A Report in Three Parts:
– How Energy efficient is your farm?
– What you can do to improve efficiency and save money?
– Nationwide farm efficiency case study
GRANTED & MORRISONS FARMING

Granted helps farmers, businesses and landowners to understand their opportunities around renewable technologies. This includes what funds there may be and how to ensure a developer doesn’t rip you off. We are firmly behind you and do everything we can to make sure you get the best deal, for you, for your family and for the future.

Morrisons Farming approached Granted due to this independence and ability to give impartial knowledgeable advice.

WHY USE GRANTED?

Our USP is that we are independent and impartial – we do not install and we do not work exclusively with any developer, supplier or funder.

The deals available to landowners and farmers vary dramatically – for example Solar PV rents per acre per year are between £750 and £1,200 – connection fee bonuses range between £0 to over £100k. Granted understand the market, understand the financial models and will help secure you the best deal for your land.

Perhaps Solar PV is not the best option? Granted have the expertise to evaluate wind, biomass, hydro and Anaerobic Digestion technology opportunities.

WHAT DO I GET?

There are currently swarms of energy developers looking for windy hilltops, sunny valleys, biomass and anaerobic digestion opportunities. You have probably already been approached by these developers or who are looking to take advantage of the high rates of return available.

What information and advice do you get?

1. Suitability and assessment of specific projects and technologies
2. Associated project timelines and planning/regulatory requirements
3. Approximate installation costs, savings, payback and carbon reductions
4. The practical implications of installing and maintaining technologies
5. Funding and finance options
6. All summarised in an accessible, jargon free Green Heat & Power Report

HOW DOES THIS HELP ME?

1. Be equipped with knowledge to have confidence in negotiating with developers and installers
2. Evaluate existing proposals from an informed position
3. Pro-actively take your project(s) to the market place as a mature opportunity, in order to secure the right deal with the right developer
4. Start a dialogue with banks and finance institutions based on a robust project plan

WHAT NEXT?

Simply call Granted on 01395 223020, and speak to Alex or Stuart or email alexc@grantedltd.co.uk / stuartw@grantedltd.co.uk

YouGen aims to make it easy for home and business owners to learn about, invest in and enjoy the benefits of renewable energy and energy saving. We specialise in the kind of practical information that helps to work out what is suitable for your property, and what you need to do to get the best possible result.

The website includes:

- Practical guides to the main renewable energy technologies and energy saving measures including how to maximise your return
- The latest information on government subsidies and support
- Expert advice from professionals working in the field
- A lively blog with new information posted regularly, and the opportunity to ask questions and share experiences
- Directory of installers with feedback from their customers

www.yougen.co.uk
1.0 Introduction
Why is energy efficiency important?

This guide shows how you can quite easily adopt a strategic approach for energy efficiency, ensuring any changes have the long term viability of your farm as their goal. It can help you assess your current energy use and where and what savings can be achieved in both the short and long term.

Why make changes to your farm?

There are three main reasons:

1. In the long run it saves money
After the initial outlay for the energy efficiency measures and/or renewable energy the reduction in energy use will save you money as your fuel bills will be less. Many of the measures that can be put in place have further tangible benefits outlined in this report.

2. It encourages the responsible use of the resources
We live on a finite planet; with climate change and the increasing population it is down to current generations to live sustainably. This will mean that there are still resources available to future generations.

3. Greenhouse gas emissions have to be reduced
Every farmer in the UK should have one date imprinted on their mind: 2020. By 2020 agriculture has to have reduced its greenhouse gas emissions (GHG) by 20% compared to the 1990 baseline. GHG emission targets are being put in place as they are the main cause of the greenhouse effect; blanketing the Earth in a reflective layer of gases which trap heat. This legislation which is being enforced means farming is under increasing pressure to manage its emissions. We have two options:

1. Do nothing but be at risk of enforced changes.
2. Adopt a proactive strategy and ensure a more resilient and efficient business.

Option 1 is a higher risk option. It means you will have less freedom of choice to implement enforced changes. It also means you may have to implement changes on a less convenient timescale, dictated by others.

Option 2 will enable you to have a far greater control over your approach. It will reduce the risk of being forced to make changes. It will also ensure that you are able to receive the full financial and business benefits.

This guide has been designed to show you how to easily and effectively implement a long term considered strategy.

It will:

- Show you where to focus your efforts and how to get the maximum impact from your time and money.
- Save you time and show you how maintain a positive advantage.
2.0 Benchmarking

Benchmarking ensures you know where you are starting from; how energy efficient is your farm compared to other farms in your sector and what is achievable.

One way of establishing this is by completing a detailed energy audit of your farm. Whilst this gives you a more accurate understanding it can be time consuming and expensive. If you are unable to conduct a full audit, yet still want some idea of your usage, some simple data gathering for a quick benchmarking exercise can still provide a good understanding.

The first step is to assess your energy bills. They provide a good indication of usage and are often available historically. Twelve months’ bills will provide a reasonably accurate figure.

The table below shows the kind of information required to benchmark your enterprise. There is a form at the back of the report that you can use.

### Table 1

<table>
<thead>
<tr>
<th>Sector/energy use area</th>
<th>Cooling</th>
<th>Heating</th>
<th>Pumping</th>
<th>Lighting</th>
<th>Field cultivation</th>
<th>Drying</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diary</strong></td>
<td>Milk cooling and 2 stage pre cooling.</td>
<td>Water heating. Renewable heat.</td>
<td>Variable speed vacuum pump.</td>
<td>Type and number of bulbs. Renewable electricity.</td>
<td>Precision farming.</td>
<td></td>
</tr>
<tr>
<td><strong>Arable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Precision farming.</td>
<td>Renewable heat.</td>
</tr>
<tr>
<td><strong>Pig</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Beef and lamb</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Horticulture</strong></td>
<td>Renewable electricity.</td>
<td>Renewable heat.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Potatoes</strong></td>
<td>Renewable electricity.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Poultry</strong></td>
<td>Renewable electricity. Heat exchanger.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2: Benchmarking for energy usage

<table>
<thead>
<tr>
<th>Resource</th>
<th>Quantity</th>
<th>Cost data</th>
<th>Benchmarking data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Per unit</td>
<td>Per year</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity Day</td>
<td>kWh/year</td>
<td>£/kWh</td>
<td>kWh/cow*</td>
</tr>
<tr>
<td>Electricity Night</td>
<td>kWh/year</td>
<td>£/kWh</td>
<td>kWh/cow*</td>
</tr>
<tr>
<td>Total Electricity</td>
<td>kWh/year</td>
<td>£/kWh</td>
<td>kWh/cow*</td>
</tr>
<tr>
<td>Dryer OIL</td>
<td>Litres/year</td>
<td>p/litre</td>
<td>£/L</td>
</tr>
<tr>
<td>LPG</td>
<td>Litres/year</td>
<td>p/litre</td>
<td></td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>Litres/year</td>
<td>p/litre</td>
<td>£/cow*</td>
</tr>
<tr>
<td><strong>Waste</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inorganic</td>
<td>Tonnes/ year</td>
<td>£/Tonne</td>
<td>£/cow*</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>kWh/year</td>
<td>£/kWh</td>
<td>kWh/cow*</td>
</tr>
</tbody>
</table>

*cow, livestock unit or acres
Now that you have established your own personal benchmark you have a good baseline to measure improvements and calculate savings. It is also possible and makes sense to compare your performance against similar farms. Each industry sector has its own benchmark data you can refer to for comparison of figures. These are detailed in tables below, further information can be found at the websites given in the resources section on Page 56.

### Table 3: Agriculture and horticulture benchmark figures

<table>
<thead>
<tr>
<th>Edible</th>
<th>Intensive</th>
<th>Typical energy consumption kWh/m²</th>
<th>Extensive</th>
<th>Typical energy consumption kWh/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat</td>
<td>Electricity</td>
<td>Heat</td>
<td>Electricity</td>
<td>Heat</td>
</tr>
<tr>
<td>675</td>
<td>15</td>
<td>250</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>450</td>
<td>60</td>
<td>175</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>


### Table 4: Beef benchmark figures

<table>
<thead>
<tr>
<th>Resource</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity per kg of beef</td>
<td>0.074kWh</td>
</tr>
<tr>
<td>Fuel use per kg of beef</td>
<td>0.184 per litre</td>
</tr>
</tbody>
</table>

Information in table 2 provided by EBLEX. Further information about EBLEX and energy use can be found at: www.eblex.org.uk.

### Table 5: Pig farming benchmark figures

<table>
<thead>
<tr>
<th>Pig farming</th>
<th>Typical energy use per pig produced (kWh/pig)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farrowing</td>
<td>8</td>
</tr>
<tr>
<td>Weaning</td>
<td>9</td>
</tr>
<tr>
<td>Finishing</td>
<td>10</td>
</tr>
<tr>
<td>Feeding System</td>
<td>3</td>
</tr>
<tr>
<td>Waste Management</td>
<td>6</td>
</tr>
</tbody>
</table>


### Table 6: Average annual consumption per cow as advised by DairyCo.

<table>
<thead>
<tr>
<th>Average consumption Range in annual kWh per cow</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 250</td>
<td>Excellent</td>
</tr>
<tr>
<td>250–350</td>
<td>Very good</td>
</tr>
<tr>
<td>350–425</td>
<td>Average</td>
</tr>
<tr>
<td>425–475</td>
<td>Room for improvement</td>
</tr>
<tr>
<td>475–550</td>
<td>Of concern</td>
</tr>
<tr>
<td>Above 550</td>
<td>Prompt action required</td>
</tr>
</tbody>
</table>

DairyCo conducted research into the annual electricity consumption on dairy farms and their conclusions were that average annual consumption on a kWh per cow basis should be in the range of 350–425kWh.

### Things to consider for the previous example are:
- Is your dairy system high or low output?
- Are you running a mixed enterprise farm with not just a dairy herd?
- Do your figures include domestic properties?
- Are your milkings taking longer than 2.5 hours?

Benchmarking will give you a good indication of what you may be able to achieve and the potential for savings. As long as you understand the weaknesses then it is a useful tool.

### Benchmarking example: Agri assist Morrisons emissions footprint analysis

There are a number of comprehensive on-line tools that can provide more detailed analysis of your GHG emissions and, in particular, energy use.

Just over 100 DCD dairy farms participated within a Morrisons funded Emissions Footprinting process from November 2010/January 2011. Farms involved covered all areas within the DCD Liquid milk field, from Devon to Lancashire, Pembrokeshire to Norfolk. Average milk production/farm was considerably larger than the UK national average with milk output at 1.54m litres/unit (range 8m p.a. to 350k p.a.).

Twelve months data was sourced from the most recent financial year end for each farm. This ranged from year ends February 2010 to February 2011, with the majority utilising data from the financial year ending 31st March 2010.

### Electricity cost/unit – results

<table>
<thead>
<tr>
<th>Electricity tariff</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>18.47p, 4.64p, 9.06p</td>
</tr>
<tr>
<td>Low</td>
<td>10.90p, 2.12p, 5.12p</td>
</tr>
</tbody>
</table>

During the financial periods covered by the data collection process, electricity prices increased enormously, with those still on tariffs secured during earlier periods enjoying a considerable advantage compared to those receiving electricity through more recent contract arrangements.

The average consumption/farm within this survey of 100 farms was 83,222 units/year

The overall range financially per farm/p.a. recorded was Low £4,260 to High £7,539

The graphs above right illustrate the ranges paid in pence/unit for both high and low rate tariffs across the dataset.

### Electricity cost Per litre

The key performance indicator for electricity efficiency on dairy farms when expressed on a per litre basis again demonstrates a large range.

Average electricity cost per litre of milk = 0.47p/litre

With many farms paying double and an extreme example paying four times this, the highest being 1.80p/litre on electricity alone.

Below are results from a benchmarking project across a broad range of Dairy Crest farm suppliers:
The results below show the prevalence of mitigating strategies that are being/or not being deployed during the survey periods in question.

<table>
<thead>
<tr>
<th>Electricity efficiency questions</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you access Economy 7 electricity tariffs?</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>Do you purchase ‘green sourced’ electricity?</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>Do you heat hot water harnessing low rate electricity?</td>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>Do you access low rate electricity to cool the majority of your milk?</td>
<td>58</td>
<td>42</td>
</tr>
<tr>
<td>Do you access low rate electricity for the majority of your milking?</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Have you installed energy saving lights?</td>
<td>89</td>
<td>11</td>
</tr>
<tr>
<td>Have you installed a variable speed vacuum pump?</td>
<td>21</td>
<td>79</td>
</tr>
<tr>
<td>Does milk pass through a plate cooler?</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Have you installed a Heat Recovery Unit?</td>
<td>22</td>
<td>78</td>
</tr>
<tr>
<td>Is your water heater insulated?</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Are hot water pipes insulated?</td>
<td>43</td>
<td>57</td>
</tr>
</tbody>
</table>

**Key findings**

Electricity costs in the past were regarded as a small aspect of the overall costs on a dairy farm, but with electricity expenditure on a larger percentage of dairy farms now accounting for up to 1p/litre equivalent and beyond, a greater focus is required.

According to Farm Energy Centre reports, typical dairy farms consume 53% of electricity costs through milk cooling, whilst a further 33% applies to water heating – so mitigation activities in the parlour/dairy can provide useful savings.

Accessing of economy 7 tariffs for milk cooling, water heating and milking present opportunities for all units, whilst pre-cooling through plate coolers is now common practice, and others now engage in the use of ice builders within tank cooling and passing iced water through pre plate coolers. These activities, which also integrate with Heat Recovery Units, enhance the position even further.

2.1 Auditing

Now that you have an idea of where your enterprise sits within industry benchmarks, the next step is to get a better understanding of the potential savings that can be made.

There are some simple tools that can help you audit your energy use and monitor energy consumption.

**Smart Meters; a glimpse into the future**

An accurate record of your electricity consumption can be obtained through the use of a Smart Meter. A Smart Meter will allow you to monitor your energy usage on an hourly basis, reducing the financial risk of estimated bills.

The government have a target to have Smart Meters installed on every property over the next 10 years. Unless you have already installed your own meter, it is unlikely you have one currently.

Installation of a smart meter could cost you up to £200 and at present the meters are not compatible between electricity companies. However, if you are considering changing electricity suppliers, some of the utility companies will offer you a free smart meter as part of their switching package.

Smart meters are easy to use and it is straightforward to utilise the information that they provide to reduce energy use.

The key advantage of smart meters is that they allow you to remain informed about where and when your electricity is being consumed and more effectively predict the impact of price rises on future bills. This means that you can target the areas that electricity is being used and help to reduce the consumption. Smart meters will also flag up a peak in electricity use when not expected, helping to identify faulty machinery.

Conducting an Energy audit is the best way to identify any hotspots in your energy usage. The best way to carry this out is to use a portable energy monitor, as shown below, to pinpoint energy usage by piece of equipment or supply. The Energy Monitor is simply attached to the feed on equipment, usually by clipping round the wire, and give you a reading of the usage on that piece of equipment. They are also able to be placed on your meter and give a live feed of energy usage which can be used, by selective switching of equipment to identify high energy users.

