Tesla Powerwall 2 battery user guide

Paul Rogers and Michael Hamer
March 2018

Overview

8 Tesla Powewall 2 batteries were installed in North Devon Homes properties between January and June 2018. The installer was SunGift Energy from Exeter. The batteries were funded by a grant from fuel poverty charity National Energy Action (NEA) as part of a year long technology trial. The purpose was to assess the ease of use of the technology and the savings which could be achieved by households off the gas grid on Economy 7 or other time of use electricity tariffs.

The battery would charge during the cheaper off peak period overnight and supply electricity to the home during the more expensive peak rate period. The homes did not have solar PV and so the batteries charged only from the electricity grid. This means the households must remain on an Economy 7 or another time of use electricity tariff. A time of use tariff has different costs for electricity at different times of the day. A high electricity consuming household could potentially save about £1 per day on their electricity due to the battery.

In case of problems with the battery please call North Devon Homes on 01271 312500 or SunGift Energy on 01392 213912

The technology – *Tesla Powerwall 2 battery storage system*

The Tesla Powerwall 2 battery has a usable capacity of 13.5 kWh. This is the maximum number of units of electricity that the battery can supply to the home in a day. The Powerwall 2 has dimensions of 1150 x 755 x 155 mm. There needs to be adequate space left around the battery to allow for cooling. The battery is less efficient and has a lower lifespan if it overheats. It should have a clearance of at least 50mm from the left side where there is an air intake, 150mm from the right side, where there is an air exhaust and 50mm from the top. Items should not be placed too close in front of the battery.

Figure 1 Internal Tesla Powerwall 2 installation

Figure 2 External Tesla Powerwall 2 installation

Some noise is produced by this system, typically a gentle hum comparable to that from a refrigerator (<40dBA at 30°C at 1 metre away). Some additional noise has been noted periodically when the system runs a bubble shedding routine for the pump.

The Powerwall 2 can supply up to 3.7 kW or 5 kW depending on the grid connection available at the site. A kettle can require 3 kW of power depending on the model, so this could be fully powered by the battery. An electric shower can require about 9 kW and this can only be partially powered by the battery. If several high power items are running at the same time, the battery can only provide either 3.7 kW or 5 kW of that power (if it is charged) with the rest of the power imported from the grid.

The energy management and communications for the battery is provided by the Tesla Gateway.unit which is a wall mounted box separate from the battery. It has dimensions of 240 x 243 x 130 mm and is connected to the household consumer unit and the Tesla Powerwall 2 battery. Although the Gateway can communicate by 3G mobile, it needs to be connected to the household WIFI router. This is usually done using TP Link power line adapters. The Gateway downloads system updates and provides Tesla with monitoring of the performance of the battery. The connection wire from the Tesla Gateway system should always be plugged into the WIFI router and the router should not be turned off. The TP Links should not be unplugged. If the broadband supplier is switched, the cable from the TP Link for the Tesla Gateway should be plugged into the new router.

Monitoring of the household consumption and battery performance is provided by the Tesla App which is available for Apple or Android phones. The procedure for downloading and setting up the app is provided in Appendix 2. The app provides details of the current state of charge of the battery as well as plotting graphs of the battery charge/discharge and household consumption for that day or the day before. The app is used to manually set the times for peak rate and off-peak rate electricity periods – defining the grid charging times.

The Tesla battery system monitors the household consumption using a blue current clamp which fits around one of the electricity meter tails. This should not be moved. If a new electricity meter is fitted at the property, it should be checked that the engineer has fitted the current clamp back on the correct meter tail. If not it could charge when it should be discharging. Normally the Tesla system measures the household electricity consumption with about 1% error. For some installations, the system did not initially measure both the main household consumption and that of the heating circuit. The installer agreed to resolve this issue, potentially by fitting a Y-splitter cable.

Since batteries charge and discharge as direct current (DC) and electricity used in the home is AC (alternating current) electricity, an inverter is required by the Tesla Powerwall 2 system to convert the electricity between AC and DC. There are inefficiencies in the power going to and from the battery due to energy losses in the inverter and battery. The round-trip efficiency is typically of the order of 90%. When fully charging off the grid, the battery can consume about 15 kWh of power and discharge 13.5 kWh to the home. Charging the battery off the grid increases the household electricity consumption. However, if the battery charges during a cheap rate period and discharges during a peak rate period, there should be a reduction in the overall electricity bill.

The Tesla Powerwall 2 comes with a 10-year warranty[1] which guarantees the system with be free from defects for 10 years following the initial installation date. Where the battery has been used for solar self-consumption and backup, the battery is guaranteed to retain 80% of the initial 13.5kWh usable capacity after 10 years for unlimited numbers of cycles. This covers grid charging with time of use tariffs as well as solar charging. For other applications such as charging from a wind turbine or the battery being used for grid services, the guarantee is limited to 10 years or an aggregate throughput of 37.8MWh.

