demand over the home to reduce peak demand, in return for a cheaper tariff.

The value streams on which these propositions rely are not mature in the UK at present. They also rely on a greater awareness and appeal of low carbon heating systems, particularly in options where the customer is expected to buy the technologies upfront or already own them. This means that they are expected to be suitable in the future but not ready for market currently.

Contents

The MADE concept

Introduction to the MADE project

Multi Asset Demand Execution – unlocking customer & system value

MADE is a multi vector Network Innovation Project funded by WPD, led by PassivSystems.

The energy landscape is rapidly evolving and moving from the traditional centralised model (central power generation) to one that is decentralised, more customer centric and lower carbon.

This transition is seeing a lot more value moving downstream, resulting in ways for domestic customers to potentially access new value streams. The increase in electricity demand from the electrification of heat and rise in electric vehicle penetration coupled with intermittent renewables means that the energy landscape is rapidly evolving. The market will need to respond by allowing homes to actively participate in the energy system by offering fair incentives to drive behaviours that enhance the reliability of the energy system.

The MADE concept looks to address the combined operation and optimised control of electric heating (hybrids / heat pumps), domestic battery storage, electric vehicles and solar PV output, in combination with variable tariffs and demand response value streams.

The goal of MADE is to conduct a feasibility analysis which can inform the design of a large field trial subject to a NIC funding submission later in 2019. MADE will in particular investigate:

- Maximising savings for customers (via maximising PV self-consumption, load shifting to maximise benefit of lower cost tariffs)
- Maximising value from demand response / other value streams
- Minimising impact of multi-vector electrification on electricity networks
- Carbon savings optimisation

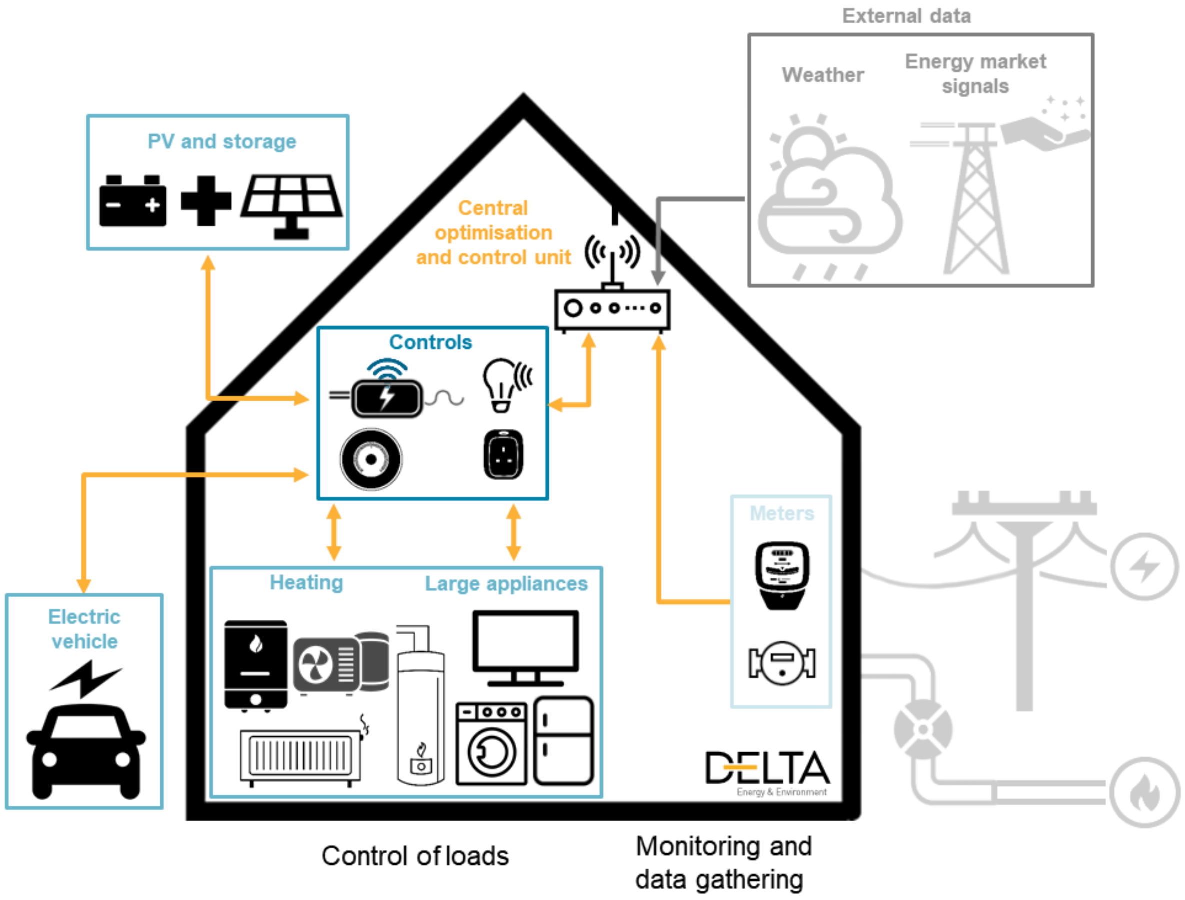
Introduction to the MADE project

MADE concept overview

A home with multiple energy assets controlled in an optimised manner in order to benefit both homeowners and the electricity networks.

The MADE project objectives include:

- Investigating the ability to manage multiple energy assets. This will also include focussing on the switch between gas and electric load to provide fuel arbitrage and highly flexible demand response services.
- Demonstrate the potential consumer, network, carbon and energy system benefits of large-scale deployment of in-home energy assets with an aggregated demand response control system.
- Gain insights into the means of balancing the interests of the consumer, supplier, and network operators when seeking to derive value from demand side flexibility.



Introduction to the MADE project

Delta-EE's role in the MADE project

Delta-EE have been asked to provide input to the MADE study which will assess the viability of the MADE concept.

The MADE project will help understand the potential for optimisation with a view to developing a large scale trial to explore and demonstrate the concept in more detail.

The focus of Delta-EE's input is to provide customer insight and help develop propositions which can be further developed and trialled.

The combination of heating, electricity and transport in an optimised approach is new and raises a number of questions in terms of customer acceptability, and delivery options. It is therefore necessary to conduct new research and assess the impact this may have on customers.

Delta-EE is supporting the project by:

- providing a firm evidence base around future uptake scenarios of the different low carbon technologies;
- carrying out primary customer research to evaluate consumer trust in new technologies, including their views on third party control of their EV charging and heating system;
- modelling the impact the uptake of these low carbon technologies has on the low voltage grid; and
- analysing new and existing business models across Europe and the rest of the world with the view to start developing some potential customer propositions in this space

Relevant UK network innovation projects

Relevant UK Network Innovation projects

Desk-based research was conducted in order to identify other network innovation projects that are relevant to the MADE concept.

UK Network Innovation projects:
The first set of investigations were into relevant Network Innovation Competition (NIC) and Network Innovation Allowance (NIA) projects listed on the ENA 'Smarter Networks' Portal. This was carried out in order to determine if there are any cross overs, synergies or learnings that could be garnered from completed or ongoing UK network projects.

Due to the large number of projects on the portal, many of which are not relevant to the MADE concept, the search of the ENA portal was limited to include only the technologies listed under the MADE entry on the portal.

Based on this criteria the projects listed had to include one of more of the following key technology groups:

- Demand (side) Response (DSR),
- Electric Vehicles (EVs),
- Heat Pumps (HPs),
- Low Carbon Generation and
- Photovoltaics (PV)

Relevant UK Network Innovation projects

Projects similar to MADE (1/5)

The projects listed below were found via the Smarter Networks Portal. Any projects listed on the portal that have some relevance to MADE have been listed

Project types:	Project lead and name	Start date	End date	Value	Gas / Elec	Technologies						Brief overview
						HP	EV	PV	Storage	DSR	SE*	
NIA	WPD – Multi Asset Demand Execution (MADE)	Mar 2019	Oct 2020	£1.7m	Elec + Gas	✔	✔	✔	✔	✔	✔	Investigate the impact, economics and flex opportunities from multiple domestic LCT deployment and optimisation.
NIA	UKPN – Urban Energy Club	May 2019	Nov 2020	£195k	Elec			✔	✔	✔	✔	Assess if those living in flats (focus on the fuel poor) can access the financial benefits of DSR from shared assets.
NIA	NG (ESO) – Residential Response	Apr 2019	Apr 2020	£587k	Elec					✔		Developing new approaches for testing, monitoring and managing portfolios of residential-scale assets for participation in ESO Balancing Services.
NIA	UKPN – Shift	Jan 2019	May 2021	£1.3m	Elec		✔				✔	Develop and test processes, system components, commercial arrangements and customer propositions to unlock EV flex through smart charging.
NIA	ENWL - Demand Scenarios with Electric Heat and Commercial Capacity Options	Apr 2015	Oct 2016	£500k	Elec	✔						Investigate the impact that heat pumps have on the distribution network – load growth scenarios and prioritisation of network reinforcements.

*SE = stakeholder engagement

Relevant UK Network Innovation projects

Projects similar to MADE (2/5)

Project types:	Project lead and name	Start date	End date	Value	Gas / Elec	Technologies: HP	EV	PV	Storage	DSR	SE*	Brief overview
NIA	SPN – Evolution	Dec 2015	Dec 2019	£2.4m	Elec		✔		✔	✔	✔	Demonstrate how operating a localised balancing market can reduce customer bills through efficient provision of services and optimised network performance while facilitating cost effective growth in local generation, demand side response and energy storage services.
LCN	LCNF – Customer-Led Network Revolution	Jan 2011	Dec 2014	£53m	Elec					✔		Assess availability of emerging and future customer flexibility to help avoid network investment. Calculating the cost of this flexibility.
NIA	ENWL – Electricity and Heat	Jul 2016	Aug 2018	£545k	Elec	✔						Assessing benefits for a Distribution Network Operator and their customers that can be derived from improved energy management.
NIA	WPD & WWU – (FREEDOM) Flexible Res. Energy Eff. Demand Optimisation. and Management	Oct 2016	Jan 2019	£5.2m	Elec & Gas	✔				✔	✔	Investigating if hybrid heating systems are technically capable, affordable and attractive to customers as a way of heating homes.

*SE = stakeholder engagement

Relevant UK Network Innovation projects

Projects similar to MADE (3/5)

Project types:	Project lead and name	Start date	End date	Value	Gas / Elec	Technologies						Brief overview
						HP	EV	PV	Storage	DSR	SE*	
NIA	WPD – CarConnect	Apr 2016	Oct 2019	£5.8m	Elec		✔				✔	Using smart chargers and substation monitoring to understand the effects of electric vehicle charging on LV networks across different levels of penetration. Development of a network assessment tool to help assist with calculating the impacts of a mass EV roll out.
NIA	NPG - Vehicle to Grid (V2G) - the network impact of grid-integrated vehicles	May 2017	May 2020	£250k	Elec		✔				✔	Assess the network impact and the potential for network support of V2G during constraint periods. Produce a design assessment process for V2G connections based on technical findings, customer behaviour and business model considerations.
NIA	WPD – LV Connect & Manage	Apr 2016	Apr 2019	£1.7m	Elec	✔	✔	✔ **				Demonstration of the active network management (ANM) of LCTs (energy storage & electric vehicles) by controlling load profiles and alleviating network constraints. Development of a replicable architecture for LV ANW. Development of novel business processes for deploying ANW to LV networks.

*SE = stakeholder engagement **not necessarily solar PV – includes all LCTs

Relevant UK Network Innovation projects

Projects similar to MADE (4/5)

Project type:	Project lead and name	Start date	End date	Value	Gas / Elec	Technologies						Brief overview
						HP	EV	PV	Storage	DSR	SE*	
IFI	SSE – Vehicle to Grid	Jan 2013	Jan 2013	£653k	Elec		✔					Investigate the potential of battery-powered vehicles, EVs, to use their excess battery capacity to provide power to the grid in response to peak load demands.
LCN Fund Tier 2	WPD – SoLa Bristol	Dec 2011	Jan 2015	£2.5m	Elec				✔	✔		Explores the effects of low carbon technologies on the LV network. Investigates if DC networks within properties can be used to help combat some of the issues. The project also looks at how to spilt the benefits of domestic battery storage.
Mostly NIC	SPEN - FUSION	Jan 2018	Dec 2022	£5.7m	Elec					✔		Create a smart energy, online platform which will allow customers to trade their electricity supply and demand capacity. Investigate a range of commercial mechanisms to encourage flexibility.

*SE = stakeholder engagement

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Relevant UK Network Innovation projects
Projects similar to MADE (5/5)

Project type:	Project lead and name	Start date	End date	Value	Gas / Elec	Technologies						Brief overview
						HP	EV	PV	Storage	DSR	SE*	
NIA	WPD – Electric Nation	Apr 2016	Oct 2019	£5.9m	Elec		✔			✔		Predicting parts of the LV network susceptible to EV penetration. Determining if EV demand control and vehicle to grid (V2G) services can be used to avoid or defer reinforcement. Monitor LV networks to detect EV charger installation growth. Deploy demand control and V2G solutions as soon as EV induced LV network stresses arise.
Mostly NIC	SSE - TRANSITION	Jan 2018	Jun 2021	£15m	Elec							Develop and demonstrate a Neutral Market Facilitator (NMF) Platform to test the operation of the market models being produced by the ENA Open Networks Project.

*SE = stakeholder engagement

Relevant UK Network Innovation projects

Project similar to MADE

There are a number of projects that have similar elements to MADE however there are no projects that address the cross-vector optimisation at a household level.

Overall project similarity
The UKPN Urban Energy Club has a similar focus on overall demand response and accessing value from flexibility streams. However, this project does not consider EVs or load optimisation and network effects.

The SPN Evolution project has reasonable overlap with MADE due to its focus on accessing value streams from operating a local balancing market. However, the focus is on market design and not energy asset interaction and optimisation. The project does also not consider EVs and PV. SPEN EVOLUTION also has similarities but is focused on the platform needed to facilitate end-user DSR participation.

The WPD FREEDOM project had a lot of similar aims to MADE, however, the focus here was purely on hybrid heating systems.

The WPD LV Connect & Manage project while looking at HPs, EVs and other low carbon technologies, the focus is on the low to medium voltage network and how to actively manage the network to deal with these types of loads. There is no household level focus.

WPD SoLa Bristol is similar to MADE in that it investigates numerous low carbon technologies. However, the project didn’t cover EVs and heat, or go into detail around household level optimisation and cross vector switching.

Electric vehicle specific projects:
The UKPN Shift, NPG Vehicle to Grid and SSE Vehicle to Grid projects all investigate to varying levels the potential impact of EV charging and V2G on the grid. In this sense they are similar to just the EV aims of MADE – but do not cover the other household assets.

Technology Forecasts

Air Source Heat Pump (ASHP)
Hybrid heating system (HHS) – ASHP with gas boiler
Solar PV
Energy storage
Electric Vehicles (EVs)

Technology forecasts overview

Summary of main factors and trends for each technology forecast 1/2

Fairly strong growth in the sales of all low carbon heating technologies is expected in the medium to long-term. This is necessary for the UK to meet its carbon targets.

Air Source Heat Pumps (ASHPs)

- The future success of AHSPs depends on policies to back up the Government's ambition to end fossil fuel heating in new homes.
- Without a replacement for the Renewable Heat Incentive (which is due to end in 2021), the life time cost of owning a heat pump will remain more expensive than gas boilers and are unlikely to be attractive to customers.
- The success of ASHPs relies on business models which can bring forward the cost parity compared to gas boilers.

Solar PV

- Despite the ending of new applications to the Feed-in tariff in 2019, solar PV is expected to increase.
- Increase is likely to be driven by falling cost of solar technology, and advances in technology.
- The greatest uptake are expected to occur if companies can successfully combine solar PV and storage technology to promote self-consumption.

Domestic storage systems

- Short-term growth of domestic battery system sales is uncertain.
- The net effect of the Smart Export Guarantee (SEG) on the residential storage market is likely to be negative.
- Innovative business models are creating additional value streams for storage in the UK.
- Climbing electricity prices, especially during times of peak demand, coupled with real-time electricity prices will be the main driver of growth in the market post 2025.

Technology forecasts overview

Summary of main factors and trends for each technology forecast 2/2

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Hybrid Heating Systems (HHSs)

- Future uptake of HHSs depends on the success of other low carbon heating technologies. HHSs are a good option to fill the gap in scenarios where:
  - ASHPs are not suitable in isolation in existing homes,
  - district heating networks do not become widespread in urban areas, and
  - supply of hydrogen is not sufficient for high penetration of pure hydrogen boilers
- In Delta-EE's view, in agreement with the Committee on Climate Change's predictions, HHSs are likely to be a key technology for existing homes – the retrofit market.

Electric cars

- A large increase in penetration of electric cars is expected to take off in the late 2020s and early 2030s.
- This large uptake will be driven by policy ambition to ban the sale of fossil fuel cars in 2040 (Scotland by 2032), increasing efficiency / CO_2 standards, and movement of major car manufacturers to producing mainstream electric cars at ever decreasing cost.
- Two thirds of UK homes with access to garage or off-street parking are likely to have charge points in the home, but other innovative business models for charging are likely to emerge, as well as car share options.

Air Source Heat Pump Technology forecast

Assumptions / Sensitivities for Technology forecast

The forecasted uptake of heat pumps depend on predictions of the regulatory and economic environment.

Regulation and subsidies

Heat pump uptake will be boosted by stronger building regulations on permitted heating technologies or minimum efficiency standards. For example:

- UK government announcing end of fossil fuel heating in new build homes
- Consultation on electrification of off-gas homes

The current subsidies for low carbon heating technologies are due to stop in 2021. Without replacement, heat pumps remain a far more expensive technology compared to gas boilers and we are likely to see a reduction in uptake of heat pumps.

Energy prices

If gas prices increase and/or electricity prices decrease, heat pumps become more favourable. We see no indication of a major change in prices out to 2025.

Electricity price decreases may be via greater availability of time of use tariffs; with the right control and storage, heat pumps could be powered by cheap off-peak electricity

Air Source Heat Pump Technology forecast

Assumptions / Sensitivities for Technology forecast

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The forecasted uptake of heat pumps also depends on competition between different types of heating systems.

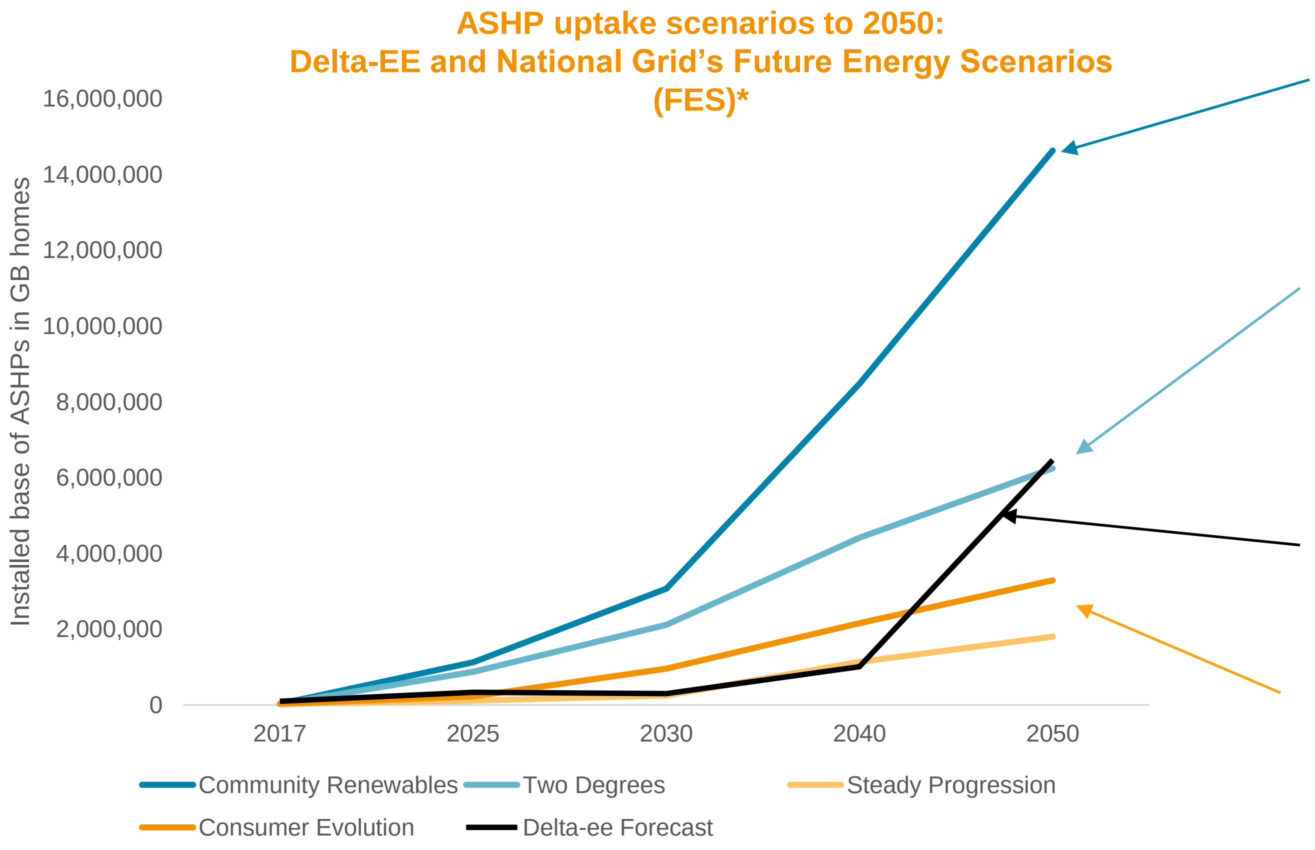
Pure electric heat pump vs Hybrid heating system
The forecasts for uptake of ASHP and HHS depend to some extent on outcome of the competition between pure electric heat pumps and hybrid heating systems:

- **New-build houses vs retrofit:** Currently it is expected that pure heat pumps will be best suited to new-build houses and hybrid heat pumps are suited to retrofits. ASHPs are also being prioritised to replace high carbon fossil fuel heating in off-gas homes.

- **The role of hydrogen in future heating:** The future availability of hydrogen will dictate whether hybrid heating systems are a transition technology - an intermediate steps between gas and pure electric heat pumps - or if they are a low carbon heating technology themselves. The UK Committee on Climate Change (CCC) Hydrogen in a low-carbon economy report championed hydrogen for hybrid heating systems. Conversely, research for the European Climate Foundation (2019) found that extending the use of hydrogen for heating would be 35% more expensive than smart electrification and a focus on thermal efficiency.

Air Source Heat Pump Technology forecast

There is large variation between the forecasts for uptake of ASHPs out to 2050.



Decarbonisation of heat is achieved through improved thermal efficiency. Heat pumps are the dominant domestic heating technology.

Greater penetration of hydrogen and district heating in densely populated areas sees lower uptake of heat pumps.

An early increase in uptake reduces due to ending of the RHI subsidy. Hybrid heating systems are a favoured technology over pure ASHPs in late 2020s. Stronger regulations in 2030s and 2040s drives increase in uptake, including assumption that gas boilers are banned in 2040s.

Limited progress towards decarbonising heat. Current heating technologies remain dominant and there is limited uptake of heat pumps.

* Delta-EE and FES scenarios are explained in the Appendix

Hybrid heating system Technology forecast

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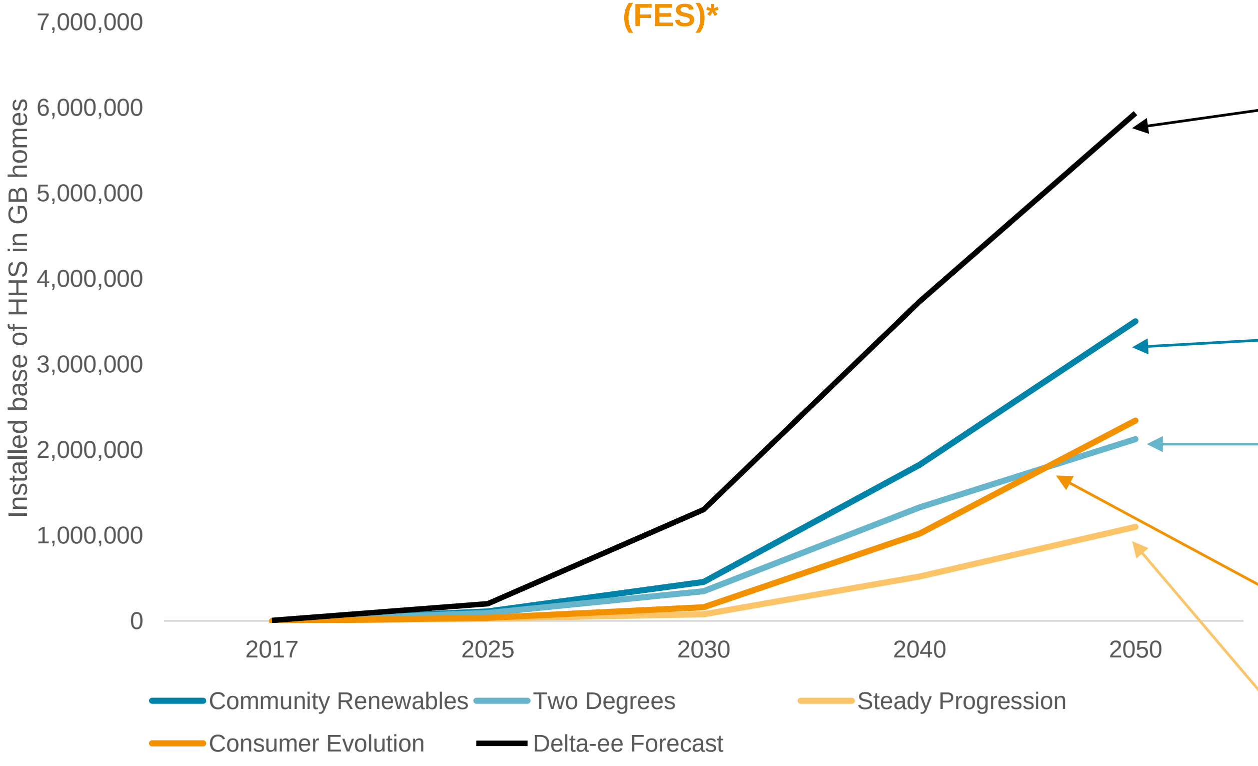
All scenarios show a sharp increase in the uptake of HHSs after 2030, but vary in how big this uptake will be. HHS are not seen as a dominant heating technology in any of the FES scenarios.

HHS uptake scenarios to 2050: Delta-EE and National Grid's Future Energy Scenarios (FES)*



Our Delta-EE scenario is higher than any of the FES scenarios and is based on the assumption that HHSs will be the technology of choice in retrofit homes instead of ASHPs. It also assumes decarbonisation of gas grids through hydrogen as promoted by the CCC.

10 bcm of green gas being produced per year in 2040s (including green hydrogen generated at times of excess renewable electricity supply), but ASHPs are the main technology choice in retrofit as well as new homes.

Greater focus on regional hydrogen networks sees pure hydrogen boilers (10m by 2050) as the focus instead of HHSs. District heating systems are also a focus in urban areas (3m connections in 2050).

