# Retrofit Journeys

## *Retrofit*

“Retrofitting” refers to the process of insulating buildings; installing renewable heating such as heat pumps; and renewable energy technologies such as solar panels and batteries.

Retrofitting creates homes that are more pleasant to live in, are cheaper to heat, and which emit dramatically less carbon dioxide.

## *Examples*

In this document I describe visits to several houses in West London which have undertaken retrofit journeys – some straightforward, some less so – which have resulted in homes that are more pleasant to live in, which enhance their neighbourhood, and which crucially emit much less carbon dioxide than they did previously. They are the homes of the future, but available today.

Below are the names of our heroes. Many are couples, and in those couples I note that there is usually one protagonist, and another follower or supporter. I have placed the protagonist’s name fist.

1. Dan & Sue: Surbiton
2. Jan & Dave: Ham
3. Fab & John: Twickenham
4. Judith: Richmond
5. Michael & Stephanie: Teddington.

Michael de Podesta

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# #1Dan & Sue: Surbiton

## *Background*

Dan & Sue live in a classic 1930 detached house in Surbiton. From the street there is no sign of anything out of the ordinary. But in the last year Dan & Sue have dramatically reduced the carbon emissions of this dwelling while improving their quality of life.

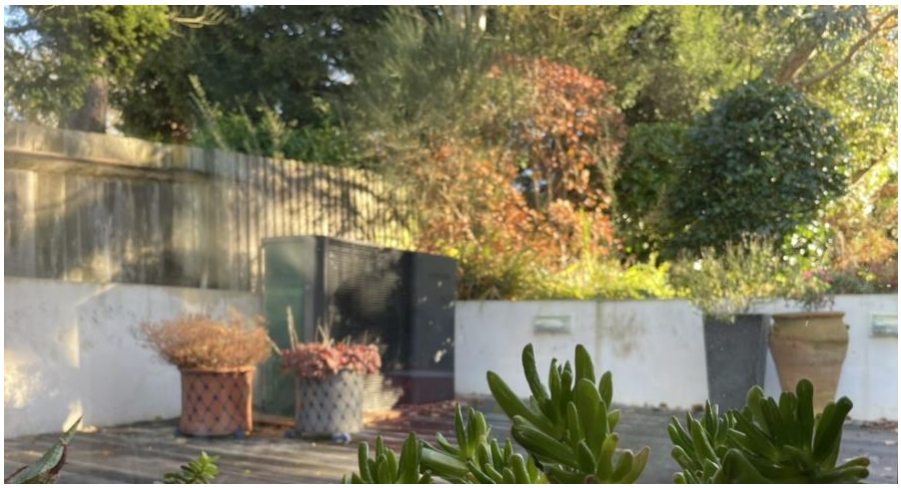
## *Details*

**Before**: EPC band D(score 65), detached 233 $m^2$ house in a Surbiton conservation area with a rear extension, which previously used 24,300 kWh of gas per year, corresponding to approximately 5.6 tonnes of carbon dioxide emissions annually!

**Insulation**: D&S reviewed the options for external wall insulation. The front of the house contained too many details to be insulated at a reasonable cost, and in the end they decided that even insulating just the sides and rear would be too expensive. The house already had satisfactory double-glazed windows and draught-proofing. But they did insulate under the ground floor.

**Renewable Heating**: The installers assessed the heat loss of the house at 11 kW when the external temperature was -1.8 °C. One challenge was to find a place to put the heat pump and they spent time with a large heat-pump-shaped cardboard box to work out which location they preferred. They considered the front of the house, and locations on the wall, but in the end, in consultation with the installers, they chose a location on the decking at the rear of the house. Because the heat pump would be visible from the kitchen, D&S chose a 12 kW Samsung monobloc heat pump over the Vaillant equivalent because they felt it looked less “industrial”.

A secondary challenge was to find a location for the domestic hot water cylinder. After consideration, a tall and narrow 250 litre cylinder was placed in the downstairs utility room using the space freed by removing the previous gas boiler. D&S chose not to replace any radiators.

The so-called SCOP from September to December 2024 has been above 4 i.e. each unit of electricity generates more than 4 kWh of heat – which indicates an excellent installation.

**Renewable Energy**: D&S installed 21solar PV panels connected to two *Tesla PowerWall 2* batteries giving 27 kWh of energy storage. Ten of the panels are on the roof of the west-facing garage and the remaining 11 are scattered across the various roof angles facing between west and south.