Tesla app

(a) (b) (c) (d)

Figure 3 Images from the Tesla app

The Tesla app is available for Apple or Android devices. Users need to initially set up an account on the Tesla website with a user name and password. After providing Tesla (or the installer) with the Tesla account user name and the serial number for their Gateway unit, it is possible to view the battery's performance when logging on to the Tesla app (see Appendix 2).

The home screen shows the state of charge of the battery (figure 3 a). It also provides options for seeing more details of the power flow and energy usage, the performance (level of self-consumption) or to customise the time-based control. Figure 3 b shows the live power flows between the Powerwall and the home, the grid and solar PV if it were present.

Energy usage data can be viewed by pressing the graph icon (3 lines) at the top right of the power flow screen. The app can show a plot of today's or yesterday's energy use (figure 3 c). It can also plot bar charts for days over the last week, weeks over the last month or months over the last year. Below these charts are values of data. Figure 3 d shows the electricity which the household consumed and the amount going to and from the Powerwall (charge/discharge). It also includes values of electricity consumed from the grid and any that was exported to the grid. These can be displayed for the whole day, peak rate or off-peak rate periods. During the project evaluation, the values displayed on the app (figure 3 d) were not always accurate.

[1] Tesla Powerwall Warranty (European Warranty Region), 9 Jun 17, https://www.tesla.com/sites/default/files/pdfs/powerwall/powerwall_2_ac_warranty_europe_1-5_english.pdf (Accessed 5 Feb 19)

Knowing the time for off peak electricity

The Tesla batteries installed in the North Devon Homes properties only charge from the electricity grid during cheap rate periods. It is therefore important know the times when your electricity supplier provides you with off peak electricity and whether this changes when the clocks switch from Greenwich Mean Time (GMT) to British Summer Time (BST).

Normally information about the time for off peak electricity can be found on the electricity meter or on your electricity bill. Alternatively you can obtain these details by contacting your electricity supplier. Sometimes there is a SSC code printed on the meter and this can refer to the peak and off peak times.

Households with older wiring and meters may have a time switch which operates when the supply switches between peak and off peak electricity. The time for off peak electricity often changes between GMT and BST for these systems.

For example an EDF customer with an older meter may have the time for off peak electricity between 00:00 and 07:00 GMT, but this may change to 01:00 and 08:00 for BST. Other suppliers or locations may have different times for off peak.

More modern meters may maintain clock time throughout the year and the time for off peak electricity may remain unchanged. For example a Utilita meter had the time for off peak electricity between 00:00 and 07:00 throughout the year.

If you switch supplier it is therefore important to check the times of off peak electricity and ensure they are altered on the Tesla app. When selecting a new supplier, it is important to select one with a cheap price for off peak electricity as 80% or more of the consumption will be at the off peak rate.

Setting up the times for peak and off peak electricity on the Tesla app

The times for peak and off peak electricity need to be set correctly in the Tesla app and this will ensure the battery charges and discharges at the correct times. Select ‘Customise’ in the Tesla app, followed by ‘Edit Price Schedule’ to check or alter the times for the peak and off peak rates (figure 4a).

Different settings can be made for the price schedule during the week and at weekends. This allows for special deals like all day off-peak electricity during the weekend. Most suppliers however at the time of writing have the same times for peak and off peak rates throughout the week. As a result the same times should be used for the week and weekend.

The example shown was for a household whose electricity was supplied by British Gas where off-peak electricity was between 12.30am and 7.30am GMT (Greenwich Mean Time). A time switch determined the change from peak to off peak electricity and this operated on GMT. As a result of switching from GMT to BST (British Summer Time), the off-peak times for this households were 01:30am to 8.30am between March and October and so the times on the Tesla app needed altering. The peak rate period is shown in yellow and off peak in blue. You can change the time of the rates by moving the circles at the end of the lines between the yellow and blue areas.

