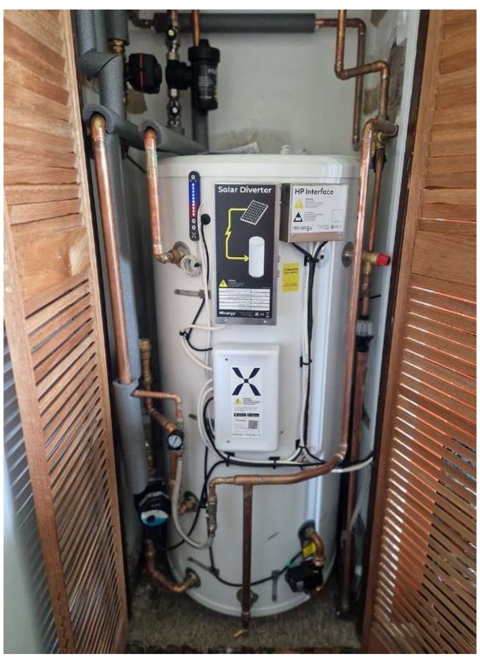
Evaluating solar PV with electric heating with North Devon Homes: Mixergy cylinders



Paul Rogers and Michael Hamer

February 2025

Background - Who we are

National Energy Action (NEA), the fuel poverty charity, campaigns so everyone can afford to live in a warm, safe and healthy home. This is something denied to millions because of poor housing, low incomes, and high bills.

Working across England, Wales and Northern Ireland, everything we do aims to improve the lives of people in fuel poverty. We directly support people with energy and income maximisation advice and we advocate on issues including improving the energy efficiency of our homes.

We do not work alone. Partnerships and collaboration have been at our heart for over 40 years, helping us drive better health and well-being outcomes for people struggling to heat their homes.

This evaluation was carried out by the Innovation and Technical Evaluation team at NEA:

Paul Rogers, Senior Innovation and Technical Evaluation Coordinator
Michael Hamer, Innovation and Technical Evaluation Manager

February 2025
National Energy Action
Level 6 (Elswick)
West One
Forth Banks
Newcastle upon Tyne
NE1 3PA
www.nea.org.uk

Acknowledgements

Funding for this project was provided by the Energy Industry Voluntary Redress Scheme

With grateful thanks to our project partners:

John Evans, Planned Improvements Manager, North Devon Homes
Tom Oldfield, Head of Sustainability & External Affairs, Mixergy
Peter McBride, Senior National Business Development Manager, Mixergy
Mixergy Technical Support
David Jeffrey, Managing Director, RES Devon Ltd
Kian Hill, Engineer, RES Devon
Ryan Harris, Contracts Manager, James Electrics Contracting
Kevin Heaphy, Domestic Energy Assessor

Table of contents

Executive Summary

Introduction

Energy Performance Certificates indicate that the water heating demand for the household can often be between 2,000 and 3,000kWh per year. One way to improve energy efficiency for water heating is to use a Mixergy smart hot water cylinder with a solar PV diverter that uses excess PV generation to heat water for free.

As part of the 'Evaluating solar PV with electric heating' project, 11 x Mixergy cylinders with solar PV diverters were installed, ranging in capacity from 120 litres to 250 litres. The lead for the project was social landlord, North Devon Homes, with RES Devon Ltd installing most of the solar PV systems and all the Mixergy hot water cylinders. A member of the Innovation and Technical Evaluation team at NEA assisted with resident liaison, partner liaison, data collection and evaluated the project.

The project began in September 2022 with the first Mixergy cylinder installation in September 2023 and the final one installed in May 2024. Performance of the cylinders was monitored and analysed until the end of December 2024.

Mixergy technology and installations

The Mixergy cylinder heats the water from the top of the cylinder down, which means faster heating and lower heat losses. A smaller cylinder can be used with no loss in performance. The cylinder is connected online and allows residents to view the level of hot water and boost it when needed. The Mixergy cylinder can learn the amount of hot water you need and avoid producing more hot water than required.

Figure ES1 (a) shows a 150-litre Mixergy cylinder installed in the loft. Each cylinder has a gauge (figure ES1 (b)) which can be used to monitor and control the level of hot water. An RJ12 male/female Ethernet extension cable can be fitted to allow the gauge to be brought down out of the loft. There is also a Mixergy app for users (figure ES1 (c), image from Mixergy). This can be used to check the level of hot water in the cylinder and boost it when required. Mixergy has also produced an installer app and monitoring portal.

The Mixergy cylinders can be controlled through settings and a schedule which can be altered using the apps and monitoring portal. The optimum setting for the heating schedule was not known by the installers and users at the time of installation. Many of the cylinders were set up to maximise the availability of hot water rather than the savings for the household.

Figure ES1
(a) 150L Mixergy cylinder (b) Mixergy gauge (c) Mixergy app

The Mixergy cylinder has an automatic schedule control feature where the cylinder learns the household hot water consumption over a period of weeks and the water heating schedule is optimised to reduce energy consumption. This feature was not enabled during the project.

The Mixergy solar diverter uses excess solar generation to power the immersion heater for free water heating. A current transformer (CT-clamp) is used to measure when there is export of electricity from the solar panels to the grid. Several of the installations had the CT-clamp fitted in the wrong orientation. This meant the cylinder was not making savings through powering the immersion heater using excess solar generation. NEA staff identified the installations where this was a problem using the Mixergy installer portal and it was possible for Mixergy Technical Support to reverse the polarity of the CT-clamp remotely.

There was a cylinder where the thermal cut-out regularly tripped following the Legionella cycle. This was resolved after the immersion heater was replaced. There were problems getting the solar PV diverter to work properly on two installations where there were Tesla Powerwall 2 batteries and storage heaters. There was also some interaction with the battery on an installation with a Wondrwall/Growatt battery.

For one household with an air-source heat pump (ASHP), there was an issue where the heat pump was not responding to the call for heat from the cylinder. This was resolved in December 2024 but prior to that the water was only heated by the solar diverter.

One household complained of insufficient hot water for a bath, but this was resolved by adjusting thermostatic mixing valves on the bath. Another household only used hot water for washing dishes. Due to the water consumption before hot water came through the tap from the cylinder, the resident preferred to use a kettle and did not heat water with the cylinder. It is hoped this household will use the cylinder once a bath and electric shower can be replaced with a cubicle and mixer shower. One household thought an isolator switch in the kitchen was a boost for the cylinder. It was only after an advice visit that this isolator was left on permanently and the cylinder performed as expected, saving the household money through the solar diverter.

Electric showers were replaced with mixer showers for five of the households during the project. This was to improve savings due to more of the hot water used being heated at off-peak times or by the solar diverter. Four of the households continued with their electric shower and one already had a mixer shower.

Energy Performance Certificates (EPCs) were produced for the properties receiving installations using RdSAP 2012. An appendix Q calculation for the Mixergy cylinder resulted in an improvement of between 2 and 7 points in the energy score due to installation of the Mixergy cylinder.

The cost of the Mixergy cylinder installations ranged from £2,656 including VAT for a direct cylinder with solar diverter to £3,334 including VAT for a cylinder with the solar diverter and heat pump interface for households with an ASHP.

Social analysis

Eight households who were using the Mixergy cylinder were interviewed at the end of the project. All eight thought they had plenty of hot water from the Mixergy cylinder. Five of the households had access to the Mixergy app and regularly used it. For the other three households, two did not have the app set up for them at installation while one household was not able to use apps.

For the five households that used the Mixergy app, all five used it to check on the level of hot water, four used it to boost the level of hot water, three had changed settings for the cylinder and one monitored consumption. On a scale of one to five for how easy the app was to use, the average response from the households was 4.6. When asked how useful the app was, the average response was 4.8 on a scale of one to five where five was very useful.

The households were also asked whether they agreed or disagreed with a series of statements about the Mixergy cylinder (figure ES2). Seven of the eight households strongly agreed or agreed that their Mixergy cylinder was better than their old cylinder. The only household that disagreed had teething troubles with the installation and the immersion heater needed replacing.

Seven of the eight households strongly agreed and the other agreed that they noticed the benefit of free water heating on a sunny day. Five households strongly agreed and two agreed that it was cheaper to heat water than with their old cylinder. The remaining household did not know. Five households strongly agreed that the Mixergy cylinder provides sufficient hot water when I need it, and the other three households agreed with the statement.

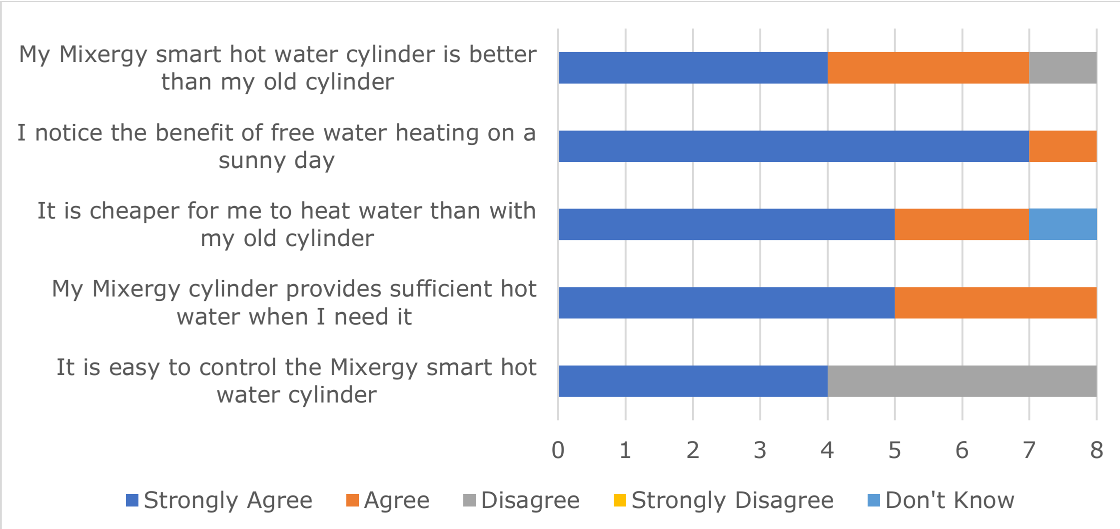


Figure ES2 Benefits of Mixergy cylinder noted by households

There was a mixed response over whether the Mixergy hot water cylinder was easy to control. Four of the eight households using the cylinder strongly agreed that it was easy to control and all four were using the Mixergy app. The remaining four households disagreed with the statement. Out of these, three of the households were not using the app. The remaining household had issues with their Tesla Powerwall 2 battery interacting with the solar diverter.

For the best customer experience, residents should have the Mixergy app installed. For those households unable to use the Mixergy app, it is important that they have easy access to the Mixergy control gauge.

Technical monitoring

It was possible to monitor the performance of six of the Mixergy cylinders over a period of six months from 1 Jul 2024 to 31 Dec 2024. This included three direct cylinders which only heated water with the immersion heater and three cylinders with a plate heat exchanger to also allow water heating by an ASHP. For one of the installations with an ASHP, there was 12 months of data available.

For the three direct hot water cylinders, the hot water energy use (total use of the immersion heater) over six months was between 679 and 1009kWh.

Household IC-01 had the highest hot water energy use but the lowest cylinder size (120 litre). Household IC-01 had a mixer shower throughout the monitoring period while the other two households had electric showers. Also, household IC-01 regularly heated the cylinder to 100% charge overnight. This may have led to greater heat losses from the cylinder during the day.

Household SH-02 with a larger 210 litre cylinder also regularly charged the cylinder to 100% overnight and used 968.5kWh hot water energy use. SH-01 had the largest cylinder (250 litres) but had a hot water energy use of 679kWh. This lower value was partly due to lower hot water demand but also due to the cylinder being set to heat the tank to 50% charge overnight and maintain the charge at between 30% and 50% during the day.