**Energy monitor examples**

When you are conducting the energy audit be sure to bear in mind not just the current rating of the equipment but its usual usage pattern and also its annual usage. For example in an office a 3kW bar heater will work out at the following high cost for the year even though it is not a very high peak energy user:

<table>
<thead>
<tr>
<th>Equipment usage</th>
<th>Hours per day</th>
<th>Days per Year</th>
<th>Total kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>3kW</td>
<td>8</td>
<td>250</td>
<td>6,000</td>
</tr>
</tbody>
</table>

At 10p/kWh this works out as £600 per year for a small office heater.

2.2 Prioritising

Prioritising is how you decide which measures to implement first and where best to commit financially.

The factors to consider are:

1. Are there simple, low cost measures I can make to my current operations that will improve my energy efficiency?
2. Where can I have the biggest impact on energy usage and costs within my business?
3. Should I concentrate on energy saving or energy generation through renewables?

In practical terms our advice would be:

1. Begin with low cost measures. You are more likely to see a better return on your money through low cost energy saving measures than on a high cost new project.
2. If you have a strong wind, south facing roofs or a head of water then it is likely you have good potential for renewable energy on the farm. In this case investment in renewables might give you a better payback than energy saving measures.
3. Look at the activities on your farm that are intensive users of energy. Consider what energy saving technologies or improved behaviours can be introduced.

This report is focused on the direct use of energy on the farm. It does not look at the indirect use of energy through the production of items such as tractors, farm machinery, bought in feeds, fertiliser and drugs/dairy chemicals but it may be that you want to look at these as a separate issue.

Between the farming sectors energy use varies. We have detailed overheads where, within each sector, the main energy saving potential exists.
2.3 Making change

It is likely that in order to reduce your farm GHG you will need to make changes. Some of these can be low or no cost measures, such as remembering to switch off lights, others may require a financial investment.

Whenever you consider a resource use on your farm, be it energy, water or other resources, it is important to adopt a two pronged approach.

On the one hand is the technology being used:

- The most efficient available?
- Well maintained?
- Suited to the task?

One the other hand, and often overlooked, is how the technology is used:

- Is it turned off when not in use?
- Is it used appropriately?
- Do people have sufficient skills to use it properly?

If you adopt the two pronged approach it will ensure you address the potential savings in a comprehensive manner and are far less likely to miss opportunities.

Prior to outlaying on new technologies it may be worthwhile to carry out actions that can quickly improve the efficiency of your existing plant and equipment.

The list below is not exhaustive but is based upon information gathered when completing on-farm energy audits and serves as a useful basis for conducting your own energy audit.

| Hot water tank | – What condition is the insulation in?  
| – Does it need to be improved with a new cylinder jacket or a couple of cans of expandable foam? |
| Thermostat | – Are they working and are they set to the correct temperature? |
| Timer clocks | – Are they working? 
| – Is the time correct? |
| Electricity contract | – Have you checked when your off peak hours are? 
| – When is your contract due for renewal? 
| – Is your contract part of a group scheme? 
| – When does your contract end? |
| Smart meters | – Put an end to estimated bills and avoid problems of contracts being renewed without your knowledge. 
| – Have you got them installed? |
| Lighting | – When were the bulbs last cleaned? 
| – Are you using low energy bulbs? 
| – Are the lights on for longer than they need to be? |
| Water | – Are any taps leaking? 
| – Are pipes carrying the hot water from the cylinder insulated? |
| Compressors | – When did you last clean the grills? 
| – Is the airflow around the compressors sufficient? |
| Wash-down procedures | – Hot wash twice a day. 
| – Is the temperature set correctly? |
| Milking times | – Can you adjust your starting times to take more advantage of your off peak rate? |
| Tractors and machinery | – Are they regularly serviced and maintained? 
| – Are staff properly trained to use machinery? 
| – Fuel consumption can increase by up to 45% if machinery is not operated in an efficient manner. 
| – Where possible ensure the horse power of the tractor is appropriate to the task in hand. 
| – Make sure machinery is stored safely and if possible in a manner to deter theft. 
| – Consider using GPS technology to improve the efficiency of field operations. |
| Diesel | – Store in plastic bunded tanks where possible. 
| – Avoid storing diesel in dark coloured metal tanks that receive direct sun light. 
| – Up to 9 gallons of diesel a month can be lost due to evaporation from a 300 gallon metal tank in full sunlight. |
| Insulation (This particularly relevant to farms with cold stores) | – Are your buildings adequately insulated? 
| – Are there gaps in the insulation? 
| – Are seals in good working order? |

3.0 Technologies to cut cost and footprint

3.1 Milk cooling

The process of milk cooling is responsible for around 30% of the energy consumed on dairy farms making it one of the most important areas to target.

The first thing to consider is the efficiency of your plate cooler i.e. what reduction in milk temperature is it achieving.

The minimum it should be achieving is 10°C and if you’re pre-cooling is very efficient reductions in temperature of 20°C can be achieved. If your plate cooler is working efficiently the milk exiting the system should be within 2–4°C of the temperature of the water entering.

Table 7 below displays the effect of plate cooler efficiency on the annual cost of cooling milk.

<table>
<thead>
<tr>
<th>Cooling provided by water source (°C)</th>
<th>kWh (per 100 litres)</th>
<th>Pence (per 100 litres)</th>
<th>Annual cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pre cooling</td>
<td>1.4</td>
<td>13.44</td>
<td>1,343</td>
</tr>
<tr>
<td>10</td>
<td>0.95</td>
<td>8.68</td>
<td>867</td>
</tr>
<tr>
<td>15</td>
<td>0.73</td>
<td>6.80</td>
<td>679</td>
</tr>
<tr>
<td>20</td>
<td>0.50</td>
<td>4.67</td>
<td>467</td>
</tr>
</tbody>
</table>

This assumes a Day rate 10.85p/kWh. Night Rate 6.4p/kWh. One million litres produced annually. DX Tank less than 10 years old with no Ice Builder.
The list below details how to see if your plate cooler is efficient.

**Size**
- Is your plate cooler the right size?
- If you have increased herd numbers since your plate cooler was installed then it could now be too small.

**Water flow**
- Do you have sufficient water flow?
- The ratio between water and milk should be 2:1.
- Plate cooler design relies upon an even flow of milk but this is not the case unless you have a variable speed milk pump fitted.
- If your milk pump is only single speed the flow of milk will be intermittent.

**Plumbing**
- The water flow should be in the opposite direction to the milk.

**Temperature of your water source**
- Ideally the water wants to come from the coldest source on the farm which on many farms will be a borehole or well.
- In the summer months the temperature of mains water will rise significantly so this will reduce the efficiency of the plate cooler.
- If you can have underground water storage the temperature could be as low as 8°C which would provide an excellent contrast to the temperature of the milk when it leaves the cow.

**Time delay solenoid valve**
- Should be fitted to ensure the water supply to the plate cooler starts at the same time as the milk pump and continues to run for a short period after the milk pump stops working.

The efficiency of your plate cooler can be significantly enhanced through a variable speed milk pump as opposed to a single speed milk pump. A variable speed milk pump will ensure a consistent flow of milk through the plate cooler. A single speed milk pump only transfers milk when a set level is reached.

Use of a single speed milk pump means that water is often flowing through the plate cooler when no milk is passing through. When the single speed milk pump kicks in the volume of milk passing through the cooler exceeds the ideal 2:1 ratio between the water flow and milk flow.

There is little difference between the energy use of a variable speed milk pump and a single speed pump. The equation of whether the capital investment is worthwhile is solely linked to the improvement in milk cooling that can be achieved.

A variable speed milk pump will cost around £1,500–£1,750 to buy and install. Research suggests that a variable speed milk pump can improve pre-cooling by 5°C. Based on table 3, on previous page, a 5°C improvement is worth around £200 a year. This gives a capital payback period on buying a new variable speed milk pump upwards of 7 years. The actual efficiency gain you achieve will be linked to how good your existing water supply and flow to the plate cooler is; the poorer your supply the greater the benefit. If you can boost the water supply to the plate cooler this could have a bigger impact and at a lower cost.

**Two stage pre cooling**
Many farms will have two plate coolers fitted. Usually the first plate cooler is supplied with water from the borehole/mains with the second plate cooler being supplied with water that has been chilled using an ice bank.

The benefit of this 2 stage process is that the milk should be entering the bulk tank at a storage temperature of 3.5°C. As a result all the bulk tank has to do is maintain this temperature.

The costs of running an ice-bank to chill the water for the second plate cooler will be relatively high. When compared to running a DX bulk tank with cooling being conducted by the DX tank, the costs could be higher.

The key to cost/benefit calculations will be your off peak electricity price per kWh compared to your peak electricity price per kWh, i.e. can the ice-bank build sufficient ice during the off peak period whilst rates are cheaper.

**There are 2 further aspects to milk cooling that are often overlooked:**
1. The type of compressor fitted to your bulk tank. For many years ‘reciprocating compressors’ were fitted to bulk tanks but these are not very energy efficient. Newer tanks with a ‘scroll compressor’ should have been fitted and it is important to check that this is the case if replacing your bulk tank.
2. Condenser unit position and maintenance. Condenser screens should be cleaned at least twice a year to maintain efficiency. Cool Airflow around the condenser is vital and this needs to be maximised to maintain efficiency.

**Types of vacuum pump: performance**

**3 Main types of vacuum pump in use are:**
- Rotary Lobe (blower) Pump
- Water Ring
- Sliding Vane Rotary

The different pumps have their own individual features with some types being more energy efficient than others and some types being better suited to variable speed vacuum.

- The Rotary Lobe (blower) Pump is both the most energy efficient and the most suited to variable speed vacuum.
- The Water Ring Pump is not very energy efficient and not suited for variable speed vacuum.
- The Sliding Vane Rotary Pump is ok from an energy efficiency angle but is not that suitable for variable speed vacuum when operating under a single phase electricity supply.

Check with your dairy engineer what type of pump you have and its suitability for variable speed vacuum.

**Variable speed vacuum: savings and challenges**

Conventional vacuum pumps operate at a constant speed and use a vacuum regulator to admit air into the system to maintain a constant level of vacuum.

Fixed speed vacuum pumps operate at the speed necessary to deliver the theoretical maximum level of vacuum demand. This is often in excess of what is required for the normal operating of the parlour. The extra vacuum capacity is built in to cover unusual events like multiple cluster kick offs. As a result the vacuum pump is operating at a much higher speed than is needed for the normal milking routine, wasting electricity as a result.

To avoid this waste of energy you can purchase a new variable speed vacuum pump or retrofit a Variable Speed Drive (VSD) to your vacuum system.

Unless your fixed speed vacuum pump is nearing the end of its life it is unlikely to be economic to purchase a brand new variable speed pump.

With variable speed control systems the computerised VSD controller is electronically installed between the vacuum pump motor and the motor control switch. The regulator is replaced with a pressure sensor and this is connected to the VSD controller. The VSD controller constantly monitors the vacuum level and adjusts the motor speed accordingly.
Trials have indicated that variable speed vacuum can reduce electricity consumption by anywhere between 30% and 70% with 40%–50% being the average.

Table 8 below details the annual energy and financial savings from the installation of VSD to a fixed speed pump costing £955 per annum to run.

### Table 8

<table>
<thead>
<tr>
<th>Percentage saving from VSD</th>
<th>Energy Saving (kWh)</th>
<th>CO2 saving (tonnes)</th>
<th>Financial saving (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>3,265</td>
<td>1.73</td>
<td>287</td>
</tr>
<tr>
<td>40</td>
<td>4,380</td>
<td>2.31</td>
<td>382</td>
</tr>
<tr>
<td>50</td>
<td>5,475</td>
<td>2.89</td>
<td>478</td>
</tr>
<tr>
<td>60</td>
<td>6,570</td>
<td>3.46</td>
<td>573</td>
</tr>
<tr>
<td>70</td>
<td>7,665</td>
<td>4.04</td>
<td>669</td>
</tr>
</tbody>
</table>

### Key points to consider with variable speed vacuum:

- The technology is most suited to a lobe pump or sliding vane pump on a three phase electricity supply.
- If you are on a single phase electricity supply you will need to discuss the options with your dairy engineer as different manufacturers recommend different courses of action.
- One VSD unit can run up to 3 vacuum pumps.
- The longer that your milking routine takes, the greater your saving from introducing variable speed technology.

### Non energy benefits of variable speed vacuum

The benefits of variable speed technology are not just financial. Table 9 below details these benefits:

<table>
<thead>
<tr>
<th>Table 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Life</td>
</tr>
<tr>
<td>Reduced Noise Levels</td>
</tr>
<tr>
<td>Increased Herd Health</td>
</tr>
</tbody>
</table>

### Vacuum pump maintenance

To keep your system operating as efficiently as possible it is important to have a maintenance programme and this should include:

- Cleaning the regulator filter on a regular basis.
- An annual service of the vacuum system to check pump oil level, condition of the pipes and the tension of the belts from the motor to the pump.
- With rotary lobe pumps, cleaning to remove accumulated chemical residue.

### Case Study

**Bicton Home Farm: Vacuum on Demand pump (VoD)**

Please turn to page 32 for details.

### 3.3 Water heating

Typically, dairy farms will have 2 or 3 water heaters:

- A main water heater to provide hot water for cleaning the milking system.
- A second water heater to provide hot water for cleaning the bulk tank.
- On some farms a third heater to provide hot water for udder washing.
- Livestock farms will often have a water heater to provide warm water for calf feeding.

Hot water heating typically accounts for around 30% of the electricity used on dairy farm. It should be one of the main areas you target when looking at energy efficiency on the farm.

#### Frequent issues with water heating on farm are:

- Water being heated on costly peak rate electricity.
- Inadequate insulation on tanks.
- Age of equipment.
- Hard or soft water creating efficiency issues.
- No time clocks or thermostats, or they are not working.
- Tank size not appropriate.

#### To review the efficiency of your water heating there are some simple questions to work through:

1. **Are you heating the correct amount of hot water for your dairy herd and plant?**

   The size of your main water heater should correspond to the number of milking points in the parlour and be sized accordingly. Table 10, above right, gives an idea of the appropriate tank capacity.

   If your tank is too large you may be heating large quantities of hot water unnecessarily. If your tank is too small additional heating on expensive peak rate electricity might be required to top up the system.

2. **How old is your water heater and are the timers/thermostats set correctly?**

   Older water heaters are unlikely to demonstrate great efficiency in converting electricity to hot water.

   The level and type of insulation on your tank has a dramatic effect on efficiency as table 11 below demonstrates:

   **Table 11**

<table>
<thead>
<tr>
<th>Level of insulation</th>
<th>Annual cost to heat 210 litres of water (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1,419</td>
</tr>
<tr>
<td>25mm Glassfibre</td>
<td>155</td>
</tr>
<tr>
<td>25mm Polyurethane</td>
<td>91</td>
</tr>
<tr>
<td>50mm Polyurethane</td>
<td>55</td>
</tr>
</tbody>
</table>

   Modern water heaters will have high levels on insulation built into their design. If you have older water heaters discuss the insulations levels with an electrician and see if they can be improved.