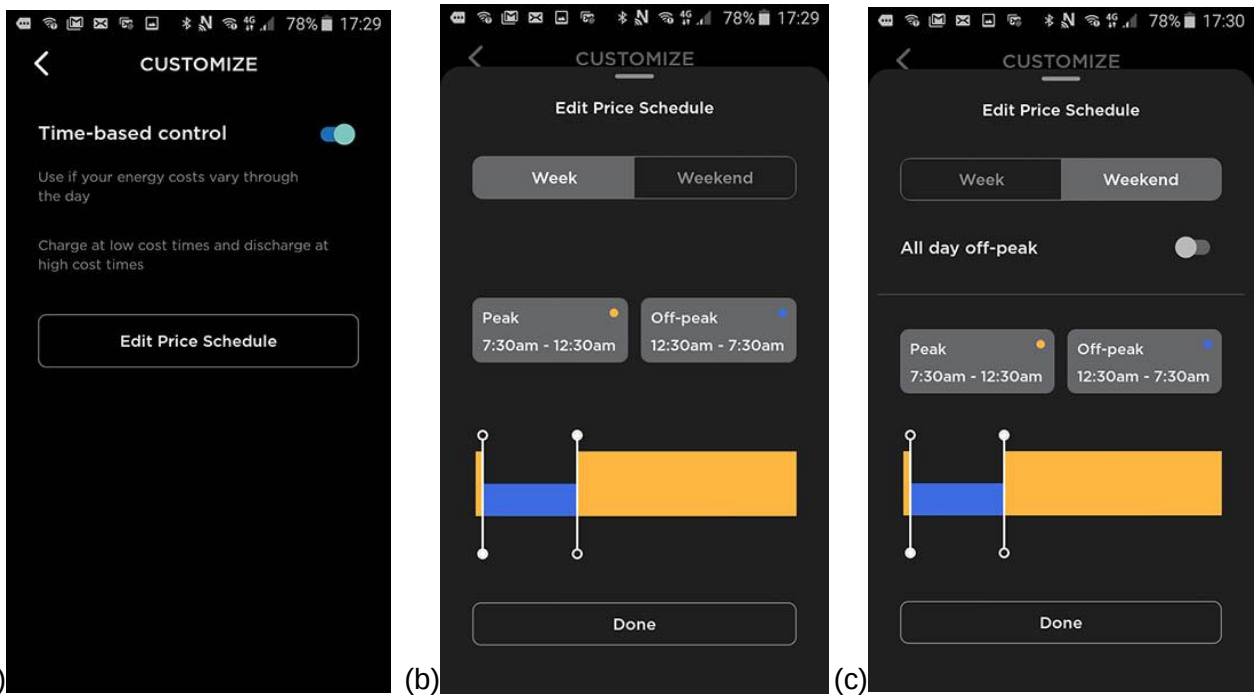


Figure 4 Customizing the Tesla app for time-based control

Reduction in the peak rate electricity consumption with the Tesla battery

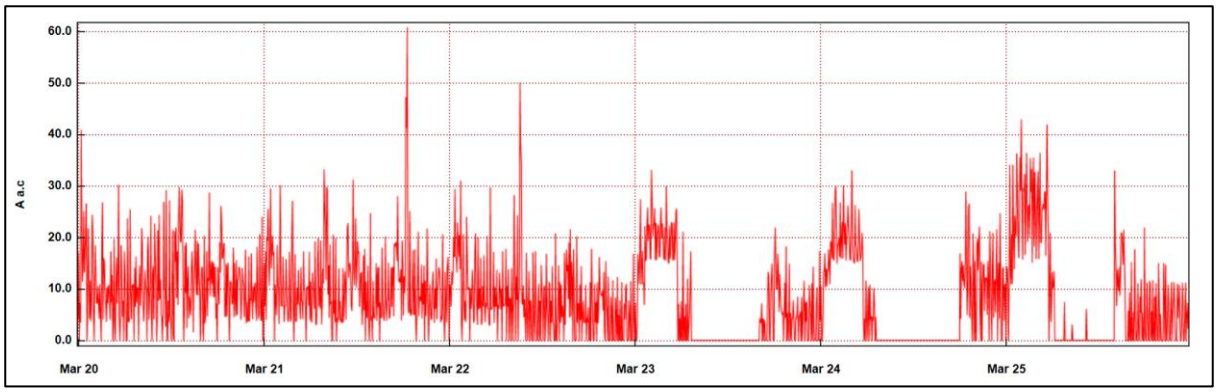


Figure 5 Household electricity consumption (amps) with and without the Tesla battery running

The consumption of one of the Tesla batteries before and after the battery was operational is shown in figure 5. From March 23rd, the battery charged overnight and discharged during the day, significantly reducing the peak rate consumption.

Figure 6 compares the average half hourly values of consumption for June 2017 with June 2018 for a household. It can be seen that there was an increase in consumption overnight due to the battery charging during the off peak rate. The household consumption was significantly reduced during the peak rate period, reducing electricity costs. In winter, the consumption was typically higher and so the battery often fully discharged before the end of the day. The time when this occurred depends on the level of household consumption. The battery may be able to supply power throughout the peak period for a low consuming household or on a day when there is low consumption.

A household on the study saw the percentage off peak consumption increase from 40-50% to 80%.