Because the exposure of the panels is so different, and there are many shading trees, it was decided use to a *SolarEdge* system which optimises the output of each panel individually. In summer, the expected peak output is 9 kW generating around 40 kWh/day on average. Over the year the generation is expected to amount to approximately 6,000 kWh.


The two *Powerwalls*, should allow the house to go off-grid for several months in summer, and to export electricity to offset running costs. In winter they allow the purchase of cheap-rate electricity at night which will be used to power the heat pump during the day. If the outside

temperature is 9 °C or above then the battery doesn't run out and they are able to home for approximately 2 p/kWh, around one third the cost of gas heating.

**Controls**: The heat pump is monitored and controlled using the *Homely* system which allows Dan & Sue to control their heating using a simplified app, while the installer and *Homely* take care of the technical settings.

The solar panels are monitored using the *SolarEdge App*, and also from the *Tesla* App, which allows control of the settings for the batteries.

## *Difficulties*

**Dan & Sue**: The installations have been relatively straightforward, but the heat pump installation was a little wearying. The heat pump – being over 8 kW – required planning permission, but this was relatively straightforward to obtain. However, the planning permission for the solar PV system proved extremely aggravating.

The original plan had called for removing the two unused chimneys to create an open west-facing roof suitable for solar panels. The council's response was to forbid the removal of one of the two chimneys because it's removal might be noticeable from the road: while such a change might be detectable from the road, it is inconceivable that anyone would actually "notice" its absence. Additionally, the Council described the solar installation as "excessive". It seems astonishing to Dan that a borough council which has declared a climate emergency and promised to achieve net zero by 2038, could insist on retaining a chimney (!) which then blocked the installation of three extra PV panels, and shaded the panels which were there.

## *Installer's Perspective*

### Leah from *Your Energy Your Way*:

This property posed several challenges, most particularly the long run of insulated pipework from the heat pump to the hot water cylinder. This had to be run under decking at the side of the house which was challenging. We made sure the pipes were well insulated and that they were also protected from rodent damage as this was a concern of the customer. Moving a

cylinder always entails extra work as well and as with many of our jobs we converted a gravity-fed hot water system to a mains pressure one.  As a result we also noticed low water-pressure which led to further work upgrading the connection from the street.

### *Last word…*

**Dan:** Sue and I thought about what to do for 3 years, but all the work was caried out in 2024 – so it's been a stressful year: The heat pump was installed in June, the battery in September, and the solar PV in November. Based on November and December consumption, our bills are about half what they were, and astonishingly about 10% of our winter demand is met by the solar PV. And the solar PV hasn't really started generating yet: I am *really* looking forward to summer!

I am a bit of a technophile and I love the *Tesla* App which manages all the timings to access the low price electricity from *Octopus*. The heat pump installation was challenging because I was worried that it might not work well enough for Sue, and it did drag on for two weeks. But happily the cold weather has been uneventful and we prefer the constant heat that it produces rather than the on/off heat from a boiler.

# #2 Jan & Dave, Ham

## *Background*

Jan & Dave (J&D) live in a 1970's detached house in Ham. Over the last 3 years, driven by Jan's environmental concerns, they have dramatically reduced the carbon emissions of their dwelling while improving their quality of life.

## *Details*

**Before**: EPC Band E, detached 187 $m^2$ house in Ham, which previously used 16,000 kWh of gas per year, corresponding to approximately 3.5 tonnes of carbon dioxide emissions annually!

**Insulation**: J&D's house is in an estate with covenants covering the appearance of the home. The house already had satisfactory double-glazed windows and draught-proofing, and so, after reviewing the options, they decided on adding 50 mm of extruded polystyrene *External Wall Insulation*. which was calculated to reduce their heating requirement by a third. They chose a render colour to match their neighbours. As a passer-by, the insulation is barely noticeable.

**Renewable Heating**: The installers assessed the heat loss of the house at 6.6 kW when the external temperature was -3 °C and J&D chose a 7 kW Vaillant *Arotherm plus* monobloc heat pump to meet the demand. Their main challenge was to find a place to put the heat pump and after reflection they chose to put the pump at the front of the house where it could be plainly seen by passers-by. Somewhat surprisingly, the unit pump is barely noticeable.

J&D already had a domestic hot water cylinder, but this was a replaced with a more modern 200 litre Vaillant cylinder which is topped up twice a day, storing water for their busy family.

