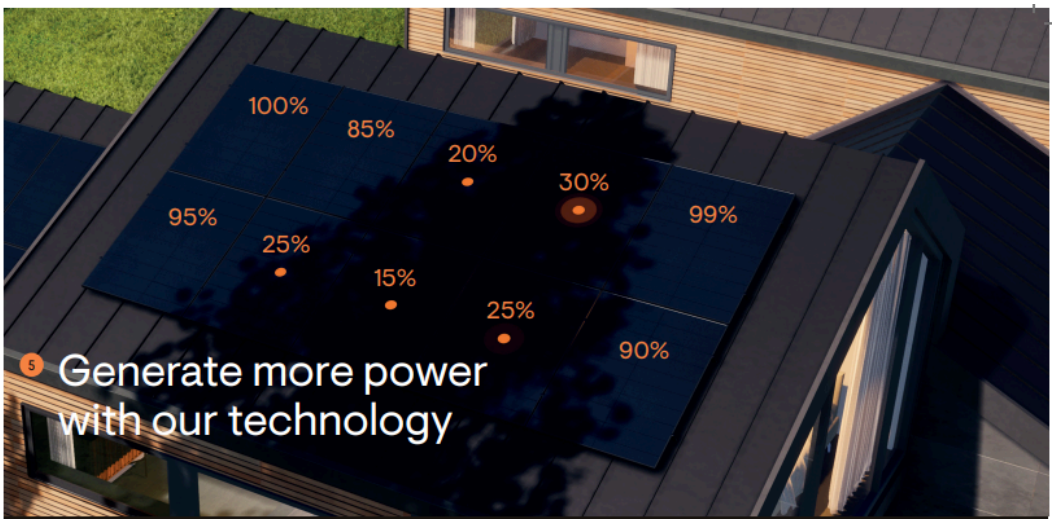
Bespoke Solar & Battery Installation with Full Property Backup

November 2023



VOLTS WAGGON

Summary

This installation settled on a design based on:

- Latest products (2023) from 2 manufacturers: **Enphase** and **GivEnergy**
- Solar PV generation of 7.2kWh per year
- Battery storage of 13.5kWh including full property backup
- Metal Roof Fixings from **K2 Systems**
- Large 500W Solar Panels from **JA Solar**

There are some substantial benefits associated with this design, skip to the end to review these or read on to get some insights into the journey that led to this along with some lessons learned.

Location of Equipment

The main components of the system to confirm location of were:

- Solar Panels
- Inverter for Solar Panels
- Inverter for Battery Storage
- Gateway for Full Property Backup
- Controller for Solar Production

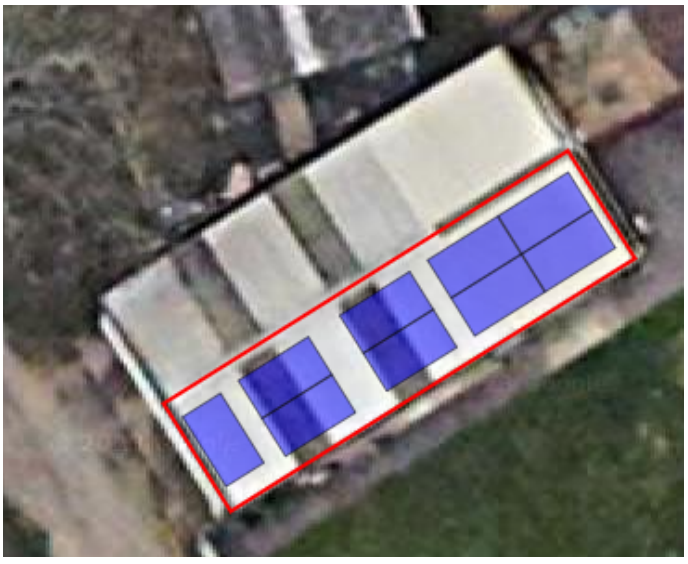
Solar Panels

Potential Locations for Solar Panels included:

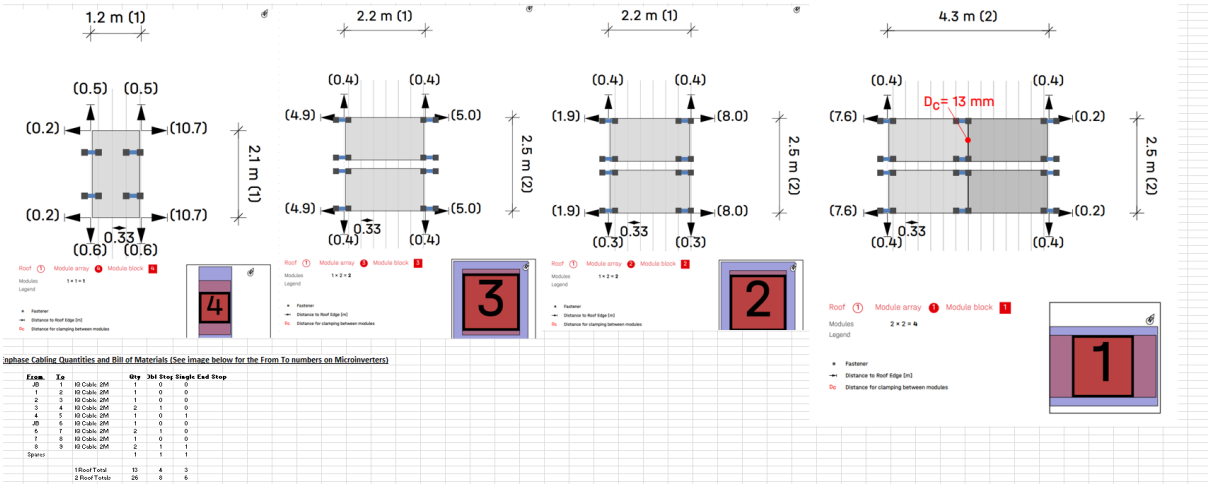
1. Upper roof on rear of property facing Southwest
2. Lower roof on rear of property facing Southwest
3. Roofs on detached garage facing Southeast and Northwest

Simulations of solar production on each location showed that option 3 was the most optimal which would avoid expensive scaffold hire cost and be a more accessible location for any future maintenance if required.

There was a design constraint for Solar panel layout in the form of 2 x 1M sections of transparent roof (shown as darker areas in the image below) incapable of supporting panel fixings. By arranging roof fixings either side of the transparent roof sections, it was possible to install up to 9 extra large panels on each roof: 8 in landscape orientation and 1 in portrait as shown.



Software provided by K2 Systems (“K2 Base”) was used to generate the design and bill of materials for the fixings. A comprehensive report includes full weight loadings which was used as part of a structural survey to ensure the garage, especially the roof, was suitable for the design.



From	To		Qty	Std Stop	Single End Stop
JB	1	I3 Cable: 2M	1	0	0
1	2	I3 Cable: 2M	1	0	0
2	3	I3 Cable: 2M	1	0	0
3	4	I3 Cable: 2M	2	1	0
4	5	I3 Cable: 2M	1	0	1
JB	6	I3 Cable: 2M	1	0	0
6	7	I3 Cable: 2M	2	1	0
7	8	I3 Cable: 2M	1	0	0
8	9	I3 Cable: 2M	2	1	1
Spares			1	1	1
		1 Roof Total	13	4	3
		2 Roof Totals	26	8	6

The pitch of the roofs is very shallow at 7 degrees. This meant that the Northwest roof could offer almost as good solar production as that of the Southeast. K2 Systems offer an optional product called “mini Five” which enables the inclination to be increased by 5 degrees.

The final solar installation looks like this:

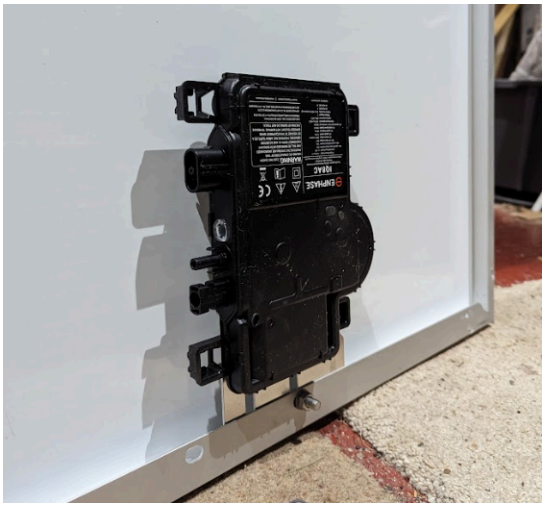
Inverter for Solar Panels

An “Inverter” is required to convert DC (Direct Current produced by Solar Panels) to AC (Alternating Current used by all the electrical circuits in the property).