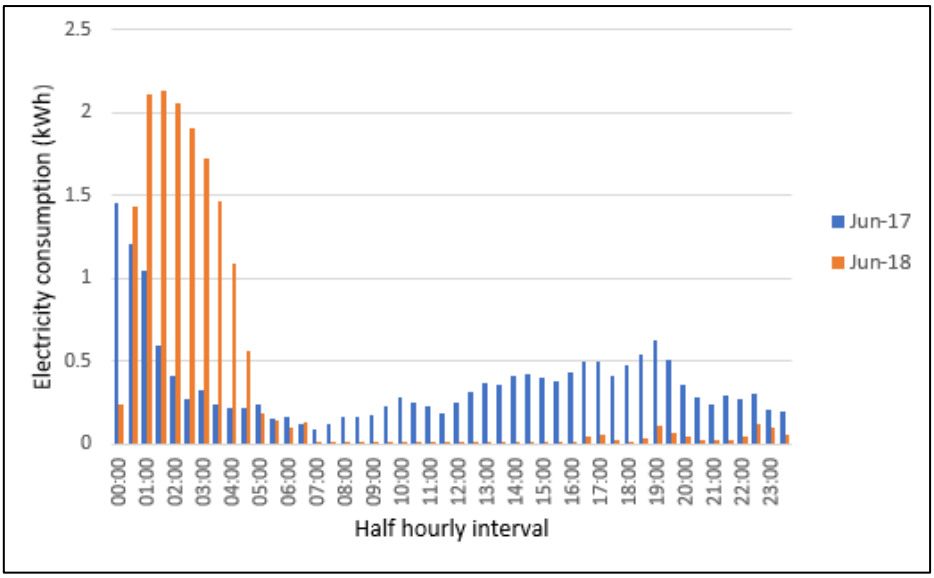
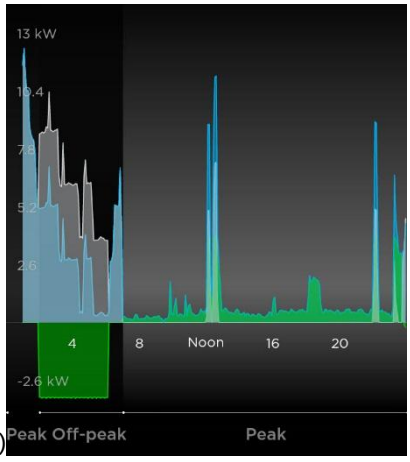


Figure 6 Plot comparing the average half hourly consumption values for a household in June 17 with June 18

Monitoring the consumption and battery performance with the Tesla app

(a)



(b)

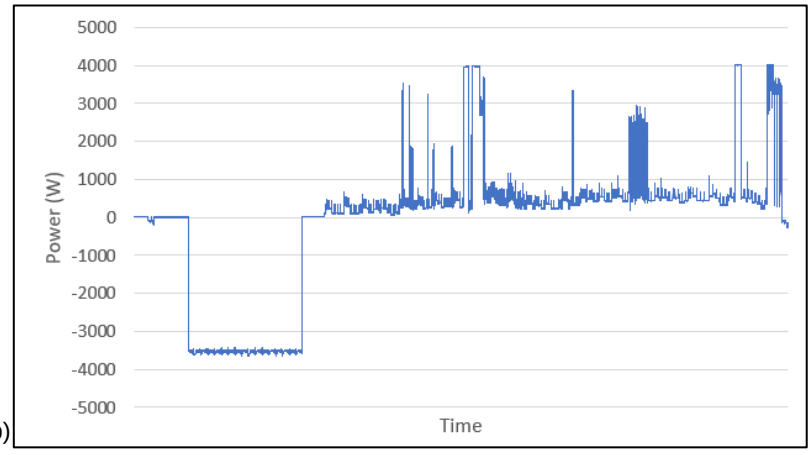


Figure 7 (a) Tesla App screenshot (b) Battery charge and discharge measured using a separate logger

A screenshot from the Tesla app is shown in Figure 7a. This shows the battery charging overnight (in green) and the consumption from the storage and water heaters in light blue. The battery discharge after 07:00 is also shown in green. At noon and about 22:00 the electric shower was used, consuming about 9 to 11 kW. Figure 7b shows a plot of the battery charge and discharge and shows that the battery discharged a maximum 4 kW. This meant that extra power needed to be imported from the grid when the electric shower was used.

Figure 8 (a) shows a Tesla app screenshot showing the consumption and battery charge/discharge on 29 Jul 18. Apart from the baseload demand from appliances like fridge and freezers, the only other overnight consumption was from the battery charging. During the day, the battery was able to supply nearly all of the of the peak rate household demand. This installation had a grid connection, which allowed the battery to discharge up to 5 kW.

The screenshot in figure 8 (b) shows the performance of a battery on 29 Dec 18. While the battery was able to supply the household throughout most days in the middle of summer, this was less

common in the winter and the battery was depleted by 19:30 in this case. Overnight, apart from the battery charging, there appeared to be peaks in consumption due to water heating. At that time, the Tesla system was not monitoring the heating circuit for the system and so did not record the consumption due to the storage heaters.

An appliance was used in the morning before lunch which may have been the tumble drier (figure 8b). There was a peak of 6.9kW at 18:10 with 5 kW provided by the battery. The sharp peak may have been due an additional appliance being used while cooking the evening meal.

