centre for renewable energy & sustainable technologies

Project Report

Future Renewables

The Special EU Programmes Body is the Managing Authority for the European Union's INTERREG IVA Programme

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Version	Date of Issue	Written by	Reviewed by
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ASHP Case Study

"Highly efficient renewable technology, that anybody building a new house should have!"

Background

In 2010, [redacted] constructed a two-storey detached dwelling on his family farm in [redacted]. This property boosts a total area of 3000ft^2 and is ideally situated in a picturesque part of the county. [redacted] aim from the outset was to build a modern home, with maximum energy efficiency and minimum utility costs. This was achieved by super insulating his walls, floors and roof, above and beyond the requirements of Building Regulations, all in an effort to maximise the thermal performance of his home. Comprehending both the financial and environmental benefits associated with an efficient energy dwelling, [redacted] decided to install an Air Source Heat Pump (ASHP) in order to generate his domestic hot water and space heating requirements.

The System

The heat pump chosen was the Mitsubishi Ecodan HW140, the largest of Mitsubishi's domestic air source heat pumps with the ability to operate between 5kW and 14kW on a single phase connection. The total installed system consists of an external box which is fitted to the outside wall of the property which is designed to harvest low temperature heat energy from the environment and turn it into higher temperature heat by using electrical energy. ASHP's make use of the fact that when liquids evaporate they absorb a large amount of energy, their specific latent heat of vaporisation, and this energy is released when the vapour condenses back to liquid. By using this property, large amounts of energy can be absorbed and released by the heat pump.

Figure 1 illustrates how the heat pump works in more detail. Low temperature heat is absorbed from the environment by the working fluid in the evaporator. This energy turns the low temperature, low pressure liquid into a vapour. This vapour reaches the compressor, which increases the pressure of the vapour, thereby increasing its temperature. In the condenser energy moves from this high temperature, high pressure vapour to the (lower temperature) environment, and the vapour condenses to a liquid.

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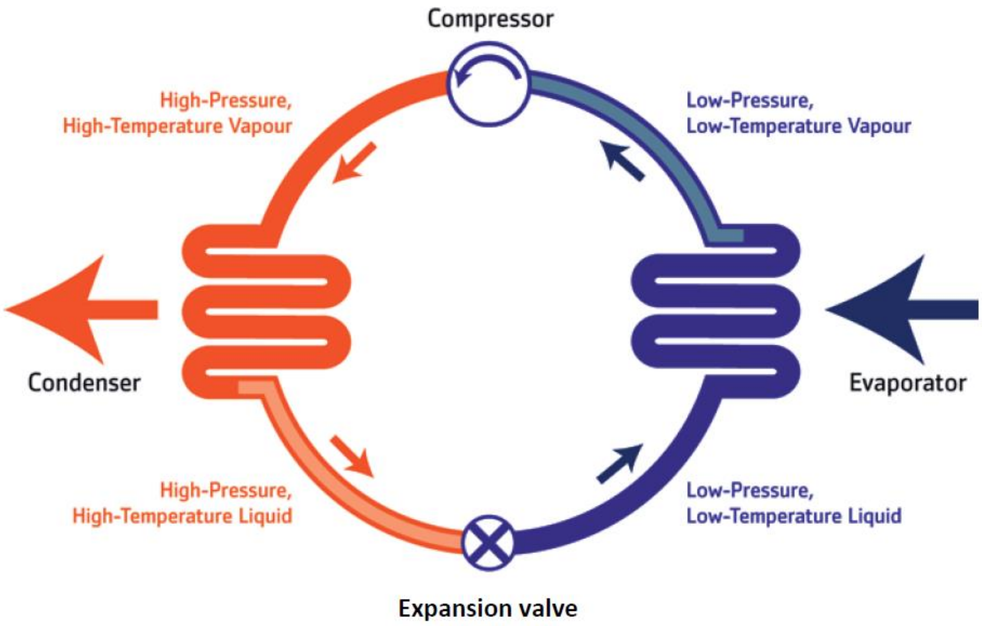
When the high temperature, high pressure liquid passes through the expansion value, it is transformed into a low pressure, and there low temperature fluid. The cycle starts again.

Fig.1 <u>Heat conversion process</u>



New build properties which can be designed with low temperature distribution systems are most suited to heat pumps than properties with existing high temperature systems. Under flooring heating systems in a new home typically requires heat at 30 – 35°C, compared with traditional UK radiator systems which emit heat at 60 - 75°C. The input temperature is also critical to the CoP of the heat pump. The higher the input temperature from the air, the lower the amount of work needed from the heat pump, the higher the system efficiency. In fact, the critical factor is the 'uplift' between the source temperature and the output temperature. Therefore an ASHP is more efficient in the autumn or the spring than in the depths of winter.

The ASHP installed at the property in question is linked to the dwelling's underfloor heating system. A large highly-insulated 300litre hot water cylinder is also powered by the ASHP which allows the homeowners to avail of off-peak electricity charges at night and minimise the need to top-up during the day.

