



Maes yr Onn Farm *Manmoel, Caerphilly*

*“Wales’ first fully ‘off-grid’
and truly self sufficient
farm house”*

PROJECT TEAM

Client: The Davies family

Main contractor: Self build

Lead Designer: Building Research Establishment (BRE)

Other project participants

Caerphilly County Borough Council (RDP Energy team),
Scottish and Southern Energy (SSE), Constructing
Excellence in Wales and Welsh School of Architecture,
Cardiff University.

KEY CONTACTS

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PROJECT DETAILS

Design, construction and monitoring of Wales’ first fully ‘off-grid’ and self sufficient three bed farm house.

Project budget: £100,000 for building construction, £55,000 on low carbon, renewable technologies, installation and commissioning (funded by SSE).

Best practice themes:

- Full engagement with end user
- Long term energy performance and behavior monitoring
- Low Zero Carbon technologies
- Water self sufficiency



Construction period: started April 2012 - completed June 2013, monitoring over 2 year period 2013-2015





THE OVERVIEW

Background

The Manmoel area comprises a small upland village with surrounding hill farms in the county borough of Caerphilly in South East Wales. The remote rural community's activity is largely based on agriculture.

The farm, established in 1825, comprises of 84 Ha and has been farmed on a commercial basis for over 30 years. Unfortunately, the original farmhouse fell into disrepair many years ago and the family lived off-site. Their efforts to re-establish a presence on the farm were hampered by a lack of electricity, gas, water or sewerage services at this upland site.

Their restrictions are not unique however as, in Wales, 19% of the population is considered off grid (from mains gas, electricity, or water), a figure of 253,000 households¹.

However, with the support of a number of organisations, the client, after a lengthy period of consultation, gained outline planning permission to construct a farmhouse on the former site in April 2012. The construction of the new farmhouse ensures effective day-to-day management of the farm and stock and will enable further expansion of the business.

Strategy

The strategy involved an effective working partnership between the key stakeholders including the Davies family, CCBC RDP Energy team, BRE and SSE. All partners have had an integral role to play in making the project happen and to turn the client's dream into reality. The Council managed the project from its initiation.

The council and BRE were already working with the Manmoel farming community on a project to refurbish hard to treat farm houses in the area. Through that project the team became aware of the Davies' ongoing desire to re-establish a farm house on their land. BRE provided the building design work (concept through to building regulations approval) and initial technical feasibility of the renewable energy technologies and SSE provided the funding, design and installation services of these technologies.

After completion, CEWales and the Welsh School of Architecture have undertaken post occupancy monitoring of the various renewable energy technologies, energy and water consumption and the occupants behavior and satisfaction with their new home.

The approach was based on the following objectives:

- Collaborative working – multi-agency working to realise an off-grid rural home
- Providing low carbon electricity and heat to this off-grid site
- Provision of water self sufficiency
- Maximising clients satisfaction
- Providing opportunity for business expansion by being present on the farm.

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THE DELIVERY

This section considers the actions taken by the team to deliver not just the design and construction of an off-grid farm house but also to enable the client to occupy the building. These are described against the following headline issues:

- The site
- Building fabric design
- Renewable energy technologies and supporting infrastructure
- Water self sufficiency
- Occupant behaviour

The site

The Maes yr Onn farm is situated on an exposed upland location and is completely “off-grid”. The site is very exposed; approx 1200 ft above sea level and at times the winds can reach over 100mph. This meant that an innovative approach was required to enable the family to return to live and work on the farm site.

Building fabric design

In accordance with the Davies family’s wishes, the building design is inspired by the traditional Welsh long house form. This concept was then developed to suit an off-grid, 21st century farming lifestyle. Drawing from the long house, and supported by careful site analysis, the building was oriented across the slope of the land to sit ‘gable on’ to the prevailing wind. This positioning allowed the simple rectangular form (which provides a good surface area to enclosed volume ratio) to shelter behind the western gable. The gable itself was designed without windows due to concerns over driving wind and rain and constructed from local stone in part to help resist this wind, as well as for the aesthetic benefits.

Orienting the building up-down the slope also realised the opportunity to house the necessary plant for ‘off grid’ living in a sheltered half basement, giving direct service routes into the house without requiring the plant to be within the inhabited envelope. The simple external form was then completed with partial stone and timber cladding, with stone stepping down from the protective western gable along either long elevation.