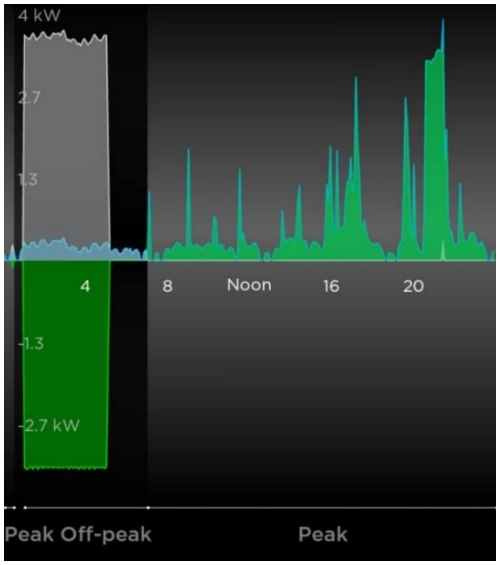


Figure 8 (a) Tesla App screenshot on 29 Jul 18

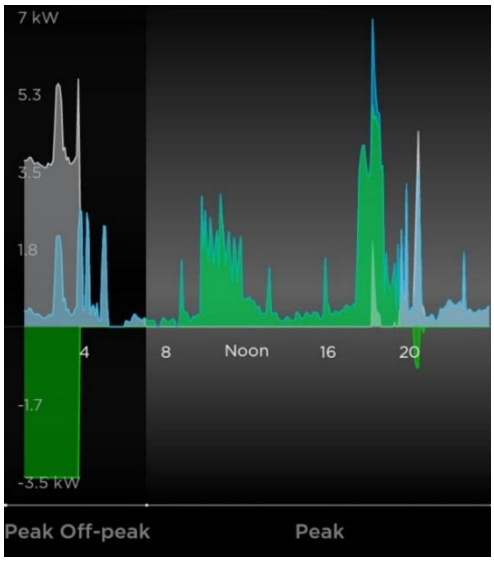


Figure 8 (b) Tesla App screenshot on 29 Dec 18

The Tesla app provides the opportunity to monitor the performance of the battery and the household consumption. It is possible to see when the household consumption sufficiently high that it requires extra electricity to be imported from the grid. Households might consider not using multiple high power appliances at the same time to avoid excess grid import. The app also shows when the battery has become fully discharged. Households might want to limit their consumption during the day to avoid this happening or be more careful with their consumption after this happens to avoid higher electricity charges.

Maximum Household Demand

The electricity supply to each home has a limit to the current that should be drawn. This is typically 80A or 18.4 kW. Homes using night storage heaters and electric water heaters will have a high overnight electricity demand. The Tesla Powerwall 2 battery charging overnight will add to this. Care should be taken that the overnight demand does not exceed 18.4 kW. Use of multiple high power appliances overnight along with all the storage heaters and Tesla battery could exceed an electricity demand of 18.4 kW.

The Tesla app is able to vary the charge rate depending on the household consumption. However this needs to be set by Tesla and the system needs to measure both the main and electrical heating consumption. There may be issues in the future if the household wanted to also charge an electric vehicle overnight. In such a situation, it would be wise to get the house upgraded to have a 3-phase electricity supply. Such supplies are now recommended by Western Power Distribution for all new homes.

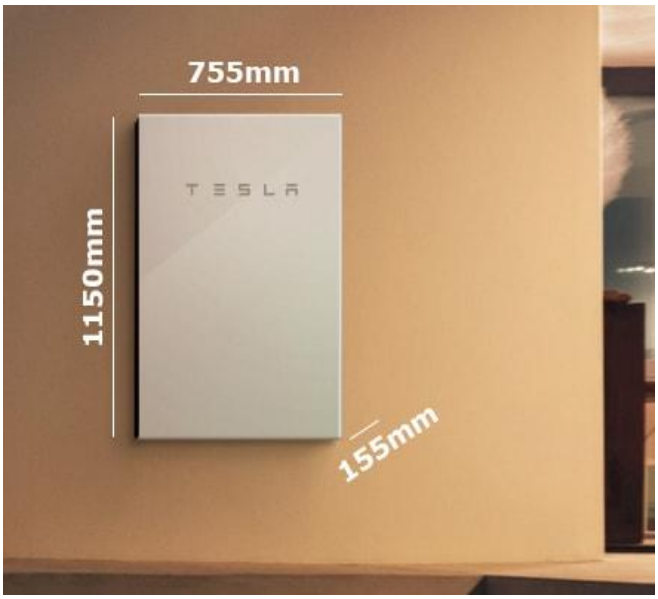
Appendix 1: Recruitment materials

NEA Tesla Powerwall 2 Battery Storage Study Information Sheet

Who is NEA?

National Energy Action[2] (NEA) is a National Fuel Poverty Charity. We are working with North Devon Homes to help them fit battery storage units into homes which are off the gas grid and using Economy 7 (or time of use tariffs). We will be assessing the benefits of the new battery storage systems on these households. .

An invitation to take part:



You are being invited to register your interest to be considered for a trial where you will receive a new battery storage system. The Tesla Powerwall 2 unit would be fitted to one of the outside walls of the house and a cable will connect it to the mains supply near your electricity meter.

The battery will be able to charge during off peak (cheaper) electricity at night and provide some of the power for appliances during the day when they would otherwise consume expensive peak rate electricity. This will be particularly beneficial for larger households with high electricity consumption. We estimate the maximum potential savings per year to be £250 to £300.