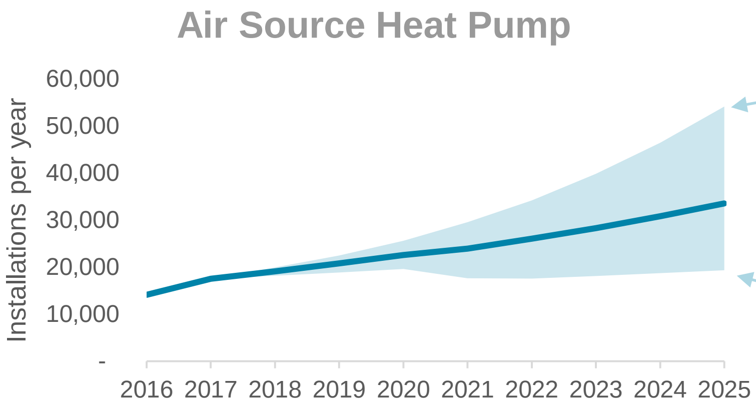
HHSs are a key technology choice for decarbonising heating of homes on the gas grid, although gas is still methane and ambition is low for decarbonising heating..

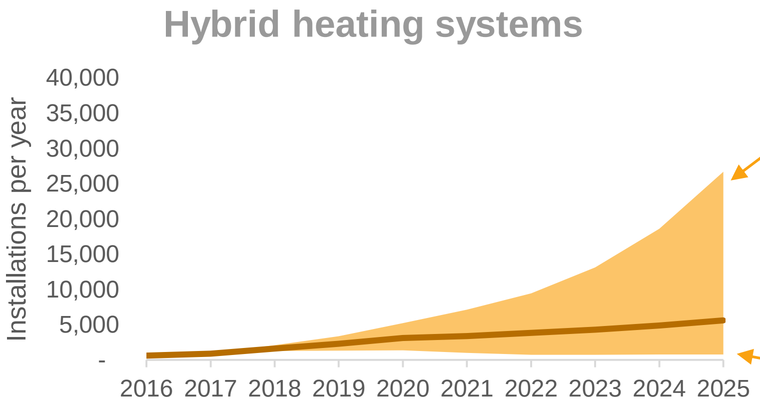
Priority is for district heating networks rather than HHS installations.

* Delta-EE and FES scenarios are explained in the Appendix

Delta-EE mid-term forecasts for heat pump installations

Delta-EE forecast installations of heating systems out to 2025. Our forecasts show a wide range between our central forecast and high and low scenarios.





Solid line shows central forecast. Shaded area shows the region between our high and low scenarios

High growth at ASHPs if:
- Building regulations favour heat pumps in new builds;
- Policy support is strengthened beyond 2021;
- Consumers are attracted by business models focussed on overcoming upfront cost of heat pumps (e.g. Heat-as-a-Service) in the shorter term
- More energy suppliers introduce time-of-use tariffs.

The ASHP market could stall if:
- An economic downturn after the UK's exit from the EU hinders growth;
- No subsidy scheme replaces the Renewable Heat Incentive after 2021;
- Oil and gas prices remain low and electricity costs continue to rise.

Growth of hybrid heating systems could be significantly higher if:
- The CCC backing hybrids encourages large retrofit projects;
- Companies begin offering Heat-as-a-Service packages based on Assignment of Rights;
- Building regulations make it necessary to include renewables in new builds towards 2025; and
- The market mechanisms for Demand Response applications emerge before 2025 and more energy suppliers introduce time-of-use tariffs.

The hybrid market could stagnate if:
- Developers choose alternatives such as solar PV to comply with building standards;
- No subsidy scheme replaces the Renewable Heat Incentive after 2021.

Solar PV Technology uptake scenarios

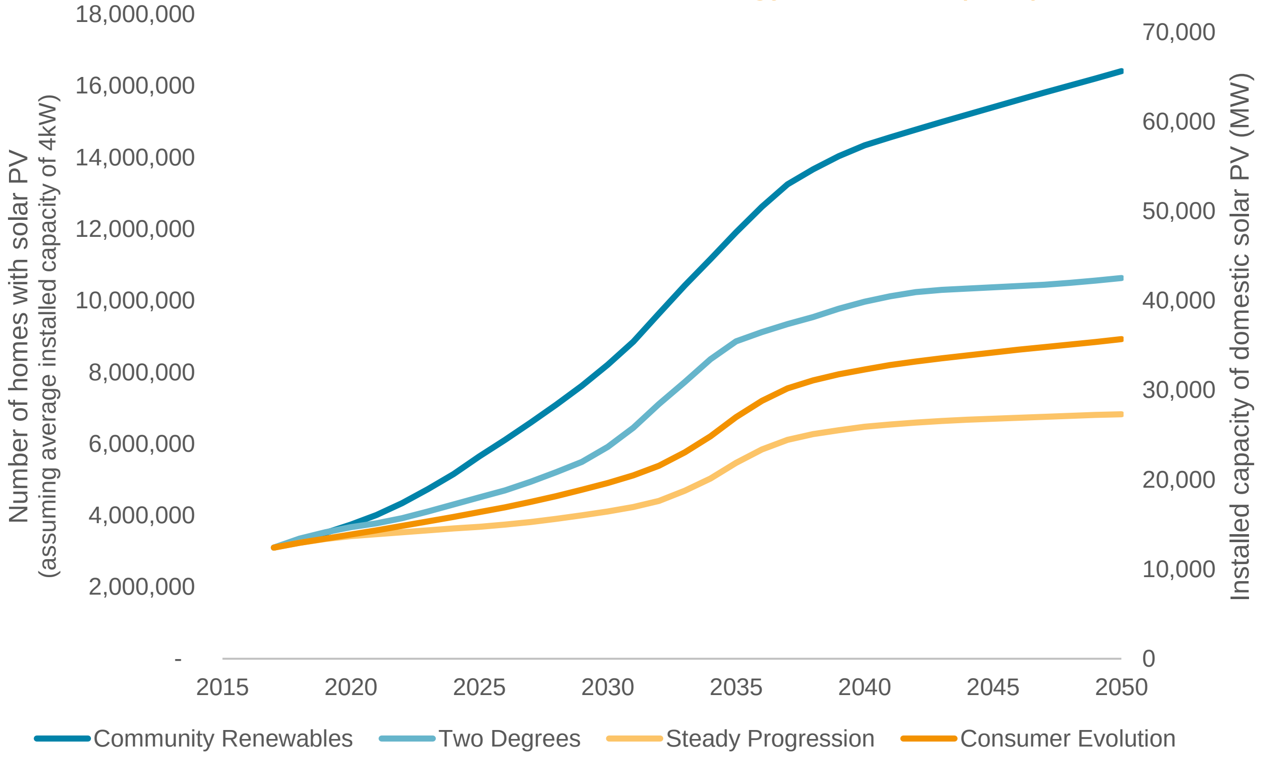
Solar PV continues to grow in all scenarios out to 2050, but the pace of growth varies between scenarios.

Despite new applications for Feed-in-tariffs ending in 2019, domestic solar capacity is expected to continue to grow. This growth is driven by falling cost of solar technology, and advances in technology in both efficiency and materials solar PV can be embedded into. Fastest growth is expected where there is co-location with storage, allowing for greater self-consumption.

In all FES scenarios, there is a step up in growth which is the point of cost parity - where solar generation is cost effective. The scenarios vary in when this will occur (2020 in Community Renewables to early 2030s in Steady Progress and Consumer Evolution) and it will depend on business models available which promote solar PV installation.

The rapid uptake in the Community Renewables scenario is based on expected take up of business models combining solar PV and storage.

Domestic Solar PV uptake scenarios to 2050: National Grid's Future Energy Scenarios (FES)*



* FES scenarios are explained in the Appendix

Domestic battery storage forecast

UK residential storage market installed base is currently 16,300 units (61.5 MWh), and could reach anywhere from 300,000 – 1,000,000 units by 2050.

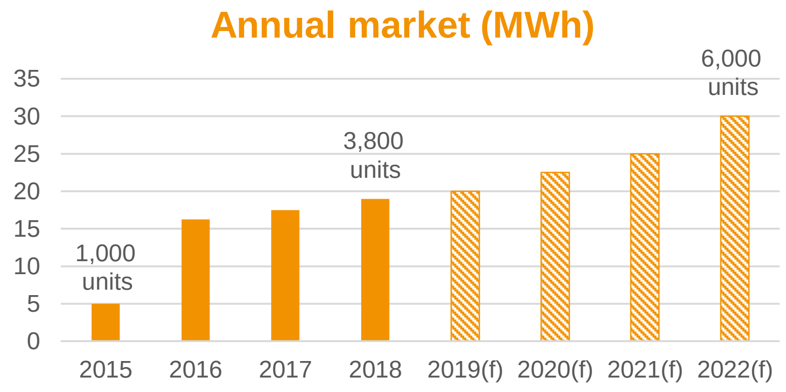
10% of new PV systems came with storage in 2018

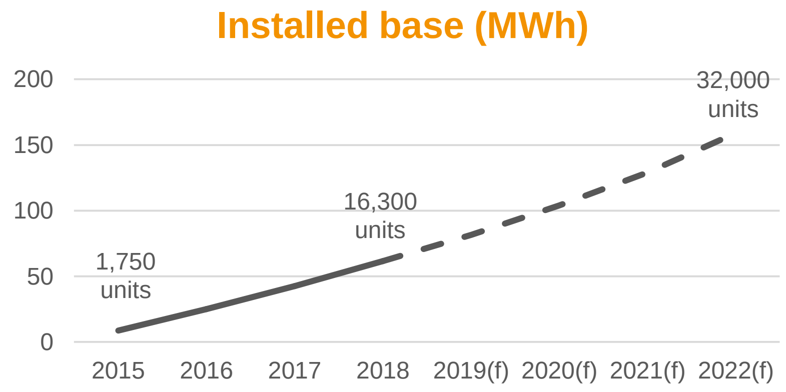
Short-term growth is uncertain. In July 2018 the UK Government announced that the Feed in Tariff (FiT) subsidy for small-scale generation will end on 31st March 2019. The replacement scheme – the Smart Export Guarantee (SEG) – is still being finalised, but will be a tariff set independently by energy suppliers and tied to half-hourly data from smart meters.

The net effect of the SEG on the residential storage market is likely to be negative. The SEG is not expected to exceed the previous export tariff and self-consumption will become a key driver for PV customers. While the proportion of PV systems including storage will increase, opportunities to upsell storage will reduce as the PV market shrinks.

Innovative business models are creating additional value streams for storage in the UK

Climbing electricity prices, especially during peak demand, coupled with real-time electricity prices will be the main driver of growth in the market post 2025. This will make the economics of self-consumption more attractive.





Electric Cars technology uptake scenarios

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The uptake of electric cars in the future will depend on the how many households have a car and the proportion of cars that are electric.

The overall trends in car ownership are disputed

Some predict car ownership will continue to increase due to increasing population estimations and reduced cost to buy a car, in particular with the increasing popularity of car leasing options.

However, many are predicting that private car ownership will decrease due to mobility shifting to car sharing, demand-responsive private hire car providers (such as uber and Lyft) and greater availability of fully automated cars after 2030, especially in cities.

Neither of these overall trends are featured strongly in the zero-growth approach of the National Grid Future Energy Scenarios (FES) shown on the next page.

The number of domestic charging points is likely to be limited to the estimated two-thirds of dwellings who have access to a garage or other off-street parking (data for England, ref: English Housing Survey 2010). This would be 16 million dwellings across the UK.

Future predictions are that electric vehicles will replace petrol and diesel internal combustion engine cars.

This is shown in all 4 of national grid's FES scenarios (see next page).

This transition to electric cars will be a combination of:

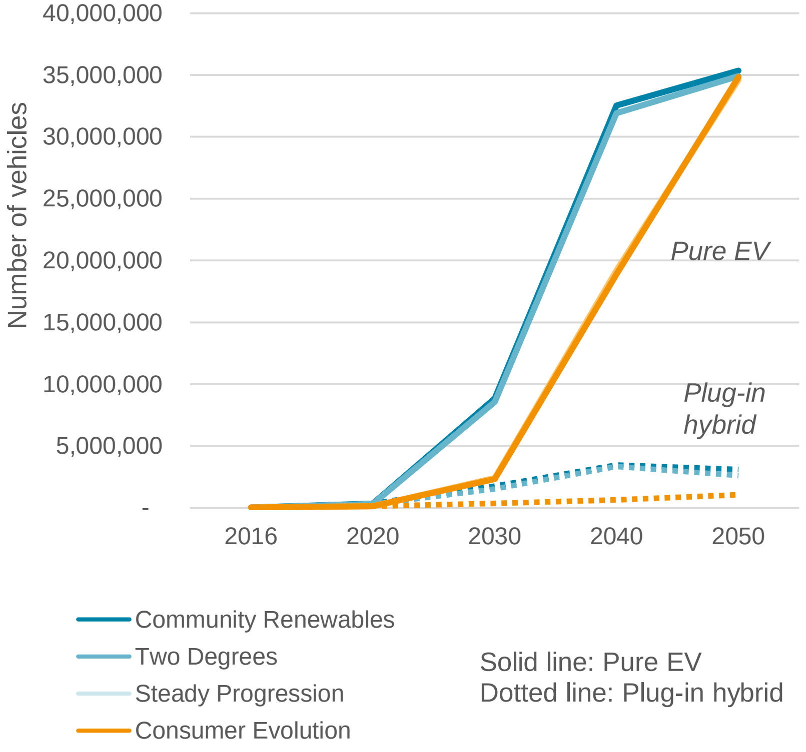
- Policy push:
  - The UK government announced "it will end the sale of all new conventional petrol and diesel cars …by 2040" and The Scottish Government committed to "remove the need for petrol and diesel cars and vans on Scotland's roads by 2032".
  - Mayor of London is tightening restrictions in central London in ultra low emission zones
- Industry leading the way:
  - All major car makers have announced plans to make their cars electric
  - Some are planning to release electric versions of all of their cars while others have said they are going to develop a new range of EVs

Uptake of Electric cars

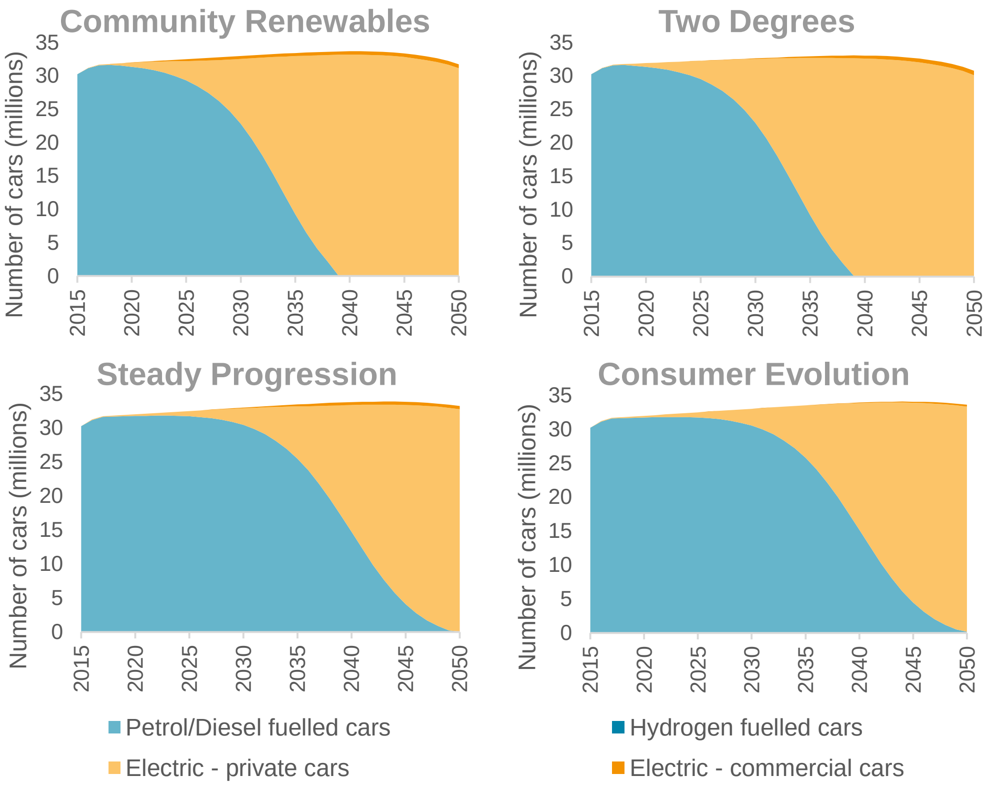
National Grid's Future Energy Scenarios predict the total number of cars to remain fairly constant, with differences in when mass adoption occurs.

In all scenarios, the entire UK vehicle fleet is >99% electric by 2050

Electric vehicle uptake scenarios to 2050 (pure EV and plug-in hybrid): National Grid's FES scenarios*



Breakdown of car fuel type and ownership: National Grid's FES scenarios*



* FES scenarios are explained in the Appendix

Technology forecast conclusions

High level takeaways

There will be a rapid uptake of low carbon technologies, under almost any scenario, starting from the late 2020s into the early 2030s.

Starting from the mid 2020s there will be a significant shift in the way homes are heated and the fuels used for transport. Under all scenarios, even the most conservative, by 2050: over 99% of cars on the road will be EVs, there will be over 3 million heat pumps installed in UK homes, and there will be over 6.5 million domestic PV installations.

The number of domestic battery storage installations will grow as well, alongside the rise in solar PV installations. This presents an opportunity for homeowners to self consume the energy they generate

The rapid rise in the installed base of the above technologies will result in a substantial rise in the demand for electricity.

Domestic PV combined with storage as well as smart charging may present an opportunity to reduce impacts on the grid. There is also a role for hybrid heating systems to help reduce the load on the grid at peak times by shifting heating demand from the electricity grid to the gas grid.

There are a lot of uncertainties, for example, around the role hydrogen will play and if the necessary government incentives are put in place. However it is certain that the electricity grid will play an increasingly important role in the future of the energy system as a pathway to decarbonisation. Demand and export of electricity at the household level (low voltage network) is set to grow immensely in the medium to long term.

Customer research

Existing customer research insights:

- **BEIS Public Attitudes Tracker**
- **FREEDOM project customer insights**
- **Delta-EE Research Services past customer research**

Primary customer research carried out for MADE

Customer research

Past and current customer research relevant to MADE

There is a lot that can be learnt from new and existing customer research that can help with modelling the MADE concept and business model development.

Overview

Customer research provides valuable insights into how customers view certain technologies and propositions. Good customer research helps build a solid foundation for developing new technologies and propositions as it helps uncover current levels of understanding and customer needs.

Past customer research

There is a wealth of past customer research to draw on that will help build an understanding of how customers perceive the technologies and issues relevant to the MADE project. The customer research covered in this section, and the reason why it was covered, include:

- BEIS Public Attitudes Tracker. This is the most comprehensive survey of its kind covering UK adult's perceptions of their energy supplier, energy needs, heating appliances and other LCTs.
- Outputs from the FREEDOM project. This project also involved HHS, and gained insights into issues around shifting people away from traditional gas boilers and their experiences of using a HHS.
- Delta-EE's past customer research from our Heat Insight Service and Gas Heating Service. This research helps understand how people want to heat their homes, thoughts on heating system efficiency, smart controls.

New customer research:

Some of the past research is slightly out of date and/or does not focus specifically on issues facing the MADE project. Therefore as part of the MADE project new primary customer research was conducted, via an online survey with 750 respondents. The respondents included owners of both solar PV and electric vehicles (EVs) – both customer segments that are relevant to the MADE project.

Existing customer research

BEIS Public Attitudes Tracker

Most homeowners are happy with their current energy suppler and trust them to give them a good deal. The majority of people pay attention to their energy demands.

The BEIS Public Attitudes Tracker (PAT) is regarded as a high quality, representative sample of the views of UK adults. The PAT collects data on public attitudes towards BEIS's policy areas such as energy, climate change, employment and consumer rights. The PAT started in 2012 and has since been run 4 times a year, with data being collected via face-to-face in-home interviews with approximately 4,000 households in the UK. The survey aims to collect the views on a representative sample of UK adults (16+). The latest survey results are from March 2019.

Trust in energy suppliers:
There is a split between people who trust and who don't trust their energy supplier. There are also some inconsistency in people's views towards their energy suppliers.

15% of people switched energy suppliers in the last year. Of those that didn't switch – ¾ said that this is because they are happy with their current supplier and ~10% due to the associated hassle.

40% of people trust their energy suppliers a lot / a fair amount to provide them with impartial information. 53% of people have little trust, or no trust at all, in their energy supplier to provide impartial information. However, seemingly in contradiction to this, 56% of people said they trust their energy supplier to give them a 'fair deal'.

Saving energy:
79% of people pay a lot/ a fair amount of attention to saving energy at home. Whereas 21% of people say that they little attention to saving energy at home. Two-thirds of people pay attention to the amount of *heat* they use. The primary motivator behind this was to reduce their home heating bills.

Existing customer research

BEIS Public Attitudes Tracker

About half of UK adults are aware of low carbon heating appliances, although specific awareness of heat pumps is low and people are unsure of their performance.

Awareness of low carbon technologies
Just over half of people are aware of low carbon heating appliances, with 52% of adults having some awareness of renewable heating systems (including HPs, biomass, solar etc). The following results apply only to this 52%:

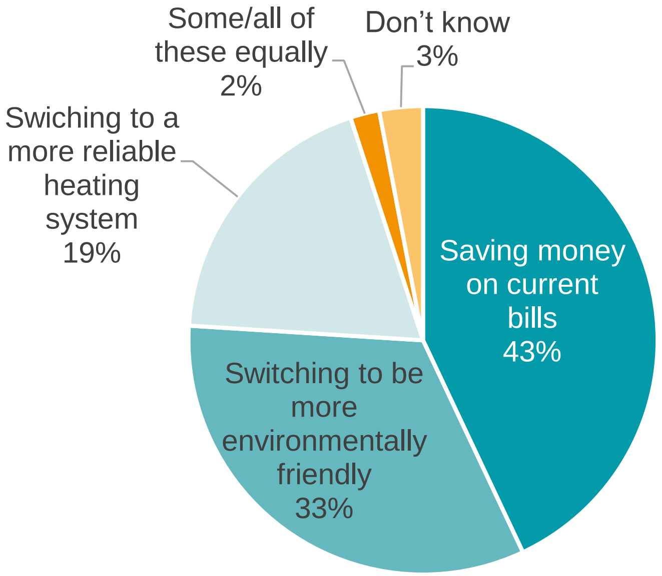
- Half have some awareness of ASHPs specifically. Of those that said that they know a lot or a little about ASHPs, 86% said it is unlikely that they will install one in the next few years. 40% cited cost as the main reason for this, and roughly equal proportions (13% each) citing issues of physical limitations, hassle and lack of knowledge.*
- Roughly half believe renewable heating systems are too expensive to install, versus 35% that are unsure.
- 41% think that renewable heating systems are cheaper to run. 42% are unsure whether they are cheap
- About half don't have an opinion on whether their home would be better heated by a renewable heating system. This is compared to 16% of people that think renewable heating systems would heat their homes better and 18% that think they would not.
- 24% think that renewable heating systems are at least as reliable as conventional heating systems. 53% are unsure how reliable they are and 13% think they are less reliable.

*excluding those that don't own their own homes

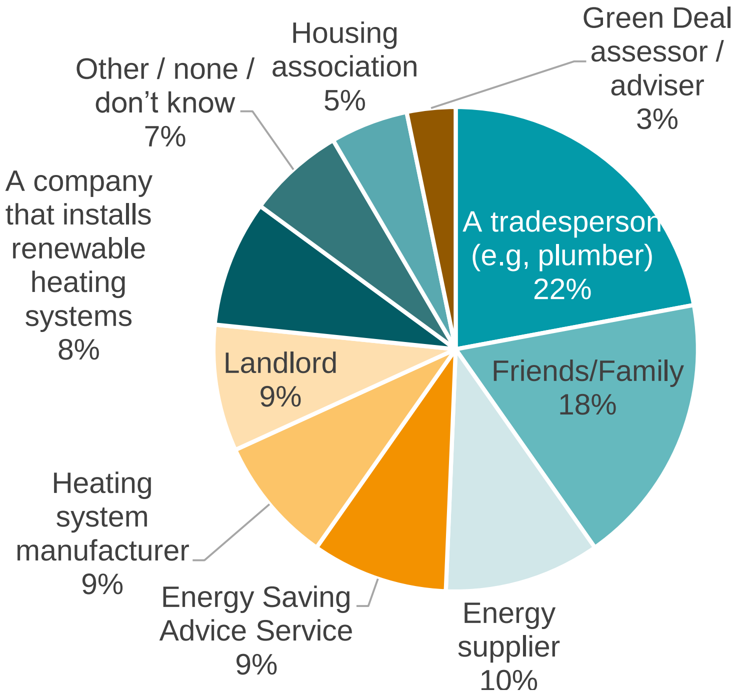
Existing customer research
BEIS Public Attitudes Tracker

Most people will only change their heating system when it breaks. Saving money is the primary driver behind those considering early replacement.

Two thirds of people said that they would only change their current heating system when it breaks. 12% said that they would be open to changing their heating system before it breaks. The chart below gives the reasons as to why they would consider early replacement:



The following chart shows the results of the question *'Which of the following would you trust to provide advice about which heating system to install in your home?'*:



Existing customer research

FREEDOM project customer research

Shifting people away from their (cheap) gas boilers will be a challenge mainly for financial reasons.

Customer research results from the FREEDOM project are based on three separate surveys of the 75 trial participants in the project.

The FREEDOM project investigated if hybrid heating systems are technically viable, affordable and attractive to customers as a way of heating homes. As part of the project, hybrid heating systems (HHS or hybrid heat pumps) were installed in 75 homes. As part of the project customer research with the trial participants was carried out. Conclusions arising from the three lots of customer research as reported in the FREEEDOM report are provided below.

Customer expectations

- Shifting customers away from their existing heating system (mostly gas boilers) will be a challenge - customers are overwhelmingly positive about their existing heating system.
- Financial motivations were the main reason for joining the trial, customers liked having “free” equipment, and expected to save money on their energy bill.
- There is an awareness gap for HHS – HHS have high appeal once explained, but, as expected initial awareness is low.
- Respondents claimed to have a good understanding of both the project goals and the objectives – this indicates the pre-trail information was high quality and well explained.

Existing customer research

FREEDOM project customer research

The hybrid heating systems performed well in the trial and customers were satisfied. Ease of use, comfort, reliability and upfront and running cost were valued most.

Customer experiences

- The initial customer experience of HHS were very positive. Reassuringly systems performed well on comfort but customers were uncertain about potential running cost savings.
- There were a high number of 'operational problems' reported but a majority of these were easily dealt with to a high standard. Some of the faults were the result of customers not understanding how to use the system properly.

Customer attitudes and appeal towards the hybrid heating system

- Overall participant satisfaction remained consistently high throughout the trial. A majority of respondents would be likely to recommend a HHS to a friend
- Ease of use, comfort, reliability and upfront and running cost are the primary aspects of a heating system which customers value. The HHS performs well with respect to ease of use and comfort provided but the up-front costs and operating costs of HHS today are likely too high for many customers.
- The control app was a top rated feature of the HHS as customers really like the ability to remotely control the system
- The aesthetics of the hybrid heating system should not act as a deterrent to uptake. Although there are minor improvements which could be made to external units, correct placement of the unit was more important.

Existing customer research

FREEDOM project customer research

It is important for customers to have high quality interfaces including easy to use controls / apps. Most people are unaware of the concept of demand side response.

Customer attitudes and appeal towards the controls and the app

- The in-home controls and mobile app were consistently rated highly by customers – both were considered easy to use.
- The in home controls, were not used as frequently as the app. Their main purpose is a secondary control if the app was to fail to connect. However, due to their potential infrequent use, they need to be simple and easy to understand – customers forgot the instruction they received at install.
- The app has been one of the customers favourite features of the HHS. In particular remote control has high appeal.
- Both the controls and the app can play a role in improving customer confidence. They need to provide enough data that reassures customers their system is working correctly without being overly complex.