   **Table 10**

<table>
<thead>
<tr>
<th>Number of milking points</th>
<th>Tank capacity (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–2</td>
<td>65</td>
</tr>
<tr>
<td>3–6</td>
<td>110</td>
</tr>
<tr>
<td>7–8</td>
<td>160</td>
</tr>
<tr>
<td>9–12</td>
<td>225</td>
</tr>
<tr>
<td>13–16</td>
<td>295</td>
</tr>
<tr>
<td>17–20</td>
<td>360</td>
</tr>
<tr>
<td>21–25</td>
<td>450</td>
</tr>
<tr>
<td>26–30</td>
<td>545</td>
</tr>
<tr>
<td>31–38</td>
<td>680</td>
</tr>
</tbody>
</table>

   **Table 12**

<table>
<thead>
<tr>
<th>Main wash-down</th>
<th>85–90°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk tank washer</td>
<td>85°C</td>
</tr>
<tr>
<td>Udder wash</td>
<td>35°C</td>
</tr>
</tbody>
</table>

3. **Do you have a heart recovery system installed or have you considered installing one?**

   During the milk cooling process heat is expelled from the condenser of the bulk tank refrigeration system. This heat is transferred into the surrounding air and in effect wasted. The refrigerant leaving a milk cooling compressor can be 70–80°C and so it makes sense to try and utilise this heat for water heating purposes.

   A Heat Recovery Unit captures some of the ‘waste heat’ and through a heat exchanger uses it to warm cold water. Following this it enters the water heaters where the temperature is then topped up to the required level.

   A Heat Recovery Unit can take water temperatures to between 45 and 60°C. At these temperature levels a reduction in water heating costs of up to 50% can be achieved.

   The design of heat recovery units varies between manufacturers with there being 2 basic types:

   - Flow Based Heat Recovery
   - Storage Based Heat Recovery

   Storage Based Heat Recovery is probably the most common. It involves the heat exchanger heating water within a storage tank. This in turn is used as a header tank for the main water heater.

   The cost of a Storage Based Heat Recovery System would typically be between £4,000 and £7,500 depending upon the size of the system and complexities of installation. The potential capital payback periods are between 4 and 6 years.

   The annual cost savings that can be achieved through the installation of a heat recovery unit are shown in table 13 below:

   **Table 13**

<table>
<thead>
<tr>
<th>Ambient cold water temperature (°C)</th>
<th>Temperature uplift from HRU (°C)</th>
<th>Temperature after effect of HRU (°C)</th>
<th>Annual kWh saving</th>
<th>Annual CO2 saving (tonnes)</th>
<th>Annual savings (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>30</td>
<td>45</td>
<td>9296</td>
<td>4.90</td>
<td>744</td>
</tr>
<tr>
<td>15</td>
<td>35</td>
<td>50</td>
<td>10,846</td>
<td>5.72</td>
<td>868</td>
</tr>
<tr>
<td>15</td>
<td>40</td>
<td>55</td>
<td>12,395</td>
<td>6.53</td>
<td>992</td>
</tr>
<tr>
<td>15</td>
<td>45</td>
<td>60</td>
<td>13,945</td>
<td>7.06</td>
<td>1,116</td>
</tr>
</tbody>
</table>
The benefits of poultry house heat exchangers are being published in the farming press and some manufacturers offer a ‘buy back’ scheme if you are not happy with the impact of the machine.

- Exchanger tubes the cold incoming air to a shed, is pre-heated and gas consumption is reduced by around 50%.
- The manufacturers of the machine claim that on 30,000 birds, 1,800 litres of gas are saved and, across 12 months, carbon emissions are reduced by 5,000 kgs.
- Trial data from the manufacturers indicate better weight gain for the chicks, reduction in feed consumption and reduction in use of litter. Based on 30,000 birds, cost savings of £7k p.a. were reported against a capital outlay of £25k.

The choice of manufacturers has been previously limited and until recently there have been very few options available to producers. As the technology is becoming widely used more manufacturers are developing the technology, bringing prices down and making it more obtainable.

Below are the claims of one manufacturer:

- Trials of the unit across 35 farms have indicated an average gas saving of 52.9%.

The units work by saving up to 80% of the energy that is discharged from poultry houses by normal ventilation methods – by passing the hot exhaust air over heat.

### 3.4 Poultry house heat exchangers

Intensive poultry producers face high energy costs through the need to manage the temperature and ventilation in poultry sheds. These energy demands vary with:

- The time of day and seasons.
- The stages in the life cycle of the flock.

If the conditions within a shed are not efficiently managed flock health and performance will suffer.

Poultry House Heat Exchangers have been specifically developed for the industry to both reduce costs and improve management. They consist of an air to air heat exchanger which captures the heat from the exhaust ventilation within a poultry shed. This heat is then used to warm the incoming air to the shed. The benefits of this are:

- Up to a 50% reduction in the energy required to maintain the required temperatures within poultry sheds.
- Improved flock health as dust and ammonia emissions are captured in the heat exchange process.
- Heat Exchangers are available to suit a wide range of flock sizes. They can be retrofitted to the outside of existing sheds.

### Lighting types

#### Tungsten bulbs

Otherwise known as incandescent light fittings, tungsten bulbs emit light through a filament. The filament is surrounded by a low pressure inert gas (often argon or neon) and has been the most commonly used light bulb in domestic and commercial settings. Some main points to consider are:

- A wide range of fittings and wattages available.
- Has the advantage of being dimmable to low levels which can be useful in agricultural settings.
- Very inefficient light bulb as 90% of the power consumed is emitted as heat rather than visible light.

#### Halogen lighting

Halogen lighting is an incandescent lighting type due to the tungsten filament and has a similar nature of fitting as tungsten bulbs. The filament is surrounded by inert gases but also a small amount of halogen which enables the light to operate at higher temperatures and emit a higher quality light. Halogen lighting is commonly used for flood lighting of yards and buildings.

#### Fluorescent lighting

Fluorescent tubes are a type of gas discharge lamp and use mercury gas in the tubes to emit light. They are more efficient than incandescent bulbs and use less power to produce the same amount of light. Some main points about fluorescent lighting are:

- Commonly used as strip lights to light offices and other smaller internal areas.
- Can be classified by diameter of the tube.
- There are 3 main types of tube lighting T12, T8 and T5 with the T number relating to the number of eighths of an inch diameter:
  - Wide older style tubes are likely to be T12 type and are the least efficient.
  - T8 tubes are slightly thinner and have been commonly fitted as standard.
  - T5 tubes are the thinnest fluorescent tubes available and are also the most efficient.
- The difference in efficacies as you go up the T numbers is about 30%.
- May face issues where dimming is required as will only dim to a stated level and then cut out.
- May have to change the ballast fittings.

#### Compact fluorescent lighting (CFL)

Using the same technology as fluorescent lighting these fittings have been engineered to replace the standard smaller tungsten bulbs found in domestic situations. They have:

- Low running cost.
- Straight replacement for tungsten bulbs and come in similar fittings.
- Quick run up to full light output.

### Sodium fittings

Sodium lighting is a type of gas discharge lighting and can be split into low pressure and high pressure varieties as detailed below.

#### Low pressure sodium

- Takes 4–6 minutes to warm up and reach optimum output.
- Emits a yellow/orange light.
- Most common everyday use as street lighting.
- Agriculture use common in low light quality areas.

#### High pressure sodium

- Takes 4–6 minutes to warm up.
- Emits a pink glow when warming up but is a whiter light than the low pressure sodium.
- Used where light quality is more important.

### Metal halide lighting

Similar method of operation to sodium and fluorescent lighting but the gases include metal halides to produce light source. Metal halide lighting:

- May take 1–2 minutes to warm and reach optimum output.
- Whiter light produced than sodium fittings.
- Commonly used to light large external areas.
- More efficiency than sodium fittings.

### Light emitting diodes (LED)

LED lights are regarded as the future of lighting. They provide high lumen of light whilst consuming very low watts of energy.

The development of LED lights for agricultural use is at an early stage. When changing lights or bulbs you should ask your electrician or electrical supplier what the LED options are.

It is particularly important to consider whole-life costing of lighting as a slightly more expensive initial cost can lead to considerable energy savings over the lifetime of the bulb.
Comparison of lighting energy efficiency

The efficiency of lighting can be measured in lumens per watt (lm/W). The fittings measured above can be rated against each other in their effectiveness to produce light from power input. This is shown in diagram 2 below.

Diagram 2

<table>
<thead>
<tr>
<th>Lighting controls</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Pressure Sodium</td>
<td>LED</td>
</tr>
<tr>
<td>High Pressure Sodium</td>
<td></td>
</tr>
<tr>
<td>Metal Halide</td>
<td></td>
</tr>
<tr>
<td>Compact Fluorescent Tubes</td>
<td></td>
</tr>
<tr>
<td>Halogen Lighting</td>
<td></td>
</tr>
<tr>
<td>Tungsten Bulbs</td>
<td></td>
</tr>
</tbody>
</table>

Lighting on farms is frequently left on for longer than necessary and often does not have any automatic control devices. There are various fittings available for lighting control. These include:

- Occupancy sensors which can detect if someone is entering building/room. These can also be set to automatically switch off again if no movement is detected after a certain period.
- Dusk/dawn sensors can be fitted to trigger the switching on/off of lights as the light levels change.
- Timers can also be used to control when lights switch on/off.
- Combination sensors can incorporate any of the 3 above.

3.6 Water efficiency and rainwater harvesting

One of the biggest challenges facing agriculture in the future will be the availability of water. Climate change, an increasing population and the urbanisation of the countryside are impacting upon a resource that for years we have taken for granted.

Water on farms will either come from an on-site supply (borehole or spring) or from the mains. Typical costs per cubic metre are shown in table 14 below.

| Table 14
| Mains | £1.40–£2.00 per m³ plus a standing charge |
| Borehole/abstraction | £0.15–£0.30/m³ |

As costs will almost certainly increase in the future it is important to consider how you can conserve water by:

- Preventing and repairing leaks, fixing dripping taps and hose pipes.
- Reducing water pressure.
- Alternative washing and cleaning processes.
- The correct schedule of irrigation to meet crop needs and reduce evaporation.

Another option to consider is rainwater harvesting. This is done by capturing the water from your farm building that would otherwise have been lost through evaporation or soaking into the ground.

Buildings under construction present the ideal opportunity to install a rainwater harvesting system but it can also be added to existing structures. There are systems available to suit all needs and budgets. A simple system might be created by diverting roof gutters into a storage tank. A more complex system could involve pumped storage, filters and UV treatment for use on ready to eat crops.

A simple calculation detailed below can be used to determine how much rainwater you can harvest. You will initially need to measure the roof area in m² and your average rainfall in mm.

Multiply the roof and rainfall readings by a coefficient as not all the rainfall on a roof will drain away (0.8 for pitched roofs and 0.5 for flat roofs). Finally, add a filter coefficient if filters are used in the downpipes to remove contaminants (0.9 filter coefficient). An example can be seen in table 15 above right.

Table 15

| Roof area | 1,500m² |
| Average annual rainfall | 819mm |
| Rainfall coefficient | 0.8 |
| Filter coefficient | 0.9 |
| Annual collection volume | (1,500 x 819 x 0.8 x 0.9) + 884m³ |
| Annual cost saving | £1.50 per m³ = £1,326 |

3.7 Precision farming techniques

Precision Farming refers to the electronic equipment used to improve the efficiency and precision of farm operations. This in turn can help optimise the use of a farm’s resources and inputs.

In the context of energy efficiency the main benefit of precision farming is the reduction in fuel use for field cultivations. This reduction can be achieved through using GPS (Global Positioning System) guidance:

- Tractor – reducing overlapping on cultivations and leading to more efficient field work.
- Combine – keeping a full cut thus maximising output.
- Sprayer – minimising over-lapping.
- Auto-steer – these benefits are enhanced with the added bonus of reducing operator fatigue.

Many new tractors and combines have performance monitoring, including fuel use, fitted as standard and this will alert the driver to inefficient use. This helps improve the overall cost effectiveness of operations. Telemetry can relay this information to a specialist who can provide immediate advice on more efficient operation.

The cost effectiveness of investing in Precision Farming Technology will depend upon the scale and efficiency of your present farming operations. It will also be important to ensure that all staff are trained in the use of the new technology.

4.0 Renewables

Renewable technologies will generate either electricity or heat and sometimes both. In order to install renewables you need to decide what you are looking to generate.

You must also decide if your objective is:

- To help reduce the energy you have to purchase.
- To cover your own energy use and be self-sufficient.
- To generate more than your own energy use and generate a revenue.

If you are going to generate the electricity you have to have permission from your District Network Operator (DNO) before connecting any device of 5kWh or above to the national grid. Your DNO will decide what amount of generating technology can be installed. This will be strongly influenced by whether you have:

- A single phase; likely to limit the size of your installation to the 6kW–15kW range.
- Split phase; this range extended to 20kW.
- Three phase electricity supply extends the range to 50kW and above depending upon the capacity of the national grid in your area.

Some points to take into account when looking at your renewables options are:

- If generating electricity and connecting to the grid there will be connection charges to pay. These may be as low as £2,000 but if a new transformer is required and you are upgrading your line costs then this could be in excess of £20,000.
- If you upgrade to 3 phase you might need to change all your motors.
- Obtaining planning permission takes a long time, around 20 weeks.
- Consider the financial safety of the company you are buying from.
- Is the company you are dealing with a member of the Renewable Energy Association and obliged to follow their code of conduct? If they are not members of the REA should you be dealing with them?

If looking to generate electricity to sell onto the national grid it is important to be aware that government incentives and payments can change with short notice.

Case study

- Paignton Zoo;
- Controlled environment agriculture

Please turn to page 38 for details
We deal with renewable technologies in the following order:
- Wind
- Solar PV
- Solar Thermal
- Hydro
- Heat Pumps
- Biomass
- Anaerobic Digestion

4.1 Wind

Wind power was commonly used on farms 50–100 years ago to power water pumps. This use has died out with water pumps now being powered by electricity.

Wind power is now used to power turbines which generate electricity. The introduction of Feed in Tariffs (FiTs) in April 2010 has seen this become an attractive financial option for many farms.

There are many wind turbines on the market and they all have variations in height, blade design, power output and track record. Typically, on farms where the primary purpose is to meet the onsite electricity demands, we see turbines ranging in size from 11kW to 100kW.

Table 16 below shows a guide to the electrical output from turbines at a wind speed of 6 metres per second:

### Table 16

<table>
<thead>
<tr>
<th>Turbine Size</th>
<th>Electrical Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>11kW turbine</td>
<td>35,000kWh – 42,000kWh</td>
</tr>
<tr>
<td>20kW turbine</td>
<td>57,000kWh – 67,000kWh</td>
</tr>
<tr>
<td>50kW turbine</td>
<td>150,000kWh – 170,000kWh</td>
</tr>
<tr>
<td>100kW turbine</td>
<td>260,000kWh – 300,000kWh</td>
</tr>
</tbody>
</table>

The amount of electricity generated by a turbine is dependent upon the wind speed. This speed is assessed as an average speed over 12 months and measured in metres per second (m/s). It is important to remember that on some days the wind does not blow and a turbine will not produce any electricity.