Early design iterations considered Hybrid (Solar and battery storage combined) “String Inverters” for which potential locations included:

- Inside the Garage
- Mounting on an outside wall

Later design iterations however settled on an Enphase system which involves installing a “microinverter” behind each panel. This means there is no separate large Inverter to install, instead there is a very small Inverter underneath each panel as shown in the image below.



This design offers significant benefits as outlined later.

Inverter for Battery Storage

Having made a decision to go for an Enphase solution on the Solar side, the new battery storage product launched by Enphase this year was a first contender. It is an excellent product offering a scalable means to generate plenty of power but it does not yet (expected next year) support full property backup which was a requirement for the customer.

A separate “AC Coupled” Inverter and battery storage system was therefore required to co-exist with the Enphase system. The most cost-effective solution to meet the customer’s needs was a new product from GivEnergy called the All-In-One (AIO) and Gateway.

Whilst the simplest location for the AIO is close to the Gateway, there was insufficient space, the only viable locations were either mounted on an outside wall or located almost 40 Meters away in the Garage.

The final installation location for the AIO (Battery and Inverter) looks like this:

Gateway for Full Property Backup

As outlined in the previous section, a new Gateway product from GivEnergy was selected for this purpose. This was located close to the Incoming Mains supply for the house which was inside a porch at the front of the property.

On the other side of the wall to the left is a cupboard inside the house where the Consumer Unit and Enphase Envoy (see next section) is located.

Controller for Solar Production

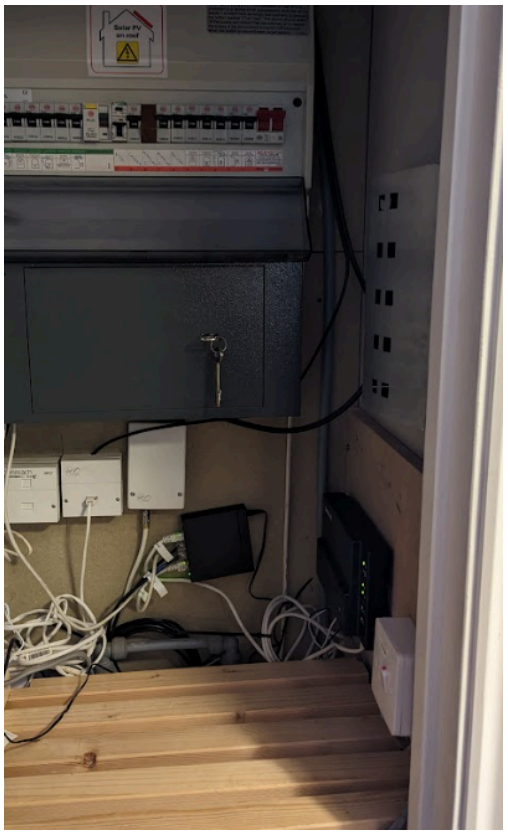
Having selected Enphase for Solar production, there is a need to locate a controller (known as an "Enphase Envoy – Metered") to manage all communication with each of the microinverters.

The potential locations for this were:

A) In the Garage, close to the Solar Panels and Microinverters
B) In the House, close to the Mains Supply

The preferred location was (B) as it would involve running less cable through 38 Meters from the house to the garage. There was some uncertainty as to whether the Powerline communication method used by Enphase would have a clean enough signal to work at this distance through various circuits in the house but it proved to work very effectively.