Customer attitudes to and opinions of DSR and fuel switching

- Overall the respondents were more aware of DSR than a general UK sample, but there is room for improvement. It is likely raising awareness would result in improved acceptance.
- The biggest barrier to DSR is customers feeing confident to trust a third-party to perform DSR. At the moment this is reflected in their strong requirement to maintain ultimate control over the system, and the fact they would prefer a big brand name (like their energy company) to perform it.
- Energy bill savings was the most appealing incentive to allow DSR. Overall it is likely some sort of financial reward would be required for it to be accepted by customers.

Existing customer research

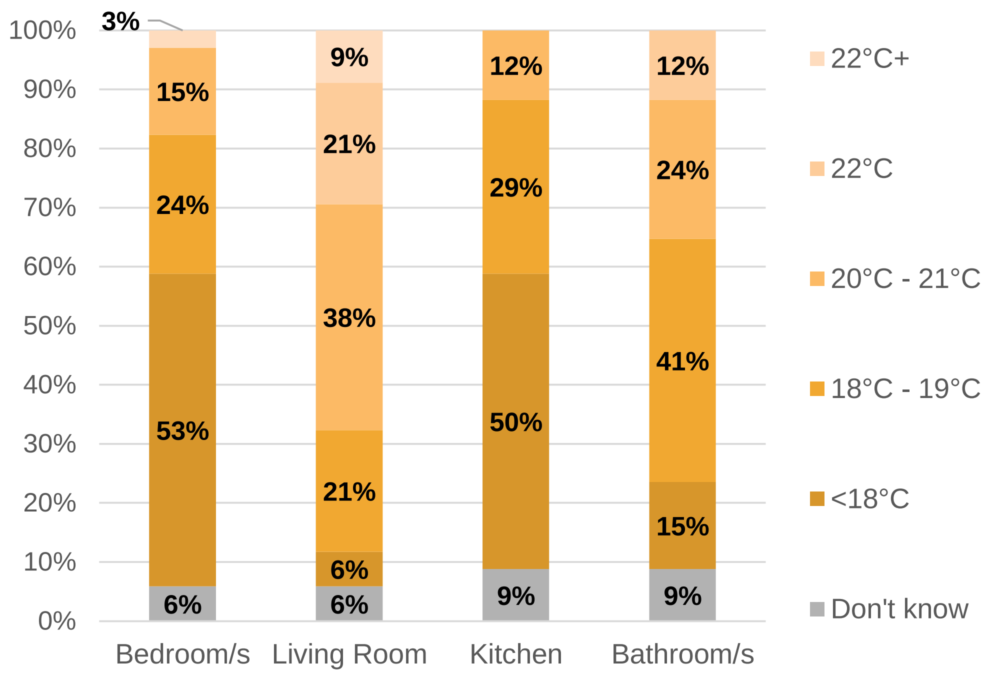
Delta-EE past customer research – HIS 2018

Most homeowners want their homes heated to between 18°C and 22°C, with the warmest temperatures in the living room.

This research is based on a survey carried out in April 2018. It comprised of online research with the Delta-EE Customer Panel. 416 UK homeowners took part. The customer survey analyses customer attitudes towards monitoring the functionality and performance of their heating systems, the information they would like to receive, and willingness to pay for these insights.

Temperature preferences in the home:
The majority of customers (70%+) know how warm they want their homes to be (between 18°C and 22°C), with a very slight preference towards the higher temperatures.

The chart below gives a breakdown of the temperatures preferences for different rooms in the home (n=34):



Existing customer research

Delta-EE past customer research – HIS 2018

Homeowners are not actively concerned about their heating system efficiency and most are unwilling to pay for heating system insights.

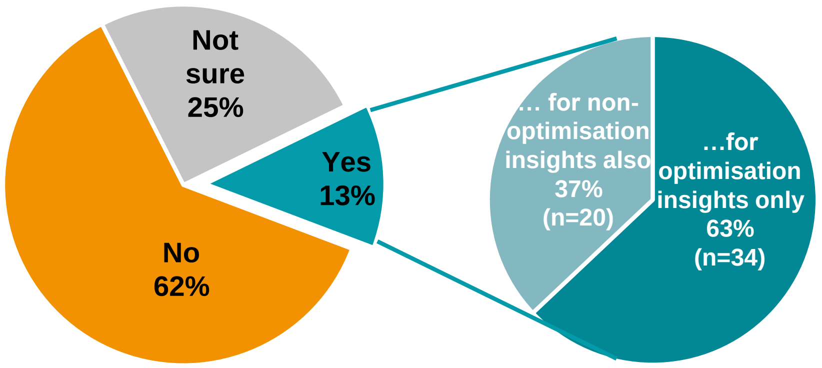
Learning about heating system efficiency:
Customers are unlikely to actively monitor the efficiency or performance of their heating systems, and many (40%) only engage once a year for their annual service.

When asked, 75% of customers want to know more about the efficiency of their heating systems, especially financial information. Wealthier respondents were also more interested in knowing how environmentally friendly their systems were.

Willingness to pay for heating system insights:
Despite 75% of customers wanting to know more, only a tenth of respondents were willing to pay for efficiency information, with a monthly payment of around £5 seen as a reasonable price.

Most customers were willing to pay more for offerings that used customer data to optimise the performance of their heating system than those that simply displayed performance data.

The chart below shows the Willingness to pay for an app/website that uses personal data to make their system run more efficiently (n=416).



Existing customer research

Delta-EE past customer research – HIS 2018 & 2016

Smart controls have broad appeal – especially amongst those that are younger. Financing of new heating systems continues to be a barrier.

Appeal for control capabilities:
Smarter heating control options were appealing to most customers, with a leak-detection app being the most preferred, followed by remote diagnostics and then remote hot water control. Younger customers (16-34 year olds) were more likely to find smart control capabilities attractive than those aged 65+, as were those already familiar with smart devices e.g. smart meters and/or thermostats.

A 2016 HIS customer panel survey* also found that Smart controls and energy storage are stand-out technologies which get customers most excited – controls are a great way to engage customers in energy, especially at the point of boiler replacement and bundling products with a storage option can improve their appeal, e.g. PV plus storage.

Financing
Consistent with findings of today, our HIS 2016 research* concluded that there is a need to develop more creative financing models and novel ways to purchase heat – the survey identified that younger customers are more engaged with a range of technologies, but up-front cost continues to be the critical barrier to uptake among them. Overall, homeowners demonstrated a modest level of engagement with heat.

*Survey was conducted during June 2016, n = 114 UK home owners

MADE primary customer research

Details about the survey

As part of the MADE project, customer research was carried out with 750 UK car owners.

This exclusively commissioned customer research was carried out in order to better understand current views around EV ownership (and usage patterns) as well as third party control of EV charging.

The research was carried out via an online survey during May 2019, with a panel of UK adults that is close to representative of the broader UK population*. The panel contained 52 respondents that own a fully electric vehicle, 57 that own a plug-in hybrid vehicle, 67 that own a hybrid (non plug-in models) and 150 respondents that own solar PV.

Depending on the technologies owned, survey respondents were directed to answer different sets of questions. The maximum number of questions answered by any respondent was 38.

The survey results were analysed and cross-tabulated. The cross tabulation were constructed under the following headings*:

- Vehicle type
- Age
- Gender
- Region
- Area
- House type
- Income
- PV ownership
- Energy supplier switching
- Attitude to the environment
- Attitude towards third party control of charging

The answers to each question were tested for significant differences at the 95% confidence level between the subgroups of the above.

*the full analysed survey results, including the demographics of the respondents and cross-tabulations, are in the 'Analysed Survey Results' Excel file

MADE primary customer research

Survey results, an overview of the main findings (1/2)

Key findings of the MADE customer research are presented here.

EV and solar PV owners are higher income and more engaged
One of the apparent trends in the results is that the EV and solar PV owners tend to be between the ages of 25-49, are more engaged with switching their energy supplier, tend to have higher incomes (over £64k household income /year) and own their own homes. They also tend to live in detached homes. This makes sense as detached homes are more likely to have their own driveway (for EV charging) and more roof space, for putting solar PV panels. The majority are also interested in installing a battery system. When asked about their attitude towards the environment they tend to think they are doing as much as they can to be environmentally friendly.

Those with electric heating are more engaged
Of the survey respondents, 22% said electric heating was their main source of heating.
A higher proportion of those with electric heating (including heat pumps) had a low emission vehicle, particularly a fully electric car. Those with electric heating also switched suppliers more often than any other group.

The laggards
There was a group of respondents, about 10% of the total, that tended to be older (>50), drive petrol cars and not own solar PV. They were not as interested in being green and do not regularly switch energy suppliers. They also had little awareness of heat pumps or smart appliances or heating controls.

MADE primary customer research

Survey results, an overview of the main findings (2/2)

Key findings of the MADE customer research are presented here – detailed findings can be found in the pages to follow.

EV charging

EV charging habits are likely to be highly varied. Evidence seems to suggest that a "little and often" charging pattern will be the preference. The most popular place for charging is at home. Most current EV owners charge their EVs less than 5 hours per session. If forced to allow third party control of their EV charging for the purposes of V2G, EV owners are willing to let their batteries be discharged to a minimum level of 30%. EV owners are mostly very positive about the idea of having an app to help them control their charging.

Third party control

There was lots of concern around third party control of charging and heating systems across all groups. If third party management of assets is to be accepted, people still want to feel as if they are ultimately in control at all times and that the third party is helping them save money.

Comparing the results of this customer research to other sources

The overall findings from this survey are not directly comparable with surveys undertaken with a representative sample of the UK population. This is due to us having set high quotas on electric vehicle and solar PV owners. This has resulted in much more awareness of heat pumps compared to the BEIS PAT (47% awareness versus 25% awareness in BEIS PAT). Another discrepancy can be found in the number of respondents that actively switch their energy supplier. Data from Ofgem and BEIS indicates that ~15 - 20% of homeowners switched their energy supplier in the last year, whereas the survey results indicate that 43% switched their energy supplier in the last year.

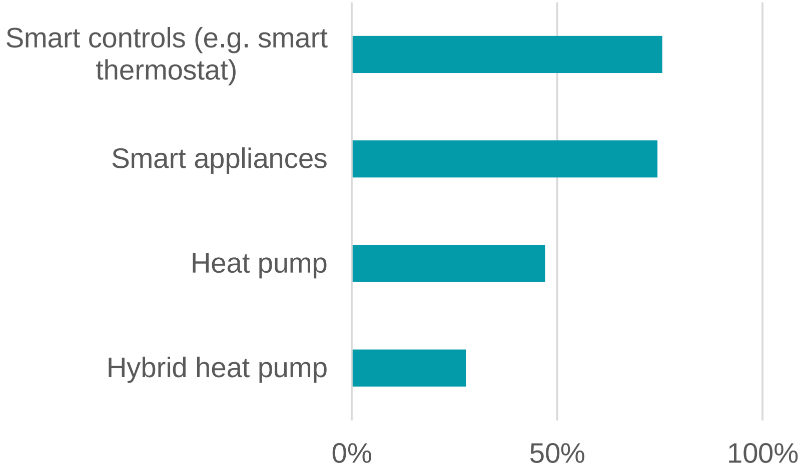
The findings amongst those with no EVs, however, are very similar to findings for the population as a whole.

MADE primary customer research

Technology awareness and views on heat

Awareness of hybrid heat systems is low compared to other smart technologies. Most people pay attention to what they spend on heat to keep costs down.

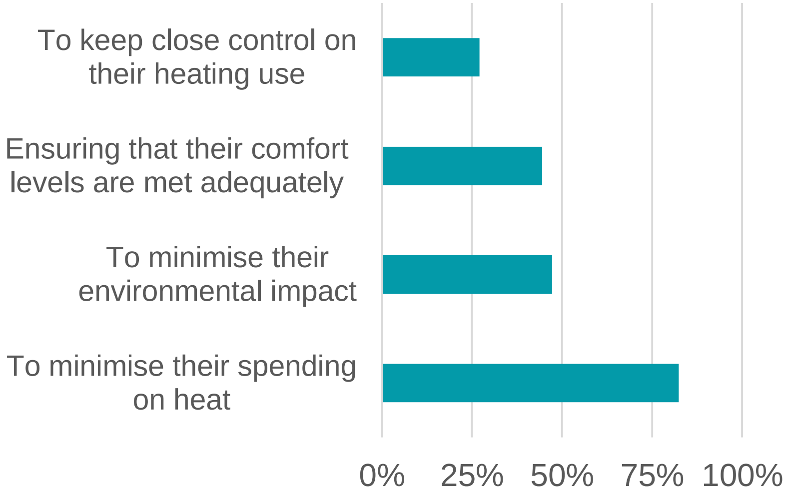
Awareness of technologies
The chart below indicates the awareness respondents had of the different technologies*:



Those aware of the different technologies were significantly more likely to be under 49, and live in a detached house, in London, earn more (over £64k), own PV, switch energy suppliers and are more environmentally conscious.

*those that reported either knowing ‘a lot’ or something

Heat
Only 14% of respondents said they ‘pay not very much or no attention at all’ to the amount of heat they use to heat their homes. For the 85% that pay a lot / a fair amount of attention to the amount of heat they use, reasons given for why this is the case were as follows*:



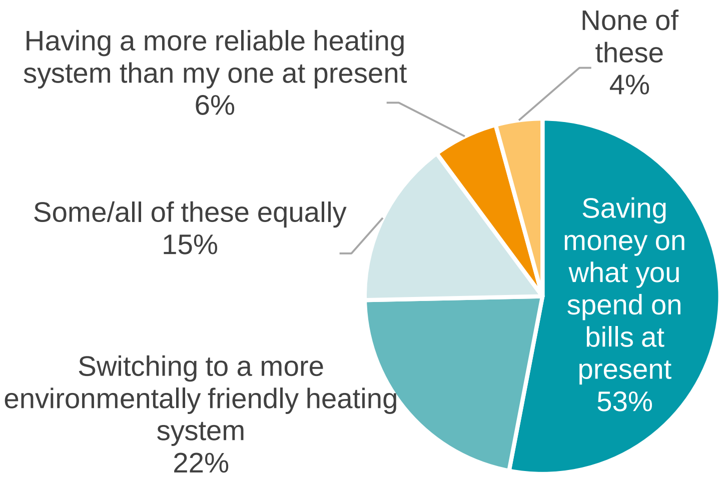
**respondents were allowed to select multiple reasons – therefore the total is greater than 100%

MADE primary customer research

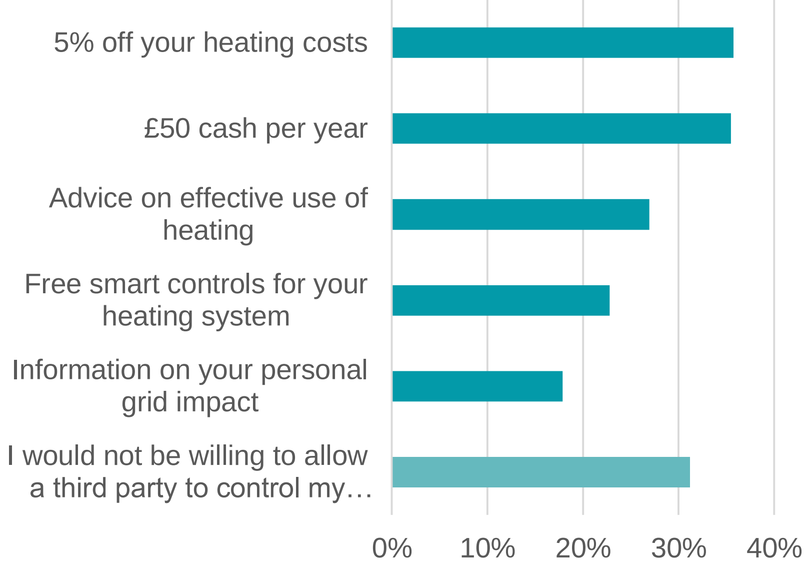
Views on heat and third party control of heating

Saving money / getting money back is the primary consideration when people are changing their heating system or as a motivator behind third party control.

Heat (continued)
The chart below shows that saving money is the most important consideration when people are looking to change their heating system. Being environmentally friendly is also an important consideration for many – these respondents were significantly more likely to be younger, wealthier and more engaged (in terms of energy supplier switching).



Heat and third party control
The following chart indicates the types of incentives that would encourage homeowners to allow third party control of their heating system. Cash back as a cash lump sum or a % off their bill, is the biggest incentive, however, there are a large portion of respondents not willing to allow control under any circumstance.



MADE primary customer research

Solar PV

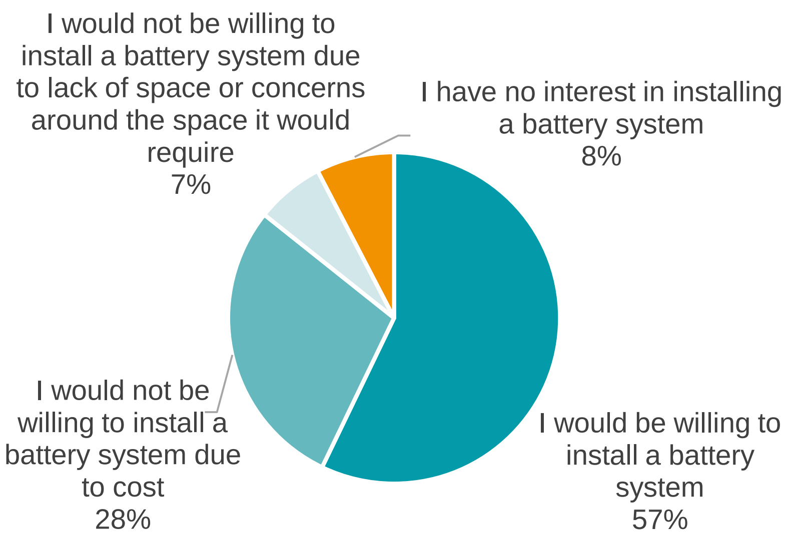
Solar PV owners tend to be wealthier and more engaged with their energy needs. The majority are also interested in installing a battery system.

Of the respondents that own solar PV (150 respondents out of 750), 47% of them are 'very interested' and 21% are 'quite interested' in the idea of maximising their self consumption. Only 4% were 'not interested at all' in the idea of maximising their self consumption. One-quarter of respondents have a battery system installed alongside their solar PV.

In terms of the output of respondent's solar PV installations, the largest group (40%) indicated their installations are 2.5 – 4 kW. The average output across all respondents is approximately 3.4kW.

Those that own solar PV were significantly more likely to live in an urban area, drive a hybrid or fully electric car, earn over £64k/year, regularly switch their energy supplier and consider themselves environmentally friendly.

Of those respondents that don't have a battery installed (113 out of the total 150 respondents with solar PV), when asked whether they would be willing to install one they gave the following responses as indicated by the chart below*:



*Respondents were told that a battery system would cost £4,500 to £8,000 and pay itself back over a period of 7-12 years:

MADE primary customer research

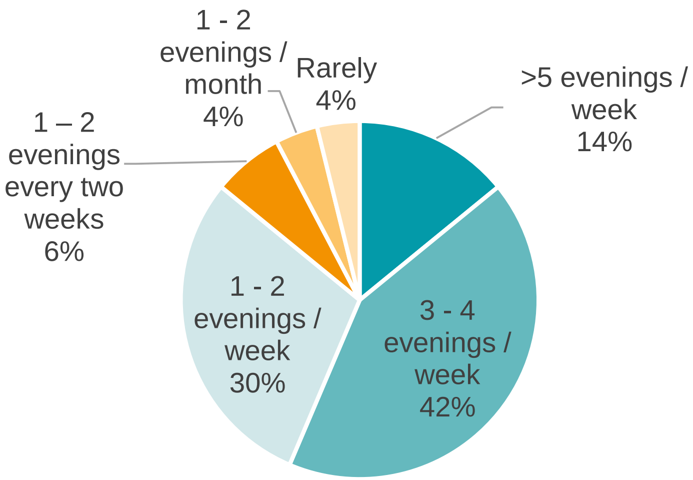
EV owners – evening use of their vehicles

EV owners are younger, wealthier and more engaged. Most EV owners tend to use their EVs at least 3 evenings per week.

Those that own EVs (78 respondents in total that owned either a plug in hybrid or a fully electric vehicle) were generally more progressive than the other respondent groups. They were significantly younger (mostly under 49), have higher incomes (£64k), paid more attention to their environmental impact, are more likely to be open to third party control of their heating system, switch their energy supplier more regularly and own solar PV. EV drivers are also significantly more likely to live in urban areas, particularly London.

Two-thirds of those that own an EV said they use it at least one or more times per day. Those that own an EV and a second or third car, tend to use their EV mainly for social purposes. Those that only own an EV had an even split between business, social and commuting use of their EV.

In terms of the evening use of their EVs, the majority of the EV owners surveyed use their EV 3-4 evenings per week. This is likely skewed by the fact that most EV owners are under 49 – the biggest single group of owners being in the 25-34 category. People may also be more inclined to take their EV to social engagements as a status symbol. The following chart presents the results:

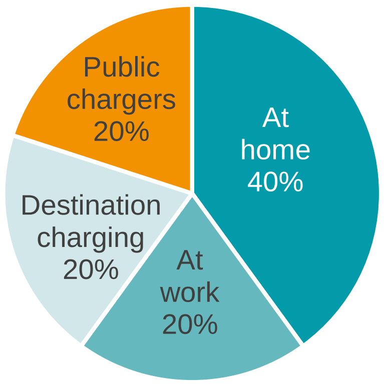


MADE primary customer research

EV charging habits - reality versus expectations

The most popular place for charging is at home.
Most current EV owners charge their EVs less than 2 hours per session.

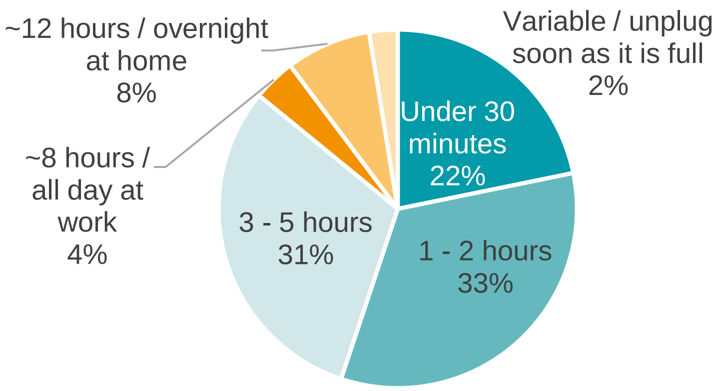
There is some variation between the different respondents in terms of where they currently charge their EVs as expected. The chart below shows the average proportion of their charging that happens in the following locations:



Those who don’t currently own an EV were asked where they think they would be most likely to charge and 67% of them said that they are most likely to charge their cars at home.

In terms of the timing of charging, 47% of EV owners primarily charge their EVs either during the morning, afternoon or evening. Only 23% of respondents charge their EVs overnight. This is in contrast to the non EV owners, where 55% of respondents think they would charge their EV overnight, if they were to own one.

The following chart gives the results of the typical duration of charging sessions across the EV owners:

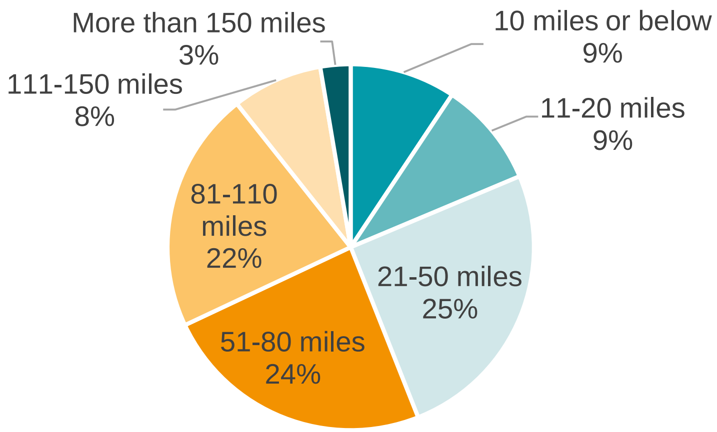


MADE primary customer research

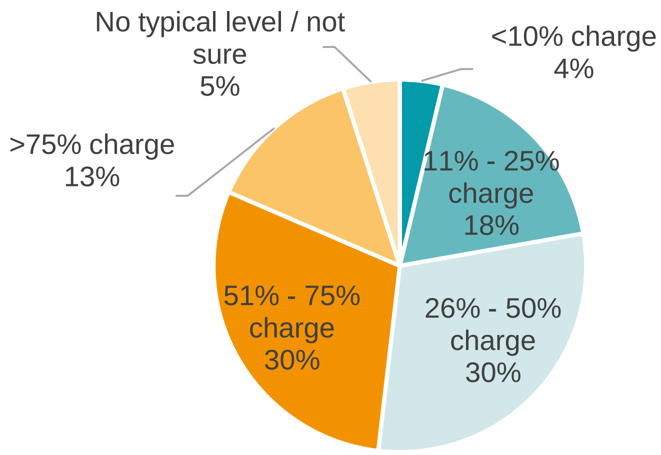
EV owner charging habits

EV charging habits are likely to highly varied. Evidence seems to suggest that a "little and often" charging pattern is the preference.

When EV owners were asked at what point they feel the need to charge their EV batteries given the range they have left, the responses indicate charging will be highly varied. The full responses are charted below and show that 89% of respondents feel the need to charge their EV when the charge level falls somewhere below 110miles, this roughly equates to a battery level of 66% for a new Nissan leaf (40kWh model).



In terms of the typical level of charge EV owners have left at the end of the day, there is a fairly even distribution amongst EV owners, as the chart below shows. The chart indicates that close to half of EV owners return home with their batteries over 50% full.



MADE primary customer research

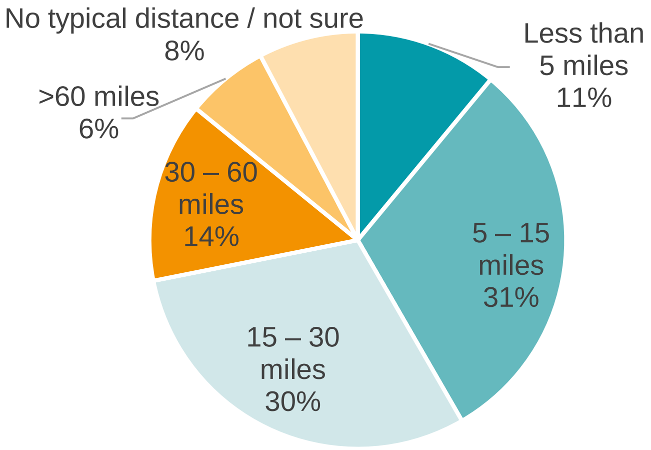
EVs and range

A large proportion of people have considered buying an EV – the biggest barrier being cost. Most people drive less than 30 miles/day, well under the range of an EV.

Considering buying an EV
When non-EV owners were asked about their attitude towards buying an EV, 64% are currently considering or have considered buying an EV. The largest sub-group, amongst the latter, at 18%, have not bought one due to cost. Nearly a third of respondents (30%) haven't thought about buying an EV at all.

Of those looking to buy an EV soon, a significantly higher proportion are under the age of 49, live in urban areas and have incomes of £64k+. Of those looking to buy in the next 5 years, a significantly higher proportion of these people live in London and are therefore perhaps partly motivated by the ultra-low emission zone expansion in October 2021. Those considering buying an EV are also more active energy switchers and consider themselves more environmentally friendly – these demographics align with the EV owners group.