The hot water PV energy use (solar diversion) for SH-01 at 347kWh was the lowest of the three direct cylinders. This was likely to be due to a combination of lower PV generation, higher grid consumption and lower hot water demand. The solar diversion for SH-02 was 400kWh and the highest of the three cylinders. Here there was a medium level of solar generation, lower grid consumption and high hot water demand. The diverter for IC-01 saved 381kWh.

Household IC-01 was on a single-rate tariff and savings for the solar diverter over six months were about £91 assuming a unit rate of 24p/kWh. Households SH-01 and SH-02 were on Economy 7. If it is assumed the solar diversion displaced overnight grid charging the savings would be about £43 and £50 over six months for an off-peak unit rate of 12.5p/kWh. In practice, some of the consumption would have been during the day and so savings would be higher.

There were three Mixergy cylinder installations for households with ASHPs. These had plate heat exchangers which allowed the ASHP to heat water in the cylinder. While the total energy used by the immersion heater was monitored, it was not possible to monitor the amount of water heating by the ASHP. The hot water energy use (total use of the immersion heater) ranged from 390kWh to 541kWh for the three cylinders over six months. The hot water PV energy use (solar diversion) was between 390kWh and 499kWh over this period.

Household AC-03 had the greatest measured solar diversion (499kWh) of all six cylinders analysed. This value excludes any diversion during 18 days in September 2024 when the CT-clamp for the solar diverter was in the wrong orientation. The high level of solar diversion may be due to a combination of high hot water use (typically 14 baths per week), low grid consumption and solar PV generation across the day with a solar PV array split across an east-west facing roof.

Household T-06 had solar PV with an ASHP and Tesla Powerwall 2 battery. Figure ES3 shows the immersion heater consumption recorded by the Mixergy installer portal during 2024. There were three days in May 2024 when the CT-clamp was reversed, and this data was ignored.

The immersion heater use was 1174.5kWh over the year with 906kWh of this powered by the solar diverter. The monthly solar PV diversion was greatest in June 2024 with 155kWh. There may have been greater PV diversion from May 2024 after the mixer shower was installed, increasing the demand for hot water from the Mixergy cylinder.

Although the ASHP was able to heat the water, there were times when the immersion heater was also used, and it was not powered by the solar diverter. This accounts for the difference of 268kWh between the hot water energy use and the hot water PV energy use for T-06 in 2024. These periods when the immersion heater was not powered by the solar PV usually occurred when there was water heating by the ASHP and the level of the hot water in the cylinder continued to fall. This was likely to have occurred when there was significant hot water demand (e.g. a bath or mixer shower) while the ASHP was heating the water.

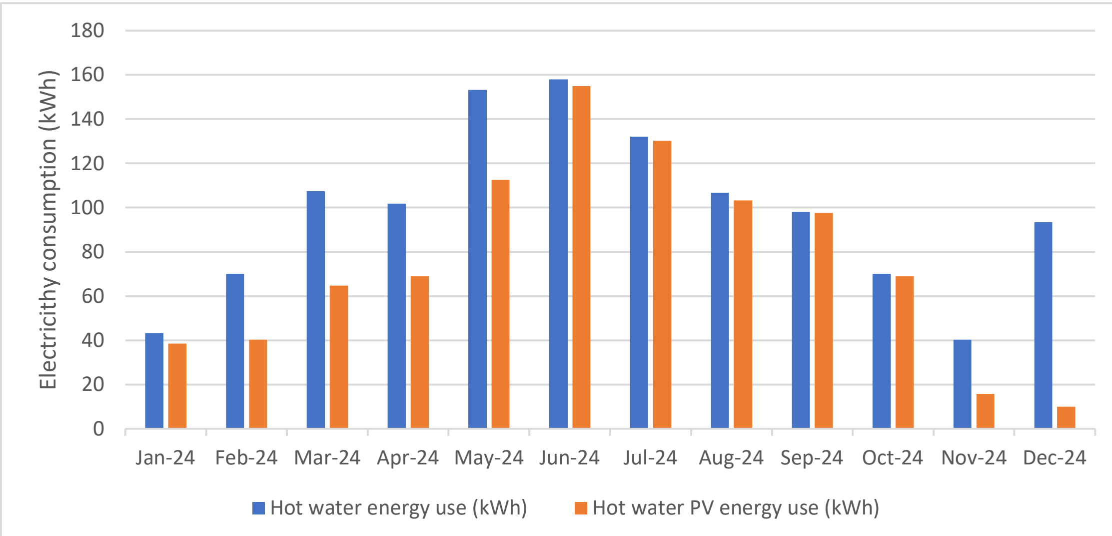


Figure ES3 Use of the immersion heater for water heating for household T-06

Over 2024, the solar PV system for household T-06 generated 4416kWh. Out of this, 1106kWh was used by the Tesla Powerwall 2 battery and 906kWh was consumed by the solar diverter on the Mixergy cylinder. Overall, the level of self-consumption of the solar generation was 80.5%.

Wibeee electricity monitors were used to monitor the electricity consumption of the immersion heater for two of the installations. The monthly immersion heater use was within 3.2 to 4.2% of the value for the Mixergy portal for household T-06 and was within 5 to 7.8% for household SH-01.

Households who heated the Mixergy cylinder to 100% charge overnight were not maximising their savings from the solar PV diverter. Household SH-01 had a schedule heating the cylinder to 50% charge overnight and maintaining the charge at between 30% and 50% during the day. This should allow ample charging by the solar diverter on a sunny day. On 11 Sep 2024, there was a total of 9.03kWh of hot water energy use for SH-01, with 7.24kWh of this powered by the solar diverter.

Conclusions and future work

- The project installed 11 Mixergy smart hot water cylinders with solar diverters in social housing with electric heating
- Five households had mixer showers installed to improve savings while four kept their electric showers and one already had a mixer shower
- Several of the installations had the CT-clamp for the solar diverter fitted in the wrong orientation which limited performance until corrected
- There was an issue which could not be resolved for two installations in homes with storage heaters and Tesla Powerwall 2 batteries where the PV diverter did not perform correctly due to interaction with the battery
- One household primarily used hot water for washing dishes and did not use the cylinder due to the water consumption before hot water came through to the tap; it is hoped that fitting a mixer shower will encourage use of the cylinder
- Eight of the households who were using the Mixergy cylinder were interviewed and provided positive feedback about the Mixergy cylinder, noting plenty of hot water, with seven agreeing the cylinder was better than their old one
- Residents rated the Mixergy app highly and it is important that they either use the app or have easy access to the Mixergy control gauge
- The performance of three direct cylinders which were only electrically heated was assessed over six months with the total consumption between 679kWh and 1009kWh and the solar diversion between 347kWh and 400kWh
- The total consumption was affected by the hot water demand and the heating schedule while the level of PV diversion was affected by the hot water demand, PV generation and grid consumption
- Three cylinders which were also heated by ASHPs were also analysed over a period of six months
- The solar PV diversion ranged from 390kWh to 499kWh with the household with the highest PV diversion having high hot water demand
- There was data for the whole of 2024 for one of the heat pump households, with 906kWh of water heating by the solar PV over the year
- In future studies, the water heating schedule should be optimised or automatic schedule control used
- It would be helpful if Mixergy could analyse data from the monitoring portal using AI to quickly detect situations where the CT-clamp is in the wrong orientation
- Otherwise, the Mixergy portal should be checked after the cylinder is installed and also after subsequent electrical work in the home to ensure the CT-clamp is not in the wrong orientation

1. Project overview

1.1 Introduction

As homes become more energy efficient with improved insulation, the energy required for water heating is becoming a more significant proportion of the energy demand. Off-gas grid homes often have a hot water cylinder where water is heated overnight using the Economy 7 off-peak tariff. Energy Performance Certificates indicate that the water heating demand for the household can often be between 2,000 and 3,000kWh per year.

One method to improve the energy efficiency for water heating is to use a Mixergy smart hot water cylinder. This can operate with Direct Electric Heating from an immersion heater. Alternatively, there can be indirect heating using a coil heated by a boiler or an external heat exchanger can be fitted to allow the cylinder to be heated by a heat pump.

The Mixergy cylinder heats the water from the top of the cylinder down, which means faster heating and lower heat losses. A smaller cylinder can be used with no loss in performance. The cylinder is connected online and allows residents to view the level of hot water and boost it where needed. The Mixergy cylinder can learn the amount of hot water you need and avoid producing more hot water than required.

For households with solar PV, a solar immersion controller can be fitted, and excess solar generation can be automatically diverted to power the immersion heater within the hot water cylinder. This allows the household to heat water for free on sunny days.

As part of the ‘Evaluating solar PV with electric heating’ project, North Devon Homes installed 11 x Mixergy cylinders ranging in capacity from 120 litres to 250 litres. Where possible, the electricity consumption of the Mixergy cylinders were measured and the energy diverted by the solar immersion controller was recorded, and monetary savings for the resident calculated.

1.2 Project partners

The lead for the project was North Devon Homes (NDH), a non-profit making housing association and registered charity. NDH provides homes for rent across North Devon District Council’s area. In total there are 3,271 socially rented domestic properties, with 584 having storage heaters.

RES Devon was the installer for the majority of the solar PV systems and was the sole installer for the Mixergy smart hot water cylinders.

A member of the Innovation and Technical Evaluation team at NEA assisted with resident liaison, partner liaison, data collection and evaluated the project.

1.3 Context

The performance of a 215-litre Mixergy smart hot water cylinder was modelled by Energy Systems Catapult for a 3-bedroom house with a fully electric heating system. There were two occupancy profiles assessed: the first was for a family of five while the second was for a retired family of two.

The performance of the Mixergy cylinder was modelled over a two-week period compared to a similar-sized conventional cylinder. There was an 11% reduction in consumption compared to the conventional cylinder for the family of five. For the retired couple, the modelling suggested a 14% reduction in electricity consumption[1].

In an earlier Energy Industry Voluntary Redress Scheme project, NEA investigated solar immersion controllers[2]. This included a case study where a Solar iBoost+ solar diverter was installed with a solar PV system. The diverter was connected to a 145-litre hot water cylinder which had an extended vertical immersion heater fitted to the cylinder. Water heating was normally provided by an oil-fired boiler. Over the first year of operation, the Solar iBoost+ recorded that 1,020kWh of the solar generation had been diverted to power the immersion heater. This equated to 29.7% of the 3,439 kWh of electricity generated by the solar panels over the first year.

1.4 Project timeline

The project began in September 2022. The households to receive solar PV and Mixergy cylinder installations were identified by North Devon Homes and surveys were carried out in late 2022. The first Mixergy cylinder was installed in September 2023 alongside an air-source heat pump and solar PV array. Two further Mixergy cylinders were fitted as part of two Wondrwall installations with solar PV, battery storage and infrared heating panels in October 2023. The remaining eight Mixergy cylinders were installed between January and May 2024.

Several of the Mixergy installations had the associated current transformer (CT-clamp) for the solar diverter installed the wrong way round. It took several weeks to identify these issues and rectify, enabling the cylinder to use the excess solar generation for water heating.

---

[1] Mixergy: Smart hot water storage tanks, Energy Systems Catapult, https://es.catapult.org.uk/case-study/mixergy-smart-hot-water-storage-tanks/ (Accessed 3 Jan 2025)

[2] Rogers and Hamer (2023), Increasing self-consumption of solar PV: Monitors and solar immersion controllers, https://www.nea.org.uk/wp-content/uploads/2023/06/CP1495-Increasing-Self-Consumption-of-Solar-PV-Small-measures-v2.pdf (Accessed 3 Jan 2025)

An assessment of savings from the solar diverter was made using the Mixergy installer portal. Data was recorded up until the end of December 2024. Households were interviewed in late November/early December prior to writing the evaluation in early 2025.