The Enphase Envoy is the small black box on the right hand side with 3 green LEDs:



Design Considerations & Installation Constraints

Metal Garage

First of all, there are some important electrical factors to take into account which are specific to the decision to locate electrical circuits in the detached metal garage which has a solid concrete floor base:

- In this case, the “PME” Earth from the main house could not be exported to the Garage outbuilding.
- A suitable earthing arrangement for the Garage is needed which is entirely separate from that used for the house. This was achieved by installing an Earth Rod.
- A small and separate consumer unit was needed in the Garage which is wired as a TT system (whereas the house is wired as a TN-C-S system).

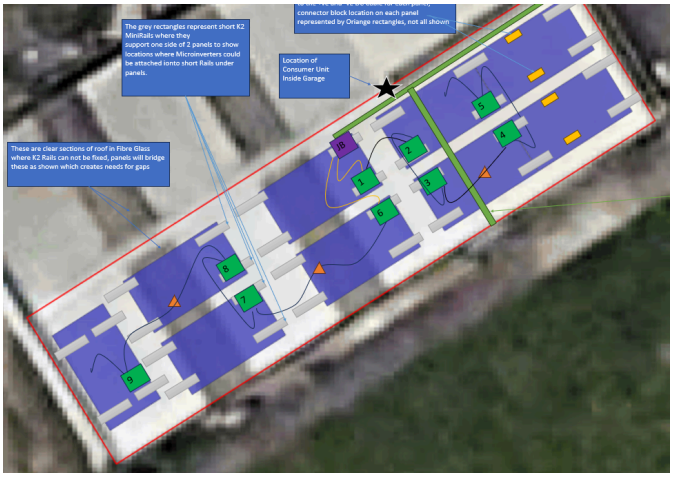
The decision to use an Enphase System means that:

- Each Microinverter underneath each panel is double insulated
- Each proprietary IQ8 Cable connecting all panels in parallel to carry AC power does not include or require any earth cable
- There is no potentially dangerous / high voltage DC electricity across the roof or in the property. Microinverters have built-in real Rapid Shutdown.

Solar Panels, Fixings and Microinverters (Inverters for Solar Panels)

Selection and layout of panels was covered earlier. Further design considerations included:

- Most solar panel installations involve fixing panels to a continuous length of solar rail:
    - In this design however, due to the need to span clear sections of roof and to keep the overall weight down, a “MiniRail” system from K2 Systems was selected. This limits options for fixing microinverters to sections of rail.
- Precise fixing location for each microinverter to the frame of a solar panel depends on the specific make and model of solar panel:
    - In turn, this constrains options for where each microinverter can be located to simplify and optimize routes and lengths of the Enphase IQ cabling required by this system. The image below shows an early sketch which led to final design:



- The Enphase system has limited tolerance for Voltage Drop which means that much thicker (and more expensive) cable must be used especially when running over long distances as was the case with this project and additional junction boxes had to be added:

    - Enphase advise no more than 2% voltage drop (or rise) between the most remote microinverter and the DNO supply. Note that BS7671 suggests up to 5% voltage drop is acceptable for cable design calculations but in this case the manufacturer requirements are stricter.
    - The upper limit on the number of microinverters per string based on the big 500W panel selected is 9. Enphase further recommend that when there are more than 8, to add a junction box halfway along the string of parallel proprietary IQ8 cables to further limit voltage drop of the built in 2.5mm cables.
- The K2 Systems “MiniFive” product involves adding stilts to MiniRails at both the top and bottom edges of a panel as shown in the image earlier. This requires a large gap between rows of panels to avoid shading and as such needs more roof area to accommodate.

Inverter for Battery Storage

The GivEnergy AIO requires a 6mm cable supplied from the GivEnergy Gateway which can be run up to 50 Meters. Also required from the house were 2 additional Ethernet cables: (i) from the Gateway to the AIO, (ii) from a router inside the house to provide LAN and Internet connectivity to the AIO.

The AIO is shipped in a very large and very heavy (130Kg) wooden crate. This makes delivery costs high as a single driver / courier can not lift this. A fork lift truck is required to move this kit around. It is time consuming to dismantle the top and all sides of the crate which is required in order to disassemble the contents and expose the battery modules which can then be carried safely.