**Renewable Energy**: The house has a large south-facing roof which was perfect for 16 PV panels to be neatly arranged for an 8 kW(peak) array which generated approximately 5,500 kWh/year in 2024. The panels are linked in two strings to a *Solis* Hybrid Inverter connected to a 6 kWh battery. For 7 summer months, J&D export more electricity than they import – 2,500 kWh in 2024 – and their electricity company pays them money. J&D use the Octopus Flux tariff to charge the battery between 02:00 to 05:00 each night and to discharge between 16:00 to 19:00 when electricity is more expensive with higher carbon dioxide emissions. And since they installed their PV system, four of their neighbours have followed suit!

**Controls**: The heat pump is monitored and controlled using the Vaillant SensoTherm controller.

## *Difficulties*

**Jan & Dave**: None of the works, were especially difficult in themselves. The main problem was confusion about what was required, and difficulties in finding trustworthy installers for the Heat Pump and the External Wall Insulation. The entire family lead busy lives, and monitoring their heating is not a priority. Fundamentally, they want to make sure they are doing the best they can for the environment.

## *Installer's Perspective*

**Leah from *Your Energy Your Way***: The installers originally assessed the heat loss of the house at 8 kW at -3 °C, but owing to the EWI work that the customer had already had completed, they were not convinced that the standard air change assumptions used in the heat loss calculation were accurate. As a result of an air tightness test, the heat loss was then reassessed at 6.6kW and J&D chose a 7 kW Vaillant Arotherm plus monobloc heat pump to meet the demand.

We didn't do the solar PV installation, so can't comment on that. Overall it was a straightforward installation once we had the heat loss accurate which meant we both had less radiators to upgrade and a smaller heat pump to fit.

## *Last Word*

**Jan**: When I realised that it was possible to reduce one's carbon domestic emissions using a relatively simple 3-step process, I was eager to set us on the road to a more sustainable way of living. I am not a technical person, and so Dave and I have struggled at times to make the right decisions. But now that it's done, the house is comfortable, the bills are lower, and most importantly emissions are lower.

The heat pump installers were great, reassuring us that we really would be warm enough, and told us that if the heat pump wasn't powerful enough, they would swap it for a larger one.

On reflection, we would now have skipped the external wall insulation step. It looks smart on the house, but it was uncomfortably expensive.

Overall, Dave and I are delighted with the finished product: we're cosy with lots of hot water, we're saving money and the neighbours are interested!

# #3 Fab & John, Twickenham

## *Background*

Fab and John live in the lower two floors of a 3-story Victorian semi-detached house in Twickenham.

Their retrofit journey began when they discovered rising damp in the lower semi-basement floor of their home. As they realised the scale of remedial work involved, they decided to re-organise and re-fit the entire ground floor kitchen/dining and living areas. And as part of this they wanted to heat their home with a heat pump and to switch to underfloor heating.


## *Details*

**Before**: EPC Band D, semi-detached 191 $m^2$ dwelling in Central Twickenham, which previously used 24,000 kWh of gas per year, corresponding to approximately 3.5 tonnes of carbon dioxide emissions annually!

**Insulation**: The windows were all double-glazed and judged to be satisfactory for now.

F&J's two-floor apartment contains several external solid brick walls and in the most exposed room, it was decided to install 15 $m^2$ of internal wall insulation (50 mm of insulated plasterboard) to avoid the need for a larger radiator in that room.

As part of the underfloor heating installation, insulation was added underneath the entire ground floor.

**Renewable Heating**: After the internal wall insulation, the installers assessed the heat loss of the house at 8.1 kW when the external temperature was -3 °C and F&J chose a 7 kW Vaillant *Arotherm plus* monobloc heat pump. The 7 kW figure is the "nameplate" capacity but in fact the specifications indicates it has an output of 8.2 kW at –3 °C.

Feeling nervous about a heat pump capacity so tightly-matched to the projected heating requirement, it was agreed to install an auxiliary in-line heater which could supply an additional 3 kW of heating power to the house on extremely cold days, colder than the design temperature of – 3 °C. The alternative to the auxiliary heater would have been to increase the heat pump size from 7 kW to 10 kW which would have involved additional costs. Additionally, a 10 kW heat pump had a volume greater than 0.7 $m^3$ and so would have required a planning application. F&J had actually begun a planning application but Richmond Council's negativity had made the process very stressful.

They chose to locate their unit at the side of their house in an enclosed side-passage/patio area. This supplies hot water to a manifold which heats the entire ground floor – extending into the children's bedrooms. The upper floor is heated by conventional radiators which they chose not to replace.