Driving distance
The majority of drivers (72%) drive less than 30 miles each day. Driving 30 miles equates to using approximately 20% of the battery capacity of a new Nissan Leaf (40kWh model).The chart below shows the typical distance travelled per day by the non-EV owners:



MADE primary customer research

EVs and range

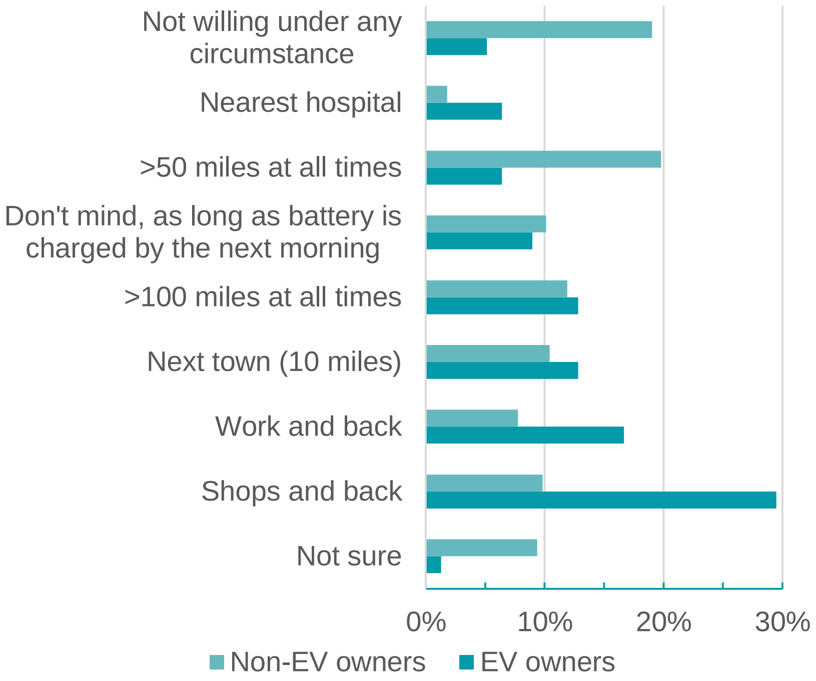
If forced to allow third party control of their EV charging for the purposes of V2G, EV owners are willing to let their batteries be discharged to a minimum level of 30%.

The minimum level of charge that people will accept for their EVs is important to understand for the purposes of using EVs to provide power to the grid (V2G). For EV owners, the largest group of respondents (30%) say that they want to be able to drive to the shops and back at all times.

Assuming that most people live within 30 miles of their work, a medical centre, the nearest town and the shops, the results indicate that 75% of EV owners would permit their battery to go down to ~30% charge (assuming a 40kWh battery).

EV owners are generally willing to accept shorter distances / lower level of charge than non EV owners. This tends to suggest that evidence taken from non EV owners in surveys can be seen as overly pessimistic.

Minimum acceptable level of charge you would allow your battery to reach as a result of a third party using your EV for vehicle to grid*:



*Respondents were told their battery would be charged to an acceptable level (set by them in advance) by the time they required the use of their EV and the company discharging the battery would also pay them a small fee every time they discharged their battery

MADE primary customer research

EVs and third party control

There is a great deal of concern regarding third party control. If third party control is to be accepted, EV owners want to still be able to take over at any point.

Over half (65%) of EV owners are ‘quite’ or ‘very concerned’ about third parties having the ability to control the charging regime of their EVs, despite being told that this would help save them money and they would be able to override the third party at any time. Only 8% of respondents were ‘not concerned’ about third party control. The breakdown of concerns among EV owners regarding third party control for V2G was similar, with three-quarters expressing some concern.

When the non-EV owners were asked the same question (having to imagine they owned an EV) regarding their concerns about a third party taking control of their charging, just under half (48%) were either ‘quite’ or ‘very concerned’. 24% were ‘unsure’ or ‘not concerned’.

When the EV owners were asked how they would like the arrangement regarding third party control of their EVs set-up (assuming that they had to allow it) – nearly half (47%) of respondents want to remain fully in control with the third party having to ask for permission every time they want to control their EV charging. Unsurprisingly, this group is also made up of those that are generally quite / very concerned about a third party taking control of their heating.

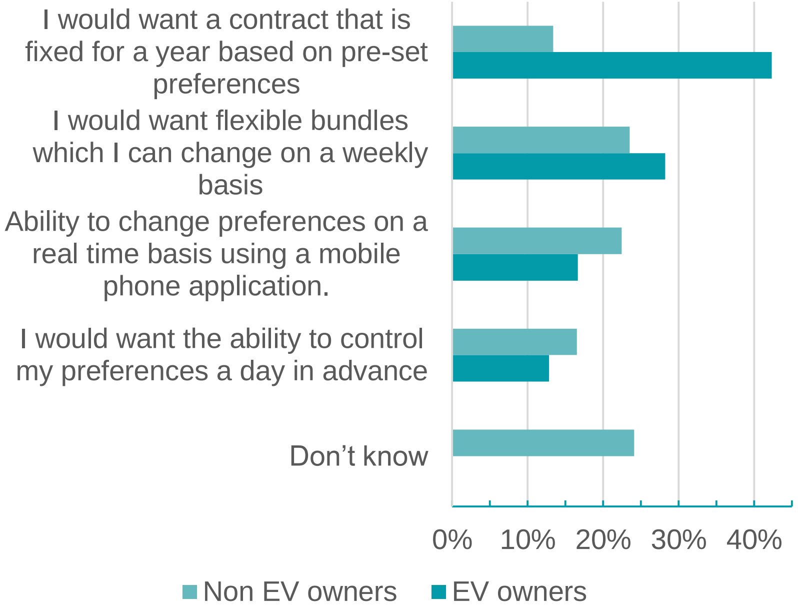
The next largest group, 36% of EV owners, wanted to be notified every time the third party was planning on taking control of their charging with the power to override them and take control at any time. The remaining groups (17% in total) were open to even more flexible schemes where they are notified in advance or the third parties had total control.

MADE primary customer research

EVs and third party control

There is no clear winner regarding how people would like to set-up the contracting of a third party to manage their EV charging and heating energy needs.

The following chart gives the results of the type of arrangement respondents would be most comfortable having with a third party to control their EV charging and heating system*:



The chart shows that there are different preferences for EV versus non-EV owners regarding the arrangement they would like to have with a third party to manage their heating and EV charging energy demands. The difference is greatest regarding the ‘fixed for a year’ contract option which was the most favoured option by the EV drivers.

The spread across the options was more even for the non-EV drivers. There is also a significant proportion of non-EV owners that ‘don’t know’ what contract type they would prefer. This group was made up of older, lower income respondents.

Overall, none of the options came out as a clear winner across the two groups. This is perhaps due to the nascent nature of this space.

*Exact question phrasing: “If you were to use a third party to help control the balance between the electricity used for heating and the electricity used to charge your electric vehicle, how flexible would you want this arrangement to be?”

MADE primary customer research

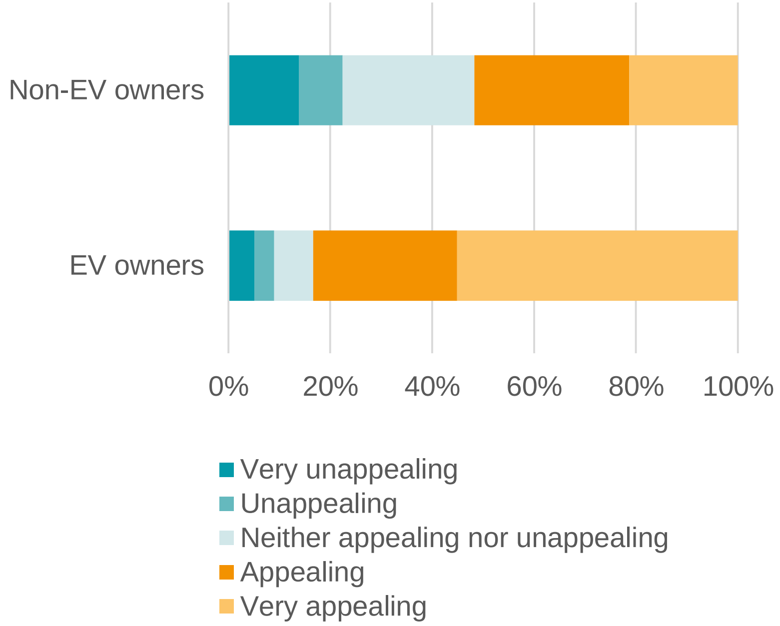
EV charging monitoring and control

EV owners are positive about the idea of having an app to help them control their charging.

Of the EV owners group, 83% of respondents find it appealing to have an app that connects to their smart charging device to optimise their vehicle charging based on their desired preferences regarding when they require their vehicle the next day and how far they plan to drive it*. Of the non EV owners group, 48% find it appealing to have an app that connects to their smart charging device.

Although the lower appeal of an app to monitor and control smart charging among the non-EV owners group is likely an artefact of this group containing a larger proportion of older and lower income individuals. For the non-EV owners group, if the responses of those >50 are disregarded, the appeal of the app rises to around 70%.

The chart below shows the full results of how appealing EV owners and non EV owners find the idea of having an app to help control their charging:



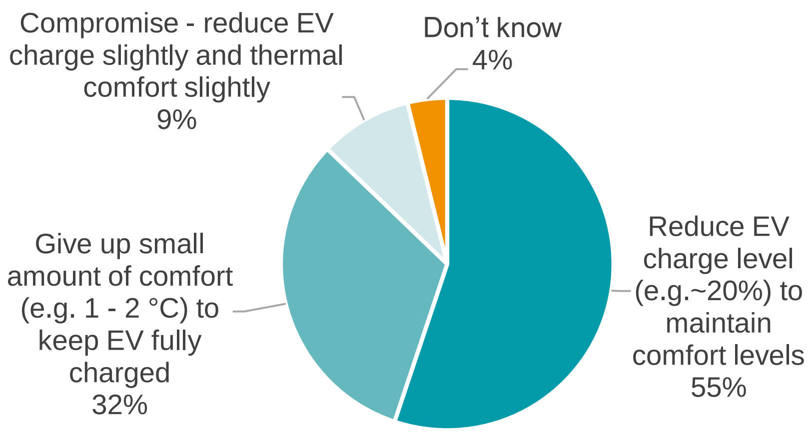
*Respondents were also told the app 'could potentially save you money'

MADE primary customer research

Trade-off between EV charging and heating

The majority of people would choose to ensure they maintain comfort levels in their home rather than ensuring their EV is fully charged.

When EV owners were asked what they would do if on a cold day there was not enough electricity to run their heating system and charge their EV, the majority would compromise on the charge level of their EV (55%) rather than having to give up some warmth to keep their EV charged (32%), as the graph below shows:



When the group of non-EV owners were asked the same question there was a more even spread across the options. However a larger proportion of respondents (33% versus 23%) said that they would be willing to give up thermal comfort instead of having to reduce the charge of their EV. Those willing to give up thermal comfort were significantly more likely to be younger. It is worth noting that nearly a quarter (24%) responded ‘I don’t know’ to the question. This likely indicates that for those that don’t own either an EV or an electric heating system the question posed is too far removed from their current circumstances to give a meaningful response.

Customer research conclusions

Past and current customer research high level findings

The outcomes presented below are based on the past customer research and the research commissioned for MADE.

Homeowners are largely unengaged with their current heating technologies. Awareness of the different specific low carbon heating technologies is also low. Saving money is the main driver behind UK homeowner's decisions related to their heating system. It will therefore be important to clearly explain what a HHS is and demonstrate how it will result in savings for the MADE concept to gain appeal.

In terms of engaging homeowners regarding the MADE concept, and ultimately driving adoption, some customer segments will likely be much easier to get on board than others. Younger, higher-income homeowners that already have existing LCTs will likely be easier to target than older homeowners that don't switch energy suppliers.

Homeowners have a complex relationship with their energy suppliers but in most cases ultimately trust them to give them a good deal. Therefore partnering with an energy supplier may help deliver the MADE concept.

There is lots of concern around third party control of charging and heating. If third party management of assets is to be accepted, people still want to feel as if they are ultimately in control. Further proof of how this will help them save money will likely also help. Providing financing for new systems may help overcome this barrier and the issue of high upfront costs.

Once installed homeowners are comfortable with the operation of a HHS. The heating system interface is a very important part of the customer experience. Modern interfaces are especially important for younger homeowners.

Feasibility study – LV network constraints

MADE modelling overview

Customer segmentation

Methodology

Results

MADE modelling task

Delta-EE involvement in the MADE modelling

The MADE project includes developing a feasibility model to assess the household and local grid impact of the MADE concept.

The MADE project has examined the impact of optimisation by modelling energy demands and optimisation at a single household level, and then aggregating this up over low voltage feeders.

Delta-EE have supported Everoze with the household-level modelling through the provision of datasets and assumptions, ensuring that different customer typologies are suitably represented.

Delta-EE's primary modelling focus has been to draw on the outputs from the household level modelling and simulating the impact on the LV network to understand the level of constraint.

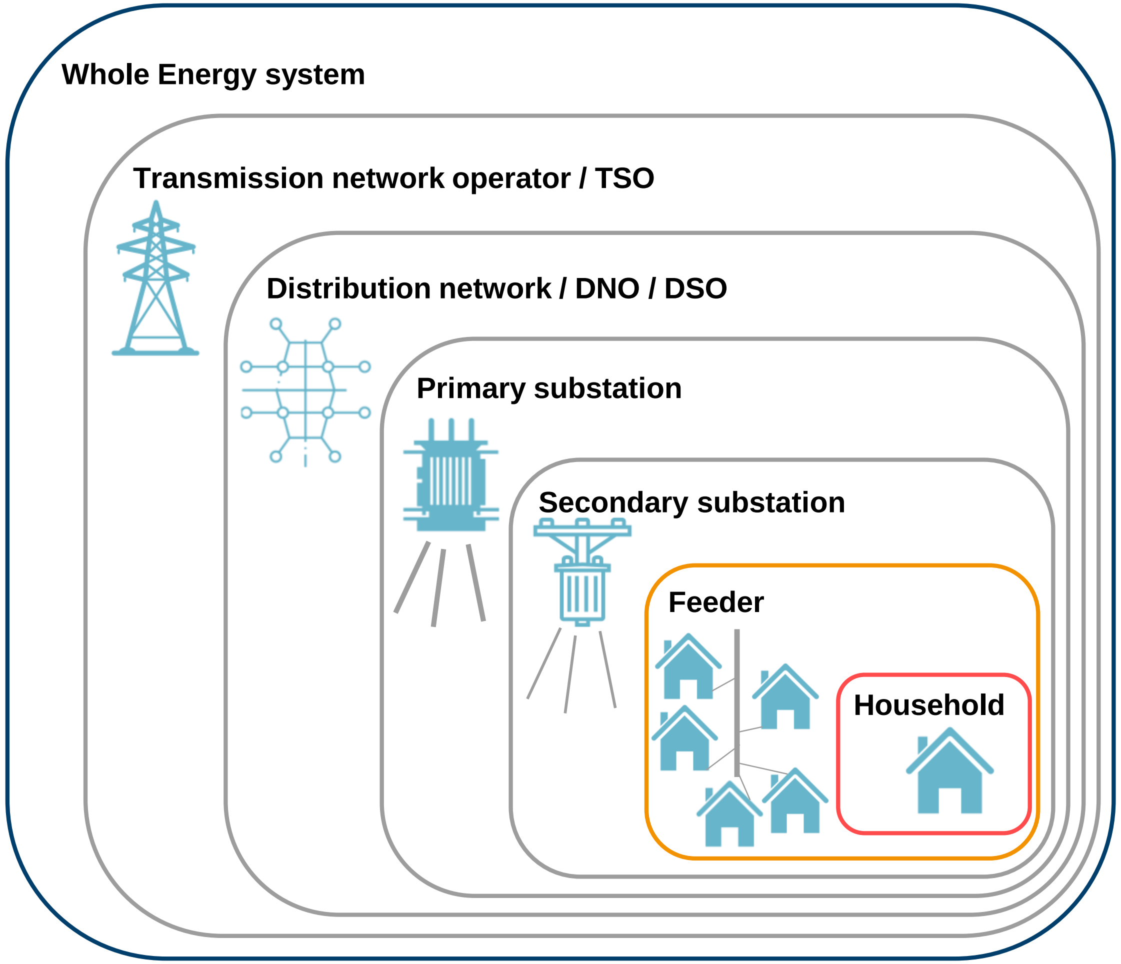
Imperial College London have provided energy system modelling to understand the broader system level impacts and benefits.

The impact of changing demands and optimisation at a householder level on the LV network feeders has been determined by modelling different customer types connected to the feeder. The customer types are assumed to all have the same base technologies – an EV, a hybrid heating system, solar PV and a battery. However, the customer types differ in their heating demands, occupancy, size of solar PV installation and transport usage pattern.

The diagram on the following page maps out the modelling landscape.

MADE modelling landscape

Different levels of the electricity grid



Whole Energy system → Imperial College

- Independent assessment of UK system level benefits (indep. of analysis below)
- Based on least regrets optimisation approach

System operator level

- Ancillary services
- Marginal generation costs

Distribution network

- Value of energy asset flexibility (e.g. deferred reinforcement, thermal loss reduction etc.)
- Optimise energy systems based on future price signals

Primary substation

- Splitting benefits on primary substation level

Secondary substation

- Splitting benefits on secondary substation level

LV Feeder → Delta-EE

- Aggregating household level loads based on ADMD assumptions
- Determining the impact of co-incident load flows and feeder level limitations
- Available shiftability in loads

Household → Everoze

- Aggregating loads under different optimised and unoptimized scenarios for common household archetypes, e.g. semi-detached homes; or customer types

Customer segmentation

Developing relevant customer segments for the MADE modelling 1/3

Customer segments can be broken down in a number of different ways based around heat demands, physical characteristics, and customer profile.

House type, age and heat demand
House type and age directly influence overall heat demand, and are therefore a primary factor in the load modelling. For the purposes of modelling it therefore may be best to consider house types as being representative of high, medium and low energy demand.

It is useful to link the heat demand bands to physical characteristics in order to draw on existing house type heat demand characteristics from trial data (along with other sources) and to make the modelling more relatable. For example:

- High heat demand, e.g.1930's semi-detached or a Victorian terraced house ~17MWh/year*
- Medium heat demand, e.g. 1960's semi-detached or terraced house ~12 MWh/year*
- Low heat demand, e.g. a flat built post 1990 ~8 MWh/year*

Behaviour / customer engagement
Customer behaviour can be important in relation to baseline energy use since this will determine the patterns driving energy demand.

Business models and associated incentives can be used to help change customer behaviour. The modelling presented here is predicated on the basis that energy demands can be optimised and shifted, and that suitable propositions and control processes will be available to customers to enable this in the absence of a regulatory approach.

*Based on Ofgem gas TDCVs. PassivSystems provided Everoze data regarding heat demands using data from a trial

Customer segmentation

Developing relevant customer segments for the MADE modelling 2/3

Occupancy patterns and volumes can be a key determinant in segmentation of energy demand characteristics.

Occupancy
Household occupancy will also effect the MADE modelling. The two fundamental occupancy criteria considered are:

- “In” versus “out” during the day
- Number of occupants

Daytime occupation variation will have a large impact on the winter heating profile. Daytime occupation will result in much longer daytime heating hours and also incur additional non-heating consumption from appliance use. It may also allow for more daytime EV charging.

Occupant numbers are also likely to have a significant impact on domestic hot water demands and electricity use, and indirectly on space heating demand.

The combination of whether the home is occupied during the day or not and the total number of occupants is likely to give rise to a range of non-heating electricity consumption. For example:

- High electricity consumption, e.g. house occupied all day and 4+ occupants
  ~5.7 MWh-e/year*
- Medium electricity consumption, e.g. house occupied during the day and 1 occupant OR house unoccupied during the day and 3 occupants
  ~ 4.6 MWh-e/year*
- Low electricity consumption, e.g. house unoccupied during the day and 1-2 occupants
  ~ 1.7 MWh-e/year*

*Data provided to Everoze, based on the Powering the Nation project Data

Customer segmentation

Developing relevant customer segments for the MADE modelling 3/3

The MADE project assumes technology uptake is the same across all customer segments. Solar PV capacity is the main differentiator.

Technology choices
In most real world case the house type and customer segment would impact the technology choices. However to allow exploration of multi-asset optimisation viability, the MADE project assumes that all customer segments will have an EV, a hybrid heating system, solar PV and a battery storage system.

There are a range of different types and capacities of EVs, heat pumps, solar PV and batteries on the market today and this will likely remain so in the future. For the MADE project, these have been standardised across all customers, assuming the same EV capacity and charging loads, and a single specification of storage system.

Full details of the assumptions can be found in the report on household modelling by Everoze.

The main variable for EV usage patterns is whether or not the EV is capable of being plugged in and charged during the day. For the purposes of the MADE project we have categorised three different EV usage patterns:

- Commuter - EV is used for commuting during the week and social trips during the weekend.
- Parent - EV is mainly used for school runs and social activities.
- Social - low intensity usage of the EV e.g. for a supermarket shop or evening event.

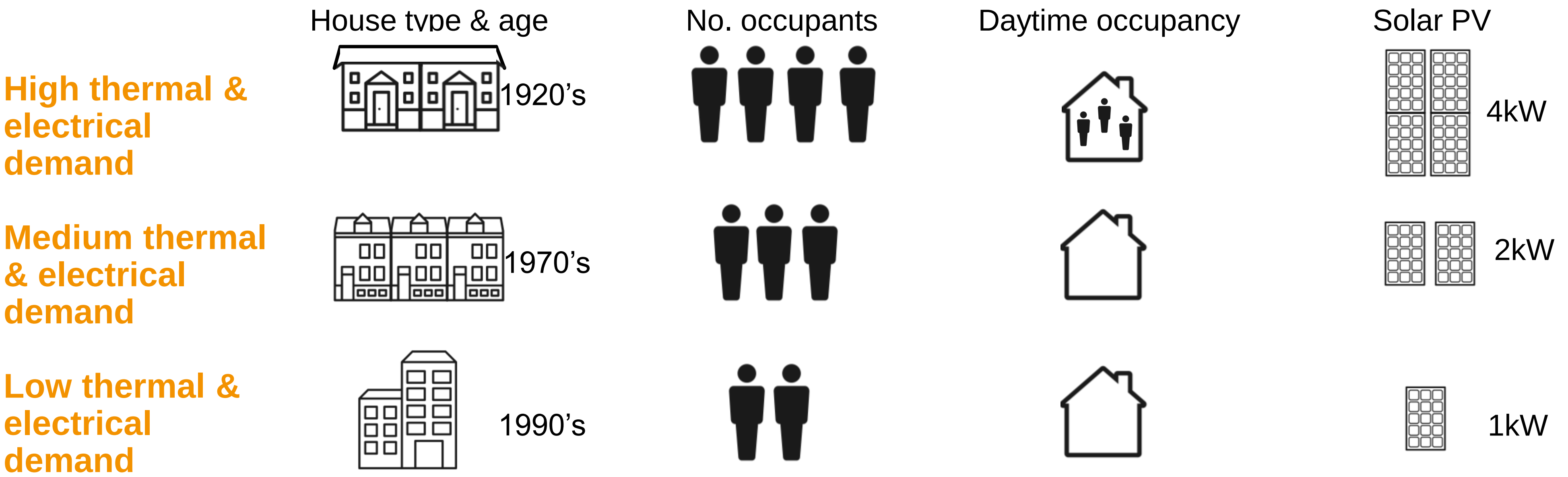
Solar PV size is dependant on roof area, with larger detached / semi-detached homes likely to have higher capacity PV arrays than those fitted on terraced homes or flats. A typical range of domestic solar PV sizes of 1 – 4 kW is assumed for the modelling depending on house type.

Customer segmentation

Three customer segments are used for the modelling

A combination of customer criteria are used to create three basic customer segments based around loads

The MADE project assumes three distinct customer segments to represent a broad customer base and key sensitivities. Whilst in reality there is a large number of possible customer segments based on different combinations of factors (house type, occupancy, technology uptake, behaviour), Made explores the extremes and central cases. The three illustrative customer segments used in the analysis are shown below.



Customer segmentation

Combining customer typologies with EV usage

DELTA Energy & Environment

EV usage is likely to be a key determinant in optimisation and the MADE project assumes a number of combinations of EV usage and customer typologies.

Each of the three different customer segments is considered in the absence of any ‘new’ technologies to understand the baseline demand conditions. The future scenarios include the ‘new’ technologies in combination with the three different EV usage patterns (commuter use, parental use and social use).

Each customer segment profile is based on typical usage patterns identified in WPD's Electric Nation and BEIS's Electric Chargepoint Analysis 2017. A diversity factor of 0.5 is then applied to these profiles to take into account that not all vehicles in this segment will exactly match these profiles. This has the effect of reducing the assumed load on the network, whilst maintaining the same profile shape. The diversity factor applied is taken from UKPN network design assumptions (UK Power Networks EDS 08-5050). We recommend that further research is done into the diversity within different customer segments to identify further the staggering of load profiles across a feeder.

It has been assumed that parents using the EV for parental use only occurs in cases where there is a high overall household demand. This therefore gives rise to ten customer profiles used in this analysis.

	EV commuter	EV parent	EV social	No technology
High thermal & electrical demand	✔	✔	✔	✔
Medium thermal & electrical demand	✔	na	✔	✔
Low thermal & electrical demand	✔	na	✔	✔

Feeder level modelling methodology

Modelling the MADE concept at the network feeder level

Presented below is an overview of the methodology adopted to analyse the impacts that the MADE concept will have on the local LV network.

Methodology used to level impacts at the LV network – feeder level

A model has been created which uses the electricity demand and export profiles across the ten different customer segments to create a demand profile at the feeder level. The model calculates demand diversity across the total number of households on a feeder based on the total number of customers, and the proportion of customers with the new technologies installed (representing the market penetration).

The feeder is assumed to have been sized based on the ADMD of a feeder consisting of the average UK home (that has no solar PV, heat pump or EV). This allows for the feeder limit to be calculated, and hence the number of occurrences where demand exceeds this limit.

Diversity and ADMD

After Diversity Maximum Demand (ADMD) values are used in the design of electricity distribution networks to identify the coincident peak load on the network for a given number of homes on an ‘average’ peak winter day, and hence the network capacity needed. The ADMDs used in the model are based on Northern Powergrid’s working values derived as part of the work done as part of the Customer-led Network Revolution project*. The diversity factors in this report are given for homes with no LCTs and for those with heat pumps. A diversity factor for homes with a heat pump and an EV are derived using a combination of the Norther Powergrid data and an assumed diversity factor of 0.5 for EVs**.

*Barteczko-Hibbert (2015), After Diversity Maximum Demand (ADMD) Report, *Customer-Led Network Revolution*, CLNR-L217
**Halsey (2017), Electric Vehicles workshop, https://www.ukpowernetworks.co.uk/internet/en/have-your-say/documents/EV_WORKSHOP.pdf

Feeder level modelling methodology

Modelling the impacts of the MADE concept at the feeder level

Customer segment demand profiles - from Everoze

The individual household-level modelling of demand profiles and optimisation has been conducted by Everoze. For each customer type, - a base case and an optimised case is modelled. In the base case there is no intelligent/co-ordinated operation of the different low carbon technologies (i.e. EVs on unmanaged charging etc). In the optimised case the operation of the different assets is optimised based on current market signals – i.e. they are intelligent/co-ordinated operation at a single household level.

For those homes that have none of the MADE low carbon technologies, the ‘no technology’ segments’ – there is no difference in their demands in the base and the optimised case.