### The basics

- For a wind turbine to be economically viable an average wind speed of above 5m/s is required at its proposed location.
- You can get an indication of the wind speed for your postcode from the Department of Energy and Climate Change (DECC) website that provides a link to the NOABL wind speed database.
- The wind speed from the NOABL database is the indicative speed for a 1km square based on your grid reference. It can vary in terms of accuracy and on-site wind monitoring for a 6 to 12 month period should be undertaken to obtain a more accurate wind speed.
- A wind turbine must be located at least 250m from the nearest neighbouring residential property and 50 metres away from the nearest hedge (if a turbine is to be closer than 50 metres to a hedge a bat survey will be required).
- A connection into the national grid will usually be required and the ability and cost of achieving this must be determined from your DNO at a very early stage.
- Income from a wind turbine is usually derived from 3 sources:
  - The FiTs you receive for each kWh unit of electricity generated.
  - The cost saving of the electricity you no longer have to buy.
  - The income from the electricity you sell.

To receive the FiTs your turbine must be have passed the Microgeneration Certification Scheme (MCS) guidelines. You should obtain written confirmation from the turbine supplier that their turbine is eligible to receive the Feed In Tariff payments.

### First steps

If you believe that your farm has the potential for a wind turbine we would suggest that you firstly establish the wind speed for your farm through the DECC website.

If the indicative wind speed for your farm is greater than 4.5 metres per second at a height of 10m, contact turbine manufacturers and ask them to undertake an initial site visit.

Many firms will offer to undertake a desk top assessment of your site for you. We would not recommend that you pay for this service as, in our experience, much of the information they provide can be obtained by you on the internet.

Contact your local DNO office and enquire what size turbine they would allow on your line and if your transformer will need to be changed.

### Next steps

If after the above initial steps the indications are that you have a good potential site and you are still interested we would suggest that:

1. You obtain a detailed site survey on the proposed location. The turbine manufacturers do provide this service but you can also obtain surveys from consultants who are independent of technology manufacturers.
2. Discuss the proposed project with your professional advisers.
3. If finance for the turbine will be required, discuss with your bank or an asset finance company.
4. Discuss your proposed project with a planning professional and obtain guidance from them on how to proceed.
5. Obtain a formal quote from your DNO on the grid connection charges.
6. Consider engaging an independent consultant to review your proposed project.

When you have gathered information from the above sources you will be well placed to reach a decision on whether to pursue your project. If you decide to proceed obtaining planning should be your first focus.

### Planning permission

Planning permission will always be required for a wind turbine irrespective of size.

#### Factors that influence obtaining planning permission for a turbine are:

- The size of the turbine.
- Proximity to roads and rights of way.
- Proximity to dwellings and hedges.
- Visual impact on the landscape.
- Ecological impact on the surrounding area.
- Noise impact from the turbine.
- The locality of a National Park or Area of Outstanding Natural Beauty.

It is recommended to use the services of a professional firm to apply for your planning permission and one that has expertise in the sector. Before engaging their services obtain fee quotes from them and make sure you understand what work the quoted fees will cover.

### Operation and maintenance

Wind turbines will require annual mechanical checks and servicing. The sensors built into a turbine also monitor the performance of each turbine component and will automatically shut the turbine down if any problems are detected. This will alert an engineer that a site visit is required.

**When considering which turbine to buy it is very important that you:**

- Consider what the annual servicing costs will be.
- Consider what warranty is offered by the manufacturer.

You should be looking for a minimum of 5 years, ideally 10, and a warranty that covers parts and labour ideally.

- When you enter into a contract to buy a turbine make sure you are aware of the terms of the deposit.

Although the majority of turbine manufacturers and turbine sellers are very professional we would always recommend using the services of an independent professional.

As wind is eligible for the FiTs it is important to be aware that the tariff amounts for these can change at short notice thus affecting the viability of a project.

### Case study

- **Frinkley Farm; Large scale wind**
  Please turn to page 40 for details
- **Cloverbank Organic Farm; Small scale wind**
  Please turn to page 42 for details
- **Bridgehouse Farm; Solar PV and wind**
  Please turn to page 44 for details
4.2 Solar

Sunlight or solar energy is probably the easiest source of renewable energy to access. Solar energy, radiant light and heat from the sun, is harnessed through solar panels which in the UK take 2 formats:

1. Solar Photo Voltaic (PV) panels for the production of electricity.
2. Solar thermal panels for the heating of water.

Solar PV

A good quality Solar PV system will generate electricity for at least 25 years. This:

- Limits your exposure to rising energy costs.
- Allows you to receive money from the FITs for every kWh of electricity generated.
- Reduces your environmental impact.

The important thing to remember is that solar panels only work when there is day light and need sunlight to reach peak power generation.

A dairy farm for instance requires electricity 365 days a year so during the winter months the PV panels are only going to provide a minor contribution to the electricity you need.

During the summer months solar panels will be generating at their peak during the middle part of the day. If you are milking twice a day this is not going to match your periods of peak demand.

From the headline number of kWh PV system will generate, the percentage of these that you actually consume might be as low as 30%. However, you get extra income from the FITs for every unit you export onto the grid.

What is a solar PV installation and what do I need?

Solar PV panels are fitted onto metal racking which can either be ground mounted or roof mounted.

Sunlight is converted into direct current (DC) electricity by the silicon inside the PV panel. This is then changed into alternating current (AC) through an inverter which is usuable within your building.

You will need to connect your system to the national grid and permission from your DNO will be required. If you are on a single phase supply the size of your solar PV system will be limited to the 10kW to 20kW range.

Meters are fitted to the system to record:

- The total number of kWh units generated (a total generation meter).
- The number of kWh units that are not used within your business and exported to the national grid (an export meter).

The approximate space required for each kWp of the PV installation is detailed in table 18 below:

<table>
<thead>
<tr>
<th>Array Type</th>
<th>Space Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof mounted</td>
<td>8.5m²</td>
</tr>
<tr>
<td>Ground mounted</td>
<td>10m² - 13m²</td>
</tr>
</tbody>
</table>

A roof mounted system will require structural integrity for the lifetime of the panels, around 40 years. It is recommended that a full structural survey is undertaken.

Sighting a solar PV system

There are 4 main factors, detailed in table 19 (opposite), which will impact how much energy a solar PV system will generate.

How do I proceed?

There are many Solar PV companies now operating and picking the right company is not easy. Solar PV companies will be happy to provide you with a free initial assessment on your potential for a successful PV installation. This initial assessment should be discussed with your professional advisors before deciding whether to proceed further.

We would suggest choosing a company that can demonstrate a long track record in the industry or using one of the large Farmer Co-operative that have set up specialist Renewable Energy Teams to assist their members.

Next steps would include:

- Obtaining a detailed project feasibility study.
- Obtaining a Structural survey if a roof mounted scheme.
- Commencing the process of applying for planning permission.
- Applying to your DNO for permission to connect your system to the grid.

Table 19

<table>
<thead>
<tr>
<th>Shading</th>
<th>% of sky blocked by obstacles</th>
<th>Overshading factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy</td>
<td>&gt;80%</td>
<td>0.5</td>
</tr>
<tr>
<td>Significant</td>
<td>60%–80%</td>
<td>0.65</td>
</tr>
<tr>
<td>Modest</td>
<td>20%–60%</td>
<td>0.80</td>
</tr>
<tr>
<td>None</td>
<td>&lt;20%</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Orientation

- The further South that a PV array is facing the more direct sunlight it will receive and the more energy it will produce.
- In general you should only site a solar PV array so that it faces between the South East and South West otherwise it’s energy generation will be significantly reduced.

Angle

- To ensure that a PV panel maximises its exposure to direct sunlight it should be mounted at an angle.
- In the UK latitudes, the best angle is between 30 degrees and 45 degrees from horizontal.

Array size

- The larger the array of solar PV panels the more energy it will generate.
- A typical single PV panel may be mounted either horizontally or vertically as required.
- Any number of panels can be combined into a single array as required.

Solar PV: FAQ

Q. How much does it cost?
A. The total installed cost will vary from location to location. As a general guideline costs will be around £2,500 per kW installed (October 2011).

Q. How much energy will it generate?
A. As a guide a 10kW array will produce in the region of 8,300kWh a year.

Q. How do I get paid for my electricity?
A. You will benefit from the FITs which are paid on every kWh unit you generate. You will also benefit through saving the cost of the electricity you will no longer have to buy. For any electricity you do not use you get paid a set rate (3p as of October 2011) as it is exported to the national grid.

Q. Do I need planning permission?
A. You should always contact your Local Authority to check the position for your farm and scheme but for the vast majority of schemes it is probable that you will need to obtain planning permission. You will always need to advise Local Building Control of your proposed works.

Case study

- Cloverbank Organic Farm; Solar PV tracker
  Please turn to page 46 for details

- Frinkley Farm; Roof mounted 50kW solar PV
  Please turn to page 48 for details

- Black Dog Farm; Ground mounted 70kW solar PV and wind
  Please turn to page 50 for details
4.3 Solar Thermal

Solar hot water systems, Solar Thermal, use sunlight to heat water. The most common types of solar water heaters are evacuated tube collectors and glazed flat plate collectors.

To date on farm use of solar thermal water heating has been limited. As the installation costs reduce and technology advances, Solar Thermal is increasingly being seen as part of an ‘integrated energy solution’. Within an integrated solution Solar Thermal is providing part of the water heating requirement but not all. To use solar thermal in farming systems the most important step is to analyse your hot water needs.

Two recent developments mean that Solar Thermal should be high up on the list of energy saving technologies you are considering adopting:

1. The costs of Solar Thermal systems has fallen at the same time as the efficiency of the equipment has improved.

2. The new Renewable Heat Incentive (RHI) payments will pay you 5p as of October 2011 for every kWh unit of heat generated from a Solar Thermal system.

To receive the RHI payments the Solar Thermal system must be installed by an MCS accredited installer.

Solar Thermal panels come in two types, flat-plate collectors and evacuated tubes. Although slightly more expensive it is the evacuated heat tube systems that are more efficient and can deliver the higher temperatures, potentially as high as 60°C.

In a domestic environment the solar thermal panels transfer heat straight into the hot water cylinder through a twin coil mechanism. For farm installations it will be more efficient for the solar panels to heat the water within a thermal store. The water from the thermal store is then transferred to the water heater using control valves and timers. An example is shown in table 20 below.

<table>
<thead>
<tr>
<th>Table 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
</tr>
<tr>
<td>Cost</td>
</tr>
<tr>
<td>Heat provided</td>
</tr>
<tr>
<td>Value of heat</td>
</tr>
<tr>
<td>Annual savings</td>
</tr>
<tr>
<td>Payback period</td>
</tr>
</tbody>
</table>

4.4 Hydro

Hydropower is the common term for electricity produced from the kinetic energy of flowing water. Hydropower is the main source of energy in some 30 countries and produces approximately 20% of the world’s annual electrical output. Hydropower can range from very small systems producing just a few watts to systems incorporating some of the largest artificial structures in the world and producing thousands of megawatts.

Hydropower is a renewable energy. The water that drives the turbines and generators is supplied from the ‘water cycle’, which naturally replenishes the streams and rivers through rainfall. Modern water turbines are the culmination of 2,000 years of technological development from the water wheel to the present day’s extremely efficient water turbine.

Prior to the development of the integrated national electricity grid network many rural areas used water power on a small scale, from streams and rivers, to deliver power to local households, farms and businesses. This form of water power is known as ‘micro-hydro’ and we are now seeing considerable interest in redeveloping this form of local energy.

Essential aspects of hydropower

The two key aspects of a hydropower site are:

**Head**

- The height through which the water falls on the available section of waterway and measured in metres.
- It can be worked out by looking at OS maps or by using a surveyor’s theodolite.
- It is worth considering if you can co-operate with neighbouring landowners to access additional height.

**Flow**

- The volume of water flowing per second.
- The daily flow rate for a potential site should be recorded over a 12 month period to determine the ‘flow distribution curve’ and the ‘mean annual flow’ in litres per second (l/s) for the site.
- A certain minimum volume of water must be left in the river to protect the ecology of the river species known as the residual flow. The Environment Agency will advise on this figure.

In micro-hydro schemes the electrical power output (kW) is roughly six to seven times the product from the multiplication of these two figures.

Either the ‘head’ or the ‘flow’ needs to be a sizeable figure in order for a micro-hydro scheme to be economically viable.

Considering a site for micro-hydro potential

Schemes are generally classified into:

- **Low head schemes**
  - A head of around 1m–10m.
  - Often involve old mills and weirs.
  - Can offer a good return if a large enough flow is present.

- **Medium head schemes**
  - A head of 10m–50m.

- **High head schemes**
  - A head of 50m+.
  - Typically these will be fast flowing upland streams and rivers which have a low flow but a high head can be achieved.
  - These sites will usually be without previous development.

Best practice dictates that schemes which do not involve a store of water are based on the flow of water in the summer months i.e. the lowest flow rate.

Environmental issues

All hydro schemes have an environmental impact as they deplete the main water flow from a stretch of water. This depleted flow can adversely affect biodiversity. Therefore the amount of flow that can be taken from the main water flow to power a turbine is regulated and an ‘Abstraction License’ has to be obtained.

Turbines are not ‘fish friendly’. Adequate screening has to be installed both upstream and downstream to stop fish entering the turbine. Where migratory fish exist in a river a fish pass must be installed to enable fish to complete their journey upstream.

A well designed scheme will mitigate any environmental damage during construction and produce ‘clean’ energy over a very long period of time.

Grid connection

Micro-hydro schemes can either be connected to the grid or ‘stand-alone’ systems.

- Grid connected systems will require the power to be fed through an inverter back into the grid.
- Stand-alone systems will usually involve a bank of batteries, an inverter and a charge regulator. These can add significantly to the cost of a system.

Costs and economic return

Although initial set up costs can be quite high, a hydropower site has the capacity to run indefinitely, representing an attractive medium/long term investment. The new FITs have made a significant difference to the financial return generated by hydro schemes.

**An indication of installation costs can be seen in table 21 below:**

**Table 21**

**Low head**

- £4,000 per kW installed up to 10kW.
- Drops per kW for schemes greater than 10kW.

**Medium head**

- Fixed cost of about £10,000.
- £2,500/3,500 per kW up to around 10kW.

The cost of connecting the scheme to the national grid will vary considerably from location to location. These costs can be significant.