The location of the hot water storage proved more problematic. Previously the gas boiler had been an "under the counter" 'combination boiler, and so removing the boiler did not free up much space for a domestic hot water cylinder. At the installer's suggestion, they opted to install an under-the-counter *SunAmp* thermal heat store.

Doors Closed

Doors Open

Heat Pump Paraphernalia

Sunamp Heat Store equivalent to a 200 litre Domestic Hot Water Cylinder

Functionally, a SunAmp has the storage capacity of a 200 litre hot water cylinder, but occupies less than half the volume. In practice, they re-charge the unit twice a day – having two young adults at home they use quite a lot of hot water!

**Renewable Energy**: F&J didn't have any roof on which to install solar PV, but they had space in an old coal storage area to install a 5 kWh Fox battery.

They use an Octopus COSY Tariff that has cheap periods during the day when the battery can top-up, and they then run the house and heat pump from the battery during the expensive times. Running costs up to December was decidedly lower than the previous winter heating with gas.

Battery Management System

5 kWh Battery

**Controls**: The heat pump is monitored and controlled using the Vaillant App.

## *Difficulties*

**Fab & John**: The whole refurbishment was stressful and exciting, but some issues with the heat pump were extremely aggravating.

One difficulty was a really poor initial survey which suggested our heat loss at -3 °C was 18 kW, and these surveyors recommend installing two 12 kWh heat pumps. Shocked by this, they measured the heat loss themselves on the coldest days of winter 2023 and saw that they only used 192 kWh of gas

per day, corresponding to 8 kW heating, one third of the survey estimate: clearly their survey was nonsense. They then contacted *Econic*, and things began to make more sense. Their survey suggested a more realistic heat loss of 9 kW and initially they planned on a 10 kW heat pump. After deciding to install the internal wall insulation and under-floor insulation, they eventually installed a *Vaillant Arotherm plus* with a nominal heat output of 7 kW, but which can actually output near to 8 kW in the design conditions. For re-assurance, they also installed a 3 kW in-line heater which will kick in if the heat pump fails to meet the heating demand on the coldest days.

### *Installer's Perspective*

**Christoph from *Econic***. This property was unusual in two ways. Firstly, the living quarters were spread over two floors of a large Victorian house, which was an unusual format. To ensure the heat pump was correctly sized we took care to check our heat loss calculations against actual historic heat consumption data that the client provided. In this case - taking account of the client's added insulation - the estimated maximum heat loss closely matched the heat pump's maximum output capacity. We were worried that in extreme cold, the heat pump might not be able to deliver the heating required, so we installed an electric backup heater to provide some extra headroom in the heating capacity. The backup heater will probably never be used, but we felt it was a sensible precaution.

Secondly, the client didn't have any space for a hot water cylinder. So we suggested using a *Sunamp Thermino* thermal storage unit which fits under a standard counter top. This provides the same capacity to deliver hot water as a 200 litres storage tank, but takes up less than half the space.

### *Last word...*

**Fab & John**: The house is just the way we want it – and knowing that heating is as ecological as possible is just one of many benefits. We love the constant stable heating from the heat pump.

# #4 Judith: Richmond

## *Background*

Judith and her husband Richard lived for many years in a Victorian era semi-detached ‘cottage’ not far from Richmond town centre. For many years they slowly re-furbished their home, and were planning a heat pump installation when Richard died. Judith has found things hard after Richard’s death, but has struggled to complete this installation.

## *Details*

**Before**: EPC Band D, detached 99 $m^2$ house in a Richmond conservation area, which previously used 12,000 kWh of gas per year, 10,000 kWh for heating and 2,000 kWh for hot water corresponding to approximately 2.7 tonnes of carbon dioxide emissions annually.

**Insulation**: Judith and Richard had renewed the windows and doors, and built a conservatory that improved the insulation at the side. But in this conservation area, it is almost impossible to do anything which alters the visual appearance of a dwelling.

**Renewable Heating**: The survey suggested that the peak heat loss for the home was 4.5 kW and the installers suggested a *Nibe* 2050 6 kW heat pump.

The outdoor unit was installed in an open-framed wooden hutch in the back garden, and the indoor unit and 200 litre hot water cylinder and heat pump controllers were installed in a specially-constructed cupboard in the kitchen.

**Renewable Energy**: there was no option to install solar PV panels.

## *Difficulties*

Judith had a really difficult time liaising with Richmond council who were – to say the very least – unhelpful. And for a combination of reasons, the installation took much longer than anticipated.

