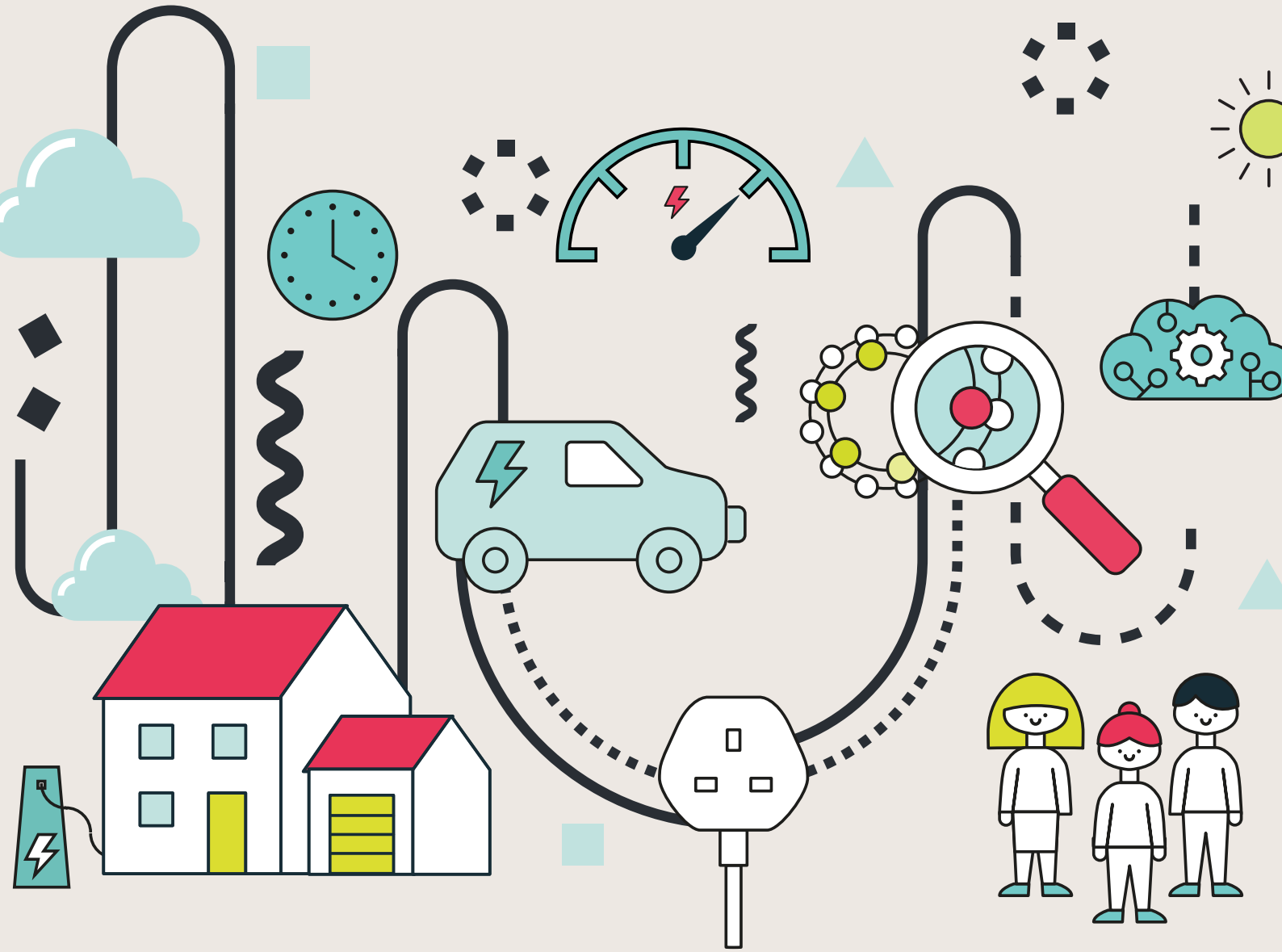
CATAPULT
Energy Systems



Demand Side Response

Putting consumers in the driving seat

Understanding what consumers want

As renewable energy generation grows, it can become harder to match available electricity supply to consumers' demands.