Customers per feeder

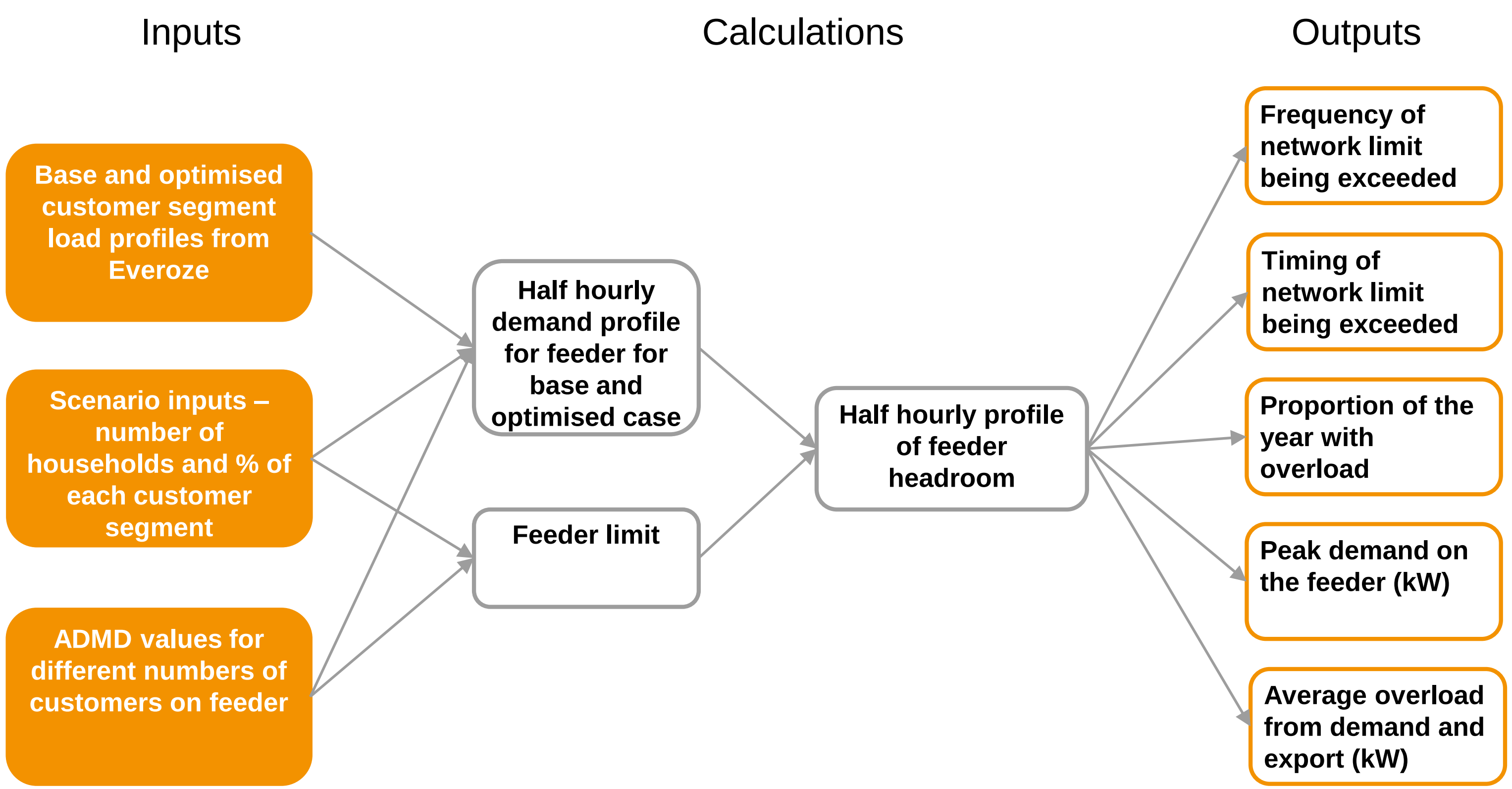
The number of customers on the feeder is a variable that can be changed in the model, but using the central assumption that there are 34 customers per feeder. In suburban areas, this can be used as a rough approximation of the average number of homes served by a feeder based on existing Delta-EE analysis). However this can vary significantly with higher figures in dense urban areas, and single figures in rural areas.

Model key outputs

- The number of half hourly periods in a year the feeder is above its thermal limit
- Proportion of the year with overload
- The peak demand on the feeder (kW)
- The time of the peak
- The average overload from demand (kW)

Feeder level modelling methodology

Model flow chart



Feeder level modelling methodology

Model assumptions and limitations

The modelling includes a number of assumptions aimed at reflecting the diversity of network conditions and typologies.

The feeder level modelling performed as part of this task is a high-level analysis necessitating a number of assumptions and resulting limitations:

- Spatial variations - there is a large range in network capacity / headroom, as well as voltage issues across UK feeders. Therefore actual effects will be very location specific and this is not captured within the modelling.
- Load profiles – there are only two profiles available for each month in the Powering the Nation dataset* - Weekday and non-working day. This means there is the implicit assumption every weekday in every month is identical. These profiles also do not capture extremes in temperatures. The load profiles used are also built on the average of a sample of 4 - 8 houses for each customer segment, so some diversity is already built into these.
- Diversity factors – diversity is fairly well characterised for houses with no LCTs. The effect of the combined operation of EV's, heat pump, solar PV and domestic battery systems is uncertain and this uncertainty increases once automation / optimisation is included. This is particularly important consideration if the optimisation algorithms respond in a similar manner to price signals, as this will act to decrease diversity. Applying a single diversity factor across the whole electricity profile was a simplifying assumption, but appropriate for the level of this analysis. Specific EV related assumptions are described on slide 66.
- Customers per feeder - we have assumed there are 34 houses to a feeder. This is based on expert input and existing Delta-EE analysis on the average number of customers per feeder in a suburban setting.

*From Powering the Nation dataset. This is used to create the baseline demand profiles for household level modelling.

Feeder level modelling methodology

Feeder level scenarios used in the modelling

Feeder composition of household stock affects the results significantly. Three different scenarios were used for our modelling as presented below*.

1. **Exclusively high demand network**
Houses in a given area tend to be of similar sizes and have similar occupancy profiles, especially in older areas of housing. This means that some feeders may consist exclusively of higher demand customers. These networks will likely be the first to experience constraints caused by deployment of EVs and other technologies, due to larger houses being more likely to have off street parking and have more wealthy occupants.

   We look at two sub-scenarios:

   a) All EVs are used for commuting (i.e. lower diversity in demand)
   b) Even mix of EV profiles

2. **Even mix of customer segments**
In urban areas, a single feeder may be serving a wide range of customer segments. This scenario investigates an even mix of both customer segments and EV usage profiles, the maximum amount of diversity possible within the limitations of this model.

3. **Medium and low demand network**
This scenario investigates a feeder supplying only low and medium demand houses.

The EV penetration levels in National Grid's Future Energy Scenarios (FES) 2019 Community Renewables scenario has been used as a measure for which years these penetration rates might be reached. These annual milestones are displayed on the graphs in the following slides.

*Details of the feeder composition can be found in the Appendix

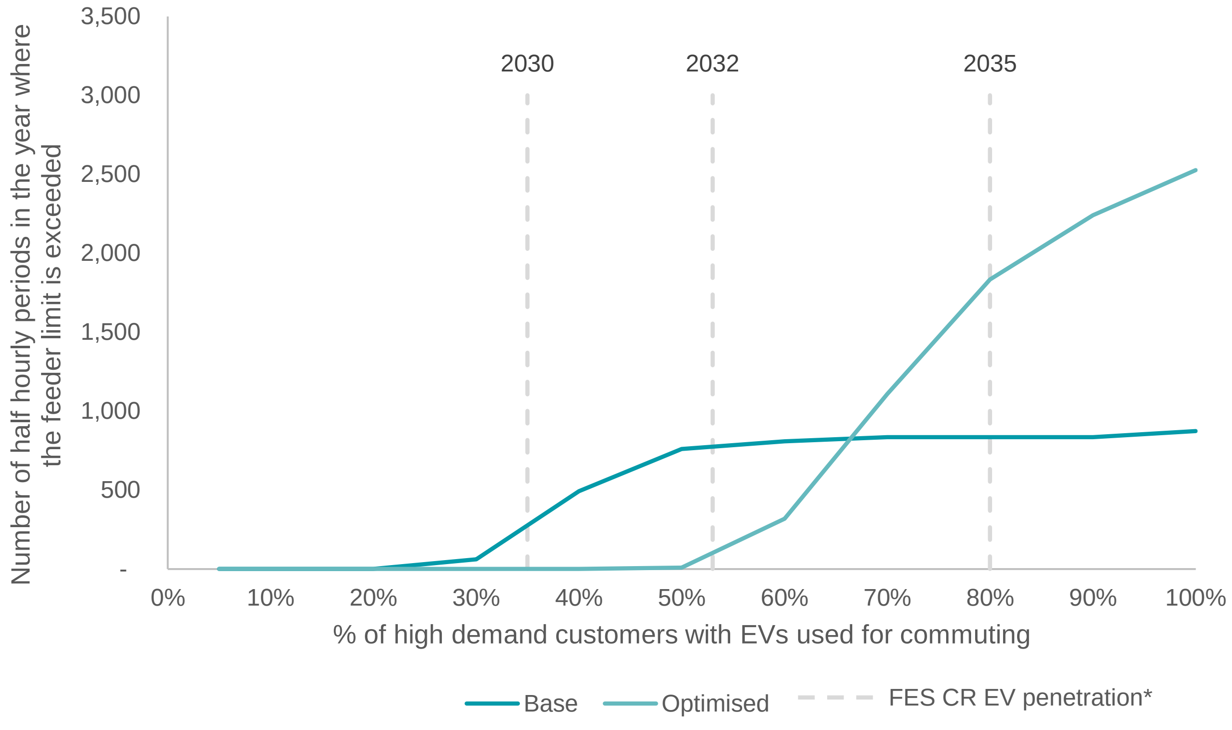
Modelling result outputs

Scenario 1a: high demand customers with low diversity on EV usage patterns

The optimisation of loads based on current price signals is beneficial to the network up the point when more than half of homes adopt the MADE technologies.

- Network issues have significant effect when more than 35% of homes on a feeder adopt the MADE technologies in the base case and 55% in the optimised case.
- At lower than 50% penetration, the shifting of EV consumption away from peak demand on the network to overnight reduces the frequency of network overload.
- The optimisation reduces the frequency of network overload until up to 65% penetration and prevents network overload entirely at less than 50%.
- At high penetrations, optimisation leads to higher occurrences of network limits being exceeded. This is due to reduced diversity on the network as a higher proportion of homes respond to the same price signals.

Proportion of high demand customers with EVs used for commuting versus the number of half hourly periods per year the feeder limit is breached



*National Grid Future Energy Scenarios 2019 – Community Renewables

Modelling result outputs

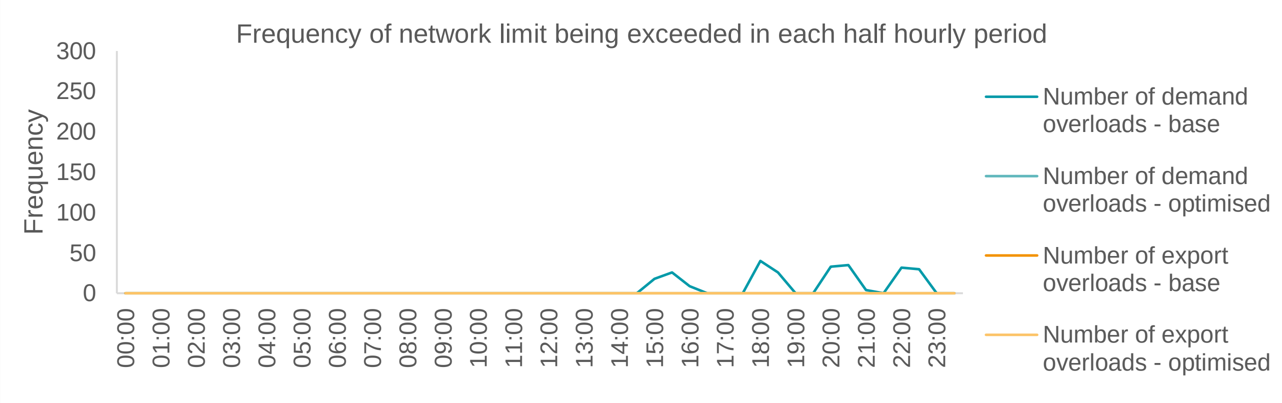
Scenario 1a: 35% penetration of technologies, EVs all used for commuting

Base case

- At 35% penetration of new technologies, the network is overloaded for 1% of the year.
- The limit is exceeded on average by 6 kW. However, during the winter this can be as high as 20 kW, which could cause significant damage to the network.
- Overloads occur at times when EV drivers return home and plug in their cars to charge.

Optimised case

- In the optimised case, overload is avoided as demand from EVs is shifted away from when other devices are operating.



		Base	Optimised
Overload from demand	Number of half hourly periods above limit	253	-
	% of year with overload	1%	0%
	Peak demand (kW)	93	58
	Time of peak	20:00	22:30
	Average overload from demand (kW)	6	0
Overload from export	Number of half hourly periods above limit	0	0
	% of year with overload	0%	0%
	Peak generation (kW)	22	38
	Time of peak export	12:30	16:00
	Average overload from export (kW)	0	0
Total overloads	Total overloads	253	0

Modelling result outputs

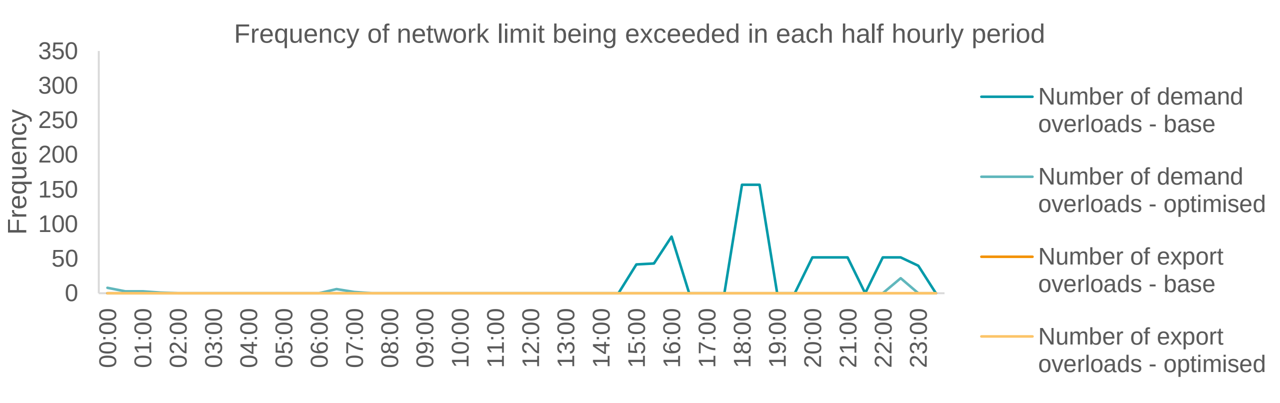
Scenario 1a: 53% penetration of technologies, EVs all used for commuting

Base case

- At 53% penetration of the MADE technologies, the network is overloaded 4% of the time.
- Overload occurs most frequently between 6pm and 7pm, when commuters are most often returning home and plugging in their EVs.

Optimised case

- For 45 half hourly periods the network limit is marginally exceeded. Due to the infrequent and small extent of overload, this is likely to be within the tolerance of the network.
- This is much lower than the base case as the EV demand is shifted away from when other devices are operating.
- Overload typically occurs at 22:30, when managed EVs begin to charge.



		Base	Optimised
Overload from demand	Number of half hourly periods above limit	781	45
	% of year with overload	4%	0.26%
	Peak demand (kW)	129	79
	Time of peak	20:00	07:00
	Average overload from demand (kW)	24	2
Overload from export	Number of half hourly periods above limit	0	0
	% of year with overload	0%	0%
	Peak generation (kW)	35	60
	Time of peak export	12:30	16:00
	Average overload from export (kW)	0	0
Total overloads	Total overloads	781	45

Modelling result outputs

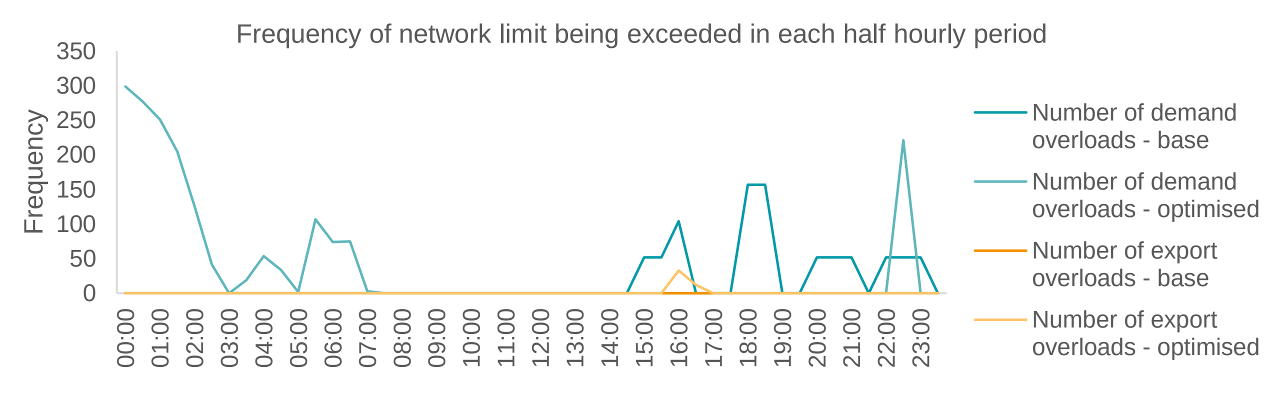
Scenario 1a: 80% penetration of technologies, EVs all used for commuting

Base case

- At 80% penetration of the MADE technologies, the network is overloaded for 5% of the year.
- Overload is large, with peak demand 2.5 times higher than network capacity at 184 kW. Peak demand occurs at 8pm, when EV drivers have returned home later than normal and plugged in.

Optimised case

- Overload is more frequent in the optimised case as a higher proportion of customers are having large amounts of demand shifted to overnight, reducing diversity. This concurrent overnight load outweighs the benefits of avoiding the evening peak.
- However, extent of overload is on average 75% lower than in the base case.



		Base	Optimised
Overload from demand	Number of half hourly periods above limit	834	1,789
	% of year with overload	5%	10%
	Peak demand (kW)	184	112
	Time of peak	20:00	07:00
	Average overload from demand (kW)	63	13
Overload from export	Number of half hourly periods above limit	0	45
	% of year with overload	0%	0%
	Peak generation (kW)	54	93
	Time of peak export	12:30	16:00
	Average overload from export (kW)	0	6
Total overloads	Total overloads	834	1,834

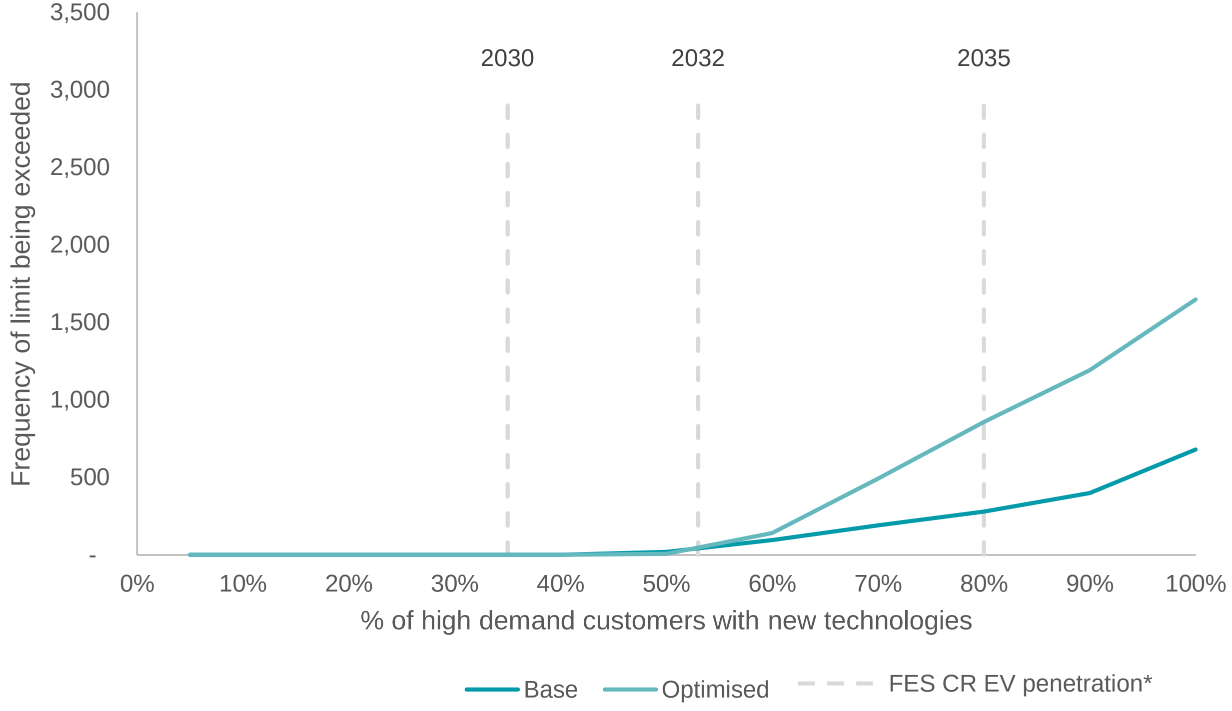
Modelling result outputs

Scenario 1b: high demand customers with higher diversity in EV usage patterns

Greater diversity of EV loads results in their being less network benefits of the optimisation of loads based on current price signals.

- Network issues occur when 60%, or more, of homes on a feeder adopt the MADE technologies in both the optimised and base cases.
- The lower network impacts in this scenario compared to Scenario 1a are due to greater diversity in EV usage. This leads to demand being more evenly spread across the evening and total consumption being lower overall at the feeder level.
- In the optimised cases, network overload starts to occur at similar technology penetrations. Automated response to price signals removes the increased diversity given by the differing EV usage profiles.
- The average extent of overload remains similar in both cases.

Proportion of high demand customers, with diversity in their EV use patterns, versus the number of half hourly periods per year the feeder limit is breached



*National Grid Future Energy Scenarios 2019 – Community Renewables

Modelling result outputs

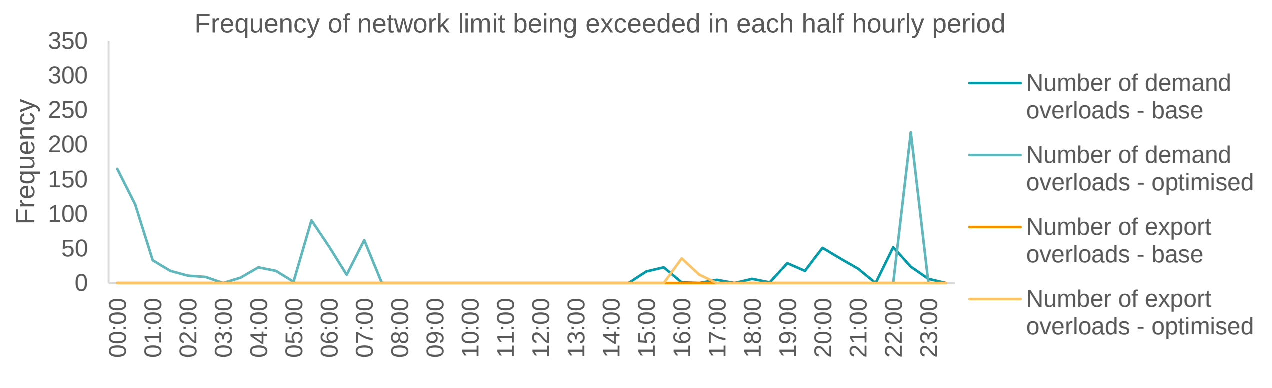
Scenario 1b: 80% penetration on new technologies

Base case

- At 80% penetration, the network is overloaded for 2% of the year. This is 3% lower than in Scenario 1a. Peak demand is also lower, at 115 kW compared to 184 kW in Scenario 1a.
- This is due to increased diversity in EV use, leading to peak demand being spread more evenly across the evening

Optimised case

- As with Scenario 1a, the number of half hourly periods where the network limit is breached is double the frequency in the optimised case compared to the base case. However, in this scenario the extent of overload is only marginally lower than in the base case.
- Peak demand typically happens at 22:30, when all EV's simultaneously start to charge. Network overloads also occur early in the morning, when heat pumps start operating.



		Base	Optimised
Overload from demand	Number of half hourly periods above limit	279	813
	% of year with overload	2%	5%
	Peak demand (kW)	115	111
	Time of peak	22:00	22:30
	Average overload from demand (kW)	15	14
Overload from export	Number of half hourly periods above limit	0	45
	% of year with overload	0%	0%
	Peak generation (kW)	54	93
	Time of peak export	12:30	16:00
	Average overload from export (kW)	0	6
Total overloads	Total overloads	834	1834

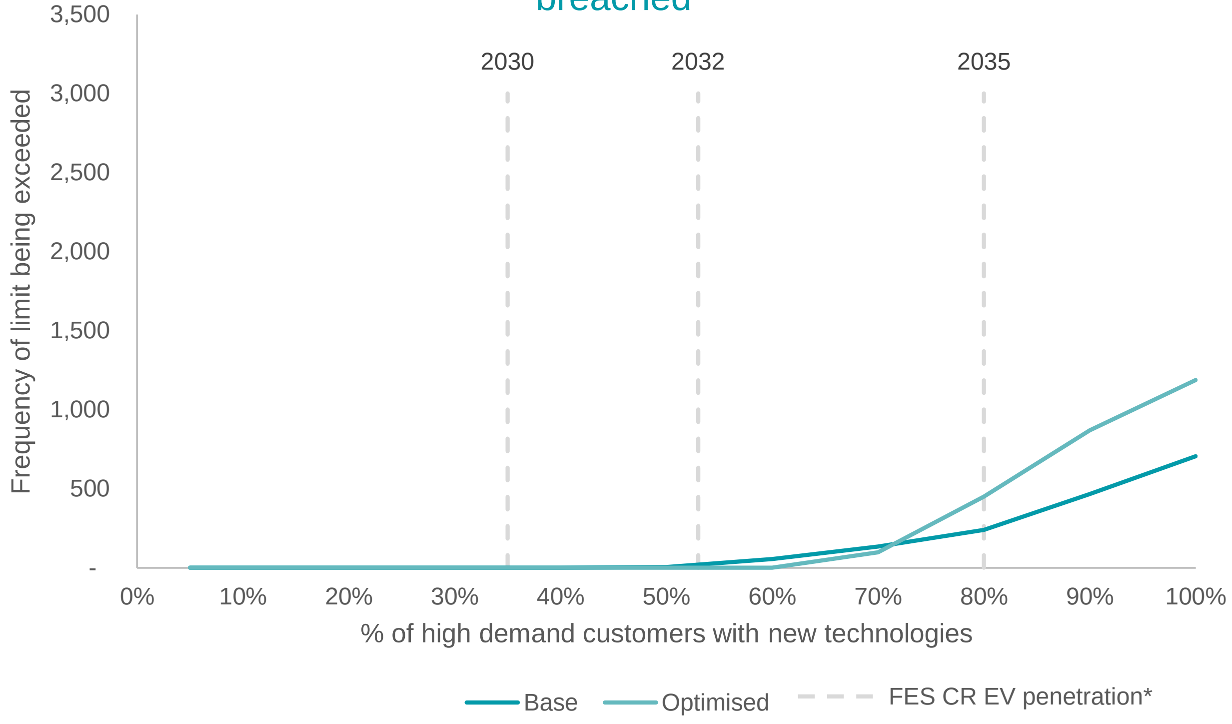
Modelling result outputs

Scenario 2: Even mix of customer segments and EV usage

Greater diversity in customer types and EV use patterns results in feeders being able to handle higher update rates of the MADE technologies.