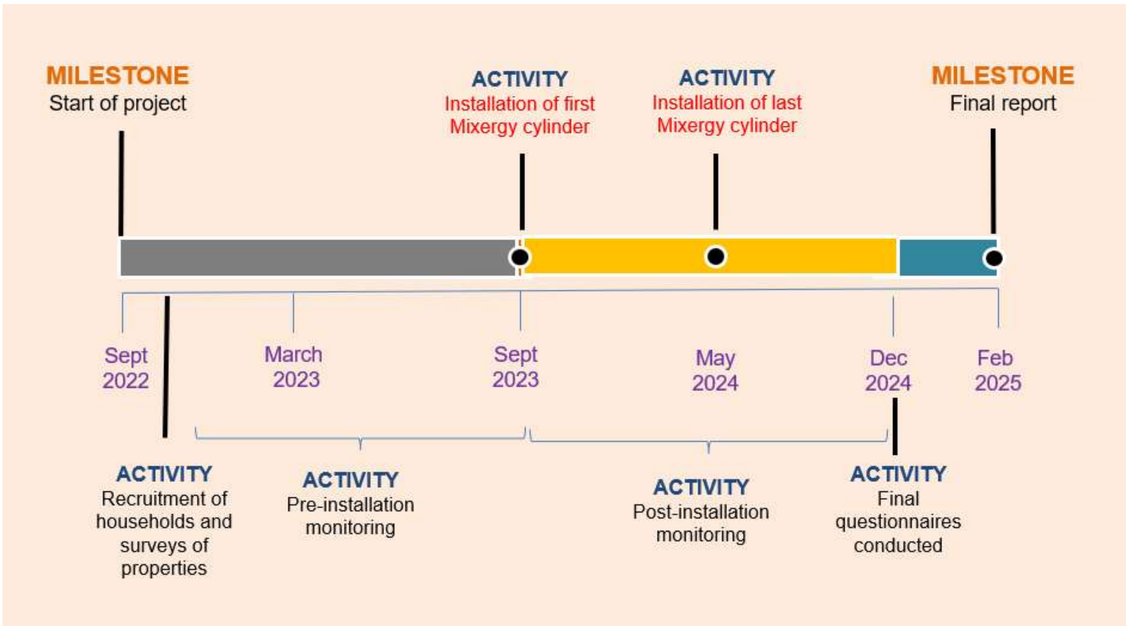


Figure 1.1 Timeline for installation of Mixergy cylinders

1.5 Mixergy technology and installations

Figure 1.2
(a) 180L Mixergy cylinder (b) 150L Mixergy cylinder (c) Mixergy gauge

Figure 1.2 (a) shows a 180-litre Mixergy cylinder installed in an airing cupboard. There is a solar diverter fitted in an external box on the upper half of the cylinder. Figure 1.2 (b) is of a 150-litre Mixergy cylinder which was fitted in the loft of another property as part of a Wondrwall installation. Some households preferred to have the cylinder fitted in the loft as it could provide them with added cupboard space.

Each Mixergy cylinder has a gauge which can be used to monitor and control the level of the hot water. There is an on/off button at the top of the gauge. The coloured LED display illustrates the amount of hot water (in red) in the tank. It is possible to manually boost the amount of hot water in the tank in 10% increments by pressing the button on the gauge with the upper facing arrow[3].

Households can also control and monitor the Mixergy cylinder via the Mixergy app. In situations where the cylinder was in the loft and the resident was unable to use the Mixergy app, there were issues over control of the cylinder. For one such household, an extension cable was obtained which allowed the Mixergy gauge to be brought down from the loft and fitted in the old airing cupboard. The extension cable used was a 10-metre length RJ12 male/female Ethernet cable.

Figure 1.3 shows several images from the Mixergy user app[4]. The home screen (left hand image) shows the level of hot water (in this case 59% charged) and allows the user to boost the amount of hot water.

[3] Cylinder controls and settings, Mixergy Knowledge Hub, https://support.mixergy.co.uk/controls-and-settings (Accessed 7 Jan 2025)
[4] The Mixergy App, Mixergy Knowledge Hub, https://support.mixergy.co.uk/how-do-i-access-and-use-the-mixergy-app (Accessed 7 Jan 2025)

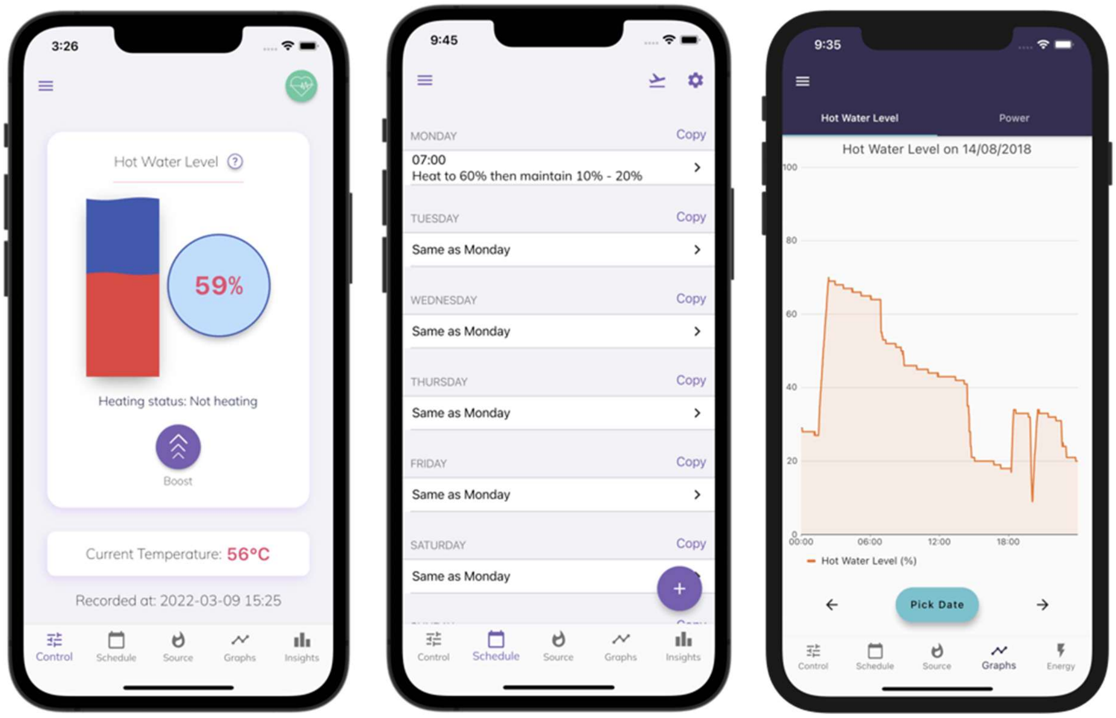


Figure 1.3
Images from the Mixergy user app

The middle image is from the schedule tab. It is possible to set the water heating schedule for each day of the week. The tank would be initially charged in this case to 60% from 07:00 and then maintained at 10-20% minimum charge for the rest of the day. A low minimum charge will reduce running costs while a higher value will ensure it is less likely the household will run out of hot water.

The optimum settings for the heating schedule were not known by the installers and users at the time of installation. The water heating schedule for some households heated the water in the morning to an unnecessarily high level of charge using grid electricity. This meant there was a limited opportunity for charging of the tank during the day using free electricity via the solar diverter as the tank was at or near the target temperature. The right-hand screenshot is from the graph tab. Here the user can view the variation in the level of hot water on a selected date.

The Mixergy smart hot water cylinder has an automatic schedule control feature. In this case, the tank learns the household hot water consumption over a period of weeks, and the water heating schedule is optimised to reduce energy consumption. In the Standard Automatic Schedule control this is done on a conservative basis to ensure the user never runs out of hot water. In the Economy mode, the algorithm is more ambitious but there is a greater risk the household may have periods without hot water. Over the monitoring period of this project, none of the households had the automatic schedule control enabled.

In addition to the user app, Mixergy has produced an installer app and installer monitoring portal. NEA staff were able to use the installer monitoring portal to assess performance of the systems and to identify faults.

The Mixergy solar diverter uses excess solar generation to power the immersion heater for free water heating. A current transformer (CT-clamp) is fitted on the neutral cable of the incoming mains supply with the arrow pointing towards the 80/100A main fuse[5]. This is used to measure when there is export of electricity from the solar panels to the grid. There were issues with several of the installations where the CT-clamp had been fitted in the wrong orientation.

Figure 1.4 shows a typical graph from the Mixergy installer monitoring portal for an installation with a solar diverter where the CT-clamp is in the correct orientation. The clamp power is shown in grey and shows the electricity import/export. Overnight this is positive due to consumption by the household. The clamp power is negative in the middle of the day when there is solar generation exported to the grid. The PV power is shown in light blue. This shows when the immersion heater is being powered to heat water by excess solar generation. Once the solar panels start generating in the morning, the clamp power initially decreases to zero and excess solar generation powers the immersion heater. This continues until the charge (shown in orange) reaches 100%. The clamp power is negative once the tank is fully charged, or the solar generation is greater than the household consumption (including the power of the immersion heater).

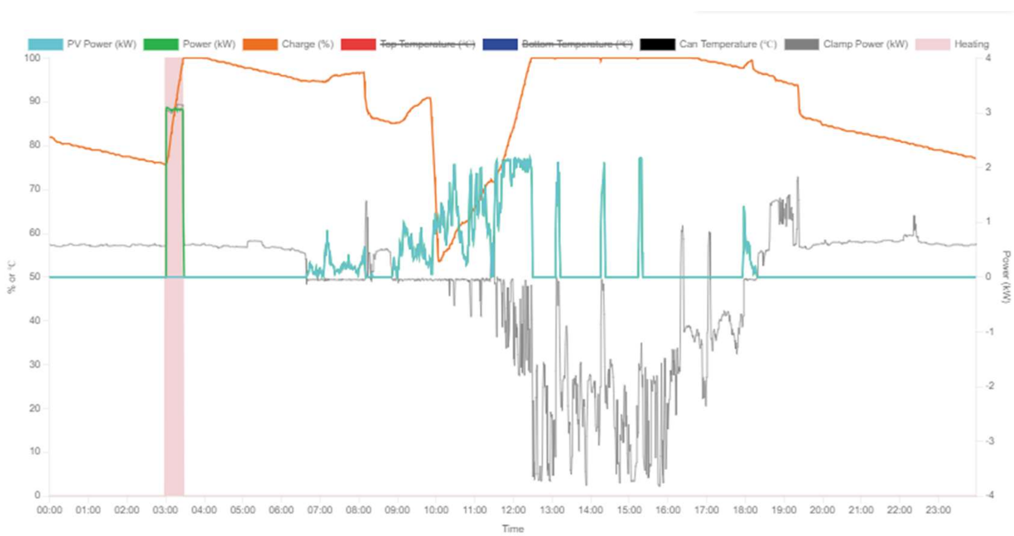


Figure 1.4
Screenshot from the Mixergy installer monitoring portal from 22 Jul 2024 with the CT-clamp in the correct orientation

[5] Installation instructions for Mixergy embedded diverters, Mixergy Knowledge Hub, https://support.mixergy.co.uk/pv-diverter-mdc0007 (Accessed 9 Jan 2025)