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Fig.2 <u>Mitsubishi Ecodan HW140</u>

ASHP's are not typically designed to meet the full peak heat load of a building, as this can lead to excessive cycling and reduced performance during warmers periods. For this reason, [redacted] has also installed two solid fuel stoves in the living and kitchen area of the dwelling to provide additional space heating during the winter peak period.

Performance

In the first twelve month period from commissioning (Mar 2011 to Mar 2012) [redacted] estimated that approx. £305 of electricity was spent on running the ASHP. This equated to approx. 42% of his annual electricity costs. Such a low cost can be largely attributed to the homeowner smartly availing of his reduced night time tariff rate of 6.85p/kWh in order to heat water and store for use in periods of peak demand; instead of consistently using his daytime rate of 13p/kWh.

The performance of a heat pump is traditionally measured using a Coefficient of Performance (CoP). This describes the ratio of useful heat produced to the energy consumed. Most heat pumps use electrically driven motors and, in these cases the CoP is measured against the electrical consumption. If the heat pump produces 3kWth and uses 1kWe it will have a CoP of 3/1 = 3. A high CoP shows good performance and lower electrical consumption.

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In order to compare the savings generated from installing this ASHP, a comparison has been made to the traditional oil-fired boiler.

Table 1 Annual ASHP Cost

Annual ASHP Cost	
CoP	3
Heat Generated	9150 kWh
Electricity Used	3050 kWh
Electricity Price (Average)	£0.10 p/kWh
Annual Electricity Cost	£305

Table 2 Annual Oil Boiler Cost

Annual Oil Boiler Cost	
Annual Oil Use	915 Litres
Net Heat Used	9150 kWh
Boiler Efficiency	95%
Gross Heat Used	9607 kWh
Oil Price	6.2p/kWh
Annual Cost	£596

The calculations above show that the annual cost of running the ASHP in comparison to a condensing oil boiler is nearly 49% (£291) cheaper per annum.

The cost of designing, supplying and installing an ASHP system as a turnkey package is subject to the same inflationary pressure as any other capital project. The overall cost of this particular project was approx. £7,500.

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Table 3 Payback Period

Payback Period	
Capital cost of ASHP	£7,500
Est. Annual Fuel Saving per annum	£291
Renewable Heat Premium Payment (RHPP)	£1,700
Discounted Capital cost of ASHP system	£5800
Est. RHI Income (£0.034/kWh)	£311
Payback period (with RHI income)	9 years

At present, under the Renewable Heat Premium Payment (RHPP) a grant of £1,700 is available for domestic customers wishing to install an ASHP. This is an interim measure that was put in place in advance of the design and implementation of the domestic RHI. At present, under Phase 1 of the non –domestic RHI scheme only GSHP's and WSHP's that transfer heat to water are supported, however, it is expected that Phase 2 of the RHI (due late 2014) will support the implementation of ASHP's. The proposal outlines that domestic applicants that have already received the RHPP will receive the ongoing tariff (expected 3.4p/kWh) and any applicants that installed without the support of the RHPP (between the period 1st Sep 2010 and the launch of the domestic RHI), would receive a higher tariff (expected 8.1p/kWh) but no upfront payment. Payments will be made on a quarterly basis and determined by the actual heat output of the system.

Following the success of the ASHP, [redacted] later decided to install a 6.5kW PV array in an effort to address his escalating electricity costs.

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Solar PV Case Study

Background

[redacted] owns and manages a dairy farm in [redacted] The daily operation of this enterprise requires an extensive amount of energy due to the intensive nature of harvesting milk and keeping it cool; along with the rigorous cleaning of all equipment/plant used. [redacted] was keen to investigate ways to stay ahead of the game and take control of his escalating energy costs. Due to high performance and low maintenance it was decided that a PV installation would be the most appropriate solution for his farm.

The System

After assessing [redacted] farm it was determined that his cattle shed was the most appropriate location to install the PV panels largely due to its south facing orientation, appropriate inclination and a minimal shading factor. In order to maximise output and avail of grid connection limitations a PV system of 20kWp was chosen. This PV system consists of 80 x 250w SolarWorld panels which are German manufactured. SolarWorld produces its own wafers, cells and modules making it one of the few vertically integrated companies in Europe.

Fig.1 PV array fixed to the roof of the cattle shed

A solar power system is only as good as its inverter – as grid Inverters convert direct current from solar cells to grid-compliant alternating current (AC). For this reason a SMA