Smart technologies can help by increasing demand when supplies are high or reducing demand when supplies are low. This practice is called Demand-Side Response (DSR).

Electric vehicles could offer valuable capacity to balance the grid as more people start to drive them in the future. However, consumers will reject DSR if it prevents them using their cars as they want to - it needs to be designed to fit into their daily lives.

The government is funding innovative domestic DSR demonstration projects. The Flexibly-Responsive Energy Delivery (FRED) project, led by Evergreen Smart Power, is one of a number of projects to win a portion of this funding.

Energy Systems Catapult is working with Evergreen Smart Power, myenergi, Tonik Energy and Swansea University to understand the potential of this technology.

Project FRED (Flexibly Responsive Energy Delivery)

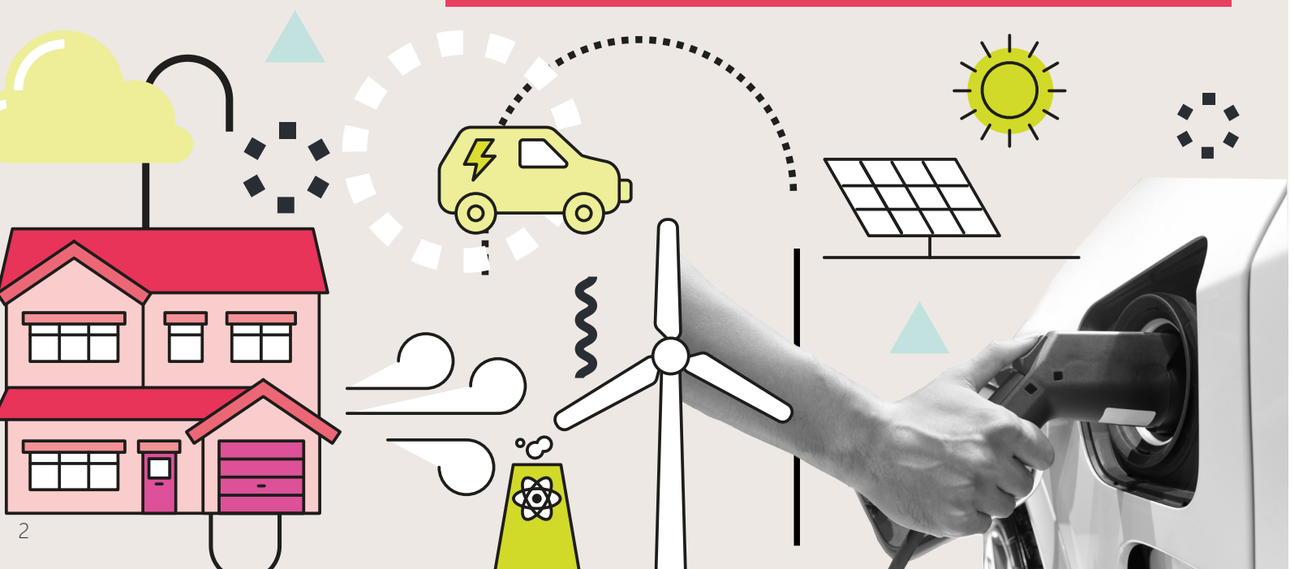
The trial uses Evergreen Smart Power's software platform to increase and reduce electricity demand in real-time. It works with myenergi's zappi, a smart EV charger that can also use power from people's solar panels (if they have them) to charge the car.

The zappi has 3 different modes:

- **Fast** (charges like a non-smart EV charger, using grid power and any available solar to charge at the maximum rate)
- **Eco** (maintains a minimum charge rate, 1.4kW, using a combination of grid power and any available solar);
- **Eco+** (as Eco but charging pauses if solar power drops below the minimum set level).

Zappi also lets users set up their charge how they like, for instance scheduling a charge to run at a certain time or setting the number of kWh they want delivered to the car. Users can see their charge history by using the myenergi app.