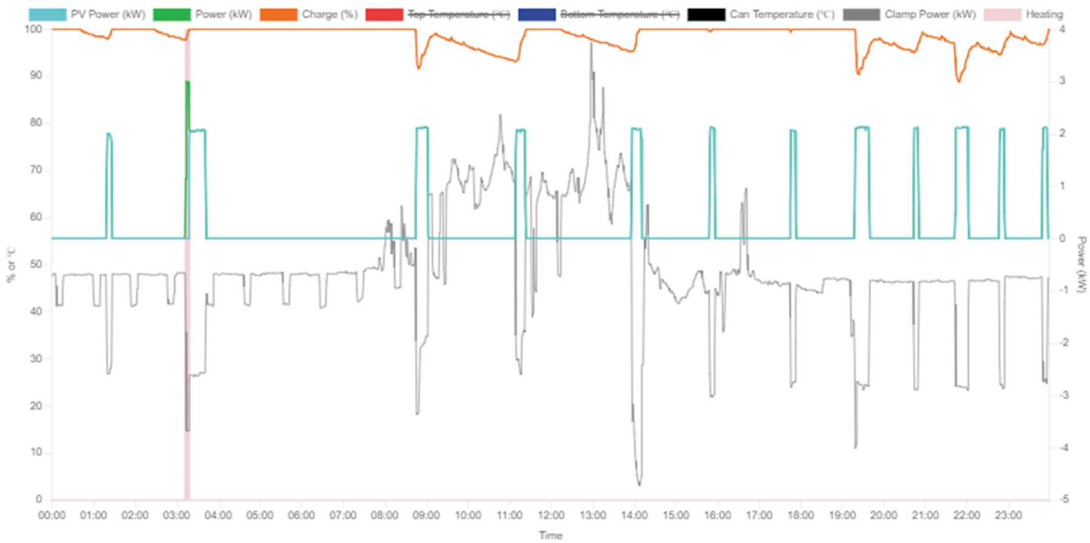


Figure 1.5
Screenshot from the Mixergy installer monitoring portal from 20 Mar 2024 with the CT-clamp in the wrong orientation

Figure 1.5 shows a graph from the Mixergy installer monitoring portal for the same installation. This was from 20 March 2024, soon after installation and the CT-clamp at the time was in the wrong orientation. The graph shows the clamp power in grey to be negative overnight – this should have been positive due to consumption by the household. The clamp power was positive in the middle of the day when it should have been negative due to solar PV generation and export.

The immersion heater was powered in bursts of about 2kW when the clamp power was recorded to be negative. The Mixergy system thought there was electricity exported to the grid overnight and powered the immersion heater at times when the charge fell below 100%. This meant the system powered the solar diverter in 2kW bursts from 1900 to 0000 despite it being dark at the time.

There are several factors that will affect the level of savings made by the solar diverter[6]:

- The solar PV generation
- Household electricity consumption
- Hot water demand
- Hot water cylinder
  - How much heating is provided by other sources
  - Time of day/schedule of any additional water heating

[6] Rogers and Hamer (2023), Increasing self-consumption of solar PV: Monitors and solar immersion controllers, https://www.nea.org.uk/wp-content/uploads/2023/06/CP1495-Increasing-Self-Consumption-of-Solar-PV-Small-measures-v2.pdf (Accessed 9 Jan 2025)

1.6 Issues affecting the project

Issue	Description and mitigation
Installation delays	There were delays in installing some of the solar PV systems for the project. This also led to delays fitting the Mixergy cylinders as these were installed after the solar PV systems were operational.
Installation issues with current transformers	The solar diverter for the Mixergy cylinder uses a current transformer to determine when there is excess solar generation that can be used to power the immersion heater. For many of the installations, the CT-clamp was initially installed in the wrong orientation. After NEA had access to the Mixergy monitoring portal, the sites with reversed CT-clamps were identified. Requests were made to Mixergy technical support to remotely reverse the orientation of the CT-clamp. This issue reduced the time available for monitoring the solar diversion for these installations.
Interaction between Mixergy cylinder and battery storage	Several of the households that had Mixergy cylinders also had battery storage. This included two properties with Tesla Powerwall 2 batteries and storage heaters and two that had Mixergy cylinders installed as part of Wondrwall installations with solar PV and battery storage. Normally when there is excess PV generation, this alone is used to power the immersion heater. With the Tesla battery, once the immersion heater was initially powered, further power was provided by the battery so that it ran in approximately 2kW bursts. Adjusting the threshold for the start of diversion did not resolve the problem. Installations where this was an issue were not monitored in detail.
Tripping of system following Legionella cycle	One of the cylinders was regularly tripping following the Legionella cycle. This was due to weeping from the cylinder into the pocket for the thermostat which checks for overheating. The issue was resolved by replacing the immersion heater.
Household complaining of insufficient hot water	The resident of one household could only use the bath and not the shower. The household complained there was insufficient hot water for a bath. A visit identified that this was due to a thermostatic mixing valve on the bath limiting the temperature of the hot water coming through the taps for the bath. Once this was adjusted, the issue was resolved.

Household not using cylinder due to high water use	One of the households was a very low energy user. There was an electric shower and the only other hot water use was for washing dishes. The resident preferred to use a kettle to heat water for the washing dishes as it was felt that too much water came through the tap before hot water was available from the cylinder. It is hoped the resident would start to use the Mixergy cylinder once the bath is taken out and a new mixer shower is fitted at the property.
Confusion over isolator switch for cylinder	One of the households had an isolator switch in the kitchen which they thought was a boost button for the cylinder. They did not realise this needed to be left on all the time. As a result, the cylinder would become cold, and the cylinder would fully charge on peak-rate electricity and then be turned off so the solar diverter would not work. Once this was explained to the residents, this switch was left on and the solar diverter reduced water heating costs. The switch later failed and caused the system to go offline for several days.

2. Details of properties

2.1 Location of the installations

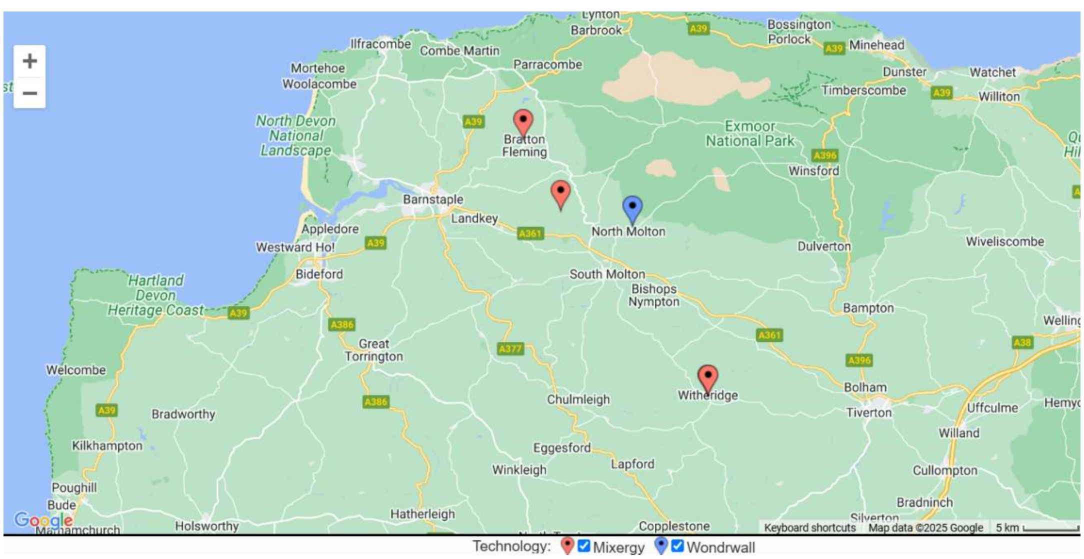


Figure 2.1 Map showing the location of installations[7]

[7] Map produced with EasyMapMaker, https://www.easymapmaker.com/

There was a total of 11 Mixergy hot water cylinders installed during the project, with two of these fitted as part of Wondrwall installations with solar PV, battery storage and infrared heating panels.

The two Wondrwall installations were in North Molton and are discussed in more detail in another report. Out of the remaining nine Mixergy cylinder installations, two were fitted in Bratton Fleming, one in East Buckland and the remaining six in Witheridge.

2.2 Details of the properties, installations and households

Figure 2.2 Semi-detached bungalow with solar PV, ASHP and a Mixergy cylinder

Code	Technology	PV size (kW)	Mixergy cylinder size (L)	EPC score before install	EPC score after install	Mixergy uplift
W-01	Wondrwall	5.81	150	E48	A94	3
W-02	Wondrwall	5.81	150	E48	A94	3
IC-01	IR panels + PV	5.81	120	E47	A92	7
SH-01	Storage heaters + PV	3.89	250	D68	B88	2
SH-02	Storage heaters + PV	4.98	210	D67	A92	2
SH-03	Storage heaters + PV	5.53	210	D62	B86	2
T-03	Tesla Powerwall 2 + Storage heaters + PV	4.74	210	D58	B82	3
T-09	Tesla Powerwall 2 + Storage heaters + PV	4.15	180	D68	A93	3
T-06	Tesla Powerwall 2 + ASHP + PV	4.57	180	C75	A103	5
AC-03	ASHP +PV	4.74	180	C70	A105	5
AC-04	ASHP + PV	4.15	180	C74	A109	4

Table 2.3 Properties which had Mixergy smart hot water cylinder installations

The 11 households that had Mixergy smart hot water cylinders installations are shown in table 2.3. This includes details of the heating technology, the solar PV system size, the capacity of the Mixergy cylinder and the improvement to the energy score for the Energy Performance Certificate (EPC) after the installation. All of the Mixergy cylinders had a solar PV diverter switch which retails for £162 including VAT.

Large domestic solar PV systems were installed which ranged in size from 3.89kW to 5.81kW. This was to provide as much solar generation as possible to lower costs for electric space and water heating.

The properties were surveyed by a Domestic Energy Assessor, with modelling and EPCs produced under RdSAP 2012. Table 2.3 shows there were uplifts of between 20 and 46 points in the EPC energy score following installation of the solar PV system and Mixergy cylinders. The improvement provided by the Mixergy cylinder was assessed using an Appendix Q calculation in RdSAP 2012. The Mixergy cylinders contributed an uplift of two to seven points to the final energy score. Household IC-01 saw the greatest uplift of seven points in the energy score and this may be due to having a single-rate tariff and producing greater cost savings. The households with ASHPs also had greater uplifts with improvements in the energy score of four or five points.

Household SH-03 withdrew from the study and was not interviewed. There was also limited data available due to issues with the internet connection to the cylinder. As a result, this installation is not discussed any further.

Household W-02 had a smart hot water cylinder as part of a Wondrwall installation. The only hot water demand the resident had was for washing dishes and boiling a kettle was preferred to using the hot water cylinder due to the water consumption before hot water was available. There was no data from this installation and the resident could not comment on use of the cylinder during the interview.

There were installation issues for the cylinder for household W-01. These were resolved but there was still some interaction between the solar diverter and the battery in the Wondrwall system. As a result, data from this system was not analysed.

Households T-03 and T-09 both had storage heaters and a Tesla Powerwall 2 battery. There were significant interactions between the battery and the solar diverter which meant the diverter did not work as intended. This issue could not be resolved during the project. As a result, data from these installations were not analysed. The residents were interviewed and were generally happy with the cylinders apart from this issue.

This meant that data from six of the installations was analysed. The Mixergy cylinders installed at IC-01, SH-01 and SH-02 were all direct cylinders with heating only from the immersion heater. These installations could measure the total consumption from the immersion heater and the amount powered by the solar diverter. Installation SH-01 had a 250L cylinder as it was a 4-bedroom house. IC-01 had just a 120L cylinder as there were only two residents.

Households AC-03 and AC-04 were single-bedroom properties with an air source heat pump. In addition to the solar diverter, a heat pump kit was fitted with the Mixergy cylinder (retail price £479 including VAT). This included a plate heat exchanger to allow the heat pump to heat the water and a heat pump interface which provided an electrical interface between the heat pump domestic hot water system and the Mixergy controller[8].