- Network issues are seen from 50% EV penetration in the base case and 70% in the optimised case.
- This is higher than in Scenario 1, due to demand for heating and other base electrical consumption on the feeder being lower overall, resulting in greater headroom.
- As with Scenario 1, the frequency of network limit being exceed is higher in the optimised case than the base case when high technology penetrations are reached, due to a reduction in diversity.

Proportion of customers, with an even mix across the different segments, versus the number of half hourly periods per year the feeder limit is breached



*National Grid Future Energy Scenarios 2019 – Community Renewables

Modelling result outputs

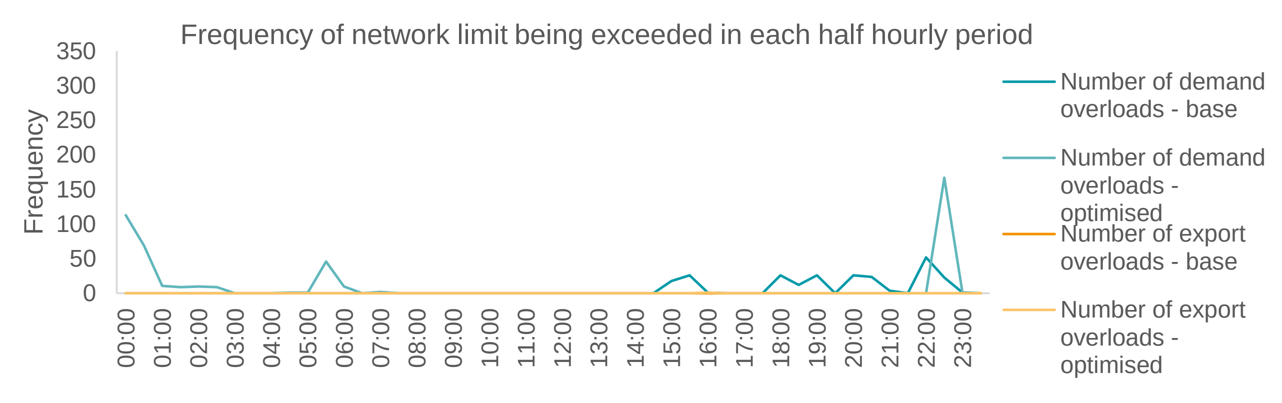
Scenario 2: 80% penetration of new technologies

Base case

- At 80% penetration, the network is overloaded for 1% of the year, 4% lower than in Scenario 1a.
- Peak demand is 114 kW compared to 184 kW in 1a.
- Overloads occur predominantly in the evening, between 6pm and 10pm.

Optimised case

- As with scenario 1b, the optimised scenario has higher occurrences of overload, but the extent of this overload is lower than the base case.
- Overloads occur exclusively overnight, as a result of EV charging, and early in the morning, as load from heat pumps is switched on whilst prices are low.



		Base	Optimised
Overload from demand	Number of half hourly periods above limit	239	448
	% of year with overload	1%	3%
	Peak demand (kW)	114	93
	Time of peak	22:00	22:30
	Average overload from demand (kW)	13	6
Overload from export	Number of half hourly periods above limit	0	1
	% of year with overload	0%	0%
	Peak generation (kW)	32	76
	Time of peak export	12:30	16:00
	Average overload from export (kW)	0	4
Total overloads	Total overloads	239	449

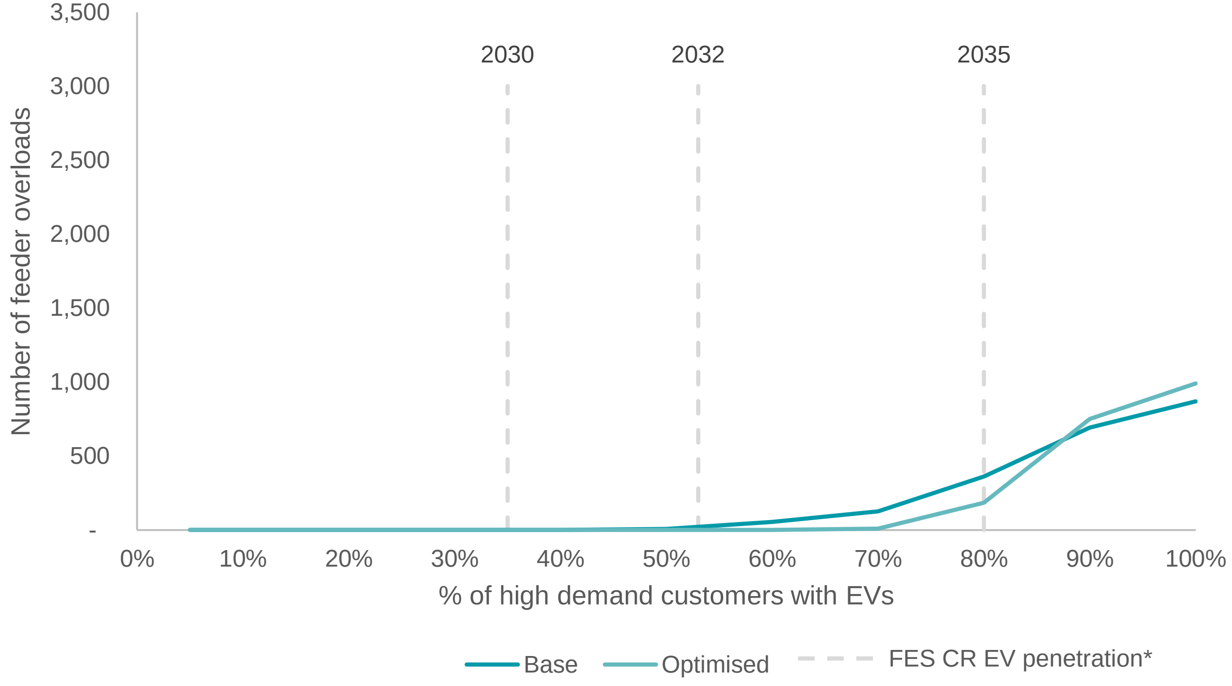
Modelling result outputs

Scenario 3: Medium and low demand network

Lower overall demand from medium and low demand customer segments, results in fewer breaches of the feeder limit.

- Network issues have significant effect from 60% EV penetration in the base case and 70% in the optimised case.
- This is higher than in Scenario 1 and 2, due to demand for heating and other base electrical consumption on the feeder being lower overall, resulting in greater headroom, and EV usage being split across different use cases.
- The frequency of network limit being exceed is higher in the optimised case than the base case when technology penetrations >90% are reached.
- Overall loads are marginally lower than in the other scenarios due to the EV charging loads being dominant.

Proportion of medium and low demand customers, with diversity in their EV use patterns, versus the number of half hourly periods per year the feeder limit is breached



*National Grid Future Energy Scenarios 2019 – Community Renewables

Modelling result outputs

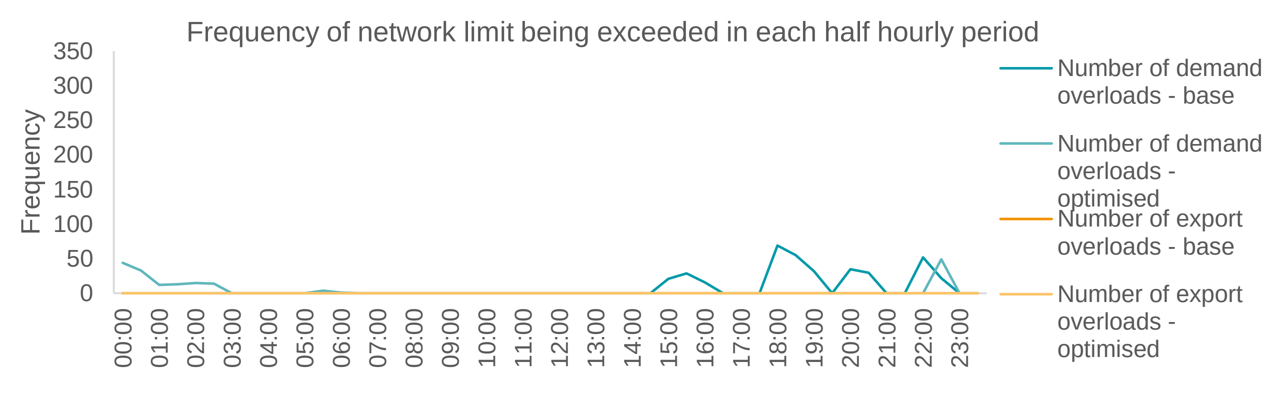
Scenario 3: 80% penetration of new technologies

Base case

- At 80% penetration, the network is overloaded for 2% of the year
- Peak demand is at 116 kW, similar to scenarios 1b and 2, but average overload is lower, at 9kW over the feeder limit.

Optimised case

- The optimised scenario performs better than the base case, with a lower frequency of the network limit being exceeded. Furthermore, the average overload is less than in the base case.



		Base	Optimised
Overload from demand	Number of half hourly periods above limit	361	185
	% of year with overload	2%	1%
	Peak demand (kW)	116	88
	Time of peak	22:00	22:30
	Average overload from demand (kW)	9	4
Overload from export	Number of half hourly periods above limit	0	0
	% of year with overload	0%	0%
	Peak generation (kW)	15	63
	Time of peak export	13:00	16:00
	Average overload from export (kW)	0	0
Total overloads	Total overloads	239	449

DELTA Energy & Environment

Modelling result outputs

Investigating the effect of the ADMD assumption

Effect of ADMD assumptions has a significant effect on the results.

The ADMD assumption effects the results significantly as the feeder being tested in the model is sized based on assumed ADMD per number of customers assumptions from DNO guidelines rather than actual data.

In reality the ADMD of different feeders varies significantly and often there is further design headroom built in to account for potential future expansion of the number of homes.

Occurrences and extent of thermal limits being exceeded will be highly location and site specific, impacted by individual feeder capacity, customer numbers and demand profiles.

Number of half hourly periods in the year where the network limit is exceeded with change in number of houses (proxy for ADMD) and penetration of new technologies

Scenario 2, optimised case

Number of houses on the feeder (Used as a proxy for varying ADMD)	% of high demand customers with new technologies									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
5	-	2	617	1,498	2,551	3,817	4,851	5,581	6,258	6,837
10	-	17	808	1,785	2,980	4,354	5,289	6,025	6,729	7,365
15	-	41	914	2,018	3,318	4,661	5,550	6,339	7,052	7,682
20	-	78	1,005	2,162	3,526	4,912	5,770	6,571	7,307	7,930
25	-	105	1,076	2,300	3,682	5,057	5,949	6,782	7,511	8,113
30	-	127	1,147	2,420	3,878	5,205	6,094	6,955	7,657	8,250
35	-	149	1,202	2,524	4,041	5,321	6,246	7,106	7,791	8,368
40	-	185	1,278	2,619	4,167	5,428	6,355	7,230	7,925	8,473
45	-	226	1,333	2,693	4,293	5,527	6,467	7,336	8,041	8,594
50	-	251	1,385	2,775	4,402	5,618	6,580	7,442	8,123	8,678
55	-	281	1,448	2,863	4,508	5,707	6,673	7,515	8,206	8,749
60	-	311	1,501	2,930	4,614	5,784	6,764	7,592	8,269	8,806
65	-	335	1,546	3,013	4,683	5,856	6,863	7,673	8,344	8,870
70	-	359	1,615	3,085	4,773	5,923	6,925	7,754	8,409	8,928
75	-	386	1,673	3,153	4,838	5,987	7,008	7,828	8,478	8,975
80	-	402	1,708	3,214	4,909	6,058	7,080	7,889	8,549	9,020
85	-	424	1,754	3,275	4,991	6,129	7,143	7,950	8,599	9,067
90	-	435	1,798	3,333	5,030	6,183	7,198	8,014	8,650	9,115
95	-	454	1,837	3,382	5,074	6,245	7,245	8,075	8,694	9,155
100	-	470	1,865	3,436	5,153	6,305	7,283	8,121	8,733	9,200

Summary of modelling results

Presented below are the key findings from our modelling of aggerated individual customer loads at the feeder level.

Base case results

- The results of the modelling show that higher penetration rates of low carbon technologies results in significant overloading of the low voltage (LV) electricity network.
- If more than 50% of homes served by the same LV feeder were to have an EV, a heat pump and solar PV the thermal limit of the feeder serving the homes in that area is likely to be breeched.
- At higher penetration levels (e.g. if 80% of homes have the aforementioned technologies) the feeder thermal limit is breeched significantly (e.g. double the limit of a 70kW feeder) and regularly (2-5% of the year)
- Assumptions around the customer types present on a feeder has a significant effect on if or to what extent overloading occurs. Higher levels of penetration of low carbon technologies can be achieved if there are more lower demand customers on a feeder.
- ADMD’s and feeder capacity varies significantly and has a large impact on these results.

Optimised case results

- The optimisation of demand and export at the household level reduces the overloading at the feeder level at low to medium penetration levels, moving consumption away from current peak times.
- However, overloading of the feeder in the optimised case still occurs at higher technology penetration levels and at extremely high levels can occur more regularly than in the base case. This is due to households optimising their consumption based on the same price signals resulting in low diversity of demand and coincidences of peak power.
- In the optimised scenarios, many more overload incidents occur at night (e.g. 10pm) as this is when peak demand has been shifted in response to current market mechanisms identically across homes.
- There are occurrences in the optimised case where the thermal limit of the feeder is breeched due to export of power from battery and PV systems. This tends to be between 3-4pm, in response to high market prices.

Modelling conclusions

The following key conclusions can be drawn from the modelling results.

- Network constraints could be significant by the mid 2030s without optimisation of demand
- Optimisation of household energy demand in many cases reduces the load on the network. At technology penetration levels of less than 50%, optimisation at the household level to existing price signals reduces occurrences of feeders being overloaded. Beyond this point, price signals will need to be altered to incentivise behaviour that reduces the aggregated loads on feeders. For example, price signals will need to be structured in order to incentivise
  - Staggering EV charging to avoid automated responses causing night time peaks in demand
  - Flattening load profiles to increase network utilisation
- Feeder capacity can vary significantly and exact effects are likely to be location specific. This has a large impact on the occurrences and extent of network limits being exceeded and should be investigated further
- The largest load is caused by EV charging. Effective EV smart charging strategies will therefore be key to reducing the likelihood of overloading the network.
- Further research should be done to better assess the impact of diversity in demand on these results, and to assess a broader range of ADMD conditions based on real network data. This is particularly relevant for the EV profiles, given the simplified assumptions used in this model.

Business model development:

A framework for building a business model and customer proposition

Applying the framework to the MADE project concept

- Customer pains and gains
- Value streams

Business model case studies

Customer Proposition development

Recommended customer proposition for a large scale MADE project trial

Building a business model

Why the focus on business models?

Developing a strong business model is a key part of supporting the MADE concept in the long-term.

The energy landscape is rapidly evolving and moving from the traditional centralised model (central power generation) to one that is decentralised, more customer centric and lower carbon. This transition is seeing a lot more value being moved downstream and this is resulting in new ways for domestic customers to access these value streams.

Constructing a business model is a key part of fulfilling PassivSystem's aim of creating a commercial proposition around combined operation and optimised control of electric heating (hybrids / heat pumps), electric vehicles and solar PV output, in combination with variable tariffs / DSR value streams.

In this section, we propose conceptual customer propositions for business models which could be developed following a trial of the MADE concept. These propositions are built upon a well used framework for developing business models and customer propositions, and build on insight taken from studying similar business models.

The structure of this section is:

Building the groundwork

- Identification of a framework for putting together a business model and customer proposition.
- Applying the framework to the MADE project concept in order to:
  - Understand the needs and wants of the customer.
  - Develop building blocks for the customer proposition.
  - Identify value streams which can bring revenue.
- Learning from emerging business models which are accessing residential demand response value streams.

Developing business models and customer propositions

- Development of future customer proposition within business models that could be launched in the future.
- Recommended customer proposition for a project trial recruitment.

A framework for building a business model

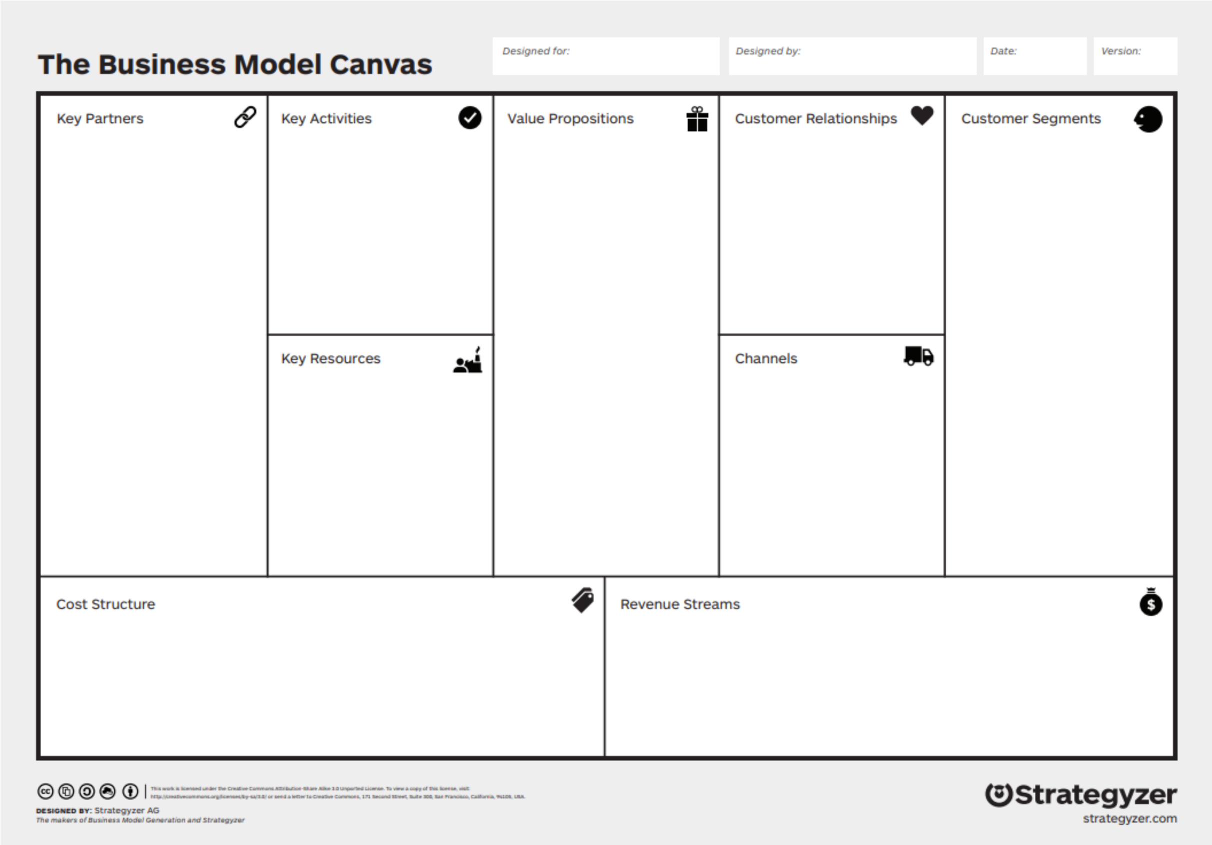
The Business Model Canvas

The business model canvas is a recognised gold standard for building and communicating business model concepts.

A business model is a plan for a successful operation of a business and outlines how an idea can be brought to life and make profit for a company.

The business model canvas was developed by Alex Osterwalder
and helps companies to think through the aspects needed to produce a successful business offering. It has been used globally by a wide range of companies. It offers a visual way of creating, exploring and refining a business idea within a team.

The right hand side shows the customer facing aspects and the left hand side show the aspects which are back-stage or internal to the company. The key to a successful business model is generating revenues which are higher than the costs by selling something that customers will pay for or which allow the company to access other value streams on offer.



A framework for building a business model

The value proposition canvas

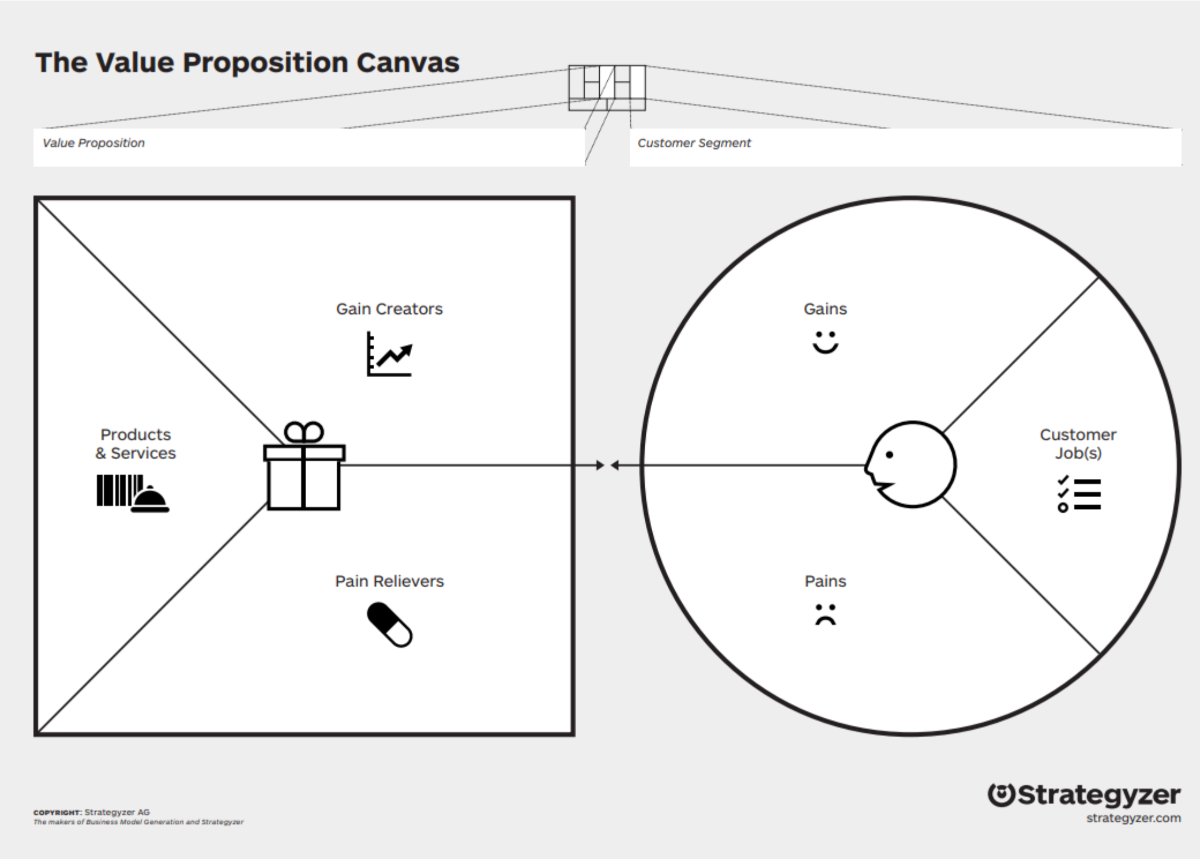
The value proposition canvas builds on the business model canvas. It provides a structure to ensure customers' wants and needs are met by what a company is offering.

"7 out of 10 new products or services fail to meet customer expectations? There's a surprisingly simple reason: misalignment between what customers care about and what companies have to offer." - Strategyzer based on source Simon-Kucher and Partners 2014

The customer proposition sits within the business model and forms the part of the structure which the customer will see. The value proposition canvas is another useful graphical tool. Any customer proposition (or value proposition) must be built around the needs and wants of the customer:

- **Customer Jobs** which may be functional, social or emotional
- **Pains** which customers hope to avoid
- **Gains** which are positive outcomes a customers hopes to achieve

By first considering the customer's needs and wants, we position the proposition around what a householder would find attractive. Some of these may be guarantees to be put in place to remove key risks, which might be overlooked otherwise. Typically companies are advised not to try to address every pain and gain identified, and these will vary for different types of customer.

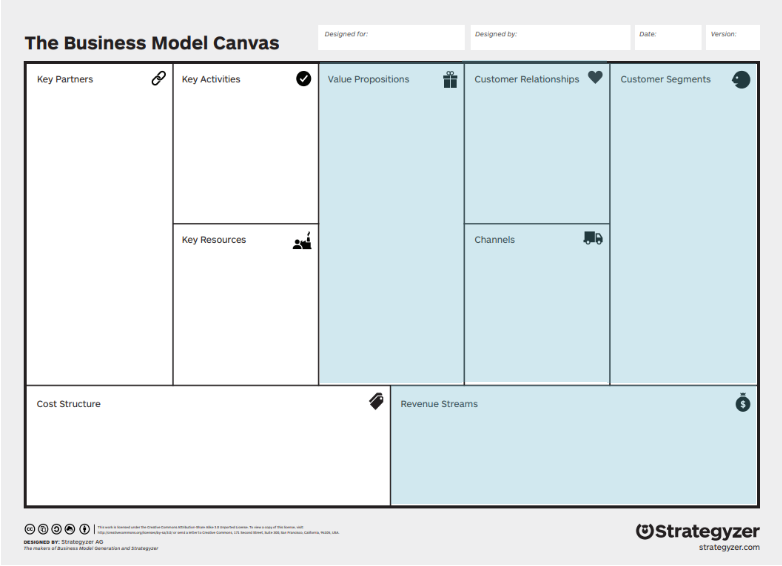


A framework for building a business model
Making the framework suitable for this project

The business model canvas and value proposition canvas help us to identify features to consider in this work, but our framework we will not be restricted to this format.

To build the proposition for a MADE project trial, we will focus on the following areas (shaded blue in the image):

- Building the customer proposition which is the fit between **value propositions** and **customer segments** (**see slide 90**).
  - We will consider how needs and wants vary for different types of customer.
  - We will create the structure for the customer proposition around products and services, pain relievers and gain creators. These will include identifying channels to reach the customers and the relationships established.
- Identifying **revenue streams** (**see slide 98**) which can be accessed using the range of technologies to be tested by Passiv (heat pump, gas boiler, EV, solar PV, smart control).



In the next section we will use this framework to develop the concept for creating a commercial proposition around combined operation and optimised control of electric heating, electric vehicles and solar PV output, in combination with variable tariffs / DSR value streams.

Applying the framework to the MADE project concept

Positioning the customer proposition to different customer types

Consumer preferences do not always appear to be rational, but considering their needs and wants can help to build more successful customer propositions.

At Delta-EE, we have carried out research on why and how customers want to buy heating and heating appliances. Not all decisions appear to be rational and often there are soft values which appeal more than financial incentives, and some risks that are immediately off-putting if they are not dealt with through guarantees.

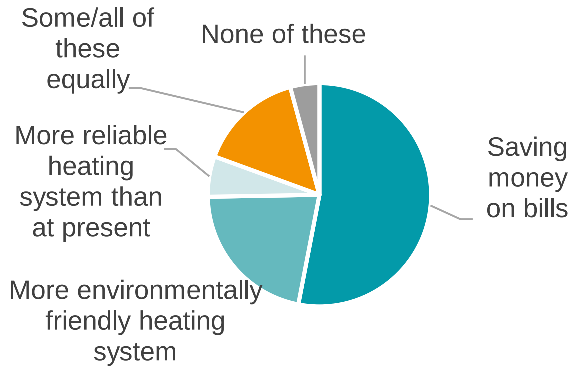
Customer segment considerations

Not all customers are motivated by the same things or experience the same problems. It is therefore important to consider what would appeal to different customers and focus a customer proposition at the right target market.