Keep reading to find out what some of the trial participants want from their EV charging and how they currently try to get that.



Control vs. simplicity

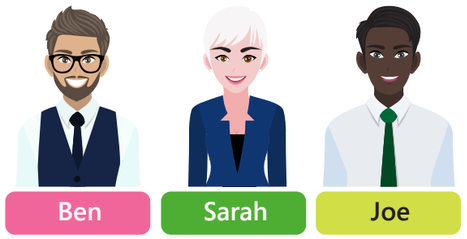
The EV drivers in our trial varied. Some wanted charging to be simple. Others were happy with more complexity if it helped them feel more in control.

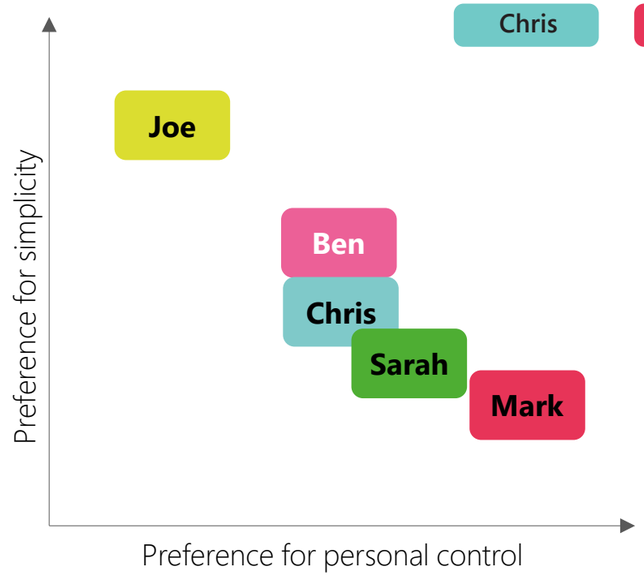
- Mark and Sarah prioritised personal control. They put time and effort into making sure they got what they wanted from their car charging, e.g. charging in time for upcoming journeys, charging when it's cheapest, or balancing car charging with other household power needs.
- Ben and Chris balanced personal control with simplicity – they had developed a routine for charging their car which they tended to follow every day (or every time they plugged the car in). Following the same routine meant they knew they'd get what they needed.
- Joe prioritised simplicity – he wanted to control the final level of charge and when he would have that by, but didn't mind when or how that charge was delivered.

The right level of charge isn't just about having enough

Participants explained that when it came to charging their car, first and foremost they wanted to make sure they had enough charge for upcoming journeys - they wanted to make sure the car was above a comfortable minimum level of charge.

However, as well as journey factors and the range of their car, some highlighted other factors that influenced the level of charge they wanted.





The personas in this publication are based closely on 5 participants from Project FRED with names/details changed to protect their identities.

Some think you can have too much charge

Battery health
Some wanted to avoid too high a level of charge, thinking that it might harm the battery's health. This was particularly the case if the car was not going to be driven immediately and was left sitting with a full charge.

Some suggested that this was a common belief among EV owners, which seemed to be reinforced by some manufacturers (e.g Tesla).

However, others appeared to have considered whether they should be concerned about battery health, but decided that they didn't need to factor this into how they charge. Factors like an in-built battery management system or a warranty were trusted to look after the battery's health, or provide a solution should the battery's health deteriorate.

> It's part of the way the Tesla works... it recommends below 90% to charge to regularly, and only to go to 100% for trips. And it does also flash up warnings if you've been filling it up too much.
>
> But also if you talk to other electric vehicle drivers it's a common subject that anyone who's taking any interest would pick up on.
>
> **Sarah**

> Nissan have an 8-year battery warranty. If it drops below 80% health during that 8 year warranty they'll replace it. As I don't plan on keeping the car longer than 8 years necessarily, and with buying the car direct from Nissan with that warranty, it means [battery health] isn't too much of a concern for me.
>
> **Joe**

Some try and get the right level of charge for the lowest cost (which may also reflect low carbon)

Cost
Some participants would rather use 'free' solar and/or cheap rates on their tariff when available and manage their charging to make the most of cheap or free power. This was particularly the case when routines were more flexible and better able to accommodate sporadic charging.