Building from the efficient design fabric principles, the detailed design of the house incorporated further building fabric technical benefits. The partial basement is constructed from robust blockwork with a precast concrete beam & block roof, topped with more than 200mm of insulation. This insulation was returned up at the perimeter of the building, effectively creating permanent formwork for the concrete slab to be cast within. This “true” raft foundation detail was combined with an innovative twin-wall timber frame structure that carries the building’s structural load on the inner leaf, allowing the timber frame to be installed onsite with the outer timber frame overhanging the perimeter of the concrete slab. This combined detail allows for a continuous layer of insulation from within the timber frame underneath the house (including its “warm” concrete slab providing thermal mass), meaning the foundation details have no thermal bridging whatsoever, barring a single service riser.

Above ground level, the twin wall timber frame construction has minimal thermal bridging due to the staggered studs, with the open pitch of the roof formed from the same timber frame construction. Due to the nature of the structural inner frame, the timber frame has a sheathing board mid-way through the construction. In order to allow the construction to be made weathertight on site quickly, this had cellulose insulation blown through holes cut in it into the outer half of the timber frame, whilst the inner half was insulated with mineral fibre (for sites without the extreme weather conditions, mineral fibre quilts to both elements would avoid the risk of settlement, but in this instance the site conditions required a different approach).

Following the completion of the superstructure, Maes-yr-Onn then received good quality (but not triple glazed) windows and doors, with the house being naturally ventilated through trickle ventilators incorporated.

Overall, the house was designed under the minimum standards of Building Regulations Part L 2010, which it notably exceeds.

In 2013 an air pressure test was carried out, the results were 3.63m³/h./m². The house has an Energy Performance Certificate grade A and is certified as Code for Sustainable Homes level 3.

On site electricity is provided by a 2.88kwp capacity solar photovoltaic array across the south facing roof and a battery bank to store surplus power from the solar panels



Element	U-value
Walls	Average thermal transmittance of 0.13 W/m ² K
Roof	Average thermal transmittance of 0.16 W/m ² K
Floor	Average thermal transmittance of 0.10 W/m ² K
Windows	High performance glazing 1.4 W/ m ² K

Renewable energy technologies and supporting infrastructure

A number of technologies were considered to address the challenge of being off-grid. The final solution for heating included the installation of a 20kw biomass boiler fed from the family's own woodland, a 1,200 litre combined capacity thermal store, serving an innovative skirting radiator system. On site electricity is provided by a 2.88kwp capacity solar photovoltaic array across the south facing roof and a battery bank to store surplus power from the solar panels. A diesel generator is used for back up electricity and to maintain battery charge levels when required

On-site monitoring has been carried out by the Welsh School of Architecture, Cardiff University. They have installed:

- 6 Electric meters in the house to look at both sockets and lighting
- 6 Electric meters in the basement to look at the building services
- A Gas meter for cooking
- Indoor Environment: 9 Air temperature and Relative Humidity
- Local Weather: air temperature, relative humidity and rainfall

Water self sufficiency

Maes yr Onn Farm has no provision for mains water supply or sewerage. Rainwater is harvested from the main house as well as adjacent barns. The tanks are manually controlled to provide rainwater to a 5,500 litre tank within the household basement. From the tank water passes through a UV purifier lamp located in the building.

The house benefits from a shower room and separate bathroom. The utility room also has a washing machine. The farm house has its own septic tank for wastewater.

Occupant behaviour

From the outset the Davies family were aware that they would need to be conscious of their water and energy consumption. The purpose of studying the occupant's behaviour was to understand their patterns of use and behaviour in the house and their perceptions of and interaction with the low carbon zero technologies.

Further qualitative studies were completed by the Welsh School of Architecture, these were:

1. semi-structured interviews with the occupants;
2. self-reported diaries of daily activities to identify typical routines at home distributed to the dwelling;
3. log of systems maintenance and use to be completed by the occupants; and,
4. questionnaires reporting perceptions, opinions, lifestyles and preferences concerning off-grid living, to be filled out by the occupants. These are based on industry standard questionnaires and building evaluation monitoring studies.

What has become evident through monitoring is that they are managing a comfortable home well within the confines that the renewable technologies and rainwater harvesting has set them.



THE OUTCOMES

Thermal comfort: Monitoring has shown that the house remains stable with temperature remaining around 19°C in winter and 21°C in the summer.

Energy: In the evaluation interviews, the family expressed that they trusted the reliability of the low carbon renewable systems. They feel able to control and operate all aspects of the building services within their home and basement plantroom. This finding is supported by diaries and maintenance logs; the monitoring results provides evidence that for much of the year the family can sustain life off-grid using renewable technologies in PV and biomass.

Water: Water efficient equipment was installed, with designers anticipating each occupant would consume around 101 litres of water per day. Our first year of monitoring shows that their consumption has remained below 80 litres /per person / per day and averages around 63 l/pp/d. The family's low water consumption compares extremely well against the national average. Dŵr Cymru Welsh Water advise that our water consumption has been steadily increasing since the 1970's when our average water consumption was 110 litres per person per day; today that figure has risen to around 157 l/pp/d.