The image below shows how the cables required by the AIO were positioned to enter a gland in the rear of the AIO and avoid having cables stick out on the right hand side of the AIO. In this image, the AIO is shown before the heavy battery modules are added, the built in Inverter is inside the top compartment.

Gateway for Full Property Backup

The GivEnergy Gateway must be installed in between the Incoming Mains Supply and everything else (such as the Consumer Unit) in the house. It is the gateway through which all electricity passes in and out of the property.

- This should be located within 3 Meters of the Incoming Mains supply (there is a way to increase this distance by adding more electrical devices and fuses).
- The 2 CT Clamps from Enphase must be installed inside the Gateway: (i) around the Grid Mains supply, (ii) around the PV Production. The Enphase Envoy ships with 2 small CT clamps. In the UK where most properties have a 100A supply, the 28mm cables ("Meter Tails") are too large for the supplied CT clamp so an additional larger one must be purchased from Enphase.

The image below shows preparing the outside Meter Cupboard (with the 100A Mains Supply) to pass the Meter Tails (the brown and blue cables) to pass through the wall and directly in through a gland in the rear of the Gateway located on the wall inside a Porch.

Controller for Solar Production

The Enphase Envoy (Metered) product uses Powerline communication to control and monitor each Microinverter. This involves passing data signals through AC cabling. In the case of this installation, the route for this communication is as follows:

- From the Envoy in the cupboard in the hall at the front of the house, through its AC supply cable to a Fused Spur and then to a circuit in the Consumer Unit. From there through the Mains cables supplying all circuits in the Consumer Unit to the “Load” circuit in the Gateway. From there via the “PV” Circuit in the Gateway through 38 Meters of 16mm SWA to the Garage. From there to a Generation Meter in the garage, then to the Mains Supply of a small consumer unit, then through 2 RBOs to each roof via a separate AC Isolator to each, then through a junction box for each roof then to each Microinverter.

Despite the various circuits involved and lengths of cables, the Powerline communication signal is shown to be very strong, the Installer app provided by Enphase can be used to analyse the signal strength.

Had this not worked, separate cabling would have been needed to run 38 Meters from the front of the house to the garage to extend the CT cables provided by Enphase.

Installation Photos

Garage Roof

This is where the JA Solar Panels, Enphase IQ8AC Microinverters, Enphase Cables and K2 Fixings were installed.

This image shows an early stage in installation:

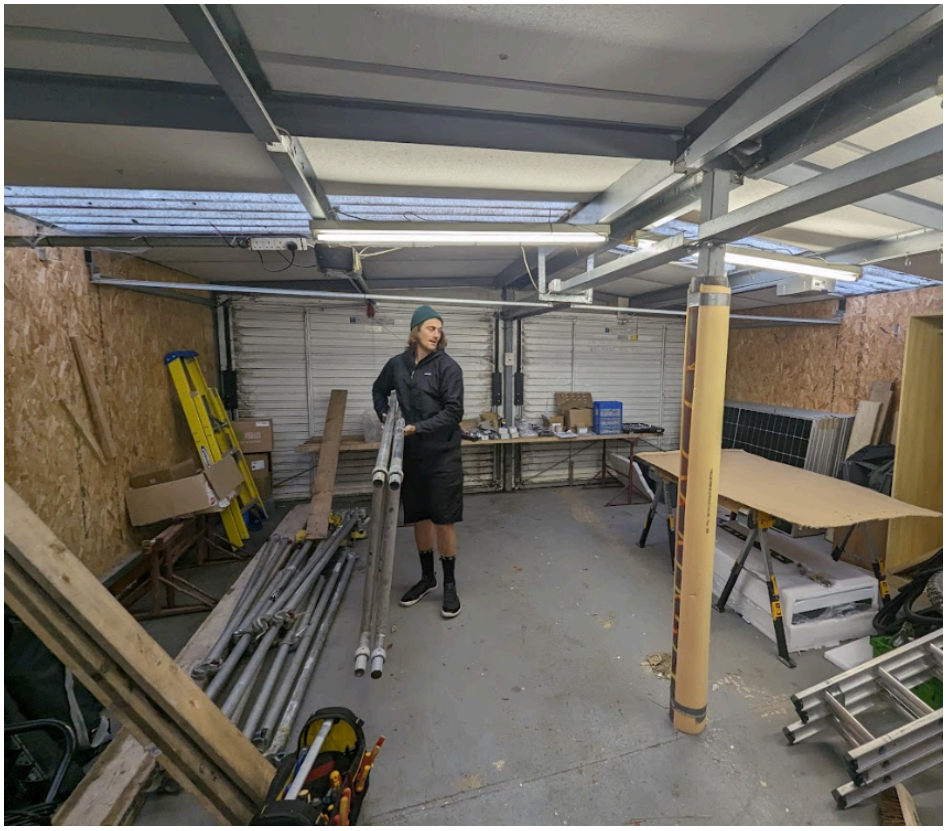
- 6 panels and microinverters on one roof installed so far
- A small scaffold tower can just be seen on the right hand side
- Planks positioned to span gaps between structural joists which hold up the roof (from the inside) to spread the load whilst carrying materials and working
- Grey AC cables from the ridge can be seen on the roof in the foreground (Kopex conduit added to protect these later)
- Some “MiniRail” sections from K3 systems can be seen on the roof in the foreground
- There is a transparent roof section in the foreground (with light showing from inside) which can not take weight or support fixings for panels.