Household T-06 was the first to have a Mixergy cylinder installed in September 2023. This was fitted at the same time that the old storage heaters were replaced by an air source heat pump (ASHP) along with a wet central heating system (both fully funded by North Devon Homes). There appeared to be no unusual interactions between the Tesla Powerwall 2 battery at the property and the Mixergy solar diverter. As a result, data from this installation was included in the study.

Heating by the ASHP was apparent with the Mixergy installer monitoring portal, however the energy consumed by the ASHP while heating the water was not monitored. In this case, the portal showed the total water heating provided by the immersion heater and the amount of that water heating provided by the solar diverter.

There was an installation issue with AC-04 where the Mixergy cylinder called for heat from the ASHP, but this was not responded to. This was resolved in December 2024 but up until then, the Mixergy cylinder was only heated by the solar diverter.

The cost of the Mixergy cylinder installations ranged from £2,656 including VAT for a direct cylinder with solar diverter to £3,334 including VAT for a cylinder with the solar diverter and heat pump interface for households with an ASHP.

[8] Heat Pump kit, Mixergy Shop, https://shop.mixergy.co.uk/product/heat-pump-kit/ (Accessed 9 Jan 2025)

3. Social analysis

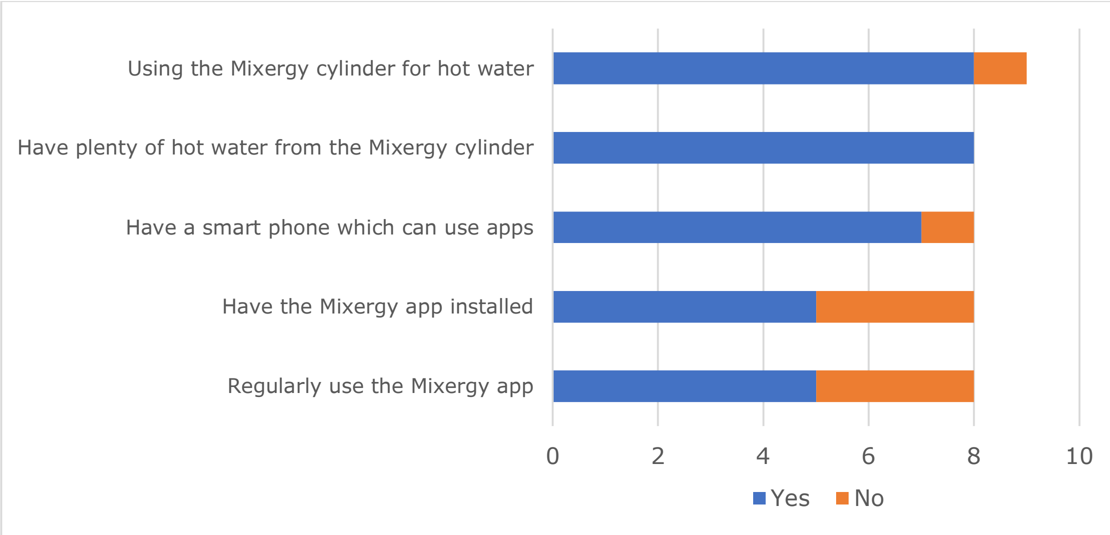


Figure 3.1 Use of Mixergy cylinder and app

There were 11 Mixergy cylinders installed in the project. Out of these households, nine were interviewed at the end of the project, with two unavailable for visits.

Out of the nine households interviewed, eight were using the Mixergy cylinder. One of the households with a Wondrwall installation had an electric shower and only used additional hot water for washing dishes. Due to the level of water consumption before hot water was available, this household preferred to boil water in a kettle for washing dishes. In the future North Devon Homes aims to replace the bath in the property with a shower cubicle with mixer shower which would encourage use of the Mixergy cylinder.

Five of the households interviewed had mixer showers installed during the project with one already having a mixer shower. The remaining two households continued to use their electric showers. One of the households had a wet room and mixer shower installed shortly before being interviewed. The water use before the wet room was installed was used in the following analysis.

The average number of baths per week among the nine households interviewed was 3.39 and ranged from zero for four of the households up to 14 for one household. The average number of electric showers per week was 3.17. The households with mixer showers no longer used the electric shower. Those with only an electric shower used between 3.5 and 15 electric showers per week. The average number of mixer showers per week was 5.11. The four households without mixer showers had zero mixer showers per week. The other five households had between 1.5 and 20 mixer showers per week.

Out of the eight households interviewed who were using the Mixergy cylinder, all eight noted they had plenty of hot water. There were seven of the eight households that had a smart phone that could use apps. Five of the eight households had the Mixergy app installed. One of the households who did not have the app was unable to use apps on their phone. The other two households would have liked to have the app, but it was not set up at the time of installation. All five of the households who had the Mixergy app installed used it regularly.

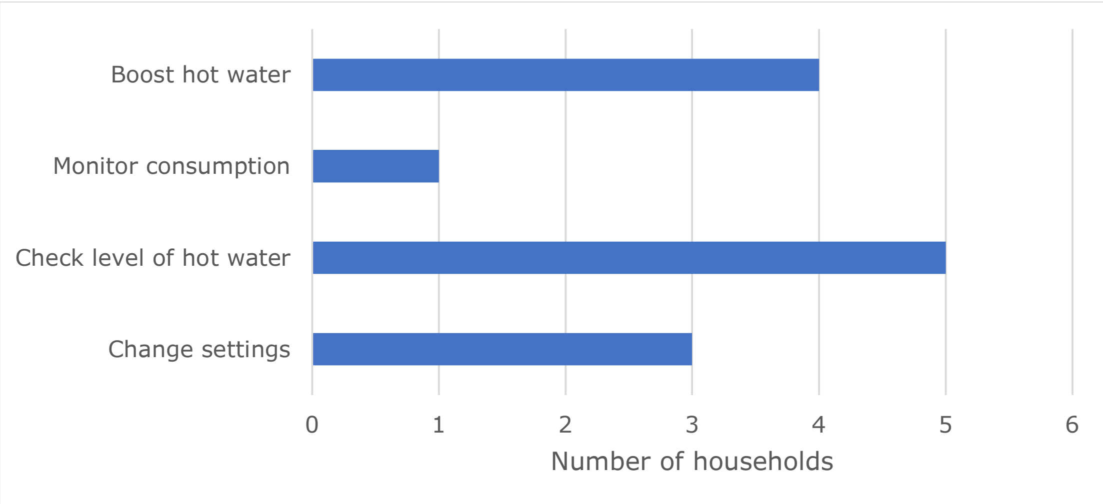


Figure 3.2 Features of the Mixergy app that were used by households

Out of the five households interviewed who were using the Mixergy app, four of them used the app to boost the hot water. Just a single household was using the app to monitor the consumption of the hot water cylinder. All five of the households used the app to check on the level of hot water available in the Mixergy cylinder. Three of the households had used the app to change settings for the cylinder during the project.

The households using the app were asked on a scale of 1 to 5 how easy the Mixergy app was to use where 5 was very easy. The average score for ease of use was 4.6. Households were also asked on a scale of 1 to 5 how useful the Mixergy app was where 5 was very useful. In this case, the average score for usefulness was 4.8 with all the households using the app scoring either 4 or 5.

The households were also asked whether they agreed or disagreed with a series of statements about the Mixergy cylinder (figure 3.3). Out of the eight households who were using the Mixergy cylinder, four strongly agreed that the Mixergy cylinder was better than their old hot water cylinder, while three households agreed with the statement and one disagreed. The household who disagreed had problems for a few weeks with the cylinder tripping every couple of weeks after the Legionella cycle.

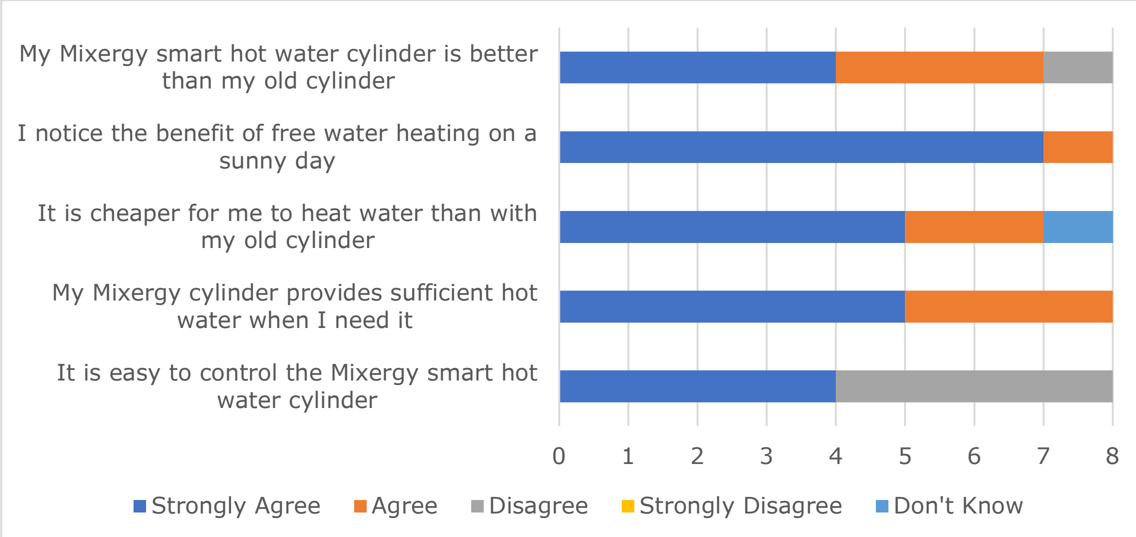


Figure 3.3 Benefits of Mixergy cylinder noted by households

Seven of the eight households strongly agreed they noticed the benefit of free water heating on a sunny day with the remaining household agreeing. This was despite two of the households having an issue where their Tesla Powerwall 2 battery was interacting with the solar diverter for the Mixergy cylinder.

Five of the eight households strongly agreed that it was cheaper to heat water with the new cylinder than with the old cylinder. A further two households agreed with the statement while one household did not know. It was difficult for households to be sure about this as their electricity bill was generally lower in the summer due to the solar PV installation. Some households however had the Mixergy cylinder installed several months after the solar PV.

There was further evidence that the Mixergy cylinder provided an ample supply of hot water. Five of the households strongly agreed the Mixergy cylinder provided sufficient hot water when they needed it. A further three households agreed with the statement.

There was a mixed response over whether the Mixergy hot water cylinder was easy to control. Four of the eight households using the cylinder strongly agreed that it was easy to control. All four of these households were using the Mixergy app. The remaining four households disagreed with the statement. Out of these, three of the households were not using the app. The remaining household had issues with their Tesla Powerwall 2 battery interacting with the solar diverter.

For the best customer experience, residents should have the Mixergy app installed. For those households unable to use the Mixergy app, it is important that they have easy access to the Mixergy control gauge. This shows the level of charge of hot water in the cylinder and enables the user to boost the level of hot water without using the app.