**Examples of economic return can be seen in table 22 below:**

**Table 22**

| Head (m) | 4.70m |
| --- |

| Flow (l/s) | 180l/s |
| --- |

| Average output (kW per hour) | 3kW |
| --- |

| Yearly output (kW) | 26,280kW |
| --- |

| Install cost (£) | £45,000 |
| --- |

| FITs tariff (as in October 2011) | 20.9p gives £5,492 |
| --- |

| Cost of electricity saved (based on 10p/kWh) | £2,628 |
| --- |

| Total | £8,120 |

Case study

– Clyst St. George; Solar Thermal

Please turn to page 52 for details.
4.5 Heat pumps

Heat pumps are in essence refrigerators working in reverse. Heat pumps use the evaporation and condensing of a refrigerant to move heat from one place to another. With a fridge this is to remove heat from the fridge, with a heat pump the heat is taken from the air/ground and ‘pumped’ into the recipient which is usually hot water heating.

Ground source heat pumps

A ground source heat pump has three elements detailed in table 23 below:

| The ground loop | – Lengths of plastic pipe buried in the ground, either in a borehole or in a horizontal trench. |
| – The pipe is filled with a mixture of water and anti-freeze which is then pumped around the ground, absorbing heat. |
| – The ground loop can be put into the ground in one of 3 ways. |
| – It can be coiled into a ‘slinky’ and put in a trench, every 10m of trench will provide around 1kW of heat. |
| – Pipe can be laid straight in horizontal trenches. This method requires a much longer length of trench than a ‘slinky’ system. |
| – Ground loops can be put in a vertical borehole that goes to much greater depths than the trench methods. Borehole systems although expensive to install require much less land than trench systems. |

| The heat pump | – With a ground source heat pump the pipe running through the ground is the ‘evaporator’ and takes the heat from the ground. |
| – The heat is then transported through a compressor, which increases the temperature and heats the water in the tank from which the heat distribution system is fed. |
| – The system is driven by a compressor, which pumps the fluid around the system. |

| The heat distribution system | – Heat pumps work best with either under floor heating or to pre-heat the water where a hot water requirement exists. |
| – Heat pumps systems typically heat water to between 35°C and 50°C. |

4.6 Biomass boilers

Biomass describes any organic matter and has been used as a source of energy for thousands of years. With the energy issues that face, us bio-energy is fast becoming an important form of renewable energy, one that can be grown and used sustainably. It is also a cost effective alternative to oil and gas.

Burning biomass is considered to have a near zero net greenhouse effect. The carbon dioxide given off during its combustion, which was absorbed during its growth, will be absorbed by the growth of the next biomass crop. It should be noted that initially biomass burning does produce greenhouse gases and it is only over a long period of time that it moves close to zero. There are also associated transport and processing emissions for the biomass fuel.

Air source heat pumps can provide cost effective space heating. A high efficiency heat pump can provide four times the heat compared to an electric heater.

Air source heat pumps should last for over 20 years with low maintenance requirements.

Energy in Farming
How can biomass play a role on your farm

The use of biomass on your farm falls into 3 main categories:

1. To fuel a small-medium scale biomass boiler (up to 250kW) that can heat the farm and its buildings and provide hot water.
2. To fuel a larger scale biomass boiler (250kW – 2mW) that can heat greenhouses or provide heat to neighbouring buildings through a district heating system.
3. You can grow energy crops such as miscanthus or short rotation coppice willow to feed either your own biomass boiler or for sale to an off-farm user.

### Table 24

<table>
<thead>
<tr>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost competitive</td>
</tr>
<tr>
<td>With the increasing price of oil and gas, biomass is a viable fuel source.</td>
</tr>
<tr>
<td>Free fuel</td>
</tr>
<tr>
<td>Within the woodworking industry your waste biomass is free fuel.</td>
</tr>
<tr>
<td>Waste management</td>
</tr>
<tr>
<td>Consuming waste wood as fuel stops it from going to landfill.</td>
</tr>
<tr>
<td>Avoids transportation and landfill costs.</td>
</tr>
<tr>
<td>Self sufficiency</td>
</tr>
<tr>
<td>Production, processing and consumption of home grown biomass fuel crops will help build our energy self-sufficiency for the long term.</td>
</tr>
<tr>
<td>Energy storage</td>
</tr>
<tr>
<td>Unlike solar, wind and wave energy, biomass is an energy source that is easily stored.</td>
</tr>
<tr>
<td>It can then be transported and used at any time.</td>
</tr>
<tr>
<td>Sustainability</td>
</tr>
<tr>
<td>Increased use of wood biomass encourages the planting of forests and biomass crops which also act as carbon sinks.</td>
</tr>
</tbody>
</table>

| Risks |
| Biomass boilers are sensitive to fuel quality and it is essential that the quality of the material matches the specifications required by the boiler. |
| Installations costs can be high. |
| Attention must be paid to matching the supply and demand of the required biomass material. Entering into long term supply contracts should be considered. |
| The long term commitment required to plant biomass crops in the context of annually changing commodity prices. This may reduce farm income in the short term when compared to annual crops. |
| Looking ahead, UK produced biomass may come under price pressure from imported sources. |

### Table 24 below details benefits and risks or a biomass boiler installation:

### Common biomass materials

In the UK we typically see the following materials used within biomass heating systems:

- Logs
- Waste wood often in the form of wood chip
- Wood pellets
- Short rotation coppice – e.g. willow
- Miscanthus

Each of the above requires a different form of burning which either means a fuel specific boiler or a multi-fuel (back) boiler.

### 4.7 Anaerobic digestion

Anaerobic Digestion (AD) is the controlled breakdown of organic matter in the absence of air to produce a combustible biogas and nutrient rich organic by-product.

AD systems can be located either on-farm or at larger centralised locations. The larger centralised operations are more commonly municipal operations and therefore this guide focuses on on-farm systems.

The most important factor for an AD plant is the long term and consistent availability of feedstock. Feedstock needs to be blended to achieve a mix that will maximise biogas production.

### Examples of feedstocks:

- Animal manures and slurries
- Energy crops such as whole-crop maize or grass silage
- Food by-products
- Animal by-products (abattoir waste)
- Sewage Sludge

### Key considerations

A number of small scale AD units are coming onto the market. At the moment these units do not have a long track record and you should be aware that this will entail a degree of risk. 95% of what goes into a digester comes out as digestate and there needs to be a route for this. However it is a valuable fertiliser and may provide an extra income stream.

### Costs

A small 15kW plant fed by manure and cattle slurry is likely to cost in the region of £150,000. At least 100 cattle would be needed to provide the feedstock required.

A 250kW plant would cost in the region of £850k. In addition to manure and cattle slurry further energy crops will be needed as feedstocks.

Upwards of 250 cattle would be needed to provide feedstocks for the 250kW plant.

### What does an AD plant produce

### Table 25 below details the products of an AD plant:

<table>
<thead>
<tr>
<th>Biogas</th>
<th>Digestate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixture of methane and carbon dioxide roughly in the ratio 60:40.</td>
<td></td>
</tr>
<tr>
<td>Low odour, slow nutrient release substance that can be applied directly to the land either in liquid or solid format (depending upon the nature of your AD plant).</td>
<td></td>
</tr>
</tbody>
</table>

There are various opportunities and risks apparent with an AD plant. These are detailed in table 26 below:

### Table 26 |

<table>
<thead>
<tr>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>The potential to power and heat part/all of the farm buildings plus sell electricity to the national grid.</td>
</tr>
<tr>
<td>Cost savings through the displacement of electricity and heat that would otherwise be bought.</td>
</tr>
<tr>
<td>FIs on every kWh of electricity generated.</td>
</tr>
<tr>
<td>Receipt of Renewable Heat Incentive on CHP systems and biogas heating.</td>
</tr>
<tr>
<td>Income from any electricity exported to the grid.</td>
</tr>
<tr>
<td>Reduction in the purchase of fertiliser is provided by digestate.</td>
</tr>
<tr>
<td>Better management of organic waste on the farm and a reduction in GHG emissions.</td>
</tr>
</tbody>
</table>

| Risks |
| High initial set up costs. |
| Supply of feedstock is important and sourcing may be an issue. |
| Needs continual management of the plant. |
| Connection costs to the national grid must be considered. |
| Bad management of the digestate and not complying with the waste regulations that apply to digestate. |

AD plants are a specialised area and it is recommended that you enlist the support of a specialist consultant. At the end of this guide we provide details on where to obtain further information regarding AD.

### Case study

– **Copys Green Farm; Anaerobic Digestion (AD)**

Please turn to page 54 for details
5.0 Finance and funding

Much of this guide refers to measures and technology that are relatively inexpensive but we do in places refer to technologies that can cost many thousands of pounds.

If you are a business that needs to borrow money to fund your journey towards energy efficiency, we provide some guidance on how to obtain the borrowing you need.

Outside of your own savings the money you need to invest in energy saving projects will primarily come from:

- Bank overdraft or loan
- Asset Finance or HP
- Grant support

5.1 Return on investment

Working out the capital payback period on any project is always a good discipline.

Take the total cost of a project and divide it by the annual cost saving you expect to achieve.

Three very important things to remember when considering your return on investment (ROI):

1. Technology costs and performance vary to an enormous degree between suppliers and manufacturers.
2. Always cross check with other sources the energy and cost savings that suppliers and manufacturers promise.
3. The small items and repair jobs will provide a much bigger ROI than spending lots of money.

5.2 Obtaining bank funding

Obtaining bank borrowing is fairly challenging. The money available within the markets for banks to lend has declined and many farmers have not been immune to pressure from their banks to reduce their borrowing.

Tenant farmers who are not in a position to provide security for their borrowings will face more pressure from their bank and are less likely to receive additional support.

Top tips for obtaining bank funding are:

- Good communication lies at the heart of any good bank/customer relationship.
- Early engagement with the bank regarding any project is key.
- Does your bank manager understand farming? If not then it might be better to look to other funding sources as they may struggle to present your case to their superiors.
- Invite your manager to visit the farm.
- At annual review of your facilities float the question on how much extra borrowing the bank would consider.
- Never go over your overdraft limit without letting the bank know first.
- Make sure you comply with your lending covenants.
- Make sure that your annual certified accounts are up to date and never more than 12 months old.
- Forget the old adage of ‘preparing accounts for the taxman’ – your ability to borrow will be heavily influenced by the financial performance of the business as reported in your accounts and if the net worth of the business is improving.
- Present a well prepared case to the bank for any new lending request.
- Show how you have researched the technology/machinery you have chosen.
- Consider using a specialist banking consultant to help present your case.
- Demonstrate that you have considered the impact of a potentially reducing Single Farm Payment post 2013.
- In the current climate the security that the bank holds will be key to their decision process.
- Be prepared to pay higher interest rates and fees.

5.3 Asset finance

The purchase of any machinery/equipment costing more than £2.5k can usually be financed through as asset finance or hire purchase agreement. This is subject to both the buyer and the seller being creditworthy in the eyes of the finance company.

Unlike the ‘long-term relationship’ nature of bank borrowing asset finance is much more of a transactional arrangement with each side simply fulfilling the needs of the other.

Using Asset Finance and not disturbing your bank relationship can avoid giving the bank a trigger point on which they seek to increase your interest rate and fees.

The term of any asset finance deal can usually be tailored to ensure that the financial benefits of the project being funded covers the costs of the loan repayments.

5.4 Grants

With the government taking measures to reduce the UK’s budget deficit the range of grant options has diminished. Agriculture however, continues to receive support for certain energy efficiency measures and this support is expected to continue until the 2013 reforms of the CAP come into force.

Support in England can be accessed through DEFRA and in Scotland and Wales through the devolved governments.

At the time of writing, farmers in England are waiting for DEFRA to announce their national efficiency grants programme, replacing the regional grants that were administered by the Regional Development Agencies.

Typically, resource efficiency grants will contribute around 40% of the cost of the equipment involved.

Independent grant and funding sourcing organisations are also available and may be able to complete Expression of Interest and applications on your behalf.

To be eligible to apply for the grant you will need to have a Resource Audit of the farm conducted and you will need to:

- Obtain quotes from 3 separate suppliers.
- Prove that you have access to the money required to buy the item before receiving the grant.
- Not commence the project until the grant has been approved.
6.0 Conclusion

Against a backdrop of constant time pressure it is very easy to let the urgent overtake the important and not take proactive action with regards to the energy efficiency of your individual farm. Not taking proactive action simply means that you will have less time in the future to make the changes you need to make. The focus of this guide has been to provide you the tools to set a clear direction towards improving energy efficiency.

The biggest single piece of advice we can give is if you write down what you want to achieve, and by when, then the odds of success are much, much higher.

7.0 Top tips for success

As the pressure to improve energy efficiency builds and the level of Greenhouse Gas Emissions from Agriculture comes under more scrutiny it will be important to focus on how to make sure your project is successful.

Our tips for this are:
- Make sure you understand where a project sits within the long term plan for the business.
- Don’t believe everything that a salesmen tells you.
- Research any project thoroughly and consider using sector specialists to provide you with advice and guidance.
- Do not be a guinea pig or pioneer for new technology – unless you can afford to lose the money you spend.
- Make sure that any new technology/equipment is compatible with your existing farm infrastructure.
- Before incurring any significant costs consider if you will be able to raise any finance that you might need to complete a project.
- Do not be driven by the availability/non availability of grants.
- Before entering into any larger value contracts consider the financial standing of the supplier – make a credit check if you are not sure.
- Do not pay out large deposits without knowing what is going to happen to your money.
- If you need to obtain planning permission engage a professional not on the basis of how much they will charge but on his expertise and the quality of his work.
- Consider the timeline between the inception and completion of any project.
- Make sure you know the payment terms with any larger project.
- Read the small print when it comes to warranties and guarantees on any project.
- Ask for details of people who have already bought what you are thinking of buying.
Case Study
Bicton Home Farm; Vacuum on Demand pump (VoD)

Background:
– Installed in 2010.
– Previous pump and newly installed pump 7.5kW.
– Previous pump was 10 years old with 2/3 years left, £4,800 to refurbish.
– The single speed pump was running at full capacity generating three x the vacuum that was required.

How it works:
– The pump maintains a balance between vacuum and airflow throughout the milking.
– Vacuum output alters subject to requirement.
– Automatic speed variation.
– Capacity to cope with the largest possible anticipated demand which occurs less than 1% of the time.

Advantages of VoD:

<table>
<thead>
<tr>
<th>Save energy and money</th>
<th>– The system can have a payback of less than 5 years.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>– There can be energy savings of between 50 – 80%.</td>
</tr>
<tr>
<td></td>
<td>– Further savings through reduced amount of oil required for drip feeding by 80%.</td>
</tr>
<tr>
<td>Noise reduction</td>
<td>– The noise level can be reduced by 30%.</td>
</tr>
<tr>
<td>Longer equipment life</td>
<td>– Using a variable speed controller slows the average speed of the pump to less than half of its full speed.</td>
</tr>
<tr>
<td></td>
<td>– Less wear means lower maintenance costs and longer life for the motor and vacuum pump.</td>
</tr>
<tr>
<td>Improved vacuum regulation</td>
<td>The variable speed drive controller can be adjusted to provide improved vacuum regulation that results.</td>
</tr>
</tbody>
</table>

Technology summary:
– 7.5kW.
– 3 phase supply.
– GEA Westfalia Surge 7.5kW pump with Westfalia VoD energy saver control unit RPS2800.
– VoD speeds pump up or down on demand.
– £6,600 fully installed.