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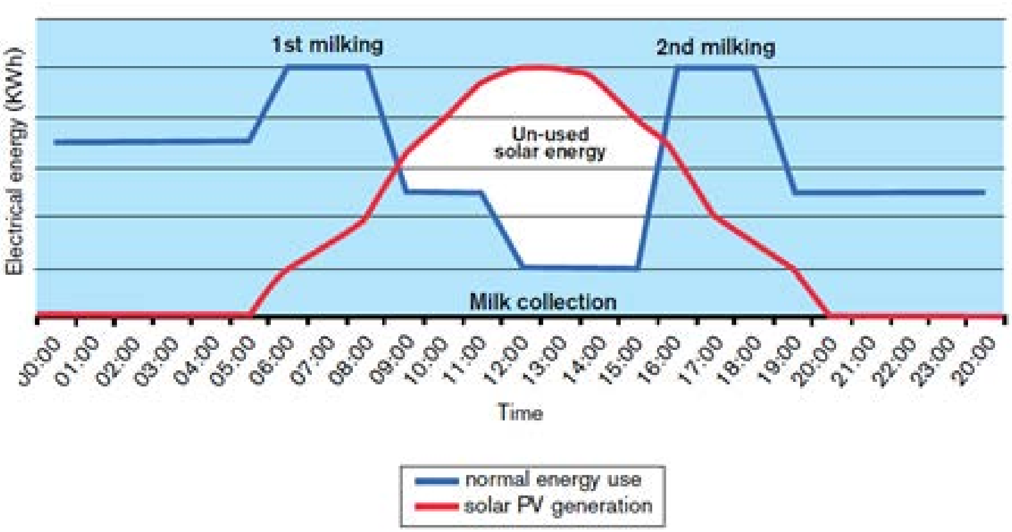
Tripower 17,000 TL, grid connect inverter was chosen due to its high performance and reliability. SMA Solar Technology is based out of Germany and is the world's largest producer of solar inverters, with 40% of the global market share. SMA has been manufacturing inverters for nearly thirty years and has gained a prestigious reputation.

The solar array was securely fixed to the cattle shed using a Hilti Rail system. This mounting system was chosen to suit the curvature of the cattle shed roof and ensure maximum sunlight collection. It is made from the highest grade aluminum which provides both long-term security and peace of mind.

Performance

Energy demand on a typical dairy farm generally peaks during morning and evening milking periods, whilst solar energy generation is commonly at its highest around midday (see Graph 1 below). Nevertheless, returns in investment, can be very satisfactory as the system is eligible to avail of the Renewable Obligation Certificates ROC's) and the NIE export tariff.

Graph 1. Typical Application of Solar PV on dairy farms



The Renewable Obligation is the main support scheme for renewable electricity projects in the UK. A Renewable Obligation Certificate (ROC) is a green certificate issued to an accredited generator for eligible renewable electricity generated within the UK and supplied to customers within the UK by a licensed electricity supplier. One ROC is issued

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for each megawatt hour (MWh) of eligible renewable output generated. The reason ROCs have a value is because a legislative obligation on all licensed electricity suppliers to submit ROCs each year to Ofgem or else pay a penalty. At present, solar PV receives 4 NIROC's for installations up to 50kWp. This equates to approx. 16.89p/kWh of energy generated. Although ROC's are subject to banding levels which may cause the value to fluctuate slightly, the generator will be eligible to claim payments for 20 years or the life-time of the system (which ever comes sooner!).

At periods when energy generated from the system exceeds demand; [redacted] can also benefit from exporting excess electricity to the grid. Currently, in Northern Ireland, only Power NI offer export tariffs for small generators. The export tariff in October 2013 was 5.59p/kWh. Export payments are generally paid annually to generators of 10kW or less – whilst generators over 10kW can choose a quarterly or annual payment.

Table 1 shows a detailed breakdown of savings generated by [redacted] from installing his PV system on the 17TH Dec 2013 to 1st July 2014.

Table 1 PV array

20kW PV Array (period 17th Dec 2013 – 1st July 2014)	
Total PV Energy Generation	
Total PV Energy consumed on farm	6338kWh
Total PV Energy exported to grid	3194kWh
Total saving from using PV Energy (avg. £0.13/kWh)	£824
Total Income from ROC's (£0.1689)	£1610
Total Income from Export (£0.0541/kWh)	£173
Total combined income & savings	£2607
Capital cost of 20kW PV System	£32,000
Simple Payback Period	6 years

Within this six month period it was determined that this PV array produced approx. 9532kWh of electricity. This equated to an electricity saving of approx. £824 and a ROC income of £1610. Taking all savings and income into consideration against the capital

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cost of this 20kW system a payback period of 6 years was determined. This is an attractive investment considering the system has an estimated life-span of 20 years or more.

Furthermore, it can be clearly identified that approx. 34% of the energy generated from this PV system was exported directly to the grid. In order to maximise return it is essential to replace as much grid consumed power as possible and use as much PV energy possible on-site. The power consumed from the grid will always be the most expensive as the cost not only includes generation costs but also transmission costs and losses (avg. 13 – 15 per kWh).

Future Renewables have accessed the practicality of using excess renewable energy to directly heat and store water in a highly-insulated tank. This configuration would ultimately reduce [redacted] energy costs further as a consistent hot water supply is essential for the cleaning of milking equipment.

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Client Agreement

I agree that the above work has taken place to my satisfaction and has been completed by Shane McBrien of the South West College.

I understand that the project has been financed by the INTERREG IVA programme part of the European Development Fund to the value of £3600 as per the project proposal.

Client Signature_________________________________ Date_________________

Company & Position_________________________________

All personal data will be held in accordance with the provision of the Data Protection Act 1998. Information provided in this questionnaire may be presented in a programme evaluation in summary format. It will not be possible to identify details about specific individuals or organisations within this report.

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