4. Technical monitoring

4.1 Comparing the performance of Mixergy unvented direct hot water cylinders

	IC-01	SH-01	SH-02
Hot water energy use (kWh)	1009.1	679.3	968.5
Hot water PV energy use (kWh)	380.5	346.6	400.2
Solar PV generation (kWh)	2360	1635	1904
Total solar PV used (kWh)	839.9		784.9
Grid consumption (kWh)	2382.7	4121.5	1960.4
Size of Mixergy cylinder	120 litres	250 litres	210 litres
Average no. of baths per week	0	2.5	10
Average no. of mixer showers per week	7	0	0
Average no. of electric showers per week	0	15	10
Minimum saving from solar PV diverter	£91.32	£43.33	£50.03

Table 4.1 Summary of the performance of three Mixergy Direct hot water cylinders between 1 Jul 2024 and 31 Dec 2024

Three of the monitored Mixergy cylinders were direct cylinders where the water was only heated by an immersion heater. The immersion heater was usually powered from the grid overnight to ensure there was sufficient hot water. Each of the cylinders had a solar diverter and this allowed excess solar generation to power the immersion heater and heat the water for free. The amount of solar diversion depended on the amount of excess solar generation and the level of charge in the cylinder. If there was a low level of charge, there was a greater capacity for solar diversion.

The total hot water energy use between 1 Jul 2024 and 31 Dec 24 for the three households was between 679.3kWh and 1,009.1kWh. Household IC-01 with the smallest 120-litre cylinder used the greatest amount of energy for water heating. IC-01 had a mixer shower throughout the six-month monitoring period and all water for bathing was provided by the Mixergy cylinder. In contrast SH-01 and SH-02 both had electric showers which were heavily used. An electric shower may use 1 to 2kWh of electricity depending on the length of the shower. Assuming an average of 1.5kWh per shower, this would add about 585kWh to the hot water consumption for SH-01 and 390kWh to the hot water consumption for SH-02 over the six-month monitoring period.

Household IC-01 comprised two adults while SH-01 had three adults and five children and SH-02 had two adults and two children.

Household IC-01 had a relatively high hot water energy use for the level of occupancy. A factor in the high consumption of IC-01 was likely to be the settings for the water heating schedule. This was set to heat the tank to 100% charge each morning at 3am and then maintain the charge at between 30% and 100%. The cylinder was likely to have been overcharged, and the high level of charging meant there was a greater heat loss from the cylinder during the day. Out of the 1,009.1kWh used for water heating by IC-01, 380.5kWh (37.7%) was provided for free by the solar diverter.

In contrast, the schedule for the cylinder at SH-01 (more than double the capacity of IC-01) was set to heat the tank to 50% each morning at 2am and then maintain the charge at between 30 and 50% during the day. The lower overnight charging of SH-01 reduced heat losses and allowed greater capacity for solar charging of the cylinder. There was 346.6kWh of solar water heating for SH-01 and this contributed 51% towards the total water heating. This was in fact the lowest amount of solar water heating for the three cylinders. The lower solar water heating for SH-01 may be due to a combination of having the lowest solar PV generation of the three households (1,635kWh), having the highest grid consumption (4,122kWh) as well as a lower hot water demand from the cylinder (an average of 2.5 baths per week).

The typical water consumption of a bath is around 80 litres while a non-power shower uses about 45 litres of water[9]. Low-flow shower heads can use even less water.

Household SH-02 used 968.5kWh of hot water during the six months between 1 Jul 2024 and 31 Dec 2024. This was only slightly lower than for IC-01, but the household had a larger 210-litre cylinder. It is likely that the consumption was significantly higher than for SH-01 due to the water heating schedule and the hot water demand. For SH-02, the cylinder was heated to 100% charge each night at 3am and then maintained at 30% to 70% charge during the day. Fully charging the cylinder overnight could have led to greater heat losses during the day and is likely to have limited the potential for solar charging. However, household SH-02 with 400.2kWh of hot water PV energy use had the greatest solar charging of the three households during the monitoring period. This was likely to be due to a combination of a medium level of solar PV generation, lower household grid consumption and a high hot water demand (10 baths per week).

---

[9] Water use in your home, tips to save water, South Staffs Water, https://www.south-staffs-water.co.uk/media/1539/waterusehome.pdf (Accessed 10 Jan 2025)

The solar water heating for SH-02 made up 41.3% of the total consumption for water heating from the Mixergy cylinder.

Household IC-01 was on a single-rate electricity tariff. Assuming a unit rate of 24p/kWh, the savings from the solar diverter over the six-month analysis period were £91.32. Households SH-01 and SH-02 were both on Economy 7 tariffs and a typical rate at the time of writing was 30p/kWh peak rate and 12.5p/kWh off-peak rate. It is possible to estimate the minimum savings for these households due to the solar diverter by assuming the electricity saved would otherwise have been used while charging the cylinder overnight. In this case over the six-month monitoring period the minimum saving for SH-01 would have been £43.33 and it would have been £50.03 for SH-02. In practice the Mixergy cylinder may recharge during the peak-rate period if the level of hot water fell sufficiently. Savings for SH-01 and SH-02 could be higher if peak-rate consumption was displaced.

4.2 Comparing the performance of Mixergy unvented water cylinders with air-source heat pump plate heat exchangers

	T-06	AC-03	AC-04
Hot water energy use (kWh)	540.7	506.2	390.2
Hot water PV energy use (kWh)	425.9	499.4	390.1
Solar PV generation (kWh)	2011.9	1709	1695
Total solar PV used (kWh)	1617.6	705.1	573.9
Grid consumption (kWh)	4099	1165.4	950.8
Size of Mixergy cylinder	180 litres	180 litres	180 litres
Average no. of baths per week	0	14	
Average no. of mixer showers per week	15	0	
Average no. of electric showers per week	0	0	

Table 4.2 Summary of the performance of three Mixergy hot water cylinders with plate heat exchangers for ASHPs between 1 Jul 2024 and 31 Dec 2024

The performance of the three Mixergy cylinders installed for households with air-source heat pumps (ASHPs) is shown in table 4.2 for the period 1 Jul 2024 to 31 Dec 2024. The hot water use was the total use of the immersion heater. In addition to this was water heating by the ASHP but the level of this was not recorded.

The total hot water energy use from the immersion heater for T-06 was 540.7kWh while the amount powered by the solar diverter was 425.9kWh. The additional immersion heater use typically occurred when there was water heating by the ASHP and the level of charge in the cylinder was still falling. This could occur when the household was using the shower.

Household T-06 had the highest solar generation of the three with ASHPs with 2011.9kWh PV generation over six months. The solar PV consumed by the household was 1617.6kWh or 80.4% self-consumption of the solar generation. This was between 778 and 1044kWh higher than the other five Mixergy households with similar data due to T-06 having a Tesla Powerwall 2 battery.

Household T-06 lived in a 3-bedroom house which required more heating than for AC-03 and AC-04 which were 1-bedroom bungalows. As a result, the grid consumption for T-06 at 4099kWh over six months was much higher. The household had a mixer shower installed at the end of April 2024 and there was an average of 15 mixer showers per week.

The CT-clamp for the Mixergy cylinder for household AC-03 was reversed on 31 Aug 2024 when additional monitoring was installed which meant the solar diverter was no longer diverting excess solar generation. There were 18 days of normal performance data lost in September 2024. The values of hot water energy use and hot water PV energy use were lower due to this period with missing data. Despite this, the hot water PV energy use of 499.4kWh was the highest of the six Mixergy cylinders analysed. This may be due to a combination of high hot water use (14 baths per week), low grid consumption and PV generation across the day with a solar PV array split across an east-west facing roof.

There were issues with the installation for household AC-04 and the ASHP did not respond to the call for heat from the Mixergy cylinder. This issue was resolved in December 2024. Prior to that, the cylinder was only heated by the solar diverter. The hot water energy use was only 390.2kWh as there was an electric shower and the resident was spending less time in the property later in 2024. Household AC-04 used 574kWh of the solar generation over the six-month analysis period, which was the lowest of the five households analysed. This is likely to be due to the low grid consumption of 951kWh over the period.

It was not straightforward to estimate the cost savings due to the solar water heating for T-06, AC-03 and AC-04. If the water had not been heated for free by the immersion heater using excess solar generation, it is likely to have been heated by the air-source heat pump. We can assume the coefficient of performance of the heat pump for water heating was at least two. For AC-03 on a single rate tariff with a unit rate of 24p/kWh, the electricity cost saving was up to £60 over six months.

4.3 Case study – Household T-06 with Mixergy cylinder, solar PV, ASHP and Tesla Powerwall 2 battery

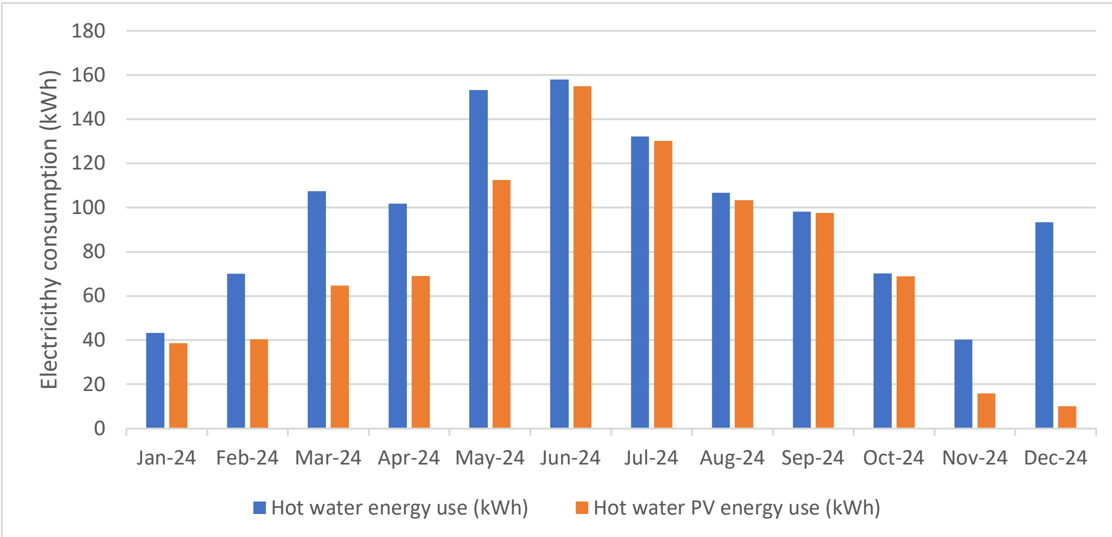


Figure 4.3 Use of the immersion heater for water heating for household T-06

The Mixergy cylinder for household T-06 was installed in September 2023, so there was more than a year of performance data available. Figure 4.3 plots the immersion heater consumption recorded by the Mixergy installer portal over the year. There were three days in May 2024 when the CT-clamp for the solar diverter was reversed, and this data was ignored.

The immersion heater use was 1174.5kWh over the year with 906kWh of this powered by the solar diverter. The monthly solar PV diversion was greatest in June 2024 with 155kWh. There was greater PV diversion after April 2024 once the mixer shower was installed. This was likely to be partly due to increased demand for hot water from the Mixergy cylinder.

Much of the hot water demand for the Mixergy cylinder was provided by the ASHP, particularly outside the summer months. Figure 4.4 shows a plot from the Mixergy installer portal for household T-06 on 2 Jan 2025. The periods when the cylinder was heated by the ASHP are shaded in pink. The cylinder was heated by the ASHP at 04:30, 07:30 and 20:00. These were periods when the charge of the cylinder (in orange) had fallen sufficiently that the cylinder called for heat from the heat pump. At the start of the first period of heating by the ASHP, the charge in the cylinder initially continued to fall at an even higher rate. This was most likely due to use of the mixer shower. As a result, the Mixergy cylinder was also heated by the immersion heater (shown in green). Situations like this where the immersion heater is powered account for the difference between 'hot water energy use' and 'hot water PV energy use' seen in figure 4.3.