The customer jobs, pains and gains are broken down on the following slide by customer with the following priorities:

- **Cost sensitive**: any customer proposition will need to be good value. For some, this may be because they have difficulty paying for energy and/or technologies at present.
- **Valuing peace of mind:** customers will pay more for greater convenience or to remove perceived risks.
- **Environmentally driven:** customers will pay more for a low carbon solution to heating and personal mobility.

Most important considerations in changing heating system?



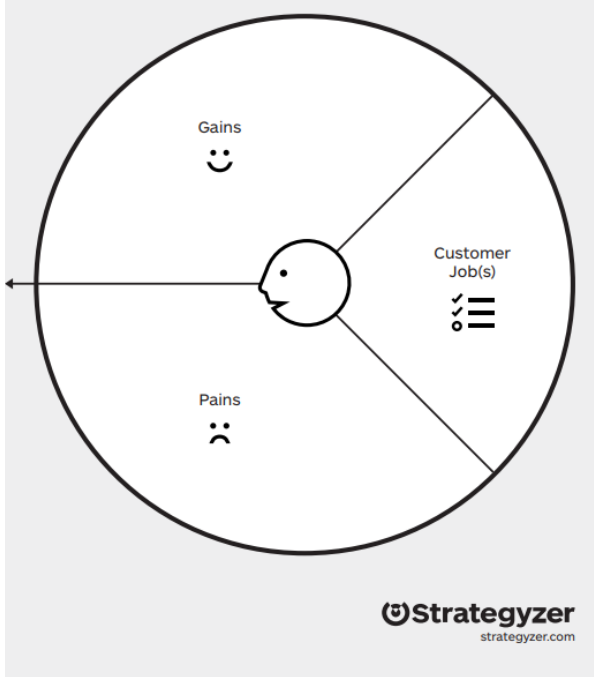
As part of the MADE customer research (see previous section) we asked respondents about their considerations when changing their heating system. The results are shown in the chart above. The biggest consideration is cost, followed by the system being environmentally friendly.

Applying the framework to the MADE project concept

Identifying what the customer cares about – their needs and wants

Gains

- Cheaper energy bills
- Getting a new heating system without having to pay for it (upfront)
- Home is warmer and/or more comfortable than before
- Car has enough charge when I want to use it
- Low carbon heating and EV reduces impact on the environment
- Good value
- Simple way of heating the house and/but being in control of heating when wanted
- Having financial risk taken away



Customer Jobs

- To heat their home and keep their family comfortable
- To commute to work and have their car for mobility as required
- To budget and balance income with outgoings
- To get warm when they need to (which they might currently do by standing by a radiator)
- To heat the house quickly if they return home unexpectedly
- To maintain dignity amongst friends and harmony within the family
- To be in sync with their personal values

Pains

- Cost of heating the house is presently too high
- Fear that the cost of heating the house will go up
- Uncertainty or risk that there will be unexpected extra cost from new ways of doing thing
- Concern over environmental impact of heating or driving
- Big cost of buying new home heating system
- Lack of trust of a third party having control of the heating system
- Fear that the home won’t be warm / comfortable
- Lack of control over the heating
- Fear of shame if house is too cold when friends/family visit
- Fear the car will be unreliable – battery low when needed
- Fear of not knowing what to do if a new type of heating system breaks down
- New technology looks ugly and will take up precious space in the house
- TOU tariffs sound too complicated to engage with

Note: Different customer segments will put different weighting on each job, pain or gain

Applying the framework to the MADE project concept

Specific customer propositions for different customer segments

Different types of customers will be driven by different needs or wants. Presented below are three customer characters and their most relevant jobs, pains and gains.

Cost sensitive

Customer Jobs
- To budget and balance income with outgoings

Pains
- Cost of heating the house is presently too high
- Fear that the cost of heating the house will go up
- Uncertainty or risk that there will be unexpected extra cost from new ways of doing thing
- Big cost of buying new home heating system

Gains
- Having financial risk taken away
- Good value
- Cheaper energy bills
- Getting a new heating system without having to pay for it (upfront)

Valuing peace of mind

Customer Jobs
- To heat their home when needed and keep their family comfortable
- To commute to work and have their car for mobility as required
- To maintain dignity amongst friends and harmony within the family

Pains
- Lack of trust of a third party having control of the heating system
- Fear that the home won't be warm
- Lack of control over the heating
- Fear of shame if house is too cold when friends/family visit
- Fear the car will be unreliable – battery low when needed
- Fear of not knowing what to do if a new type of heating system breaks down

Gains
- Having a simple way of heating the house and being in control of heating

Environmentally driven

Customer Jobs
- To be in sync with their personal values

Pains
- Concern over environmental impact of heating or driving

Gains
- Low carbon heating and EV reduces impact on the environment

General

Customer Jobs
- To get warm when they need to (which they might currently do by standing by a radiator)

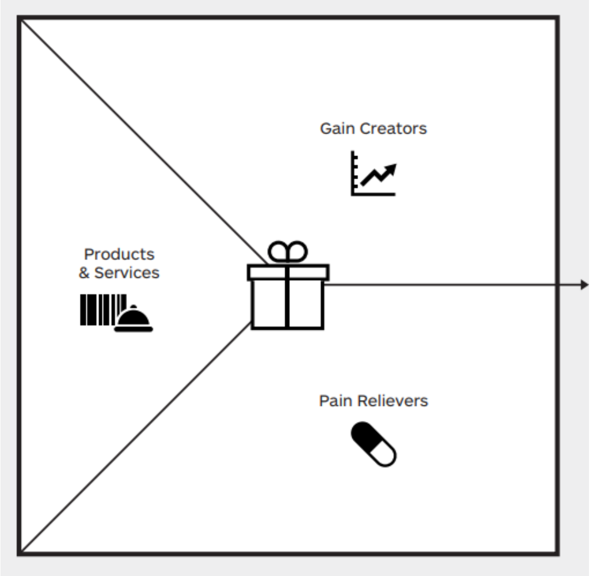
Pains
- New technology looks ugly and will take up precious space in the house

Gains
- Car has enough charge when they want to use it
- Home is warmer and/or more comfortable than before

Applying the framework to the MADE project concept

Focussing on what the relevant building blocks for the customer proposition

Having understood the customer's jobs, pains and gains, we can build up a customer proposition which delivers these.



Now that we have identified the customer needs and wants, we can try to build an attractive customer proposition.

The customer proposition (also called the value proposition) should address the pains which are currently experienced and which are feared in a new proposition. It should also seek to maximise the gains offered to customers (within financial limits). The products and services offered may be similar to what is already being offered in customer propositions and business models of similar companies, although these will need to be adapted for the UK market in many cases.

Options for building the customer proposition are shown on the following slides, following the structure of building blocks opposite.

The structure of the building blocks for consideration for building the customer proposition

Products and services	Purchase and ownership
	Customer relationships
Creating gains	Financial benefits
	Other benefits
Relieving pains	Guarantees
	Removing other risks

Applying the framework to the MADE project concept

Creating the customer proposition – products and services

Purchase and Ownership - as the market for heat services is growing, different structures are becoming more common for customers to own or lease a heating system or EV.

The business model is based on a bundle of technology being in the home:

- Hybrid heating system (air source heat pump and gas boiler,
- Electric car (EV) and charger,
- Solar PV and battery storage.

There are a range of options for how this technology is purchased by the household and/or whether they will own it throughout or at the end of the contract. Each has associated positive and negative*.

Option	Description	Pros	Cons	Implications for service provider
Bought upfront	Household pays full cost of technology upfront	– Customers not tied into long contract period – Customers (who can afford to) see paying upfront as best value option	– Many households unable to afford upfront cost – Risk of not making return on investment	– This is easiest for service provider – limits target market to those with sufficient savings.
Finance	Household gets technology installed without an upfront cost and pays off the cost over the contract length (with option for paying part upfront)	– No upfront cost – Customer owns technology at end of the contract	– Customer tied into long contract – Customers can find high interest rates off-putting	– Would need to offer low interest to appeal to most customers – Contract needs reasonable get-out clause
Lease	Household leases the technology and does not own it at any point	– No upfront cost – Minimum financial risk of ending contract early	– Customers can feel that money is wasted if they do not own the technology at the end of contract**	– Service provider must finance technology therefore taking on greater risk

*** Pros and cons are informed by Delta-EE customer research outside of this project – Focus groups to investigate customer views on purchasing a low carbon heating technology through a heat service contract.**

**** This is based on response in other areas of life e.g. rental housing, and not tested by Delta-EE for heating systems**

Applying the framework to the MADE project concept

Creating the customer proposition – products and services

Customer relationship - there are a number of stakeholders who need to be involved in the business offering, but not all need to have a direct relationship with the customer.

The business offering involves some form of relationship between the company and the customer. This may be one-off, such as when the company sells a product; light touch, such as selling energy; or it can be more involved when selling more of a service to a customer.

There are a range of stakeholders who may be involved in delivering the a large scale trial based on the MADE concept:

- Technology manufacturer and installer (different for each type of technology)
- Energy supplier
- Control supplier / operator
- Maintenance / servicing company
- Insurance provider
- Finance provider

A business model may include many products and services within one relationship with a service provider. This simplifies the whole package for the customer and can relieve some pains around finding the right installer or making sure technologies are compatible. Alternatively, the customer may have relationships through many channels. This may be preferred if they already have relationships or ways of judging good value.

Who do customers trust?
In recent focus groups we asked householders who they would trust to sell them a heating package. The most common answers were energy suppliers and technology manufacturers, which brands that they recognise. This was particularly strong when they would be entering into a long contract - they wanted reassurance that the company was reliable. They also trusted that these companies knew about heating and energy supply as it is their core business and would need reassurance on the credentials of any unknown service provider.

Contract length
The customer relationship is often formalised within a contract. The contract length will affect whether a customer proposition sounds attractive.

- If it is too long, customers are likely to be cautious due to risks of changing circumstances or poor value
- Is it is too short, the price of equipment is unlikely to be paid back or the monthly payments are going to be high

Recent Delta-EE research suggests that 5 years is the maximum contract length UK households are willing to accept at present. Longer contract lengths may be accepted with the following in place:

- Guarantee that the energy price will be as good, or better than competition,
- Acceptable get-out clause for contract if situation changes or moving house,
- Option to upgrade contract if a better technology or value stream emerges.

Applying the framework to the MADE project concept

Creating the customer proposition – promoting gains / value streams

A customer is likely to incur additional costs by participating in any future MADE business model. Most customers will require that these costs are off-set in some way so that they feel they are getting good value.

There are different ways that the customer can be rewarded financially within a future MADE business model:

- Self consumption of PV with battery
- Customer being paid a share of saving or revenue from flexibility* via:
  - Fixed credit payment per DR event
  - Credit payment as % of savings/revenue made by company
  - Cheaper tariff all day (not TOU)
  - Free or cheap technology lease
- Energy bill savings on dynamic TOU tariff via optimised control provided by energy service company
- Customer pays for an outcome (or a set of outcomes) and the service company manage their value streams* to make this profitable.

Non financial benefits that can be promoted

- Environmental benefits of:
  - low carbon heating
  - EVs
  - Solar PV and battery enabling guaranteed renewable electricity

In the MADE survey only ~2% of respondents said they were not interested or motivated to reduce their impact on the environment. In terms of monitoring their heating, only 14% of respondents said they pay not very much or no attention at all to the amount of heat they use in their homes. Of the respondents that own solar PV (150 respondents out of 750), 47% of them are 'very interested' and 21% are 'quite interested' in the idea of maximising their self consumption.

There therefore are non finical benefits that can be levered.

Value streams that aren't presently applicable to the UK

- Maxem's customer proposition provides value to the customer through the avoidance of high annual network charges. This isn't relevant to the UK as network charges are paid as a proportion of the unit price
- FCTR-E's customer proposition relies on customers being attracted to "luxury energy independence" and "upgrading to an e-home". With ~55% of UK homeowners not having heard of a heat pump** compared to ~20% in Netherlands (FCTR-E's market)***, this is not expected to be as attractive to UK customers.
- Green Mountain Power appears to get far more value from DR than currently available in UK, enabling them to lease technology to customer at low price.

*** These savings or revenue may be made by company via:**

- Demand response (turning down demand),
- ancillary services (selling stored energy to the grid),
- Buying cheap energy on static or dynamic TOU tariff.

**** MADE survey results**

***** based on results from another recent Delta-EE survey**

Applying the framework to the MADE project concept

Creating the customer proposition – avoiding pains / minimising risks

To participate in the MADE business model, a customer is required to buy expensive technology. In return, they are going to want some guarantees from the company to reduce their own risks.

What are the risks?

Financial

- They won't recoup the value of the technology they have bought,
- The energy costs won't be cheaper,
- Unexpected additional costs from changing from unfamiliar.

Performance

- New company won't control their heating / EV charging well and they are left with a cold home / insufficient mileage.
- Fear of technology breaking down and not knowing what to do / facing costs,

Other

- Being locked into a long contract without exit option if personal situation changes.

The customer proposition will need to offer some guarantees and contract terms which alleviate these risks for the customer:

Financial

- Customer could pay fixed monthly energy costs which are lower than their present costs,
- Customer could have a sufficiently lower energy price tariff that their energy bill reduces significantly, regardless of uncertainty,
- Customer could have a guaranteed maximum monthly bill or receive credit if their bills are above a certain level
- Leasing technology options can reduce the risk taken on
- Transparency around price structure so there aren't any unexpected costs

Performance

- Guaranteed performance around delivered temperatures or EV battery charge level written into contract (with high penalty paid to customer if it is not delivered)
- Maintenance / insurance included as standard

Other

- Contract lengths should be flexible
- Exit clauses need to be manageable
- It needs to be clear what happens if the customer moves house – e.g. contract passed on to next owner or technology taken with them
- Leasing technologies can reduce risk for get out clauses

Applying the framework to the MADE project concept

Identifying the five key value streams

Typically, revenue is paid from customer to company, but in future energy business models, revenue in is increasingly expected to come from other value streams.

A successful business model needs to ensure than revenues are higher than costs in order to make a profit and be sustainable long term.

In most business models, the main revenue source is the customer. In contrast, future energy business models are expected to generate revenue from other sources, mainly by providing flexibility to the electricity grid. In the future, the cost of energy is predicted to be more tied to when energy is drawn from the grid than how much energy is used.

There are a range of value streams which a business model based on the MADE concept could access. Some exist now whilst some will only emerge, or will grow stronger in the future. These value streams are shown on the following slides, and the 5 key types of value streams are shown opposite.

The aim of a large scale MADE project trial is to test how well residential demand response value streams could be accessed. These value streams are prioritised in the next section when we recommend business model options.

Summary: 5 key types of value stream

- **Flexibility through revenue generation:** predominantly through ancillary services, also potential for capacity market and DSO services
- **Flexibility through cost avoidance:** buying at cheap time on the wholesale electricity market or reducing network charges (e.g. in Netherlands)
- **Reducing energy being bought by customers, especially at expensive times:** through self consumption or through optimising timing of energy demand from the grid
- **Accessing incentives for low carbon (or avoiding penalties):** such as renewable heat incentive (RHI) or avoiding penalties for high carbon (e.g. a future domestic carbon tax)
- **Diversifying business offering:** Generating additional revenue buy selling add-on services and retaining customers

Applying the framework to the MADE project concept

A description of the value streams and the value they yield (1/4)

Value stream	Description	Estimate of value available	Future direction	Comments
Shifting demand to avoid expensive electricity periods (TOU optimisation)	Static (or dynamic) TOU tariffs can enable electricity to be bought at a cheaper price at times of high supply or low demand	The Octopus Energy trial reported savings of £45/yr for E7 storage heaters, £91/yr for engaged consumers, £132/yr EV drivers	Increase if domestic customers are exposed to wholesale price	Requires large electrical load (e.g. EV or heat pump), flexibility of that load. Optimal if have battery storage
Residential demand response (ancillary service income)	Making large electrical loads available to be switched off (or on) during DR events. Value comes from providing ancillary services.	£50-60/MWh for Balancing mechanism ~£100/MWh for Fast Reserve	Balancing mechanism expected to increase to ~£150/MWh in future	General view from market is that it would be risky to build a business model purely on ancillary services
Reduced network costs if electricity demands are more flexible	In the UK where residential customers pay fixed network charge, this is not a direct value stream, but cost savings from avoided network reinforcements can be high if electricity is fully flexible in the future	No value currently	Cost saving estimates of £8bn/yr in 2030 for a fully flexible grid – price would be passed on to companies and consumers	Not a direct value stream for customers or companies
Providing frequency response to the grid	Batteries (static or in EV) can provide small amounts of energy to help maintain frequency		Increasing in future	Can earn revenue with only small amounts of energy storage

TOU: Time of use
EV: Electric vehicle
DR: Demand response
E7: Economy 7 tariff

Applying the framework to the MADE project concept

A description of the value streams and the value they yield (2/4)

<table>
<tr><th>Value stream</th><th>Description</th><th>Estimate of value available</th><th>Future direction</th><th>Comments</th></tr>
<tr><td>Energy companies optimising wholesale price of electricity for their customers</td><td>Cost savings can be attained if an energy supplier can fix a demand profile for their customer base which has lower demand at peak times,</td><td rowspan="2">Limited value currently, but expectation in industry is that these will be significant value streams in the future as electricity prices become more volatile</td><td rowspan="2">Increasing in future as households have larger electrical loads (e.g. EVs or heat pumps)</td><td rowspan="2">Requires company to become an energy supplier</td></tr>
<tr><td>Energy companies balancing portfolio to minimise imbalance charges</td><td>Imbalance charges can be avoided if an energy company can control their customer portfolio so they don’t go above their estimated peak demand.</td></tr>
<tr><td>Selling electricity back to the grid to balance demand
e.g. Vehicle to Grid</td><td>Vehicle (or static battery) to Grid provides value from providing additional supply at times of high demand. Demand most likely to balance local network imbalance</td><td>Currently residential activity is at trial phase only.</td><td>Increasing once penetration of EVs (or batteries) gives predictable geographic coverage</td><td>Relying on V2G as a value stream would be challenging initially. Requires (10,000s?) of vehicles in known locations - not expected before 2030s.</td></tr>
<tr><td>Self consumption / optimisation</td><td>Using solar PV and battery (which may be in an EV) to optimise generation and demand within the home to minimise electricity bought from the grid (at peak).</td><td>Approximately 50% savings on energy bill from home battery.</td><td>Increasing as larger electrical loads and electric price increase (at peak times).</td><td>Requires Solar PV and battery. May enhance some of the other value streams (e.g. TOU optimisation).</td></tr>
</table>

TOU: Time of use
EV: Electric vehicle
V2G: Vehicle to grid
PV: Photovoltaic

Applying the framework to the MADE project concept

A description of the value streams and the value they yield (3/4)

Value stream	Description	Estimate of value available	Future direction	Comments
Selling generated electricity to electricity grid	Feed-in-tariff has historically provided a value stream for installing solar PV Government is currently consulting on a direct purchase alternative for future (Smart Export Guarantee (SEG)).	Currently 5p/kWh export tariff but no value for new installations. SEG likely to be <5p/kWh.	Unlikely to be a very large value stream in the future if not addressing demand / supply imbalance.	This has been a good value stream in the past for solar PV installations but is unlikely to be so in the future.
Optimising heating by price to reduce the cost of delivering heat outcome	Minimise cost of energy being bought to meet demand of multiple appliances (e.g. heat pump and EV), by managing sources of energy (gas, grid or solar PV electricity).	Freedom project found savings are highly reliant on the gas vs electricity price	Increasing as households are exposed to time varying price of electricity.	Will be particularly valuable for hybrid heating systems as there can be a price play off between electricity and gas.
Optimising heating to enable electricity and gas demand reduction	Minimising energy demand for appliances e.g. by optimising heating control to meet time and level of heat demand based on weather and occupancy patterns.	Smart heating controls can currently save up to 10% on heating bills.	Likely decreasing as smart heating controls become more wide spread – saturation.	Greater value if building retrofit can be included in business model along with long contract lengths (longer than the payback period).
Incentives for low carbon heating (e.g. RHI or successor)	Renewable heat incentive (RHI) has historically provided a funding stream to reduce payback period of low carbon heating, but it is to end in 2021.	Currently ~10p / kWh heat generated for ASHP and ~20p/ kWh heat for GSHP.	There is uncertainty of the replacement of the scheme after 2021 but it is likely to be lower.	Due to the uncertainty over this income stream after 2021, it would be risky to build proposition around this.

SEG: Smart Export Guarantee
PV: Photovoltaic
EV: Electric vehicle
RHI: Renewable Heat Incentive
ASHP: Air source heat pump
GSHP: Ground source heat pump

Applying the framework to the MADE project concept

A description of the value streams and the value they yield (4/4)

Value stream	Description	Estimate of value available	Future direction	Comments
Avoided carbon pricing for low carbon heating / transport	If in the future a carbon tax was brought in, low carbon heating, solar PV and EVs would bring value through avoided price increase.	No value currently. Likely to start off low if this is brought in.	Value could increase significantly in the future if carbon pricing is a key climate policy.	High uncertainty on this value stream.
Customer retention – reduced churn	There is currently value in energy suppliers or manufacturers differentiating from other suppliers, and building relationships to keep customers.	Estimated at ~ £50 per customer. A new customer is typically only profitable in year 3	Increasing as there is increasingly less profit to be made from energy supply.	Ultimately Passiv may not want to be an energy supplier, but this business model may be attractive to existing suppliers.

PV: Photovoltaic
EV: Electric vehicle

Business model case studies

Introduction to business model and customer proposition case studies

We can get relevant insight from emerging business models which are also accessing residential demand response value streams.

We need to understand how new emerging business models are capturing value from residential demand response (DR). This will help us to develop our own customer propositions within potential business models for accessing UK DR value streams.

At Delta-EE, we have a broad understanding of new energy business models across Europe and beyond. On the following slides, we present the most relevant companies that we know of. An overview of the companies which we are including is given in the list opposite. We also include details of some companies who have propositions at trial stage, which can also show the direction the market is going in.

After presenting an initial profile of each company, we compare them in the same framework which we will use to build and explain our conceptual business models and customer propositions. We assess how applicable the models are for the UK and summarise insights this exploration of existing business models has given us.

Companies being included

- **Maxem:** a Dutch controls manufacturer, minimizing maximum power draw across the home
- **Jedlix:** a Dutch aggregator, reducing the cost of charging an EV
- **Green Mountain Power:** an energy supplier based in Vermont, USA, offering customers resilience against power outages and better heating control in return for permission to turn down demand at peak times
- **Social Energy:** a UK aggregator, saving customers money through self consumption and making revenue through ancillary services
- **aWATTar:** an Austrian energy supplier, helping customers reduce their energy costs through a time of use tariff
- **North Star Solar:** a UK energy service provider, helping social housing tenants maximize self consumption of renewable electricity generation
- **The FCTR-E:** a Dutch energy service provider, selling customers a luxury electric home and energy independence for a fixed monthly fee

Business model case studies

Maxem and Jedlix

Maxem (Netherlands)

MAXEM focus on co-ordinating electricity generation, storage and consumption (including EV charging and heat pump use) to prevent grid overload and minimise overall electricity demand across the house, thereby avoiding high network charges (existing in NL).

Maxem design and sell a home energy management software to customers (basic control costs €795) which creates a smart grid within the home, optimizing self consumption and minimizing peak energy demand. Maxem controls and optimises the EV charge point and other electrical loads. This provides the customers with lower energy bills, faster EV charging and maximising the use of renewable energy generation.

Key value stream is the avoidance of higher network connection fees which are based on maximum power demand rating of the grid connection in Netherlands – typically an EV owner would have to upgrade the connection and pay higher annual charge. Customer buys technology and energy supply independently from their contract with Maxem.

Jedlix (Netherlands)

Jedlix offer a software based solution that calculates the best charging plan based on driving requirements, available renewable electricity and lowest energy prices, and the customer is guaranteed a fully charged EV when they need it.

When the customer arrives home they plug their car in and set the desired departure time via the app. Customers receive financial rewards (average saving of 0.02 €/kWh, quoting up to €200 per year) for allowing Jedlix to control the charging to balance the grid.

Acting as an aggregator, Jedlix create value by smart charging according to grid and network signals and renewable generation.

Jedlix is a spin-off from Eneco which has subsequently received investment from Renault. Jedlix has partnered with four Dutch energy companies and financial rewards are only paid to app users who buy their energy from these suppliers.

Business model case studies

Green Mountain Power and Social Energy

Green Mountain Power (Vermont, USA)

Green Mountain Power reduce peak demand by controlling demand of batteries, EV chargers, heat pumps, air conditioning and water heaters. Customers get technology for free or through a low cost lease contract.

Green Mountain Power are a utility company that are piloting a program of residential demand response across a range of electricity technologies.

Customers on the resilient homes pilot can lease two Tesla batteries for $30/month and this provides them resilience against power outages (which are common due to snow and high winds).

Customers on eControl pilot get a free Sensibo heating control for their heat pump in return for GMP being able to turn demand down at peak times (limited to 1-3 hours 6-8 times per month and customer can opt out). Similar for eWater pilot with electric water heating.

Social Energy (Yorkshire, UK)

Social Energy is a UK utility who are the first to have a contract as an aggregator*. They use a 5.5 MW bank of batteries across 1,600 customers to provide 1MW of demand response to the grid.

Customers buy or already own solar PV and a battery (social energy can sell them a battery when they sign up, but customer covers this cost).

Social Energy claim to reduce customers' electricity bills by up to 70%. This saving is from two sources:

- revenue from ancillary services to the grid - social energy pass on 70% of this income to customers
- self consumption of electricity generated from the solar PV reduces the excess electricity a customer needs to buy.

Social Energy is aiming to expand its platform into a complete home energy management (HEM) solution, and is partnering with Nissan and Wallbox to incorporate EVs.

* Social Energy are fully compliant with National Grid's dynamic frequency response service.

Business model case studies

aWATTar and North Start Solar

aWATTar (Austria)

aWATTar focus on reducing peak demand and promoting use of green electricity through a dynamic pricing tariff. Heat pumps and EV chargers can be automated to respond to price signals through data interface.

aWATTar provides different options of tariffs which includes an “hourly” tariff is which is promoted as “synchronising your consumption with nature” where the lower price hours are the ‘greenest’ hours (for more ‘engaged’ customers).

aWATTar help customers to shift their consumption to cheaper time periods either through their SYNCER hardware and software package which intelligently shifts heat pump operation into lower-price hours as much as possible (as well as maximising efficiency), or by providing hourly pricing data to heat pumps which contain similar intelligence within the heat pump. It can also help to maximise PV self-consumption.

aWATTar claiming to save customers around 10% on their bills through the dynamic tariff.

North star solar (UK)

North Star Solar focus on maximising customer self consumption from solar PV to deliver cost savings to the customer. Flexibility value streams may be added in the future too.

North star solar are offering a solar PV and battery package (including IOT sensors and smart thermostat) to housing association tenants with no upfront cost.

Tenants continue to pay energy supplier for their energy plus a charge to cover cost of technology which is paid back to supplier through pay-as-you-save arrangement).

Tenants are offered lower energy bills and protection from future price rise and ‘free’ broadband (needed to control the battery) worth ~£20/month.

They are looking at additional value stream in the future through residential demand response – ancillary service

Business model case studies
The FCTR E and selected similar propositions in trial phase

The FCTR E (Netherlands)

The FCTR E focus on providing a full suite of electricity generating, storing and consuming devices which are optimised to provide an outcome for the customer. Flexibility value streams may be added in the future too.