Maes Yr Onn water use litres per day per person



Regulations & planning: A development of this nature was setting a precedent and tested the authority's planning policies and regulations. The project also provided an exciting opportunity to learn more about renewable energy, water technologies and low carbon building design with a fabric first approach.

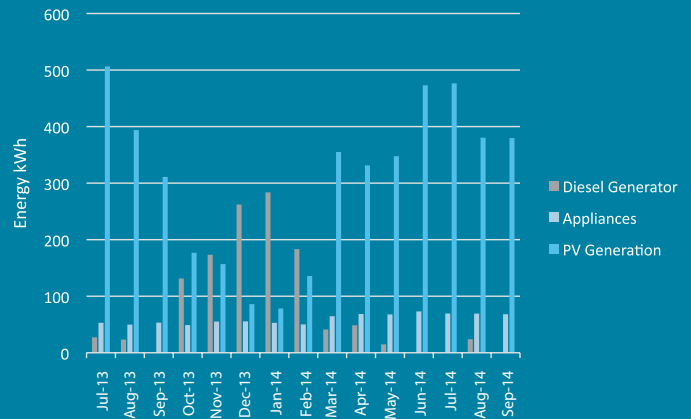
In recognition of the collaborative approach taken by the team, the building won the prestigious RTPi Cymru Planning Award in 2013. The judges paid particular attention to the role of the planner in working collaboratively with the project team to bring the various schemes to fruition. It is notable that the winning schemes scored highly in respect of mitigation against the threat of climate change, how they addressed all aspects of sustainable development, and key issues that were overcome in implementation.

LESSONS LEARNT

Planning: Prior to the council and BRE being introduced to the Davies family the family had been seeking to secure full planning permission for over 10 years. To move the project forward, from November 2011, the project benefited from a more collaborative discussion and debate involving a broad range of partners to secure planning permission.

Electricity generation: The energy profile below shows the energy generated by the PV array and diesel generator, also shown is the energy consumed by the appliances within the home (this includes all floor sockets and lights but not the parasitic loads from the plantroom). It can be seen from the graph that the PV array is capable of meeting the electricity demand of the building occupants, but that the diesel generator is needed in winter months to ensure battery charge levels remain above minimum levels; 40% of their charge level.

Maes Yr Onn Electrical systems monthly totals



Batteries: The bank of sixteen 12v gel batteries requires the occupants to monitor and manage their charge and discharge of energy. On days when the PV array has had a low output top-up charge is provided to the batteries by the diesel generator. In the future, as battery technology improves, the gel batteries may be replaced with more resilient batteries (capable of greater discharge) and prove a more cost effective solution.

Water consumption: In September 2014 we experienced the driest September on record, with just 20% of our average rainfall². The rainwater harvesting collection area has been expanded to include the adjacent barns and three 1,800 litre tanks installed for additional storage. The family feel more concern for the water supply than they do their energy supply, confident that the PV, biomass and if need diesel can meet their energy demands. The Davies' monitor the water tank storage and water pressure from a monitoring device in their kitchen.

Behavioural change: The behavioural study by the Welsh School of Architecture has shown that the occupants have adapted well to the house and the necessity to adapt activities to the weather. For example, data and diaries show that on sunny days the family carry out tasks such as washing and ironing to make the most use of the solar energy collected from the PV array.

Similarly on sunny days the family remain confident that their batteries will remain fully charged and be able to meet their energy needs. On cloudy days, when PV generation is poor the occupants run the diesel generator to protect the battery bank.

As the family has settled into living in the house and become accustomed with the systems, they feel confident about their lifestyle and patterns in the house. They consider that no significant changes have been made to live in the house.

Maes Yr Onn

Living Better, Using Less

'People were telling us we will have to change, we'll have to do this and you have questions, what is different, what is? And it's not different, it's not, you turn the tap and the water comes out!'

Davies family member



CONCLUSION

- The evidence provided by this case study demonstrates that life off-grid in rural Wales is possible with some behaviour change.
- The enhanced building fabric, u-values and air permeability have reduced the buildings energy demands considerably.
- Better battery technology would give a more efficient energy backup.
- Water supply is the key risk for the site and mitigated through extensive storage.
- The collaborative approach by the client, design team, planning authority and delivery partners have created a demonstration building for rural farmers in Wales and further afield.



References: ¹ Source: Off Grid Energy: An OFT market study, OFT Oct 2011 ² <http://www.metoffice.gov.uk/news/releases/archive/2014/early-september-stats>