Grants and funding:
– Home Farm received £5k from SWARM (South West Agricultural Resource Management) towards the installation of the VoD and a Heat Exchange unit.
– Funding is available from: Carbon Trust Loan Scheme.

Practicalities of Switching:
– The old pump can be left in situ as a backup if required.
– The VoD Pump needs to be checked every three months.
– Oil usage down by 80% reduction of 50 litres per year which saves on waste disposal.
– Spikes in electricity may trip out control box – Only requires a reset if this occurs.
– Short installation time – One day installation between milking, the original pump can be run if needed.

Carbon Reductions:
Based on the amount of electricity saved by the installation of a VoD, carbon emissions for Home Farm are reduced by:
– 17 tonnes per year.
– This equates to an £850 saving per year based on a carbon price of £50 per tonne.

Background information:
Home Farm is situated at Bicton College on the South Coast of Devon. It is a working farm which is also used for training students and apprentices at Bicton College. As of October 2011 the farm has:
– 190 crossbred cows with block spring calving, milked in groups of 24 two a day.
– Out all year using a paddock grazing system, with average paddock size at 2ha and a stocking density of 2.61ha.
– Mainly forage diet supplemented with home grown maize, grass/red clover bale and small amount of concentrates.
– Rotational grazing helped achieve a milk yield of 72% from forage against an average of 44%.
– Calving interval is 368 days with a culling rate of 13%.
– Costs per litre are kept below 1p, leaving a healthy profit margin of 7ppl last year (2010).
– The pump was installed by Venture Dairy, Holsworthy, Devon.
Case Study
Porthilly Farm; Heat Recovery Unit

Background:
- The Heat Recovery Unit (HRU) was installed in Dec 2010.
- The system was installed when a large (2 x 600) milk tank was installed and the installer prompted that at that time it might be a good opportunity to install the HRU.
- The HRU transfers waste heat from the refrigerant of the milk cooling system into water.
- The HRU was installed in the refrigerant line where the temperature of the refrigerant is at its highest.
- A 40% grant through the R4F scheme was obtained.
- The grant helped significantly with payback.
- An additional radiator taken from the HRU replaced an electric heating unit in the office.

Advantages of a Heat Recovery Unit:

<table>
<thead>
<tr>
<th>Efficient</th>
<th>As the HRU uses heat that would otherwise be wasted it is an efficient way of utilising energy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy saving</td>
<td>The energy saved per year equates to approximately 1,500 - 3,000 kWh per annum.</td>
</tr>
<tr>
<td>Cost saving</td>
<td>The unit reduced the use of other fuels and has a predicted savings of between £100 - £300 per year. It is not possible to have an exact cost saving due to changes in heat demand during this time at this location.</td>
</tr>
</tbody>
</table>

How it works:
- The HRU works by taking excess heat that would otherwise be lost from the refrigerant and using it to pre-heat the water used in the dairy shed.
- The technology is fairly straight forward and can have significant impact upon the amount of fuel, normally electricity, that is required to heat the water.
- It should be adopted in conjunction with low-cost measures such as lagging and insulation of hot water systems.

Technology Summary:
- The actual system is fairly straight forward and a simple install.
- An HRU is installed in the refrigerant line between the compressor and condensing unit where the refrigerant is at its highest temperature. The refrigerant is placed in contact with the water and heat transfer takes place.
- In addition a radiator was added to the upstairs office, see picture below.

Grants and funding:
- Funding was received for 40% of the cost from the R4F scheme.
- If no funding were available payback would be approximately 6 - 10 years.

Cost Savings:
- In this particular installation other changes in farming practices, such as the number of cows, has increased which has diluted immediately obvious cost savings.
- On average the HRU would displace costs from electrical usage of between £100 - £300 per year.
- These figures are based on a 100 cow herd and equate to approximately 30% of the water heater electricity consumption*. 

*Figures and further information taken from ‘Heat Recovery Units on Dairy Farms’ by IEA Services, Stoneleigh Park, Kenilworth, CV8 2LS

Installation considerations:
The HRU interacts closely with the refrigeration system so the following should be considered to ensure both work effectively:
- Fit a non-return valve to stop refrigerant flowing from the HRU into the compressor outlet.
- Fit anti-vibration fittings to reduce noise and vibrations which can lead to failure in the pipes and fittings.
- Be aware that it is possible to overcool the refrigerant which reduces the cooling capacity of the bulk tank.

Carbon dioxide reductions:
- The HRU saves 1.5 tonnes of CO2 per year.
- This is based on a savings of 3,000kWh per year.
- Dec 2011 the shadow price for CO2 was £7.59 per tonne. Hence the reduction in CO2 emissions has an equivalent carbon price of approximately £11.39.

Background Information:
Porthilly Farm is situated in Cornwall and has a herd of dairy cows as well as a shellfish business. The farm has been run as a dairy farm for over 50 years.
Case Study
Poultry farm in Devon; Heat exchangers

Background:

- Three helical ramp Clima Unit 2 heat exchangers have been installed to service the four poultry sheds which house 75,000 chickens.
- The heat exchangers were installed in January, September and November 2011.
- Heat exchange is an additional technology to traditional poultry farming. It provides the heat needed to keep the sheds at the correct temperature (32°C) reducing the need to use gas or oil powered heaters.

How it works:

- The heat exchangers run on electricity and can operate up to temperatures of -30°C.
- They maintain constant air temperature in the poultry shed, reducing the moisture content.
- The heat exchanger runs on a ramp system, it sucks damp, warm air out of the poultry shed, removing the heat as it passes through the filters.
- Clean fresh air is then filtered into the heat exchanger and cooled tubes.
- These tubes are part heated by the extracted hot air and return incoming air to 32°C.
- This is then pumped back into the poultry shed as clean, fresh, warm air. The air is distributed into the sheds through retractable fans.

Advantages of heat exchangers:

<table>
<thead>
<tr>
<th>Unit Number of sheds</th>
<th>Number of chickens</th>
<th>Cost for heat exchanger and install</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 Sheds, 18,500 birds each, 37,000 in total.</td>
<td>£46,850</td>
</tr>
<tr>
<td>2</td>
<td>1 Shed, 25,000 birds.</td>
<td>£31,750</td>
</tr>
<tr>
<td>3</td>
<td>1 Shed, 12,000 birds.</td>
<td>£19,000</td>
</tr>
</tbody>
</table>

Save energy and money: 52.9% reduction in gas use for the poultry shed leading to a payback of 3 years.

Reduce litter: The litter laid down at the beginning of the crop does not need to be changed throughout the 38 day duration of maturing. This is due to the dry air maintaining low moisture levels in the litter and the bird waste.

Improved air quality: The warm clean air being circulated into the poultry sheds provides a better environment for the birds.

Reduction in gas use: The use of gas for heating the poultry sheds has been reduced by 50%. Previously the heaters were run 30 days a month. This has been reduced to 15 days.

Technology Summary:

- Three Clima Unit 2 heat exchange units installed on site. A 2 INTO 1, a 1.5M and a small custom unit.
- Delivers fresh air at a rate of 0.7m3/kg/hr.
- Easy to maintain, with self clean ‘jet mist’ technology
- Complies with IPPC (Integrated Pollution Prevention Control Directive from the EU).
- Collects 75.9% of dust particles leaving the shed in the first 14 days (according to the manufacturer).

Grants and funding:

- £20,000 grant funding was awarded from the Rural Payments Agency; covering 40% of the first installation and the balance of the second.
- Low interest loans are available from the Carbon Trust.

Cost Savings:

- In this location the heat exchangers have been found to reduce fuel consumption by 50%.
- Additional cost savings are retrieved through reduced litter use.

Practicality of installation:

- The installation takes between 2 and 3 days depending on the size of the heat exchange unit being put in place.
- The poultry sheds must be empty while the installation is carried out.
- An electricity supply is required.
- Most installers run a 12 month guarantee if the farmer is not satisfied with the results of the heat exchanger.
- Filters have to be replaced once a year at a cost of around £60.

Carbon Reductions:

- The largest of the heat exchangers saves 6 tonnes of carbon per year.
- This is based on a 52.9% reduction in gas use for the poultry sheds operating with the heat exchange units.
- This is an overall reduction of 40% for the carbon footprint of the farm.

These figures were provided by the manufacturer. For accurate carbon savings raw data should be taken for your farm.

Background information:

- The farm has capacity for 75,000 chickens which are raised to RSPCA Freedom Food standards. This means that all of the birds have perches, daylight, straw and pecking toys.
- Until 1984 the farm was a working dairy farm before changing to poultry.
- The farm has 4 poultry sheds. Two are serviced by individual heat exchangers and two share a split exchanger unit.
- The Clima Unit 2 heat exchangers were installed by Vencomatic Environmental Solutions based in Yorkshire.
- The large heat exchange unit which is split to service two sheds was built in Holland. The two smaller are UK built.
Case Study
Paignton Zoo; Controlled environmental agriculture

Background:
- The Zoo was looking for a sustainable approach to its supply chain.
- High Density Vertical Growing (HDVG) system was installed in 2009.
- 11,200 plants can be grown at any one time.
- Aims to allow using reduced resources.

How it works:
- The plants are housed on 8 levels of hanging rigs suspended on a conveyor chain that constantly rotates.
- The rotation allows even airflow and equal exposure to natural daylight for all the plants.
- The structure is orientated east-west to further optimise light capture.
- The yields are higher than conventional approaches and energy efficiency is also improved.

Advantages of VoD:

<table>
<thead>
<tr>
<th>High output</th>
<th>The 120m² greenhouse in which the system is housed grows three times the 3,000 that would be grown using a conventional hydroponics system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal growing environment</td>
<td>A computerised Priva control system provides the optimal growing environment and automatically provides the nutrients and water to the system.</td>
</tr>
<tr>
<td>Reduced land resource</td>
<td>An equivalent 6m high system requires 87% less land and building footprint. This represents projected savings in excess of 40% on buildings and associated costs.</td>
</tr>
<tr>
<td>Reduced transport and improved freshness</td>
<td>As the plants are able to be grown at demand source, the amount of fuel and logistics required is reduced and plants arrive just 15 minutes after harvesting.</td>
</tr>
</tbody>
</table>

Technology summary:
- Vertically integrated system over eight levels.
- Each level is stacked 3m high.
- Covers a ground area of 85m².
- Seasonal variation of between 3–20kg per square metre between winter and summer.
- Can grow approximately 125 plants per m².

Yield (fresh kg/m-2) and energy use (kWh kg-1):
- A spinach comparison between VertiCrop and a single layer greenhouse shows a yield of 6.34kg m-2 vs 2.2kg m-2.
- The same comparison shows energy use of 1.85kWh kg-1 vs 5.64kWh kg-1.

Carbon Reductions:
- It is difficult to give exact carbon reduction figures as savings from transport, food quality and waste would need to be included.
- Given the above kWh in comparison to a conventional system, savings of 67% may be achievable but these are not definitive and wider sustainability issues should be considered.

Comparison of area required to grow lettuce plants.

Background information:
Paignton Zoo Environmental Park is an education, scientific and conservation charity dedicated to protecting our global wildlife heritage and inspiring in people a respect for animals, plants and the environment.

The HDVG system has been successfully trialled as a public educational exhibit with various fibrous rooted leafy vegetables.

Integrated zoo horticulture (Freidani 2009).

Practicalities and further adoption:
High Density Vertical Growing Systems yield in excess of 20 times that of field crops and reduce building and land use and associated energy costs. There is excellent potential for the adoption of this technology in urban environments and for the reductions in associated costs such as transport, packaging etc to improve the sustainability of horticulture in the UK and further afield.
Case Study
Frinkley Farm; Large scale wind

Background:
- Frinkley Farm obtained planning permission in March 2011 for a 330kW wind turbine to be erected on the 15th January 2012 with earthworks and foundations carried out in October 2011.
- The turbine cost in total £800,000 to install and is expected to have a 4 year payback.
- The turbine will satisfy the farm’s electrical needs and also provide electricity to be exported to the national grid.
- The turbine location has an average wind speed of 6.7m/s.
- Planning permission is valid for 20 years and took 5 months to be granted from the date of submission.
- In order to get planning permission the generation of the turbine had to be proven. This meant measuring the wind speed accurately with a anemometer and modelling the outputs of the turbine.
- In addition to the wind speed visual montages had to be created as well as a noise plan.
- The grid has had to be upgraded to cope with the amount of electricity to be exported from the site. The transformer has been upgraded by 430kW at a cost of £50,000 to Western Power (the DNO for Lincolnshire).
- Following this the turbine will bring in a yearly income of £216,600. This is a combined income of the export of electricity and the FITs (as of January 2012). This will be for 20 years.

Advantages of the E33 Wind Turbine on the Pig farm:

<table>
<thead>
<tr>
<th>Reduced noise</th>
<th>The direct drive turbine in the E33 claims to reduce noise and lower maintenance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low emissions</td>
<td>Generating your own electricity reduces fumes from a generator.</td>
</tr>
<tr>
<td>Self sufficient</td>
<td>Not relying importing electricity means you are not subject to price fluctuations.</td>
</tr>
<tr>
<td>Cost saving</td>
<td>A large turbine will not only provide all of your own electrical needs, saving the cost of importing electricity, but it will also bring in returns from the Renewable Obligation Certificates (ROCs) and FITs.</td>
</tr>
</tbody>
</table>

How it works:
- The yaw turns the turbine so that it’s facing into the wind.
- The blades, connected to the hub and nacelle (the box), draw energy from the wind.
- The Enercon E33 is a ‘direct drive turbine’, this means that it has no gear box, based on the technology of larger mega watt turbines. The direct drive utilises the angular multiple pole generator, reducing issues from torque on the bearings.
- The blades turn the rotor hub which is connected directly to the annular generator to form one gearless unit.
- The generator creates electricity using the magnetic field of the poles.
- This is then put through a transformer to change the generated electricity into around 33,000V which is then exported on the national grid.

Technology Summary:
- Planning permission has been received for a 330kW Enercon E33 wind turbine to be installed at Frinkley Farm.
- The E33’s turbine is a direct drive turbine meaning it has no gears.
- All of the preliminary works have been carried out including the foundations which incorporated 19.6m³ of concrete, the concrete slab for the turbine shed, earthworks for the cables and the access track. This will vary depending on ground conditions at your location.

Practicality of installation:
- The first hurdle to overcome is obtaining planning permission. In Frinkley Farm’s case this has taken 2 years in total to obtain and at a cost of £55,000. Once the application was submitted a decision was granted in 5 months.
- The result of planning often comes down to the members of your committee. In Frinkley Farm’s case the campaigning to get people on side started prior to the planning application being submitted.
- The cables for the turbine were laid in between crops to reduce the impact of the earthworks on the farm.
- An access road has to be constructed to the turbine site for installation and maintenance.
- The turbine has a maintenance contract with Enercon and is connected to an online alerting system for any issues which may arise. This is monitored by Enercon’s office in St Ives, Cambridge.