The trial is likely to last about six to nine months. The battery will remain at the property where it is installed after the trial so you will be able to continue to benefit from the battery, and make savings. If you would like more information about the technology, you can contact NEA or NDH.

Households receiving the batteries will be required to provide access to an internet connection where the wifi router is left on 24 hours a day. This will be necessary for the operation of the battery and the online monitoring. The data traffic is extremely low, and you'll not notice any impact on your broadband performance.

Several other projects are taking place, trialling different technologies, across the country. As this is a trial, only those eligible households selected by North Devon Homes who agree to take part in the monitoring will receive the measures. We would very much appreciate you being involved, to help us learn how the new technology works in your home, and understand your experiences of using it.

[2] More information on NEA available at http://www.nea.org.uk/

What is the purpose of the study?

The research will help housing providers and Government to target investment in energy saving products and services which have the most beneficial impact on households.

Do I have to take part?

It is up to you to decide whether or not to take part, but we value your views and hope that you will help us by being involved. If you decide to take part, you will be asked to sign a consent form. This will record the fact that you give your permission for NEA to keep your data for the purposes of this study and that you are happy to be involved. It also confirms that all data we collect is confidential and that you will not be identified in any report or publication.

What happens if I agree to take part in the study?

It will be necessary for the installer to conduct a survey of your home to determine where the battery can be fitted and whether any ancillary electrical work may be needed. The battery installations are taking place in January or February. NEA staff will also agree a convenient time to visit you at your home prior to the installation work, and again at the end of the study period, which is likely to be during Summer 2018.

When we visit, we will fit small data logging devices which monitor your electricity use. These are likely to be fitted near your electricity meter, to record how much electricity your heating system and appliances use. We will also fit small battery powered temperature and humidity loggers which can be hidden behind an ornament etc. We may also fit another logger for electricity which plugs into a mains socket, but only consumes a very small amount of power. Pictures below illustrate what the loggers look like. Our visits will last around an hour. At the first visit, we will ask you about your energy use and the energy efficiency of your property.

Temperature & humidity logger (below left), energy logger (middle) which clips around the wires of your electricity meter (right). Where possible, we may fit an additional electricity logger powered by a mains socket

As energy use is a key part of the project, we will need **copies of your electricity bills from the last year. If you don't have these, we'll ask you to help us to obtain copies from your supplier**. We will ask you to provide bills (or meter readings) for the coming winter – we may ask to obtain these from your electricity supplier. We would like to read your energy meters when we visit, and we will ask you to take regular meter readings during the study. (We'll show you how, and give you a log book.)

When we visit again at the end of the study we will ask about your new battery storage system, what benefit it has provided you, and your views on using it. At this time we will also collect your completed meter read log book, data loggers and copies of any energy bills you have, so that we may assess the performance of the battery in detail. We may ask you to help us to obtain energy data from your energy supplier if you have a suitable meter.

What will I gain from taking part?

Firstly, you will receive a new Tesla battery storage system. As a thank you for taking part in the trial, to recognise the time you have given during the surveys, recording your meter readings and providing electricity bills, we will give you a £50 shopping voucher on the final visit when we collect our data loggers.

How many households will be taking part in the study?

At present we are planning to install 8 Tesla Powerwall 2 systems in NDH properties which are off the gas grid and on Economy 7. There are also opportunities for others to be part of the study by taking part as one of the *control group*. These households will not receive the battery, but there will still be monitoring of their electricity consumption and interviews to compare with the other households. The control group will also receive £50 in shopping vouchers. Taking part as one of the control group may be suitable for households who are unable to have a battery installation or are just interested in being part of the project.

Will my taking part in the study be kept confidential?

YES, all information collected about you and your household during the study will remain strictly confidential. Your contact details will only be kept if you agree to be involved in our study and will be stored securely on NEA premises. Personal details will not be shared with anyone outside the team involved in this study.

You will not be personally identified in any report or publication: Any quotes we use in our final report will be anonymous: no names of people, addresses or organisations you are part of will be used. If you think there is any other way that it might be possible to identify you from the discussions then please let us know and we can talk about it further.

What will happen to the results of the study?

The results of this study will be used to write a report on the benefits of the Tesla Powerwall 2 battery storage system for residents using Economy 7 and the savings that can be achieved. The study may influence decisions on whether to install battery storage like the Tesla Powerwall 2 in social housing in the future.