In the next image:

- All 18 panels are up, bird mesh can be seen around some of them
- Roof on the left uses the “MiniFive” stilts from K3 Systems to raise the inclination slightly
- Enphase IQ8 parallel AC cables can seen running between some of the gaps

Inside the Garage

It was extremely useful to have plenty of workspace, especially with the weather in November. Inside the garage was perfect to store materials and establish some work areas.



Here’s a panel being prepared with the correct Microinverter for its location, prior to lifting it onto the roof. In this image the DC cables from the Microinverter to the positive and negative terminals of the panel are already connected. The Enphase IQ8 AC cables will be connected once it is in position on the roof.

It is important to plan the layout and positions of Microinverters so it’s clear which one goes where, the image below shows an example which worked well:

A substantial supporting wall, resting on the floor, has been prepared to mount the AIO, the brackets are already in place (secured by M8 Bolts). The image shows plasterboard, this is mounted on thick plyboard behind it, the left and right brackets for the AIO are in place and a hole is ready to pass cabling through a gland in the rear of the AIO once mounted.

Om the left: AIO mounted without batteries. Most of the weight will be taken by the robust and height adjustable feet included with the AIO.

On the right: AIO with batteries (which just slide in, no additional cabling involved):


Some cabling & trunking:

Outside Cabling

The project involved some significant cabling work.

From the front of the house to the Garage at the rear, 3 cable routes can be seen:

1) 16mm SWA for Enphase PV
2) 6mm SWA for AIO
3) 2 x External Ethernet cables for comms

Because there is a narrow pinch point on the right and in order to avoid various obstacles on the right hand side of the house, cables are routed up high out of the way.

A new Earth Rod and inspection pit was needed to provide suitable earthing arrangements in the event of a power cut to support full property backup.

Some sections of patio slabs and block pavers had to be removed to dig a trench to route cables.

The image below shows location of a second inspection pit and earth rod for separate earth arrangements required for metal garage once the slabs are back in place.

This image shows cables fixed to a small concrete plinth at the base of the garage and the entry point for cabling into the Garage.

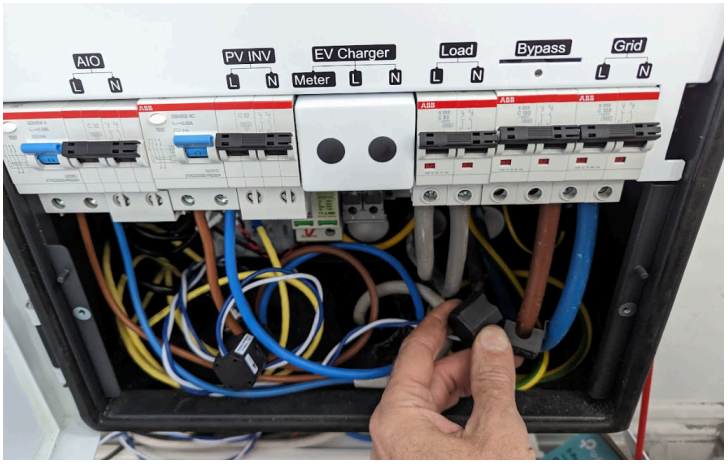
Inside Porch and House

Photo of inside of cupboard the other side of the wall from the Porch. This shows where the Enphase Envoy is located (small black box on the right with some green LEDs) and where a small Ethernet hub was added to extend the LAN to the garage.