Saving money or carbon?
Periods when electricity is cheap often coincide with when energy is low carbon. This makes it hard to tell if people are more motivated by saving money or carbon.

Using solar when it's sunny
Almost all participants have their own solar panels that generate 'free' low carbon electricity. Some said they tried to use that solar power for day-to-day household power, with this taking priority over charging the car. Charging a car might not be as necessary as other household uses like running computers to work from home or running a heat pump. Charging a car can also be more flexible - people can charge overnight, or charge at local public chargers, whereas other tasks like cooking dinner or using the washing machine might need to be done at certain times or be inconvenient to do away from the home.

> I'm on a tariff where the cost changes depending on wholesale electricity prices. The prices are cut up into half-hourly periods. I arrive home mid-afternoon and plug the car in. In the evening, when the new prices for tomorrow are announced, I decide whether I'm going to charge and at what time.
>
> **Mark**

> It depends what my driving's going to be like for the next few days – if I don't need to charge I will turn the timer off overnight and I'll hopefully capture some solar power the next day
>
> **Sarah**

People have different 'ideal' target charge levels, for different reasons

We asked participants what they might set as a 'target charge level' on a typical day, and why.

The target charge levels people said they would choose varied, but not just as a function of upcoming journeys they knew they'd be making. Other factors that influenced the level of charge they wanted varied from person to person (and sometimes also from day to day). Those factors included things like battery health, leaving space for solar power, how much certainty they wanted over having enough charge for journeys and how much they wanted to have 'in reserve' for spontaneous trips.

How do people talk about target charge levels?
We talked to people about target charge levels as a % of battery. This reflects how many participants (among these interview participants and among the wider trial sample) tended to talk about charging their car: they often spontaneously referred to % charge and appeared confident in knowing what % charge they would need to cover upcoming journeys.

How else might people frame target charge levels?
Range – the car's measure of how many miles it can cover with the current charge – is arguably the most 'tangible' measure of a car's charge level, allowing it to be directly linked to the distance the car can cover.

But participants' trust in range varies. Some felt that their car offered an accurate estimation of range while others did not.

Participants also understand that range varies depending on other factors like weather or type of driving (e.g. urban vs motorway).

Notably, range as a measure of available battery seems to be considered while journeys are in progress, but not at other times like when the car is charging or not in use.

A few participants talk about setting their car to charge by a particular number of kWh – again, they confidently translate this into % charge and/or estimated mileage.

Considering charge in terms of kWh may reflect using solar to charge their cars – the zappi displays kWh delivered to the car. It may also reflect what modes they use to charge the car. For example, the zappi can be set to deliver a certain number of kWh to the battery.

This may be specific to early adopters and/or to those familiar with self-consuming solar.

> I will get 4.5 miles to a kilowatt hour.
>
> **Ben**

> You can set it to only charge a certain amount or set a certain amount of output. I've got mine set so that it only charges up a certain amount of output, which happens to be enough to charge my car to 100%.
>
> **Joe**

> In the winter on a really cold day when the battery's icy cold and if it's really kind of clammy and wet air or if it's been raining or it's foggy....my range then can actually be under 60 miles. That's quite a big difference of at least 25% of the range just at different times of the year.
>
> **Ben**

Factors that might influence suitability for DSR

Participants (and of course, consumers more generally) will vary in the extent to which they are 'suitable' candidates for DSR.

Suitability will be influenced:
- 'Technical' or objective factors, such as how often the car is plugged in, battery capacity, state of charge, and
- Individual or subjective factors, like participants' goals, needs and values.

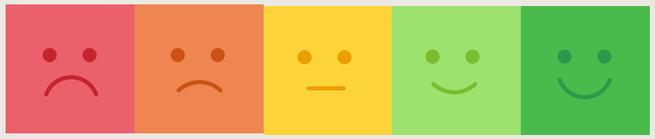
The following table discusses how some of these factors might make some participants more or less suited to DSR.