If you would like any further information on this study, please contact:

NEA's Technical Co-ordinator for this project, Paul Rogers, on 01271 855332

Our head office address is:

National Energy Action (NEA),
Level 6, West One,
Forth Banks,
Newcastle-upon-Tyne
NE1 3PA

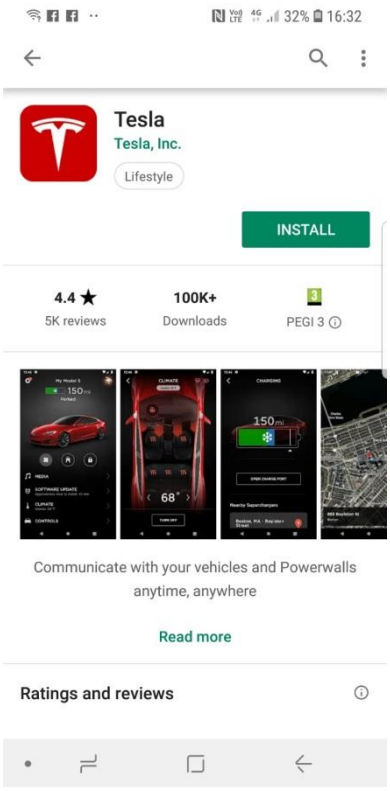
Thank you

Recruitment leaflet produced by NEA for North Devon Homes customers

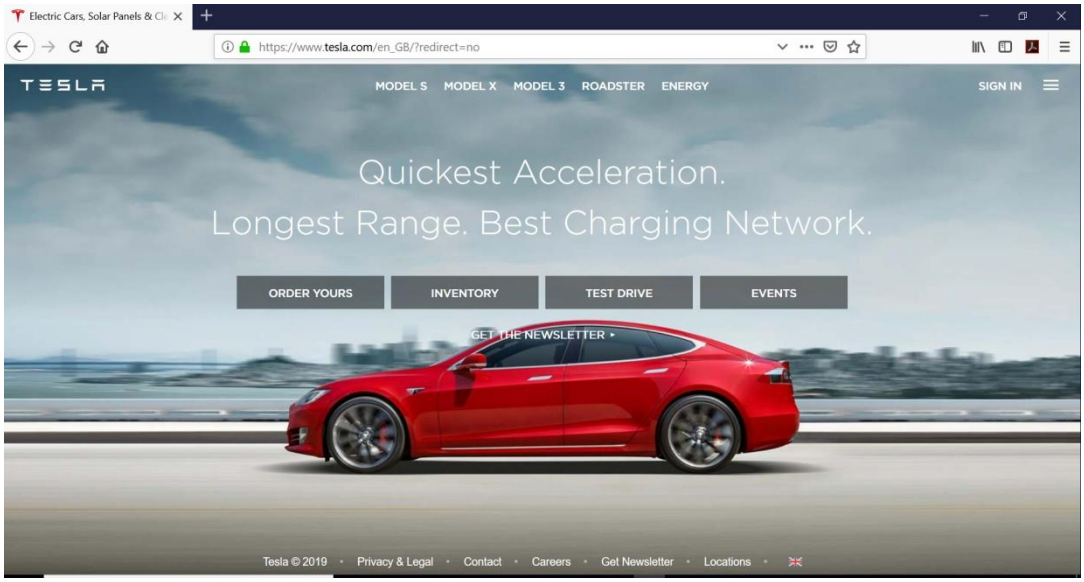
Appendix 2: Setting up the Tesla app on a phone

Below is the procedure for installing the setting up the Tesla app on a phone.

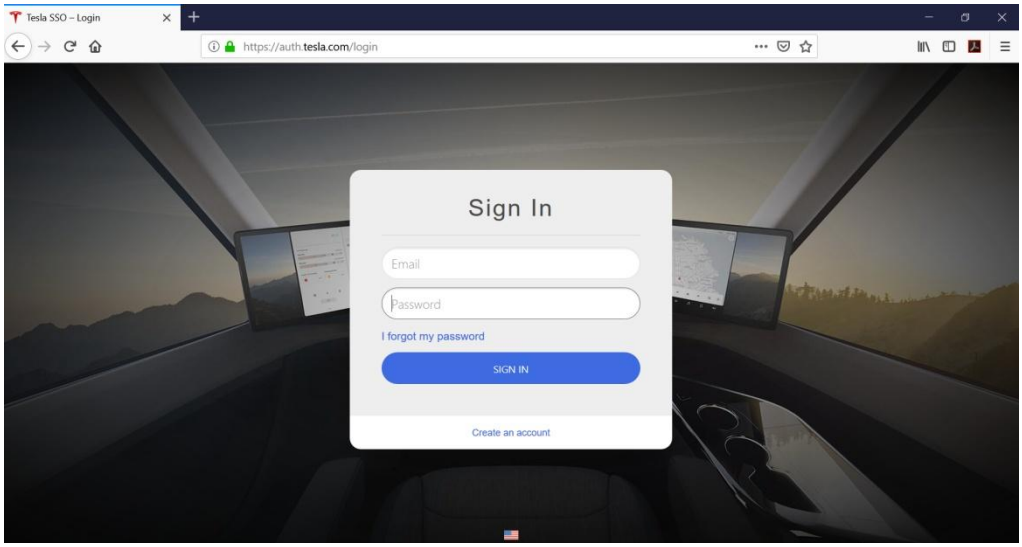
Step 1
Download and install the Tesla app from the Play Store for Android or App Store for iPhone