This is inside the porch, the cupboard shown above is the other side of the wall to the left.

The wall the Gateway is mounted on has the Main Supply Meter Cupboard on the outside wall behind this.

This is inside the bottom section of the gateway, it shows how the CT Clamp that ships with the Enphase Envoy is too small. A larger one needs to be purchased separately.



A video which runs through the entire installation from end to end, is available on request.

Conclusion and Summary of Benefits

The customer is delighted with the system, solar production is already exceeding expectations even though it's December and production is at its lowest. The ability to see production by panel in real time is a great way to see how the actual production of each panel varies even from new and first install and as such the benefits in wiring these in parallel (rather than in series as with a String Inverter) can be realised from day 1. As an installer with many other installations to compare with, we too can see that this system is outperforming comparable installations based on lower cost String Inverters.

There were some teething problems with the new AIO product from GivEnergy which caused both us, as the installer, and more importantly our customer, a great deal of frustration and lost time. Following belated support from GivEnergy and updated firmware, the system seems to have stabilized and when it is working, it works very well.

The screenshot below shows solar production over the period shown by panel.

Whilst the decision to go with an Enphase system increased the cost, the resulting benefits are substantial and longer term cost may be less than that of a less costly string inverter system.

The information that follows is provided by Enphase.

Why chose microinverters?

Do you know the expression "*buy cheap, buy twice?"*

Your solar system has to work hard every day of the year for 25+ years. It is therefore important to choose a system which not only generates as much electricity as possible but is also safe, reliable, and doesn't cost money to maintain.

With payback periods at their shortest ever, there is no need to opt for the cheapest solar system. When we buy a car or book a holiday, we don't tend to choose the cheapest, so why would it be any different for your solar system?

Below are the main benefits of Enphase microinverters:

1. **25-year warranty as standard** – Not a marketing gimmick, given because of its unmatched reliability. Compared to 5-12 year on string inverters
2. **Safety** – No dangerous DC electricity across roof or in property. Microinverters have built-in real Rapid Shutdown.
    - Video on solar safety Safety and Solar - YouTube
3. **Increased generation** - Microinverters start generating earlier and stop later and will outperform string inverters even on completely due south roofs. They are also best solution to combat shading and arrays across multiple roofs, which means more savings on your bills.
4. **Highest reliability** – 99.95% reliability rate (1 in 2000 chance a microinverter will fail). What other solar manufacturer even publishes their failure rates?
5. **No single point of failure** – A string inverter is the least reliable component on a traditional system and typically needs replacing every 7-10 years. **When a string inverter fails the whole system shuts down**. Microinverters split the system at panel level meaning if one panel has an issue the rest of the system keeps working.
6. **24/7 technical support** – lines open 24/7 365 days per year, average wait time <1 minute. Per panel monitoring means most issues can be diagnosed and resolved remotely.

7. **Solar is a Long Term investment** – Pay slight premium now but far cheaper in the long term with no maintenance costs or string inverter replacements 2-3 times during system lifespan.
8. **Panel level monitoring** – Monitor individual panel production. Enphase monitoring includes consumption monitoring, so you can manage your power usage according to your solar generation.
9. **Scalable** – Can add to the system later without the need to replace components. Many households add more panels as consumption increases e.g.. buying an electric car.
10. **Storage ready** - Compatible with all AC coupled batteries

Independent UK Enphase review: https://www.youtube.com/watch?v=q6t0AAi5Jws

Demo App:

Get a taste the Enphase monitoring platform and explore live Enphase installations

Download the Enphase Enlighten App from the Play/Apple store on your mobile

Enter login credentials:
Email: demo-uk@enphase.com
Password: Enlighten@2021