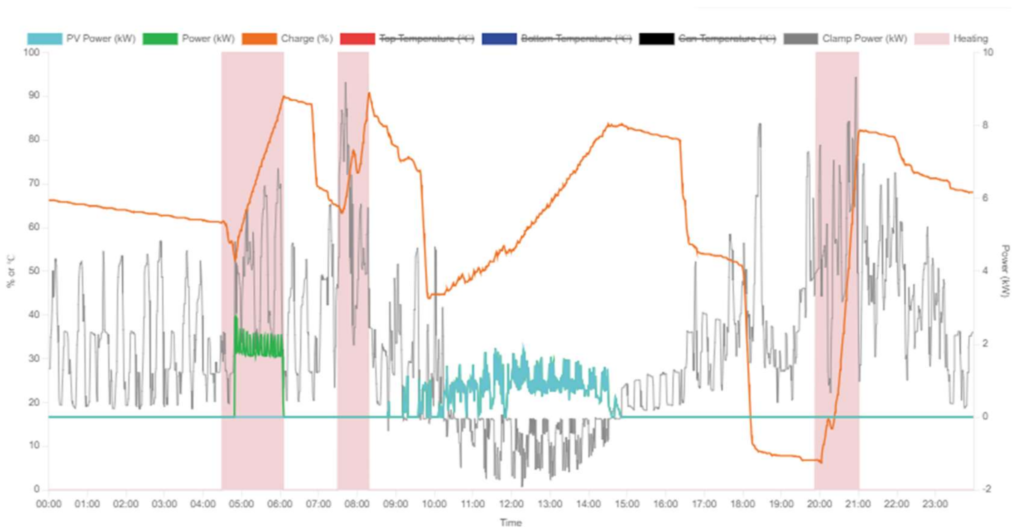


Figure 4.4 Graph from the Mixergy installer portal for household T-06 on 2 Jan 2025

There was some sunshine on 2 Jan 2025 from about 09:00 to 14:45. This led the solar diverter to power the immersion heater (shown in light blue) at times of excess PV generation. The charge level in the cylinder rose from 44% to 83% due to the solar diverter over this period.

Table 4.5 shows monthly values of hot water energy use and hot water PV energy use (total immersion heater use and PV diversion for water heating) from the Mixergy installer portal. The remaining data in table 4.5 is based on data from the app for the Tesla Powerwall 2 battery. This includes the solar PV generation and the amount of the generation used by the Tesla battery. The table also shows the amount of PV generation used in the home apart from for the battery. This value includes the electricity used by the solar diverter for heating water. The percentage self-consumption of the solar generation was calculated by the following formula:

$$Self\ consumption\ (\%) = \frac{\text{PV generation} - \text{PV export}}{\text{PV generation}} \times 100$$

In June 2024, the PV generation was 605kWh with 163kWh of this used by the battery and 339kWh of the generation used in the home. Out of the 339kWh used in the home, 155kWh was used by the solar diverter to power the immersion heater. This was the month with greatest amount of PV used in the home and greatest hot water PV energy use. Overall, the percentage self-consumption in June was 83%.

The hot water PV energy use was low in the winter when there was limited PV generation. In December 2024, there was 92.8kWh of PV generation, with 25.7kWh used by the Tesla battery and 66.7kWh using in the home. Only 10.1kWh was available for solar water heating out of the 66.7kWh used in the home. During December, 99.5% of the solar generation was self-consumed.

Month	Hot water energy use (kWh)	Hot water PV energy use (kWh)	Solar PV generation (kWh)	PV used in the home (kWh)	PV used by battery (kWh)	% Self consumption
Jan 24	43.3	38.5	222.8	116.6	73.9	85.5%
Feb 24	70.1	40.3	160.4	98.2	43	88.0%
Mar 24	107.5	64.7	351.8	208.4	76.9	81.1%
Apr 24	101.8	69.1	436.7	223.8	91.7	72.2%
May 24	153.2	112.5	627	327.1	174.8	80.0%
Jun 24	158.0	155.0	605.1	338.8	163.2	83.0%
Jul 24	132.2	130.2	540.1	306.8	120.7	79.2%
Aug 24	106.7	103.3	498.8	248.7	98.2	69.5%
Sep 24	98.2	97.5	406.5	238.2	101.3	83.5%
Oct 24	70.1	68.9	318.3	184.1	87.1	85.2%
Nov 24	40.2	15.8	155.4	90.2	49.9	90.2%
Dec 24	93.4	10.1	92.8	66.7	25.7	99.5%
Total	**1174.5**	**905.9**	**4415.7**	**2447.6**	**1106.4**	**80.5%**

Table 4.5 Monthly hot water energy use, solar generation and consumption for T-06

During 2024, 25.1% of the solar generation was used by the Tesla Powerwall 2 battery and 55.4% used in the home which included 20.5% of the generation used for hot water PV energy use (the Mixergy solar diverter). Overall, 80.5% of the 4416kWh generated by the solar PV system was self-consumed. Despite there being a battery with 13.5kWh storage capacity, household T-06 saved 906kWh in 2024 from the solar diverter with the Mixergy cylinder.

A Wibeee electricity monitor was fitted in late August 2024 for household T-06. This could monitor the electricity consumption of three electrical circuits using current transformers (CT-clamps) fitted around the circuits. The monitor was used to assess the accuracy of the measurements from the Mixergy installer portal.

Data from the Wibeee monitor could be compared with values of hot water energy use recorded by the Mixergy portal. The Wibeee monitor measured the immersion heater used 102.3kWh in September, 72.6kWh in October, 41.7kWh in November and 96.4kWh in December 2024. These values were close to those in table 4.5 with differences of only 1.5 to 4.1kWh (3.2 to 4.2%).

4.4 Case study – Household SH-01 with Mixergy cylinder, solar PV and storage heaters

Month	Hot water energy use (kWh)	Hot water PV energy use (kWh)	Solar PV generation (kWh)	Wibeee PV used in the home (kWh)	Wibeee Immersion heater (kWh)	% Self consumption
Jul 24	122.6	74.9	456 *			
Aug 24	110.9	95.0	421 *			
Sep 24	107.6	72.7	320.6	216.2	113.0	67.4%
Oct 24	118.0	78.1	261.6	216.4	123.2	82.7%
Nov 24	105.3	17.2	78.7	75.9	113.5	96.4%
Dec 24	114.9	10.8	63.7	61.9	121.0	97.1%
Total	**679.3**	**348.6**				

Table 4.6 Monthly data on hot water energy use, solar generation and consumption for household SH-01 * data from Solis inverter

Household SH-01 had a direct Mixergy cylinder where the cylinder was only heated by the immersion heater. While the household had an average of 2.5 baths a week supplied by the Mixergy cylinder, the 15 showers per week were provided by an electric shower.

Table 4.6 shows the monthly hot water energy use from the Mixergy cylinder along with the amount of the water heating provided by solar diversion. The table shows values of solar PV generation, with those for July and August from the Solis inverter and the values from September to December recorded by a Wibeee electricity monitor. Note that the PV system tripped for six days in November, reducing generation.

The Wibeee monitor also measured the amount of the solar PV generation that was used in the home and the total electricity consumed by the immersion heater. The difference between the immersion heater consumption recorded by the Mixergy portal and the Wibeee monitor was between 5.2kWh and 8.2kWh or 5 and 7.8%.

The monthly hot water demand from the Mixergy cylinder was in the range 105 to 123kWh between July and December. The monthly hot water PV energy use was between 11 and 95kWh over this period. In August 2024, the solar diverter supplied 95kWh (85%) of the Mixergy hot water demand of 111kWh. The diverter also provided more than 60% of the hot water for the cylinder in July, September and October. This fell to 16% in November and 9% in December.

The solar PV installations for T-06 and SH-01 were both south facing. The PV array for T-06 was 4.57kW compared to 3.89kW for SH-01. As a result, the monthly generation for T-06 was higher than for SH-01.

Comparing the hot water PV energy use (solar diversion) for the two installations in tables 4.5 and 4.6, it is apparent that there was greater PV diversion for water heating for T-06 between July and September. However, the PV diversion was greater for SH-01 between October and December. For months with lower PV generation, the Tesla Powerwall 2 battery at T-06 was likely to have consumed much of the excess generation, reducing the amount free for the Mixergy solar diverter.

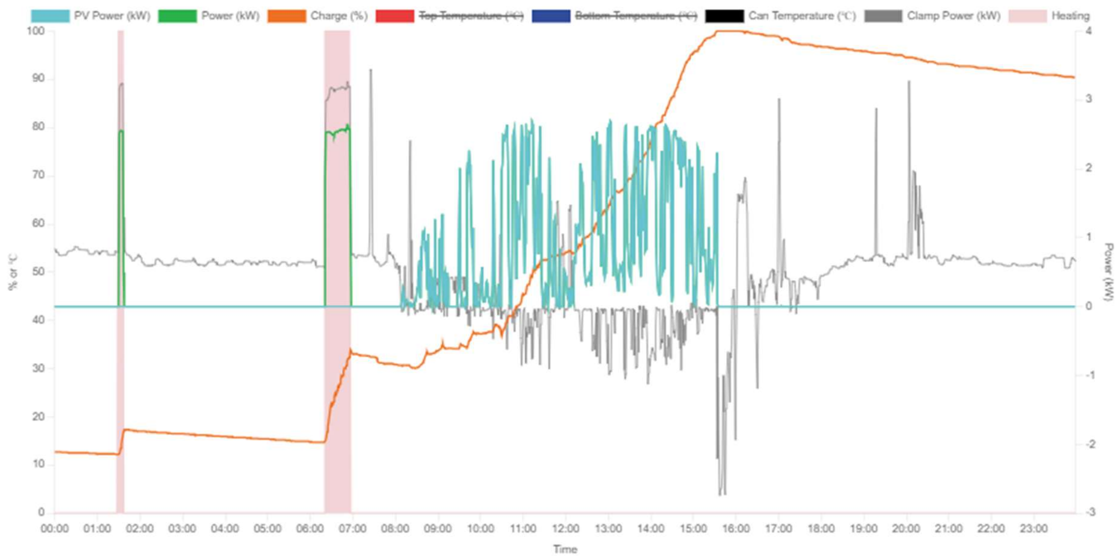


Figure 4.7 Graph from the Mixergy installer portal for SH-01 on 11 Sep 2024

As mentioned previously in section 4.1, the Mixergy cylinders for households IC-01 and SH-02 had the schedules set to heat the tank overnight to 100% charge. In contrast, the schedule for SH-01 was set to heat the tank overnight to 50% charge or less.

Figure 4.7 shows a graph from the Mixergy installer portal for SH-01 on 11 Sep 2024. There was overnight water heating at 01:30 and 06:20 which is highlighted in pink. This took the charge of the tank (in orange) up to 34%. There was significant solar diversion (in light blue) over the day which took the charge of the hot water cylinder to 100% by mid-afternoon. The total hot water energy use over the day was 9.03kWh with 7.24kWh provided by the solar diverter.

Had the water cylinder been charged to 100% overnight as for IC-01 and SH-02, there would have been less capacity for water heating via the solar diverter. This shows the importance of having an appropriate schedule to ensure plenty of hot water and maximise savings from solar diversion.