## *Last word…*

**Judith**: I am so happy to finally have this completed. It's taken much longer than I anticipated and at times I have felt desperate. But now it's completed I feel so happy to be living as ecologically as possible.

# #5 Michael & Stephanie: Teddington

## *Background*

Michael & Stephanie live in a classic 1927 semi-detached house in Teddington. The house has been extended in multiple stages since the 1970's. In 2008, an additional bedroom was added over a side extension and the loft converted for domestic use.

M&S were scientists at the National Physical Laboratory in Teddington, and they took a systematic measurement-based approach to their retrofit.

## *Details*

**Before Retrofit**: EPC Band E, semi-detached 162 $m^2$ dwelling in Teddington, which previously used 15,000 kWh of gas per year, corresponding to approximately 3.5 tonnes of carbon dioxide emissions annually!

By reading electricity and gas meters weekly, M&S could accurately assess the performance of the house before, during and after the retrofit.

**Insulation**: The windows were a mixture of single- and double-glazed, but were all very old. It was easy to agree that this was a good first step, and almost all the windows were replaced with triple-glazed units in August 2020. The chimneys in the house were then blocked with *Chimney Sheep* to minimise through draughts. Measurements showed that this resulted in about a 10% reduction in winter heating requirement.

In October 2021 they added External Wall Insulation to the whole house, using 100 mm of Kingspan K5 insulation. This was the most expensive part of the retrofit, and the most difficult in terms of disturbance. Weekly measurement showed that combined with the Triple Glazing this resulted in about a 50% reduction in gas consumption.

**Renewable Heating**: In August 2022, after the *External Wall Insulation*, the installers assessed the heat loss of the house at 4.1 kW when the external temperature was -3 °C and M&S chose a 5 kW Vaillant *Arotherm plus* monobloc heat pump to meet this demand

This was located at the rear of the house and initially M&S were concerned that the unit might re-circulate cold air, reducing the performance of the heat pump. A later test with a "smoke pellet" showed that in fact the air dispersed quiet easily.

Initially M&S chose not to change any radiators but to just see how things went for the first winter – they were ready with back up fan heaters! In fact, the back-up heaters were not needed, and the system performed well with an annually averaged COP of 3.5. In subsequent years M&S tried various adjustments to the installation, but the COP remained the same. In 2024 they finally replaced most of the radiators and the annually averaged COP improved to 4.0, corresponding to a 15% reduction in electricity consumption and carbon dioxide emissions.

**Renewable Energy**: In November 2020, while the scaffolding was up for the *External Wall Insulation*, M&S added 4 kW(peak) system of 12 panels, 6 each on the south- and west-facing roofs. In March 2021, they added a 13.5 kWh Tesla Powerwall 2 battery, and immediately went "off-grid" until September. In winter they download cheap electricity at night and run the heat pump from the battery, resulting in dramatically lower bills. In November 2022 they added an additional 8 panels on the east-facing and flat roof.

No pigeon protection was installed with the panels, and after pigeons began to roost under the panels, in November 2024 they engaged *SolaSkirt* to add protection.

**Controls**: The heat pump is monitored and controlled using the Vaillant App, and the solar and battery systems are monitored using the Tesla App.

### *Difficulties*

**Michael & Stephanie**: Despite being quite technical, we found the whole exercise stressful, unsure if any or all of the steps we took would work.

Much of the work was carried out during COVID times, and getting people to visit the house was difficult.

### *Installer's Perspective*

**Kaspar from *Next Step Heating*:** This installation was well planned out by Michael and we went through a few designs to work out how the hot water tank and heat pump accessories could be located in a new bathroom cupboard. Michael also decided to add a metering and monitoring package which meant additional heat metering equipment to gather data on the heating systems performance. This cost more than £1,000 but is very good value for people who are very invested in their refurbishment. Overall we were impressed with the efficiency of the system however for further improvement we worked to size larger radiators for even better SCOP efficiency.

### *Last word...*

**Michael & Stephanie**: We've reduced carbon emissions from the house from 4.2 tonnes per year to 0.8 tonnes per year. That's an 80% reduction with an improvement in our quality of life. Being off-grid in summer is a truly magical feeling: like floating. In 2023 we bought a second-hand EV with a range of just 100 miles which we use for local journeys, and in summer it runs on sunshine!

But now that it's all done, it is all – so far - essentially maintenance-free and we can just get on with our busy lives!