The standard offer includes a heat pump, water tank, solar PV panels and smart home controls. EV charging and battery storage options are also possible. No upfront cost (saving a ~€35k lump sum. Customer pays a membership fee (variable, typically ~€250/month) including technology costs, installation, monitoring, maintenance, guarantees and service (assumed 15 year contract).

Customers continue to pay energy supplier for residual energy (To be offered as flat fee in 2020). There is potential for a future value stream through residential DR, acting as a virtual power plant by aggregating their customer base and provide grid services.

Business model case studies

Selected similar propositions in trial phase

A number of other companies are developing similar business models and customer propositions, still in trial phase.

Beegy (Germany)
Beegy are trialling a flat rate offer where customers pay a fixed monthly price for electricity so the company is incentivised to control it well. Risk to the company is minimised as the customer buys technologies (heat pump, solar PV, storage). In the future they intend to generate more value through TOU tariff

B-Snug (offering from PassivSystems)
B-Snug are developing an offer for customers to get a hybrid heating system at no upfront cost. B-Snug are paid £39/month by the customer and access RHI payments for the heat pump. Smart controls enable optimisation of the heating system and customers are guaranteed savings of at least £350.

Eneco (Dutch utility)
Eneco is running Heat Comfort 20 trial, offering a “Comfort-as-a-service” proposition, initially via landlords. Eneco install a heat pump and the customer pays for an agreed outcome, e.g. 20 °C in their house plus 30 minutes of hot water. Motivated by need for energy suppliers to find other income streams.

Boxergy (Edinburgh, UK)
Boxergy are developing an offer of a heat pump at the same upfront cost as a boiler. Their controls enable them to participate in the flex market to access an extra value stream. Their aim is to be able to deliver heat at 1p/kWh.

Summary table of business model case studies (1/2)

DELTA Energy & Environment

	Maxem (Netherlands)	Jedlix (Netherlands)	Green Mountain Power (Vermont, USA)	Social Energy (UK)
Technologies included	Solar PV, battery, EV, heat pump, smart home controller	EV smart charger	One or more of: Battery, smart control for heat pump and AC, EV smart charger	Solar PV and battery (intending to add others in the future)
Purchase / ownership of tech	Customer buys upfront	Customer buys upfront	Can be leased (at cheap cost) or bought by customer or given free (depending on tech)	Customer buys upfront (many already own solar)
Energy supply	Bought separately	Bought separately	Included	Bought separately
Contract	No monthly fee, no minimum contract length	No monthly fee, no minimum contract length	Monthly leasing fee ($30 for battery, $10 for EV charger)	No monthly fee, no minimum contract length
Customer value streams	Avoided network charges	Financial rewards (credit) for allowing Jedlix to control charging time	Resilience during outage periods Low cost or free technologies	Self consumption of solar electricity reduces electricity costs. Credit passed on to customer from flex services.
Company value streams	Selling smart home controller (€795 for basic controller)	As an aggregator, responding to grid and network signals. Paid for DR	DR cost savings and/or revenue	30% of revenue from selling ancillary services to the grid (70% is credited to customers)
Risks	Minimal risks for customer	Minimal risks if customer doesn't have irregular demands for car over night	Minimal risks as customer has control to opt out of DR events	Minimal risks for customer
Target customer	Those who own or want an EV and heat pump	Those who own an EV	Battery – anyone at risk of power outages, EV, heat pump or AC owners, or those who want to own these.	Those who already own solar PV, and/or who want to maximise their consumption of renewable generation
Company type	Control manufacturer	Aggregator	Energy supplier	Aggregator

EV: Electric vehicle
PV: Photovoltaics
DR: Demand response
AC: Air conditioning

Summary table of business model case studies (2/2)

	aWATTar (Austria)	North Star Solar (UK)	The FCTR-E (Netherlands)
Technologies included	Smart controller, plus one or more of heat pump, EV, solar PV, battery	Solar PV and battery, IOT sensors and smart thermostat (intending to add others in the future)	Standard offer: heat pump, water tank, solar PV, smart home controls. Optional extra: EV charger, battery.
Purchase / ownership of tech	Customer buys upfront	Technology installed at no upfront cost to household	Technology installed at no upfront cost to customer
Energy supply	Included	Bought separately	Bought separately
Contract	No monthly fee, no minimum contract length	20 year contract, Cost of technology is paid back through pay-as-you-save arrangement (via extra charge on energy bill)	Membership fee (typically ~€250 per month) including technology costs, installation, maintenance and servicing (assumed 15 year contract).
Customer value streams	Cheaper energy bills by shifting to cheap periods on TOU tariff or by maximising self consumption	Lower energy bills, protection from future price rise and 'free' broadband	No upfront cost, mainly non financial value: appealing to desires to have an all electric home and seeing it as luxury, easy budgeting, peace of mind
Company value streams	Customer retention, sale of smart charger	Partnerships with local authorities (this may provide the benefit of a large market) Additional flex value streams in future	Profit from delivering energy services at cost lower than monthly fee through self consumption and good control. Potential for future flex value streams.
Risks	Minimal risks for customer	Tied into long contract to pay off cost of technologies. Risk to company that technology won't be paid off	Tied into long contract to pay off cost of technologies. Risk to company that technology won't be paid off
Target customer	Those who want to reduce impact on environment, or who own technology and want to save money	Tenants of social housing	Wealthy / high income households who are attracted by an all-electric home
Company type	Energy supplier	Energy service provider	Energy service provider

EV: Electric vehicle
PV: Photovoltaics
IOT: Internet of things

Business model case studies

Identifying what we have learned from studying similar business models

Through investigating other business models we have learned:

No-one is currently offering the same range of technologies which Passiv is focussing on. The closest are the FCTR-E, Green Mountain Power and aWATTar, but they give customers the flexibility over which technologies to include across heat pump, solar PV and battery and EV and charger. All require a smart controller of some form.

Some business models are built on value streams that are not expected to arise in the UK. E.g., Maxem rely on there being value in reducing peak load over the house, and Green Mountain Power benefit from high value being placed on resilience due to common power outages.

Where some business models rely on customers owning or buying technologies, we do not think this is directly replicable in the UK at present as technologies such as heat pumps are not currently well known or desired.

Company	Applicable to UK market?	Reason
Maxem	No	Main customer value is in avoiding high network charges. In UK, network charges are charged per kWh not for the connection rating to the house so this value stream doesn't currently exist.
Jedlix	Yes	Similar to the model of Social Energy, but using EVs instead of static batteries. Would need to know location of charging vehicles to sell grid services to DNOs (i.e. to relieve load on local networks).
Green Mountain Power	Not to the same extent	Value for DR is lower in the UK than in Vermont, USA. Therefore there is not so much value available which can be passed on to attract customers. Most UK households also don't suffer the same frequency or duration of power outages.
Social Energy	Already in UK market	n/a
aWATTar	Yes	Although the demand or awareness for electric or low carbon heating or personal transport is not as broad as in Austria.
North Star Solar	Already in UK market	n/a
The FCTR-E	Yes	Although the demand or awareness for electric or low carbon heating or personal transport is not as broad as in Austria.

Customer Proposition development

Introduction to Customer Proposition Development

Introduction to three customer propositions within business models that access residential demand response value streams.

In this section we present three conceptual customer propositions. They focus on using combined operation and optimised control of electric heating (hybrids / heat pumps), electric vehicles and solar PV output, in combination with residential DR value streams or variable tariffs. The propositions are:

- All energy services (heating, personal transport and other energy needs) provided for single monthly fee.
- Company optimises energy demand across technologies and pays income to customer.
- Balancing electricity demand over the home to reduce peak demand, in return for a cheaper tariff.

The propositions are constructed using the framework outlined opposite and based on learning from studying similar business models. The value streams on which these propositions rely are not all mature in the UK at present. They also rely on a greater awareness and appeal of low carbon heating systems, particularly in options where the customer is expected to buy the technologies upfront or already own them. This means that they are expected to be suitable in the future but not ready for market currently.

Features for building the business model and customer proposition

- **Technologies**: The purchase arrangement of the technology and whether the customer owns or leases these technologies
- **Energy supply**: Whether energy supply is included in the proposition or if it is bought separately
- **Contract**: Details of what is included in the contract and whether the proposition has a fixed contract length
- **Customer value streams**: How the customer gets value out of the relationship
- **Company value streams**: where value can come from to both reduce costs and access new revenue
- **Risks**: level of risk to customer and company and how these risks are managed
- **Target customer**: who the specific customer proposition might appeal to, to judge the size of this target market
- **Most suitable provider**: whether the business model is best delivered by an energy supplier, manufacturer or third party energy service provider

Customer Proposition development

Customer proposition 1: All inclusive

All energy services (heating, personal transport and other energy needs) provided for single monthly fee.

This option focusses on minimising the cost of buying electricity from the grid by maximising self-consumption.

The main aim of this business model is to deliver heating to the home using electricity generated by the solar panels. Control strategy of the heat pump would predict when heating is needed and pre-heat the home using available electricity if appropriate. If insufficient electricity is generated, then cheap electricity could be bought from the grid or heating could be delivered via the boiler.

Any excess electricity could be used to charge the EV, supplemented by grid electricity which is expected to be sufficiently cheap over night.

Excess stored electricity could also be sold back to the grid at times of high demand.

Business Model

Technologies included

- Heat pump,
- Gas boiler,
- EV,
- Solar PV,
- Battery storage,
- Smart controller hub.

Company value streams

- Minimising electricity demand on the electricity grid, and only buying at low cost times by optimising self consumption and storing cheap electricity,
- Selling electricity back to grid at times of high demand.

Target customer

Customers who seek low carbon heating and personal transport. House may need a minimum level of thermal efficiency to be viable.

Customer Proposition

Technologies provided at no upfront cost.

Monthly fee to include:

- Cost of technologies,
- Energy supply (monthly cost based on some description of service demand, and potential to change if energy demands change significantly),
- Maintenance, servicing and insurance.

Contract could be either:

- Fixed contract period (i.e. 5 years) – monthly fee higher for a shorter contract length, or
- Rolling contract (with no minimum length) with get-out fee for removal of technologies if before e.g. 10 years.

Risks are low for the customer as main risks are taken on by company. Perceived risks of entering an extended contract

Customer Proposition development

Customer proposition 2: Buying enhanced control

Flexible package where company optimises energy demand across whichever assets the customer has. Customer buys technologies and energy separately.

This option provides flexibility to the customer who can include whichever technologies they have or want to buy and has no tie-in to a contract.

The main feature of this business model is the smart controller hub which optimises energy demand for heating across heat pump and boiler and optimises EV charging based on pricing signals or other choices given by the household (i.e. it could be to minimise cost or CO_2 emissions).

The customer is responsible for buying the technologies and energy separately, and the company delivers energy savings compared to each technology being controlled separately. If the package includes battery storage, additional revenue can be gained from selling electricity back to grid at times of high demand and the customer is paid credit for each of these DR events.

Business Model

Technologies can include

- Heat pump,
- Gas boiler,
- EV,
- Solar PV,
- Battery storage,
- Smart controller hub (required).

Company value streams

- Sale of smart controller hub
- DR revenue from selling electricity back to grid at times of high demand.

Target customer

Customers who seek low carbon heating and personal transport. House may need a minimum level of thermal efficiency to be viable.

Customer Proposition

Technologies bought upfront or through finance arranged by the customer.
Energy supply bought separately by customer.

No Monthly fee, no minimum contract

Customer value streams

- Energy bills are reduced by smart controller optimising energy demand across heating, EV charger and storage (not all have to be included).
- Greater savings can be made if customer is on a TOU tariff.
- Credit paid back to customer as share of revenue for selling electricity back to grid at times of high demand.

Risks are low if the customer was seeking to buy these technologies already. It would take some years to pay back capital cost so not suitable if cost is main motivation.

Customer Proposition development

Customer proposition 3: Minimising peak demands

Minimal benefits to customer, and minimal risks. Main benefits are in balancing electricity demand over the home to reduce peak demand, in return for a cheaper tariff.

*Solar PV and storage are not included in this proposition. This tests the performance of the hybrid heating system and EV combination in homes where PV and storage are not possible. Different combinations of technologies may be suitable for different households.

This option is the closest extension to the FREEDOM project, testing the ability of control across the house to minimise costs and reduce peak demand.

The main aim of this business model is to minimise overall power draw of the house by controlling the heating and EV charging assets without the a requirement for storage and PV*.

Hybrid heating system operation is controlled to optimise efficiency of the heat pump, overall cost on a dynamic TOU tariff, and ideally also minimising gas usage. EV charging is optimised for times of low electricity demand in the home and cheap grid electricity.

Where chargers are compatible, some stored electricity in the EV could also power the heat pump operation.

Business Model

Technologies included*:

- Heat pump,
- Gas boiler,
- EV,
- Smart controller hub.

Company value streams

- Minimising overall power draw across home – no current value to this but good research for network operator.
- Reacting to TOU tariffs to make heating and EV charging as cheap as possible. HP delivering heating during times of cheap electricity and using gas boiler at other times. EV charging overnight reacting to TOU cost profile.
- DR turn down – via TOU tariff or as grid services.

Target customer
Customers who are looking to buy a heat pump and EV.

Customer Proposition

Energy supply: included (business model relies on a dynamic TOU tariff) – could be charged separately or within a monthly fee.

- recommend charging separately as there is risk to company from un-restricted energy demands.
- If included in monthly fee, recommend including maintenance to ensure technology is working efficiently.
- Value could be given over to the customer via a cheap flat energy price on the tariff (customer not being exposed to high TOU prices).

Technologies could be bought upfront or on subscription for a monthly fee.

Risks are low if the customer was seeking to buy these technologies already (costs cannot be higher than controlling all technologies separately).

Customer Proposition development

Summary table of customer proposition options

	Option 1: All inclusive	Option 2: Buying enhanced control	Option 3: Minimising peak demand
Technologies included	Heat pump, Gas boiler, EV, Solar PV, Battery storage, Smart controller hub.	Smart controller hub plus any combination of Heat pump, Gas boiler, EV, Solar PV, Battery storage.	Heat pump, Gas boiler, EV, Smart controller hub.
Purchase / ownership of tech	Leased at no upfront cost to customer.	Bought upfront by customer (or through finance arranged by customer).	Bought upfront by customer (or through finance arranged by customer).
Energy supply	Included within monthly fee.	Bought separately by customer.	Included but paid per unit energy used.
Contract	Monthly fee covers lease of technology, energy supply, MS&I. Approx. 5 years (could offer choice).	No monthly fee, no minimum contract length.	No monthly fee, no minimum contract length.
Customer value streams	Monthly fee which is an acceptable price to customer, easier budgeting, peace of mind.	Energy bills are reduced by smart control hub. Credit paid back from any DR revenue.	Cheap flat rate energy price (not being exposed to TOU variation).
Company value streams	Minimising cost of electricity through self consumption and buying at cheap times (company keeps costs savings), selling electricity to grid at peak times.	Sale of smart controller hub DR revenue from selling electricity back to grid at times of high demand.	Minimising peak power draw over home (no current value in this in UK), Minimising cost of heating and charging EV via dynamic TOU signals, DR Revenue - turning down demand.
Risks	Low for the customer, except for perception of entering a contract. Main risks taken on by company.	Low if the customer was seeking to buy these technologies already (but long payback period if all tech bought).	Low if the customer was seeking to buy these technologies already.
Target customer	Customers who seek low carbon heating and personal transport.	Customers who own or would like low carbon heating and personal transport.	Customers who are looking to buy low carbon heating and personal transport.
Most suitable provider	Energy Service Provider (could be energy supplier, manufacturer or other).	Controls company.	Energy supplier, DNO.

EV: Electric vehicle
PV: Photovoltaics
DR: Demand response
MS&I: Maintenance, servicing and insurance of technologies
TOU: Time of use
DNO: Distribution network operator

Creating customer propositions for the MADE concept

creating a proposition for a large scale trial of the MADE concept

Separate to understanding a potential future business model, PassivSystems also want support on creating a proposition for participants in a large scale trial of the MADE concept.

Core to a trial of the MADE concept would be testing how the suite of technologies interact and can access flexibility value streams as they emerge or increase in the future.
In order to have a focus on these value streams, PassivSystems intend to structure the MADE concept as a business model and not just a technology trial.

The fixed aspects of the trial

- All households with have all technologies: hybrid heating system (heat pump and boiler), EV and charger, solar PV and battery, control hub
- Households will pay for or already own heat pump, boiler, solar PV and battery Household will be provided with EV, charger and control hub
- Trial length will be 2 years
- No further relationship or contract is intended to be offered after 2 year trial

To build a strong customer proposition, Passiv need to understand their potential trial participants. To enable this, we have used the Value Proposition Canvas structure [introduced on slide 88] to identify what the customer needs and wants, what pains could be overcome and what gains they would be willing to pay for. Based on this, we have recommended pain relievers and gain creators which might attract participants to the trial. If it is intended that the trial targets different types of consumers, this could be explored using the same structure in more detail. The outcome is shown on the next slide.

Based on the constraints and the recommended additional services to be included, we have recommended options for a large scale MADE trial [on slide 119].

Summary

The options for a trial proposition are limited by the requirements on which technologies must be include, and that the customer must pay for them. The main variation between different options are whether energy supply is included, and how the customer is financially incentivised to participate.

Unlike in some other countries where these business models are more developed, we are not aware of consumers being sufficiently attracted to the concept that an all electric home is a luxury, and therefore attracting participants with this proposition is likely to be a big challenge as they are put off by the upfront cost. The recent rise in awareness of the climate emergency might be a bigger drive amongst some, in supporting a transition to a zero carbon future.

Creating customer propositions for the MADE concept

Understanding the potential trial participants

Customer Jobs (assumed)
- To heat their home, keep their family comfortable
- To commute to work or travel where and when they need
- To budget and save money by balancing incomes with outgoings
- To maintain dignity amongst friends and harmony within the family

Products and Services (defined by Passiv)
- Technologies are: hybrid heating system (heat pump and boiler), EV and charger, solar PV and battery, control hub
  - Customer already owns solar and a compatible boiler
  - Customer pays for heat pump and battery
  - Customer is given the lease of an EV
- Energy supply may or may not be included

Pains (assumed)
- Problems with heating the home: cold rooms, dampness
- High cost of energy for heating or fuel for driving
- High cost of new technologies and uncertainty over whether investment will be worth it if they move house
- Impact on environment of heating and car travel
- Not knowing what to do if there's a problem – possible high cost

Pain Relievers (recommended)
- Guarantees on performance of heating system that it will deliver sufficient level of comfort, and EV will have sufficient charge when needed
- Guarantees that energy costs will not be higher than now
- Including maintenance, servicing and insurance
- Display to show that heating system is working properly

Gains (assumed)
- Cheaper energy bills
- Home is warmer and/or more comfortable, no dampness problems Reduced impact on the environment
- Better control over heating
- Owning new, attractive technology

Gain Creators (recommended)
- Easy to use controls for controlling heating
- Including new, attractive technology (e.g. an EV)
- Reducing (or subsidising) energy bills by accessing (or replicating) new value streams
- Periodic reporting on CO_2 savings made

Creating customer propositions for the MADE concept

Summary table of options for a large scale MADE trial

	Option 1: fixed monthly cost	Option 2: low price energy tariff	Option 3: credit payment	Option 4: social housing
Technologies included*	Heat pump and battery storage (paid for by customer), Gas boiler and Solar PV (assumed customer already owns) EV (leased to customer for free), Smart controller hub (assume given for free)			
Purchase of tech*	Bought upfront by customer For social housing, this would be paid for by			Bought by social housing provider through grant funding
Energy supply	Included: within fixed monthly fee	Included: paid per unit used	Bought separately by customer	Bought separately by customer
Contract *	Length of trial (2 years) Guarantees include: sufficient level of comfort delivered, sufficient mileage in car when required			
Customer value streams	**Low fixed monthly price for energy** (based on level of existing usage or similar) MS&I included Lease of EV for free	**Low price tariff for energy** Lower energy demand (due to increased self consumption) MS&I included Lease of EV for free	**Monthly or periodic credit payment** for being involved in the project Lower energy demand (due to increased self consumption) MS&I included Lease of EV for free	**Monthly or periodic credit payment** for being involved in the project Lower energy demand (due to increased self consumption) MS&I included Lease of EV for free
Company value streams	Experiments demonstrate value of: optimising dynamic TOU, self-consumption of PV, selling electricity back to grid via DR.			
Risks	Financial benefit to customer is unlikely to cover capital cost of technologies Value streams cease to exist after trial			
Target customer	Wealthy / high income households who are attracted by all-electric home or minimising environmental impact			
Partners needed	Energy supplier, provider of EVs	Energy supplier, provider of EVs	Provider of EVs only	Provider of EVs, social housing provider

***Our understanding is that these are already fixed by PassivSystems**

EV: Electric vehicle
PV: Photovoltaics
DR: Demand response
MS&I: Maintenance, servicing and insurance of technologies
TOU: Time of use

DELTA Energy & Environment

Appendix

References
Technology forecasts methodology and assumptions
Modelling feeder composition

Appendix – Delta-EE scenarios methodology

Summary of technology uptake forecasting methodology for HHS and HPs

1) Build the assumptions database.

Via detailed conversations / interviews, and by reviewing reports and public sources of data, we gathered assumptions on the current and future values for: Energy prices, technology prices, technology efficiencies, annual maintenance costs, incentives for lower carbon appliances / energy efficiency measures, customer & installer attitudes towards lower carbon appliances.

2) Housing stock segmentation of the dwelling stock.

By reviewing various sources of housing stock data and applying our housing stock modelling approach we segmented the housing stock by fuel type (gas, oil, electric/other), thermal demand and new build vs retrofit.

3) Techno – economic modelling of different heating appliances in different housing segments.

By combining technology, policy & energy price data (step 1) with our housing stock model (step 2), we:

- Calculate the marginal upfront cost and marginal payback period of each technology in each segment of the housing stock
- Calculate the 'physical fit' % of each technology in each segment using the % fit assumptions above and the housing stock segmentation.

4) Calculate the market uptake % of each technology in each housing segment.

Using marginal upfront cost / payback versus market uptake curves, and the physical fit % of technologies in different housing segments, we convert the techno-economic performance of each technology into a **market uptake %**. Using qualitative views & research on installers & customer attitudes towards low carbon technologies, we generate a **'customer soft factor' uptake %.**

5) Apply the final market uptake % for each appliance to the addressable market in each housing segment

For each technology, we combine the **market uptake %** with the **'customer soft factor' uptake %** to arrive at a **FINAL uptake %** for that technology in a particular housing segment. This FINAL uptake % is then applied to the 'addressable market' in each housing segment to give an annual sales figure for that appliance in that segment. The overall annual sales figure for each technology are calculated as the sum of the sales achieved by each technology in each housing segment

Appendix – Delta-EE scenario assumptions

The main assumptions for the central scenarios for ASHP and Hybrid uptake to 2050 are as follows:

Notes

- Scenarios were developed by Delta-EE for Gas network companies.
- Scenarios were not optimised to meet carbon reduction target, but assumptions were based on predictions of policy decisions
- Penetration hydrogen. Scenario is based on assumption that gas grids will remain functional but will be decarbonised through generation of low carbon hydrogen as promoted by the Committee for Climate Change report. The level of hydrogen available is assumed to be sufficient to power the gas boiler part of a hybrid heat pump, but insufficient to heat homes with hydrogen boilers alone. This leads to an assumed higher uptake of hybrid heating systems than the FES scenarios.
- ASHP for new-build and off-gas grid homes, HHS for retrofit. ASHPs are assumed unsuitable for most existing homes due to the challenge of meeting thermal comfort demands in the UK's existing thermally in-efficient housing stock, and the low ambition for improvement. We assume that installation of ASHPs in existing homes will be prioritized for off-gas homes.
- Policy drivers. We assume that there will be increased government commitment to carbon mitigation and decarbonization of heating after 2030. Modelling was undertaken before the latest commitment to end fossil fuel heating for no homes after 2025, but does include regulations in new build to accelerate the transition to high efficiency, low carbon forms of gas heating.

Appendix – Future Energy Scenarios (FES) scenarios

National Grid produce the Future Energy Scenarios (FES) to identify a range of credible scenarios for the energy system for the next 30 years and beyond.

Community Renewables
This scenario explores how the 2050 decarbonisation target can be achieved through a more decentralised energy landscape.

Two Degrees
This scenario explores how the decarbonisation target can be achieved using larger and more centralised technologies.

Consumer Evolution
This is a more decentralised scenario which makes progress towards the decarbonisation target but fails to achieve the 80 per cent reduction by 2050.

Steady Progression
This is a more decentralised scenario which makes progress towards the decarbonisation target but fails to achieve the 80 per cent reduction by 2050.

Source: Main FES document (2018)

Appendix – Future Energy Scenarios (FES) scenarios

	Community Renewables	Two Degrees	Consumer Evolution	Steady Progression
Heat	Homes become more thermally efficient, and heat pumps are the dominant technology. Green gas and increased use of district heating also have a role.	As with Community Renewables, homes become more thermally efficient as there is a drive towards decarbonisation. By 2050 the dominant heat source is hydrogen, supported by a mixture of gas boilers, district heating and heat pumps.	Limited progress is made towards decarbonising heat. There are only small improvements in thermal efficiency. There is some progress in the rollout of heat pumps, but current heating technologies remain dominant.	Most residential properties rely on gas boilers. There is limited use of heat pumps and smaller improvements in the thermal efficiency of houses. Decarbonisation of the heating sector is slow.
Transport	The Government's aspiration to end the sales of conventional petrol and diesel powered cars and vans by 2040 is met. EVs become the most popular personal mode of transport.	The Government's 2040 transport aspiration is met. EVs become the most popular choice for personal transport. Increased use of public transport features in this scenario.	Private ownership of personal vehicles remains popular. The Government's aspiration for transport in 2040 is not met, though EVs are still the dominant choice for personal transport by 2050.	The Government's aspiration for transport in 2040 is not met, though EVs are still the dominant choice for personal transport by 2050.
Solar PV	There is a push to decarbonise electricity using small scale generation.	High levels of renewable generation exist in a decarbonised scenario but this centralised scenario favours large scale generation.	Slow pace of decarbonisation of electricity but there is a focus on small, domestic solar over ground mounted installations in this decentralised scenario.	There is a slower pace of decarbonisation of electricity and focus on larger ground mounted solar rather than domestic.

Source: Main FES document (2018), Scenarios framework document (2018, .xls file)

Appendix – feeder composition

Details of house types on each feeder for each scenario modelled

Scenario 1a: 35% penetration of technologies, EVs all used for commuting

Segments % on feeder	EV commuter	EV parent	EV social low	No technology
High	35%			65%
Medium				
Low				

Scenario 1a: 53% penetration of technologies, EVs all used for commuting

Segments % on feeder	EV commuter	EV parent	EV social low	No technology
High	53%			47%
Medium				
Low				

Scenario 1a: 80% penetration of technologies, EVs all used for commuting

Segments % on feeder	EV commuter	EV parent	EV social low	No technology
High	80%			20%
Medium				
Low				

Appendix – feeder composition

Details of house types on each feeder for each scenario modelled

Scenario 1b: 80% penetration on new technologies

Segments % on feeder	EV commuter	EV parent	EV social low	No technology
High	27%	27%	27%	20%
Medium				
Low				

Scenario 2: 80% penetration on new technologies

Segments % on feeder	EV commuter	EV parent	EV social low	No technology
High	11%	11%	11%	7%
Medium	11%		11%	7%
Low	11%		11%	7%

Scenario 3: 80% penetration on new technologies

Segments % on feeder	EV commuter	EV parent	EV social low	No technology
High				
Medium	20%		20%	10%
Low	20%		20%	10%

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