5. Conclusions, recommendations, and future work

5.1 Conclusions

There were 11 Mixergy smart hot water cylinders installed as part of the Evaluating Solar PV with Electric Heating project

- The Evaluating Solar PV with Electric Heating project installed solar PV on 18 North Devon Homes properties
- 11 of the households had their old hot water cylinders replaced with Mixergy smart hot water cylinders, each with a solar diverter
- The large solar PV systems and Mixergy cylinders led to an improvement of between 20 and 46 points in the energy score of the Energy Performance Certificate under RdSAP2012
- The Mixergy cylinders led to an uplift in the energy score for the EPC of between two and seven points
- All the households receiving Mixergy cylinders had electric heating
- Three of the households had air source heat pumps (ASHPs) and these Mixergy cylinders also had a heat pump kit which included a plate heat exchanger
- Three of the households had infrared heating panels with two of these installations part of a Wondrwall smart heating system
- Five of the households had storage heaters and a Mixergy direct cylinder was fitted which only provided water heating via the immersion heater
- Where possible, mixer showers were fitted for households with electric showers to maximise savings from the solar water heating

There were installation issues to be resolved including several of the cylinders having the current transformer for the solar PV diverter fitted in the wrong orientation

- The Mixergy cylinder has a current transformer (CT-clamp) which measures the excess solar generation exported to the grid – this was originally fitted in the wrong orientation for several cylinders
- When the CT-clamp is in the wrong orientation, the solar diverter does not work as intended and powers the immersion heater in periodic pulses, often at night
- The installations where the CT-clamp was in the wrong orientation were identified using daily energy graphs from the Mixergy installer portal
- Mixergy technical support was able to reverse the polarity of the CT-clamp remotely, avoiding a visit
- The thermal cut-out protection for one installation regularly tripped after the Legionella cycle due to weeping into the pocket for the thermostat which checks for overheating; this was resolved by replacing the immersion heater
- There was a problem where the Mixergy solar diverter interacted with the battery storage systems used by some households

- This was a minor issue for one of the households that had a Wondrwall battery but was more serious for two households with Tesla Powerwall 2 batteries and storage heaters; it was not a problem for a household with an ASHP and a Tesla Powerwall 2 battery

Several of the households with Mixergy installations had electric showers replaced by mixer showers to improve energy savings

- Out of the 11 households that had Mixergy installations, five had mixer showers installed during the project which replaced electric showers while four continued with their electric shower and one had an existing mixer shower
- One of the households had low hot water demand and apart from an electric shower, only used hot water for washing dishes
- Due to the time taken for hot water to come through to the taps, this household decided not to use the hot water cylinder; it is hoped the resident will start to use the Mixergy cylinder if a mixer shower cubicle is fitted to replace the bath and electric shower
- One household complained there was insufficient hot water for a bath, but a visit identified that the problem was due to a thermostatic mixing valve on the bath
- One household thought that an isolator switch in the kitchen was a boost button which meant that initially the Mixergy cylinder was turned on only occasionally and the cylinder was heating water from cold using peak-rate electricity; once this was explained to the household, the cylinder reduced rather than increased water heating costs

There was positive feedback about the Mixergy cylinders from eight of the households who were interviewed and used the cylinder

- All eight of the households who were interviewed and were using the Mixergy cylinder thought they had plenty of hot water with the cylinder
- Five of the eight households had the Mixergy app; one household did not use apps while the remaining two did not have it set up at installation
- Out of the five households using the Mixergy app, the average score on ease of use was 4.6 out of 5 while the average score on usefulness of the app was 4.8 out of 5
- Five of the households used the app to check on the level of hot water while four used it to boost hot water; three had changed settings for the cylinder using the app and one household monitored consumption
- Seven of the eight households strongly agreed or agreed that the Mixergy cylinder was better than their old cylinder; one household disagreed who had teething problems with the installation and the immersion heater needed to be replaced due to tripping out
- Seven of the eight households strongly agreed they noticed the benefit of the free water heating on a sunny day while the remaining household agreed with the statement

- Five of the households strongly agreed it was cheaper for them to heat water than with their old cylinder while two households agreed, and one did not know
- Five of the households strongly agreed the Mixergy cylinder provided sufficient hot water when needed and the remaining three agreed
- Four of the households strongly agreed that it was easy to control the Mixergy cylinder while four disagreed; out of those who disagreed, three were not using the Mixergy app and one had issues with the solar diverter interacting with their Tesla Powerwall 2 battery

The performance of three of the Mixergy direct cylinders was assessed over a period of six months

- Three unvented direct hot water cylinders were compared where water heating was only provided by the immersion heater
- The Mixergy cylinder recorded both the total consumption of the immersion heater and the amount of the water heating provided by the solar PV diverter
- Household IC-01 had the highest total hot water use with 1,009kWh over six months; this was despite having the smallest cylinder (120 litre)
- Household SH-01 had the lowest hot water use with 679kWh despite having the largest cylinder (250 litres)
- The hot water consumption from the Mixergy cylinder for SH-01 was likely to be lower than for IC-01, partly due to use of an electric shower but also due to the cylinder heating water to a maximum of 50% charge overnight compared to 100% for IC-01 and SH-02
- The solar PV diversion over six months ranged from 347kWh for SH-01 to 400kWh for SH-02; the diversion for SH-02 was likely to be higher than for the other two installations due to a high hot water demand and medium level of PV generation and grid consumption
- The saving from the solar PV diverter over six months for IC-01 on a single-rate tariff was about £91
- For SH-01 and SH-02, the minimum saving from the solar diverter was about £43 and £50 respectively with the households on Economy 7 and assuming the savings were at the off-peak rate; in practice, some of the water heating would have been during peak-rate periods and so savings would have been higher

The performance of the three Mixergy cylinders with air-source heat pumps (ASHPs) was also assessed over a period of six months

- For the households with ASHPs, the Mixergy cylinder could monitor the total use of the immersion heater and the amount of solar PV diversion but not the level of water heating by the ASHP
- There was additional water heating by the immersion heater when there was water heating by the ASHP and the hot water charge level continued to fall, usually due to hot water consumption at the same time

- The solar diversion for household AC-03 was 499kWh over six months but this excludes 18 days in September 2024 when the CT-clamp had been reversed after additional monitoring was fitted
- The solar diversion for AC-03 was the highest for all the six cylinders analysed and may be due to a combination of high hot water demand (an average of 14 baths per week for most of the monitoring period) along with low grid consumption
- Household AC-04 had the lowest solar diversion of the heat pump households at 390kWh; this was likely to be due to low hot water demand through having an electric shower and low occupancy
- The solar diversion for household T-06 over six months was 426kWh and over the whole of 2024 was 906kWh
- The hot water energy use (total immersion heater use) for T-06 over 2024 was 1175kWh; the larger difference between the level of solar PV diversion and total immersion heater use was likely to be due to the household using hot water at times when the ASHP was heating water, causing the immersion heater to also be powered
- Household T-06 also had a Tesla Powerwall 2 battery; in 2024, there was 1106kWh of solar generation used by the battery in addition to the 906kWh used by the solar water heating – overall there was 80.5% self-consumption of the solar PV
- If the water was not heated by the immersion heater using excess solar generation for free, it is likely to have been heated by the ASHP with a coefficient of performance for water heating of at least two
- If we assume Household AC-03 was on a single-rate tariff – assuming a unit rate of 24p/kWh, the saving from the solar diverter could be up to £60 over six months
- It is likely that cost savings for households T-06 and AC-04 were lower due to lower water heating costs from being on a time-of-use tariff and benefiting from the coefficient of performance for the heat pump
- A Wibeee electricity monitor recorded the monthly consumption of the immersion heater for two of the Mixergy cylinders to be within 3.2 to 7.8% of the value recorded by the Mixergy portal

5.2 Recommendations and future work

- The settings for the water heating schedule were not optimised for the households during this project – households and installers could benefit from greater advice on the most appropriate settings to maximise savings for a Mixergy cylinder with solar diverter
- The Mixergy smart hot water cylinder has an automatic schedule control feature where the tank learns the household hot water consumption over a period of weeks, and the water heating schedule is optimised to reduce energy consumption
- This project did not enable automatic schedule control, and it would be worthwhile to have a follow-on project where this was investigated with these installations
- A follow-on project could also compare the performance of the Mixergy cylinder against a standard cylinder and solar diverter
- Many of the installations had the CT-clamp for the solar diverter reversed after installation or electrical work on the home
- It would be helpful if Mixergy could develop analysis by AI to determine if it is likely that the CT-clamp is reversed and notify their technical support team and/or the customer/installer
- Otherwise, the Mixergy portal should be checked after installation and subsequent electrical work in the home to ensure the CT-clamp is not in the wrong orientation
- It is important that households have some level of control of the cylinder – where possible households should be provided with the app at installation
- For households unable to use apps, there should always be access to the Mixergy gauge or an extension lead installed to provide easy access in situations such as the cylinder being installed in the loft

6. Appendix

6.1 Appendix 1 – Data sheet for Mixergy Solar X Direct Cylinder

Standard

With the Mixergy Solar X, you can make the most of solar power consumption without needing a traditional battery. It can save up to 40% on the household's hot water bill and up to 21% of gas when connected with a gas boiler.

The Mixergy Solar Diverter monitors your solar power and automatically diverts the excess energy for your hot water. or you can choose how much of your excess energy to use for hot water, allowing the remainder to be used to top up your batteries or to charge your EV.

- **Unique volumetric heating** Only heats what the household needs to save on energy and hot water bills.
- **Smart tariff ready** Households can save even more when they integrate with smart tariffs
- **Smart systems** Mixergy app features machine learning, schedule setting and insights
- **Built to last** 25-year warranty

EMBEDDED SOLAR DIVERTER DETAILS

Thermostat cut-out temperature	80 °C
Immersion heater(s) rating	230-240 V~ 2.7-3.0 kW
Immersion heater(s) specification	EN 60335-2-73
Immersion heater(s) type	356 mm Incoloy/Ti
Modulation range	30W - 3000W
Immersion heater(s) type	100W

Model	120L	150L	180L	210L	250L	300L
Product code	MX-120-ELE-549-PVE	MX-150-ELE-549-PVE	MX-180-ELE-549-PVE	MX-210-ELE-549-PVE	MX-250-ELE-549-PVE	MX-300-ELE-549-PVE
Nominal capacity	120 Litres	150 Litres	180 Litres	210 Litres	250 Litres	300 Litres
ErP rating	B	B	B	B	C	C
Insulation thickness	50mm	50mm	50mm	50mm	50mm	50
Connection size/ type	22mm/ comp.	22mm/ comp.	22mm/ comp.	22mm/ comp.	22mm/ comp.	22mm/ comp.
Immersion heater rating (kW)	3kW	3kW	3kW	3kW	3kW	3kW
Height	888mm	1075mm	1203mm	1389mm	1701mm	1924mm
Diameter	549mm	549mm	549mm	549mm	549mm	549mm
Weight empty (kg)	35kg	38kg	42kg	45kg	51kg	55kg
Weight full*	155kg	188kg	212kg	255kg	301kg	355kg
Standing heat loss ** (kWh/24h)	0.68-1.06 kWh/24h	0.68-1.22 kWh/24h	0.68-1.34 kWh/24h	0.68-1.44 kWh/24h	0.68-1.75 kWh/24h	0.68-2.04 kWh/24h
Standing loss (W)	44W	51W	56W	60W	73W	85W
Minimum reheat time (15-65 °C)	44 mins	44 mins	44 mins	44 mins	44 mins	44 mins
70% charge reheat time (15-65 °C)	98 mins	123 mins	147 mins	172 mins	205 mins	245 mins
100% charge reheat time (15-65 °C)	140 mins	176 mins	210 mins	246 mins	293 mins	350 mins

Table A1 Technical data for Mixergy Direct Standard (549mm) cylinder[10]

Out of the 11 Mixergy cylinders installed on the project, nine were standard cylinders with a diameter of 549mm while one of a 580mm cylinder and another a 479mm slimline cylinder.

[10] Technical Data for Direct Standard Mixergy Solar X cylinder, https://support.mixergy.co.uk/solar-x-datasheet#direct-standard (Accessed 21 Jan 2025)

National Energy Action (NEA) is the national fuel poverty and energy efficiency charity. We've worked across England, Wales, and Northern Ireland for over 40 years, to ensure that everyone in the UK can afford to live in a warm, safe and healthy home.
We work together with frontline practitioners, companies, regulators and the government for customers in vulnerable circumstances to make positive changes.