Note that their 'objective' suitability, which will also be critical for a DSR operator to consider, may be very different.

Suitability for DSR

	Ideal charge level	Reasons	What might work well with DSR?	What might restrict DSR?	Suitability for DSR (based on goals, needs, values)
Ben	100% (giving him ~80 mile range)	He uses most of his car's small battery capacity on a typical day. Having less than 100% charge - even 80-90% charge - would concern him because it would introduce some level of risk to his journeys. If he had a car with a bigger battery, he'd be satisfied with a lower level of charge.	• Frequently plugged in • Predictable behaviours • Predictable desired outcome	• Needing to have a full charge every morning • Wanting to charge during tariff's off-peak hours • Main charge is done overnight	
Sarah	It would vary day to day, anywhere between 50% and 90% (which works out between about 110-200 miles)	Ahead of a sunny day, she'd like 50% charge - enough for short trips out, but with plenty of room for excess solar. If she had longer journeys coming up she might want a higher level of charge, but probably not 100% which she thinks is bad for the battery.	• Frequently plugged in • Flat rate tariff	• Unwillingness to use back up (ICE) vehicle • Wanting to leave plenty of capacity to charge with excess solar • Not wanting the car to reach 100% charge	
Joe	Would prefer 100% (giving him ~150-165 miles in summer) but could accept 75%	75% would get him to and from work each day and give him "a bit of extra leeway if I needed anything else". However, he'd prefer 100% because that gives him the most flexibility – the car is there and ready to go any time that he might need it.	• Regularly plugged in • Predictable behaviours • Predictable desired outcome • Open to having less than 100% charge • Able to charge at work • Willing to hand over control	• Wanting to charge during tariff's off-peak hours • No back up vehicle • Mostly charges overnight	
Chris	A minimum of 40-50% (which would be ~65-80 miles in good weather)	40-50% would work out to about 60 miles in their car, which would usually be perfectly adequate given they don't do a lot of mileage.	• Often plugged in • Short, local journeys • Happy to use backup vehicle	• Very little	
Mark	On some days, 100% would be needed (giving him ~250-260 miles). On other days, anything above 50% would be ok	He describes having two kinds of typical days. For the first kind, where he uses the car to "just buzz around in my local area", anything above 50% would be quite comfortable. For days when he makes longer journeys, he always wants to set off with 100%.	• Regularly plugged in • Not having a full charge would 'seldom be a problem'	• Wanting to charge when electricity is particularly cheap and green (if this differs from when DSR might happen) • Mostly charges overnight	

LOW SUITABILITY FOR DSR



HIGH SUITABILITY FOR DSR

Unleashing innovation
and opening new markets
to capture the clean growth
opportunity.

Visit peoplelab.energy to find out more information on this project, the Consumer Insight Capability, and to download our latest report.

You can read more about the participants' personas in the accompanying publication - DSR in Practice - what goes on behind the wheel?

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The FRED trial - who's involved

Energy Systems Catapult is an independent not-for-profit research organisation with a mission to support innovators and help the transition to a clean, renewable energy system. ESC will be gathering feedback to understand how people interact with flexibility.

myenergi are an award-winning team of passionate people whose zappi, eddi and harvi products are already transforming living and working environments by increasing self-consumption of renewable energy.

Evergreen Smart Power are the creators of the Smart Power platform. The software lets zappis and eddis to respond in real time to grid conditions and energy prices to use electricity in a more intelligent and environmentally-responsive way.

Part of Swansea University, Specific is at the forefront of developing tech for energy efficient living. Their "Active Office" and "Active Classroom" buildings showcase low carbon technologies from solar walls to heat pumps to energy storage solutions

Tonik Energy is a challenger energy supplier whose ambition is to use renewable energy and smart home technologies to cut energy bills in half over the years ahead. They will be using data generated in the trial to demonstrate how flexibility technology can result in cost savings and lower bills.