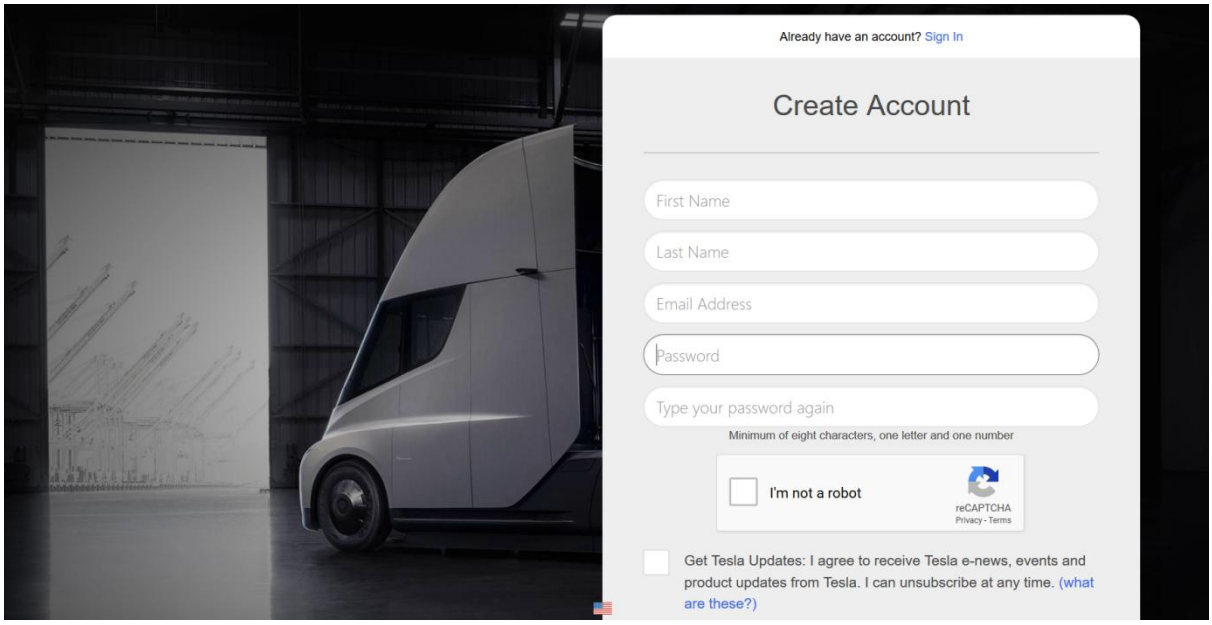
Step 2 – Set up a Tesla account



Go to the Tesla website www.tesla.com
You should be redirected to the GB site.
In the top right corner of the home page is ‘SIGN IN’ – click on this.



At the bottom of the ‘Sign In’ screen is a link to ‘Create an account’ – Click on this



Type in your name and your email address and create a password.

The email address and password will be your login details for the Tesla App.

Step 3 – Linking your account with your battery

Contact SunGift Energy or North Devon Homes with details of your email address for the account and the serial number on the Tesla Gateway unit. They will then be able to organise for Tesla to link your account with your battery.

Appendix 3: Health and Innovation Programme 2015 – 2018

The Health and Innovation Programme (HIP) was a £26.2 million programme to bring affordable warmth to fuel poor and vulnerable households in England, Scotland and Wales.
The programme launched in April 2015 and was designed and administered by fuel poverty charity National Energy Action as part of an agreement with Ofgem and energy companies to make redress for non-compliance of licence conditions/obligations. To date, it remains the biggest GB-wide programme implemented by a charity which puts fuel poverty alleviation at its heart.

The programme comprised 3 funds

- **Warm and Healthy Homes Fund (WHHF):** to provide heating, insulation and energy efficiency measures for households most at risk of fuel poverty or cold-related illness through health and housing partnerships and home improvement agencies

- **Technical Innovation Fund (TIF)**: to fund and investigate the impact on fuel poverty of a range of new technologies

- **Warm Zones Fund (WZF):** to install heating and insulation and provide an income maximisation service to households in or at risk of fuel poverty, delivered cost-effectively through partnership arrangements managed by NEA's not-for-profit subsidiary Warm Zones Community Interest Company

What it involved

- **Grant programmes** to facilitate the delivery of a range of heating and insulation measures and associated support. Grant recipients were encouraged to source match and/or gap funding to increase the number of households assisted and to enhance the support provided to them
- **Free training** to equip frontline workers with the skills needed to support clients in fuel poverty
- **Outreach work and community engagement** to provide direct advice to householders on how to manage their energy use and keep warm in their homes

In addition we undertook substantial **monitoring and evaluation** work, to assess the effectiveness and measure the performance of the technologies, and to understand the social impacts of the programme. Our **communications programme** helped partners to promote their schemes locally as well as share best practice with others. The programme generated a considerable amount of **knowledge and insight** which will be made freely available to help support future policy and delivery.

Proper investment of advanced payments allowed us to generate interest which, along with efficiency savings, was reinvested back into the programme in the form of additional grants and support which helped us further exceed our targets.

For more information see www.nea.org.uk/hip

NEA Technical
March 2019

Action for Warm Homes