Cardon reductions:
- It is estimated the turbine will generate 867.24MWh of electricity per year, saving 462.24 tonnes of CO₂ per year.
- This equates to 11,556 tonnes of CO₂ over the lifetime of the turbine.
- Based upon a carbon price of £12 per tonne this equates to a total carbon price of £138,672.

Background information:
- The array was installed by British Eco who have a national coverage for installations.
- The farm’s accommodates 430 sows, producing 200 pigs a week for slaughter and they are fattened on straw.
- The farm’s also has 600 acres of arable land which is used to produce the cereals for feeding the pigs.
- Frinkley Farm has 10 rooms in the farrowing house, 4 rooms of first stage weaners and a further 3 rooms of second stage weaners.
- The farm’s uses the slurty produced by the pigs on their 600 acres to produce cereals for feeding.
- Frinkley Farm has already erected a 50kW PV array (November 2011) More information can be found in the Frinkley Farm PV case study.

Grants and funding:
- Very few grants are available for large scale wind turbines.
- Low interest loans are available and very often the installer is willing to invest in the wind project due to the high return on investment achieved.

Cost Savings:
- The 330kW wind turbine will suffice all of the pig farm’s electrical needs and have electricity left over to export onto the national grid.
- This will save Frinkley Farm £20,000 in electricity bills.

Excerpts from the ‘Conversion Manual’:


The base of the wind turbine.
Case Study
Cloverbank Organic Farm; Small scale wind

Background:
- Cloverbank Organic Farm had a wind turbine installed on site in Spring 2007.
- The technology was installed due to the farm being off grid and so needing to be completely self sufficient.
- Full planning permission was required for the turbine.
- The turbine feeds into a large battery store which is able to even out the fluctuations in electricity generation.
- The turbine cost £30,000 to install.
- The turbine produces around 15MWh of electricity a year. This is eligible for ROC (renewable obligation certificate) payments at £45 a megawatt (as of November 2011).
- The ground conditions at the site are very good and so minimal ground works were required, taking 2 weeks to complete.
- The erection of the turbine took 10 days in total.

How it works:
- The Proven 6kW wind turbine starts generating at 2.5m/s.
- The blades turn the shaft which is connected to a direct drive motor meaning it has no gearing.
- This creates an electrical charge in direct current (DC) which is carried to an inverter, changing it to alternating current.
- The electrical layout consists of one 6kW inverter, a turbine control panel which includes both a voltmeter and an ammeter and a rotary isolator switch which isolates the turbine output and can be locked to the out position if needed, for example if maintenance needs to be carried out.
- A meter is installed to measure the amount of electricity being generated so that the ROCs can be claimed. For newer installations this would also be used for Feed in Tariffs (FITs).

Advantages of small scale wind turbines:

<table>
<thead>
<tr>
<th>Reduced noise</th>
<th>The turbine can be situated further away from the end location than the diesel generator previously used.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>This means that noise is reduced in the working environment as well as the noise produced from the wind turbine being much lower than the generator. The turbine produces 45dB(A) at 5m/s wind speed (hub height) as opposed to 70dB(A) at 7m distance.</td>
</tr>
<tr>
<td>Self sufficient</td>
<td>The farm is off grid so not only does it need to produce its own electricity but it also make the farm non-reliant on fluctuating fuel prices.</td>
</tr>
<tr>
<td>Low maintenance</td>
<td>The turbine is self supporting (no guy ropes).</td>
</tr>
</tbody>
</table>
| Mixed output | The turbine output can be used for:  
  - A direct electrical supply  
  - Storing the electricity in a battery.  
  - Generating heat. |

Technology Summary:
- 6kW proven wind turbine which operated at 6kW in a 12m/s wind speed.
- The turbine is 15m to tip height and has a 5.6m rotor diameter.
- Cut in wind speed at 2.5m/s.

Grants and funding:
- A £5,000 grant was available although this made the installation ineligible for ROC payments.
- Grants and funding are available for small wind turbines. Some of these grants make installations ineligible for FITs.
- Interest free and low interest loans are available for micro-turbines from the Carbon Trust.

Cost Savings:
- £8,000 was being spent on diesel for an electricity generator.
- The turbine produces half the electrical needs of the farm. This is a saving of £4,000 a year on generator costs as well as the ROC’s payments of £675.
- The cost saving does not take into account the rise in fuel prices. This saving will increase.

Practicality of installation:
- The works were carried out over a month and require the animals to be kept out of the field during installation.
- Maintenance is carried out periodically and a major service happens every 3 years.
- The turbine had to have a new blade installed after 3 years.

Cardon dioxide reductions:
- The installation saves 8.2 tonnes of CO2e per year.
- This is based on a generation of 15MWh per year.
- Dec 2011 the shadow price for CO2 was £7.59 per tonne. Hence the reduction in CO2 emissions from Cloverbank Organic Farm has a carbon price of £62.24.

Background information:
- Cloverbank Organic Farm was established in 2004.
- The farm has 40 sucklers and 129 sheep.
- The farm is completely self sufficient and is not connected to the grid for either electricity or gas.
- The farm consists of 130 acres.
- A biomass boiler is used in the house to provide heat.
- Bottled gas is used to provide heat and hot water for the cutting room but the farm is looking at piping heat over from the biomass.
- Cloverbank Organic Farm also has a tracking solar PV array on site. More detail can be seen on Cloverbank Organic Farm, Solar PV Tracker case study.

Proven 6kW Wind Turbine, 6kW Proven Workings, Accessed on 12/12/11. Available at: http://www.turbinetechs.co.uk/wind-turbines/proven/proven-6kw/

Case Study
Bridgehouse Farm; Solar PV and wind

Background:

- Bridgehouse Farm has a 50kW PV array installed on a south facing roof to provide electricity for its house containing 20,000 free range layers. This was installed in March 2011.
- The array was installed in addition to 4 hybrid sets of 1kW wind turbine and 1kW PV arrays on the roof of the 4 mobile units which contain a further 20,000 free range layers. This was installed in March 2009.
- The PV and wind was installed to provide electricity for lights, feeders and pumping fresh water from the borehole.
- This generates £1,200 a month from the Feed in Tariffs (FiTs).
- The installation generates almost all of the electrical requirements of the farm.
- Bridgehouse Farm installed the array to reduce outgoing costs and with the aim to become carbon neutral.
- Obtaining planning was contentious and took a long time to obtain.

Advantages of 50 kW solar PV and wind:

<table>
<thead>
<tr>
<th>Cost saving</th>
<th>The array saves money from importing electricity as well as generating revenue from the FiTs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low maintenance</td>
<td>The ammonia resistant modules and small hybrid system are low maintenance and efficient in comparison to other renewable technologies.</td>
</tr>
<tr>
<td>Chicken friendly</td>
<td>The PV and wind does not interfere with the movements of the chickens nor affect their quality of life.</td>
</tr>
<tr>
<td>Low emissions</td>
<td>The installations are emission free and reduce the carbon footprint of the farm as it is not importing ‘dirty’ electricity.</td>
</tr>
</tbody>
</table>

How it works:

50kW PV

- Photovoltaic means turning sunlight into electricity by absorbing photons of light and turning them into electrodcs.
- The cells which carry out this process are contained on a photovoltaic panel which is, at its peak, generating 240W.
- The panels are connected together to form an array. The charge produced from the array is taken to an inverter which transforms the current from direct current (DC) to alternating current (AC).

Hybrid system

- The system is made up of both wind and PV.
- The PV works on the same system as the large PV.
- The wind turbine blades turn a geared shaft which determines how fast the generator spins. The generator creates electricity by using the magnetic poles contained within its coils of copper wire. This is then transferred to the inverter.
- The feed into the same inverter changes the current from DC to AC.
- The mobile chicken sheds are not connected to the grid and so the electricity is stored in a battery.

Technology Summary:

- The 50kW of PV take up 350m² of roof space.
- The 50kW PV array are ammonia resistant modules.
- The mobile chicken sheds are not connected to the grid, the electricity generated is stored in batteries.

Grants and funding:

- Funding was not available for this installation.
- Low interest loans are available from the Carbon Trust and Sallix.
- PV for free schemes are also available.
- The FiTs are reviewed regularly. Once you are registered on a tariff this is valid for the 25 year duration.

Cost Savings:

- The 50kW array brings in an income of £1,200 a month from the FiTs.
- In addition, the generation of electricity saves approximately £300 a month on electricity bills.

Practicality of installation:

- In order for by the hybrid system and the large array to be erected, scaffolding has to be in place.
- Space is needed for the inverters and metering equipment.
- When installing PV in a farm environment it is advised to use ammonia resistant modules.
- In order to claim the FiTs it is necessary to register your array with your local District Network Operator (DNO).
- The DNO has to approve before any connection can take place and hence any payments received.

Cardon dioxide reductions:

- The 1kW PV and Wind array installations save 0.5 tonnes and 0.8 tonnes of CO² each per year respectively.
- The 50kW PV array saves approximately 25 tonnes of CO² per year.
- This gives a total CO²e saving of over 30 tonnes per year.

Background information:

- Bridgehouse Farm is one of five farms that rears birds for pullets, free range eggs and vaccines.
- Bridgehouse Farm is home to 40,000 free range layers.
- The current stock is 53 weeks old, having arrived at point of lay at 16 weeks, and laying at 95%.
- All of the sheds have natural ventilation.
- In addition to the 50kW array four of the temporary sheds have a 1kW PV array and a 1kW wind turbine installed. These were put in during 2009 and did not require planning permission.
- Bridgehouse Farm is currently going through an appeal to have a 250kW wind turbine installed on site.

One of the four hybrid renewable systems.
Case Study

Cloverbank Organic Farm; Solar PV tracker

Background:
- The tracking photovoltaic (PV) array was installed in May 2011.
- The array is 3.9kW peak generation capacity and has a dual axis, meaning it can rotate as well as change pitch.
- Full planning permission was required for the installation.
- The array is connected to a large battery store so that the electricity requirements of the farm can be met when the PV is not working to its full capacity.
- The tracker has been shown to be 40% more efficient, moving to find the strongest sunlight as opposed to fixed in one location.
- The tracker cost £18,000 to install.
- The tracker is eligible for the Feed in Tariff (FiTs).
- One of the main points highlighted by the farm owners was to ensure that you have an experienced installer for a tracking array as it is more complex than a standard array.

Advantages of solar PV tracker:

- Efficient
  - As the array is always moving to find the best angle of incidence it has been shown to be 40% more efficient than a fixed array in the same location.
- Roof space
  - No south facing roof is required for the installation.
  - No cost for structural surveys and roof strengthening.
  - The array is mounted off the ground on a single pole. This reduces disruption to grazing.
- Cost saving
  - The array reduced the use of other fuels, in this case diesel for the generator, saving money.
  - The array is eligible for FiTs, acting as a revenue stream.
- Storeable energy
  - The electricity produced by the array can be stored in a battery.

How it works:
- The PV modules operate in the same way as a standard module. For further information see other case studies and the report.
- On a tracking array the modules are mounted on a pole, about 4.5m off the ground.
- Sensors are mounted on the array which measure the incoming light levels and the wind speed.
- The sensors cause the panels to be moved by motor and gear chains to minimise the angle of incidence between the panel and the incoming light photons.
- When winds are too high the array moves to a horizontal position to avoid damage.

Technology Summary:
- The 3.9kW tracking array is constructed of Samu panels. These have been shown to be more efficient in lower light levels.
- The array is made up of 16 modules, each having a 240kW peak generation.
- The array has a 27m² surface area.

Grants and funding:
- Funding is available through the Carbon Trust low interest loan scheme.
- Grants are available, caution should be taken as this can often make a project ineligible for FiTs or Renewable Obligation Certificates (ROCs).

Cost Savings:
- The array alleviated the £8,000 diesel consumption on the generator.
- The array generates approximately 3.1MWh of electricity a year (based on 800 radiance hours) which returns £1,350 from the FiTs (on pre 12th December 2011 rates).

Practicality of installation:
- The foundations and earth works have to be carried out prior to the installation of the tracker.
- The full installation including groundworks takes 3 weeks. This will vary depending on the number of people working on the installation.
- The area needs to be kept clear of animals when the works are being carried out.

Cardon dioxide reductions:
- The 3.9kW PV installation saves 1.8 tonnes of CO₂ per year.
- This is based on a generation of 3,500kWh per year.
- Dec 2011 the shadow price for CO₂ was £7.59 per tonne. Hence the reduction in CO₂ emissions from Cloverbank Organic Farm is an equivalent to a carbon price of approximately £13.60.

Background information:
- Cloverbank Organic Farm was established in 2004.
- The farm has 40 sucklers and 129 sheep.
- The farm is completely self sufficient and is not connected to the grid for either electricity or gas.
- The farm consists of 130 acres.
- A biomass boiler is used in the house to provide heat.
- Bottled gas is used to provide heat and hot water for the cutting room but the farm is looking at piping heat over from the biomass.
- Cloverbank Organic Farm also has a 6kW Proven Wind Turbine on site. More detail can be seen on Cloverbank Organic Farm, Wind case study.

![Image of tracking PV array](Image)


The tracking PV array (at night).
Case Study
Frinkley Farm; Roof mounted 50kW solar PV

Background:
- A 49.8kW array of solar PV was installed in November 2011.
- The array is anticipated to produce 42,000kWh per annum.
- The structural stability of the roof was unsuitable. It is always important to have the structural integrity of any roof to have technology installed checked by a structural engineer. The roof was strengthened at a cost of £5,000.
- The PV installation cost £112,470, this breaks down to £2,300 per kW including install.
- Planning permission had to be obtained, this took 8 weeks from application submission.
- To accommodate the installation the transformer on the national grid at the farm had to be upgraded. In total it was upgraded 430kW. This was to allow for future installations and cost £50,000.
- Within pig farming the installation of renewable energy technology can be incorporated with energy efficiency measures. It is important to make sure that they are combined to ensure the best return on investment. Frinkley Farm has done this by changing all of the light bulbs in the pig houses to be energy efficient, they have cut power on the heat lamps and dimmers and use straw which is self heating.

How it works:
- Frinkley Farm has PV installed on the roof of the machinery and feed store.
- The photovoltaic polycrystalline cells take the solar radiation from the sun, converting it into direct current using semiconductors.
- The PV modules are connected to an inverter which is located in the store. The inverter changes the direct current which is generated by the photovoltaic cells into alternating current.
- The alternating current can then be used on the farm. Frinkley Farm uses all of the electricity it generates. For a large array (over 30kW) exporting to the grid the electricity generated needs to be metered on a half hourly export meter.

Advantages of 50 kW solar PV:

<table>
<thead>
<tr>
<th>Generation of electricity</th>
<th>Maintaining temperature in the pig houses is one of the major uses of electricity within pig farming. Self-generated electricity means that you are self sufficient.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost saving</td>
<td>PV should be used in addition to other cost saving measures such as more efficient heat lamps and lighting. As well as receiving FiTs you are reducing the amount of electricity you use and are also not paying for your electricity from the grid.</td>
</tr>
<tr>
<td>Reductions in emissions</td>
<td>Generating ‘green’ electricity means you are not using electricity from power stations or generators, powered by fossil fuels.</td>
</tr>
<tr>
<td>Cleaner environment</td>
<td>Reduction in emissions leads to a cleaner working environment.</td>
</tr>
</tbody>
</table>

Technology Summary:
- 48.9kW of 235W polycrystalline PV panels made by Canadian Solar.
- The three inverters are Sunny Tripower by SMA.

Grants and funding:
- This installation was self funded but is eligible for the FiTs. It has a 15% return on investment.
- Low interest loans are available from installations as well as funded options in return for the FiTs payments.

Cost Savings:
- The installation is forecast to save £4,200 a year in electricity costs. This saving will increase as energy prices rise.

Practicality of installation:
- The installation took a week and required scaffolding to be erected around the shed. This time will vary depending on the number of people carrying out the installation.
- The roof had to be strengthened before the installation could take place which took several weeks.
- A standard 5 year guarantee was issued with the installation.
- Permission has to be obtained from the DNO (District network operator), in this case Western Power, to connect to the grid. This can result in time delays.
- To connect to the national grid, especially from a location which is not currently grid connected, earthworks for underground cables may be required.

Cardon dioxide reductions:
- The 48.9kW PV installation saves 24.5 tonnes of CO2 per year.
- This is based on a generation of 46,000 kWh per year.
- This is an overall reduction of 16% for the carbon footprint of the farm.
- Dec 2011 the shadow price for CO2 was £7.59 per tonne. Hence the reduction in CO2 emissions from Frinkley Farm has a carbon price of £118.96.

Background information:
- The array was installed by British Eco who have a national coverage for installations.
- The farm accommodates 430 sows, producing 200 pigs a week for slaughter.
- The farm also has 600 acres of arable land which is used to produce the cereals for feeding the pigs.
- The pigs are fattened on straw.
- Frinkley Farm has 10 rooms in the farrowing house, 4 rooms of first stage weaners and a further 3 rooms of second stage weaners.
- The farm uses the slurry produced by the pigs on their 600 acres to produce cereals for feeding.
- Frinkley Farm is in the process of erecting a wind turbine (As of December 2011). More information can be found in the Frinkley Farm; Wind case study.
**Case Study**

**Black Dog Farm; Ground mounted 70kW solar PV**

**Background:**
- The ground mounted photovoltaic (PV) array was installed in May 2011.
- The array is for 69.9kW and is ground mounted in 2 arrays.
- Full planning permission was required for the installation.
- The array cost £170,000 to install.
- The array is eligible for the Feed in Tariff (FiTs).
- The system has been angled to the optimum angle and direction to ensure the maximum generation can be attained.
- Due to the size of the array, upgrading of the local trans former from 50 to 200kVA was required and was an additional cost of £17,000.
- The array was installed in addition to a smaller domestic scale installation on the farm house and each runs through a different meter meaning separate FiT registrations are possible.

**Advantages of 70 kW solar PV:**

<table>
<thead>
<tr>
<th>Income</th>
<th>The array generates income from importing electricity as well as generating revenue from the FiTs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continued grazing</td>
<td>The ground mounting enables continued grazing of the field by smaller livestock, such as sheep and chickens.</td>
</tr>
<tr>
<td>Optimum efficiency</td>
<td>The PV is angled and sited correctly so that it maximises the generation and therefore the efficiency of the installation.</td>
</tr>
<tr>
<td>Clean energy</td>
<td>The installation is emission free and reduces the carbon footprint of the farm as it is not importing ‘dirty’ electricity.</td>
</tr>
</tbody>
</table>

**How it works:**
- Photovoltaic means turning sunlight into electricity by absorbing photons of light and turning them into electrodes.
- The cells which carry out this process are contained on a photovoltaic panel which is, at its peak, generating 240W.
- The panels are connected together to form an array.
- The charge produced from the array is taken to an inverter which transforms the current from direct current (DC) to alternating current (AC).

**Technology Summary:**
- The 69.9kW array is constructed of REC panels. These have been shown to be more efficient in lower light levels.
- The array has a surface area of approximately 490m².
- The array has performed well so far and outperformed predicted generation.

**Grants and funding:**
- Some grants are available but caution should be taken as this can often make a project ineligible for FiTs or ROCs.
- The array has been registered for FiTs, meaning a rate of income per unit of electricity generated and a further smaller rate for each unit exported to the grid.

**Cost Savings:**
- The array generates a rate of 19p/kWh for each unit generated and has an export rate of 3p/kWh for each unit not used on-site.
- This results in an average monthly income of £1,350 per month and a payback of approximately 10–12 years.

**Practicality of installation:**
- As the system is ground mounted, installation is more straightforward than roof mounting but does require additional resources to create the stands.
- Insurance was hard to obtain. It is important to ensure you engage with potential insurers who have a proven track record early in the installation process.
- Metering was more expensive than initially indicated and it is important to ensure installers cover all potential costs in the installation or at least highlight those costs that are not covered.
- Ground mounting still enables chickens and smaller livestock to utilise the space.

**Carbon dioxide reductions:**
- The 69.9kW installation saves 33.5 tonnes of CO2e per year.
- This is based on a generation of 64,000kWh per year.
- Dec 2011 the shadow price for carbon was £7.59 per tonne. The generation of kWh at Black Dog Farm would be the equivalent of £254.

**Background information:**
- Black Dog Farm has a herd of beef cattle, lambs and arable crops.
- The well regarded REC Solar panels used are made in Norway at low carbon, hydro powered factories and consistently perform well in field trials. It is important to ensure the panels specified during the design phase of the project are the best ones suited to the application.
- Black Dog Farm is a certified Organic farm and the low carbon initiative fits well with the environmentally sustainable ethos of the farm.

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**Image:**

The 2 inverters.

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**Diagram:**
- Black Dog Farm; Ground mounted 70kW solar PV
### Case Study

**Clyst St. George; Solar thermal**

**Background:**
- The Solar Thermal array was installed in November 2011.
- There are 3 main types of Solar Thermal systems, evacuated tubes, flat plate and unglazed.
- Installation is fairly straightforward.
- In this instance the installation was carried out by a local plumber as this reduced the cost. However this did mean that the installation was not applicable for Renewable Heat Incentive (RHI) payments.
- Cost was approximately £2,500 for the kit plus installation.
- As with all renewables Solar Thermal must be suited to the situation it is in and those farms with high hot water demand such as dairy.

**How it works:**
- The panels situated on your roof absorb heat from the sun – they are known as the collector.
- The water or substance in the collector is heated up.
- This is then pumped through a coil in the water cylinder which heats up the water in the cylinder.

**Flat plate vs Evacuated tubes:**

The main difference is efficiency. In evacuated tubes, the vacuum provides almost perfect insulation. A flat plate panel has insulation at the back and sides, with glass on top, and isn’t so efficient per square metre. Flat plate panels are generally slightly cheaper. During the summer, there’s little difference in performance. In winter, on cold days, and lower light levels, the evacuated tubes will perform slightly better.

<table>
<thead>
<tr>
<th><strong>Advantages of Solar Thermal:</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year round system</strong></td>
<td>Contrary to popular belief the system will work year round.</td>
</tr>
<tr>
<td></td>
<td>It will generate around 60% of year round heat demand with approximately 20% of winter demand and over 70% of summer demand.</td>
</tr>
<tr>
<td><strong>Cost saving</strong></td>
<td>The array reduces the use of other fuels, in this case electricity, for the heating, saving money.</td>
</tr>
<tr>
<td></td>
<td>This array is ineligible for RHI payments. However if an MCS accredited installer was used it would create 8.5p per kWh of heat generated as well as savings on fuel replaced.</td>
</tr>
<tr>
<td><strong>Storable energy</strong></td>
<td>The heat produced can be stored in a thermal store, such as a well insulated hot water tank, and needn’t be used immediately.</td>
</tr>
</tbody>
</table>

**Technology Summary:**
- The array is constructed of REC panels.
- The array is made up of modules, each generating approximately 720kWh per m² per year.
- The panels require very little maintenance.
- The panels take up approximately 4m².

**Grants and funding:**
- Funding is available through the Renewable Heat Incentive (RHI).
- Grants are available, caution should be taken as this can often make a project ineligible for RHI or Renewable Obligation Certificates (ROC’s).

**Cost Savings:**
- The array generates approximately 2,800kWh of electricity a year (based on 800 radiance hours) which would return £245 from the RHI had the system been installed by an MCS accredited installer.

**Carbon dioxide reductions:**
- The installation saves 1.7 tonnes of CO₂ per year.
- This is based on a generation of 2,880kWh per year.
- Dec 2011 the shadow price for CO₂ was £7.59 per tonne. Hence the reduction in CO₂ emissions from Clyst St George Farm is an equivalent to a carbon price of approximately £12.91.

**7 Things to check before you install:**

1. The most important thing is to have a suitable roof for the collectors (panels). South-facing is ideal, but anywhere between south east and south west is ok.
2. Is the roof strong enough?
3. How we get the pipe work to where the cylinder is.
4. Is there space for the larger cylinder needed by a Solar Thermal system (or space for a cylinder, if there’s a combi-boiler?)
5. If the cylinder is to be situated in the loft it’s important to check that the floor is strong enough to hold it, and the roof is high enough for it to fit in.
6. Is the building suitable – will the occupants use enough solar-heated water to make it viable?
7. Holiday homes, where there are long gaps where residents are absent, are not suitable.

![A couple of wine vats on site, the heat generated will be used to provide the hot water needs of the site.](Image)

Case Study
Copys Green Farm; Anaerobic Digestion (AD)

Background:
- The AD plant was installed in 2009. The initial Combined Heat and Power unit (CHP) was faulty and its replacement began running to the current generation of 1280MWh per year in February 2011.
- The system cost £800,000M with a payback of 8 years.
- The system has additional costs of £85,850 a year to feed and maintain, this includes the feedstock, maintenance, meter rental, electricity standing charge and an electricity network availability charge.
- The AD plant satisfies all of the farm's electricity needs, generating 3.5MWh/day and exporting 2.7MWh/day of this to the national grid.
- The AD plant produces sufficient heat to power a 200kW radiator which dries the grain. Sufficient heat is also produced for cheese making, to maintain the digester temperature, heat the farm house, heat the dairy wash water, warm the drinking water for the cows and dry crops.
- The digestate from the AD plant is used on the farm's arable crops.
- Due to not using food waste the feedstock for the AD plant does not have to be pasteurised.
- A condition of planning permission was that the AD plants should be fed from within the farm.
- Two wood chip boilers were previously used to help provide heat requirements, a 50kW and a 34kW.
- In the future the farm is looking to do a mini district heat system to the local village.
- The farm uses carbon neutral fuels where possible for the machinery.

How it works:

Advantages of Anaerobic Digestion:

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>The digestate is a strong fertiliser which is very efficient on the land.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop</td>
<td>The sugar beet crop previously being grown was not very profitable. By switching to short crop maize it could be used as both feed for the cows and feedstock for the digestor.</td>
</tr>
<tr>
<td>Warm water</td>
<td>The excess heat from the plant is used to heat water for the cows. This means the animals are having to use less energy to heat the water and keep themselves warm, hence being more efficient.</td>
</tr>
<tr>
<td>Income</td>
<td>The electricity brings in income of £155,000 a year from the Feed in Tariffs (FiTs) and £400,000 from electricity sales. By producing your own energy you are not subject to price fluctuations.</td>
</tr>
</tbody>
</table>

Technology Summary:
- The plant is comprised of a 800m³ digester tank and a 350m³ gas holder (at low pressure of 20mbar).
- The CHP unit produces 170kW of electrical power and 200kW of heat.
- The feed has a residence time of 40-50 days with a temperature of 37-42°C.
- The digester is agitated by gas mixing, with 36 pipes in the digester floor.
- The feedstock consists of 7 tonnes of slurry, 7 tonnes of maize silage or fodder beet plus whey from cheese-making.

Grants and funding:
- £100,000 was available from the Department of Agriculture and Rural Development farming grant scheme for the AD on the farm but this would have made it ineligible for FiTs or double ROCs.

Cost Savings:
- The AD plant saves the farm £34,700 a year. This is based on savings from electricity, heat and fertiliser.

Practicality of installation:
- Access to the site will be needed for construction, maintenance and feedstock.
- Groundwork’s for the plant were carried out over 6 months from Oct ‘08 to March ’09.
- The plant itself was commissioned on 24th June 2010.
- It is good to have a solid understanding of the system as there may be a lot of starting up problems.
- The Environment Agency’s policies for waste water and transportation of waste must be complied with.
- The silt and stone traps have to be emptied monthly. Stones and tramp metal can cause damage to machinery.
- The belts on the gas compressors have to be replaced regularly and nipples greased.

Cardon dioxide reductions:
- The installation saves approximately 670 tonnes of CO²e per year.
- This is based on a generation of 1280MWh per year (3.5MWh/day).
- Dec 2011 the shadow price for CO² was £7.59 per tonne. Hence the reduction in CO² emissions from Copys Green has a carbon price of approximately £5,080.

Background information:
- Copys Green Farm currently works 230 hectares; 65ha of grass consisting of pasture, buffer strip and ley and 162ha of arable which consists of barley for both seed and feed, spring beans for feed, silage maize and fodder beet.
- The Farm has 100 pedigree cows mostly Holstein, some Brown Swiss and 100 followers.
- The milk herd averages 10,500 litres of milk a year.
- A quarter of the milk is used for cheese making on site which retails as Mrs Temples Cheese and the remainder is sold wholesale.
- The plant was installed by Greenfinch, now Biogen Greenfinch. Many of their staff now work as Marches Biogas.

The digester tank (left) and gas holder (right).
Useful resources and further reading

Agriculture and Horticulture Development Board
Levy board for UK farming.
www.abhb.org.uk

BPEX
Industry levy board for pig farmers in England and Wales.
www.bpex.org.uk

Dairy Energy Europe Website
Specific website for dairy farmers in Europe.
Advice on all types of technology and case studies.
www.dairysenergy.eu

DairyCo
Industry levy board that provides technical advice and support for all aspects of dairy farming including resource efficiency.
www.dairyco.org.uk

DECC
Department for Energy and Climate Change.
www.decc.gov.uk

DEFRA
Department for Food, Farming, Agriculture and Rural Affairs.
www.defra.gov.uk/food-farm

EBLEX
Beef and sheep meet industry levy body.
www.eblex.org.uk

Horticulture Development Company
Levy body for horticulture in the UK.
www.hdc.org.uk

HGCA
Levy body for cereals and oilseeds in the UK.
www.hgca.org.uk

Microgeneration Certification Scheme
The MCS website provides guidance on the certification of renewable technologies for the production of heat and electricity. Details are available from the website of suppliers and installers that have been MCS accredited.
www.microgenerationscheme.org

Potato Council
Levy body for potato farming in the UK.
www.potato.org.uk

Funding
For information on interest free loans and resource management, contact The Carbon Trust.
www.carbontrust.co.uk