A Low Carbon Route Map

Guidance for communities applying to the
Climate Challenge Fund

Energy

It's our future
natural scotland
SCOTTISH GOVERNMENT

Foreword

All over Scotland and beyond, people are working together in communities to reduce CO2 emissions. These are early days and there is still much to learn about what works – and lots of new approaches and ideas to be tried and explored. Any community thinking of developing carbon reduction projects will be at the forefront of the journey to a low carbon society. This means that while there is much to learn from others' successes (and occasional failures), some of this is uncharted territory in which you'll be pioneers.

The Route Maps aim to help you and your community develop projects that are relevant, engaging and have maximum chance of success. Most of the Route Maps cover four areas to help you start your community's low carbon journey:

Surveying the landscape: Before starting any new journey it's important to learn as much as possible about what lies ahead. Here you'll find an introduction to the topic, relevant carbon emissions, and how they can be reduced.

Choosing your particular route: There are many ways communities can reduce CO2, and many different routes to success. Here you'll find information to help you think through different approaches and to choose ones that are right for your community, and, ideally, not only reduce CO2 but have other benefits as well.

Planning your journey: Here you'll find advice to help you make the detailed plans for your journey – and how to keep track of where you are so you know if you're making progress.

Signposts: To sources of further information and advice.

There are currently six Low Carbon Route Maps covering Project Planning, Energy, Travel, Food, Community Buildings, and Feasibility Studies.

Two warnings:

- The Route Maps don't replace the detailed Climate Challenge Fund guidance on completing an application – read that as well
- Not all the measures mentioned are eligible for funding from the Climate Challenge Fund – but they help present the bigger picture. If so, you may want to include them in a project with funding from other sources as well.

Every community is different; the aim of the Route Maps is not to tell anyone the 'best' way to do any project (because there is no one 'best' way) but to help you develop projects that work for your community.

Good luck – enjoy the journey!

The *Low Carbon Route Maps* have been researched, written and designed by Footprint Consulting Ltd; Environmental and Resource Economics Limited; and Alan Speedie Associates Ltd for the Climate Challenge Fund, July 2009.

Surveying the landscape

Energy is used for a range of activities, from when we turn on the lights at work or the heating at home. In Scotland we have abundant wind, wave and other sources of renewable energy. This route map charts a course for communities to improve their energy efficiency and explore new ways of meeting their energy needs.

Even though it's sometimes seen as less exciting – or even glamorous – reducing energy demand through increased efficiency is typically far cheaper than new power generation. There is considerable potential to reduce energy use through behaviour change and insulation.

New renewable power generation can be developed at a household or local scale. Communities may wish to promote new renewables generation by supporting individual households to install systems or to develop community owned renewables assets. In most cases, renewables and micro-generation options will be considered as a means of directly replacing an existing fossil fuel source of energy and may also create a community asset, generating revenue for the benefit of your local community.

This journey plan is intended to illustrate possible routes to a funded community renewables, energy efficiency or micro-generation project. The Feasibility Studies Route Map will also be useful in developing your project.

Energy consumption and emissions

Domestic energy consumption in Scotland is 11.1 *MWh* per person and each household in the UK creates about five and a half tones of CO2 each year. This comes from the energy we use in heating and lighting our homes, as well as powering household equipment.

However Scottish communities have access to some of the largest sources of renewable energy in the UK. This means there is an opportunity to reduce Scotland's energy consumption by way of behaviour changes and technological improvements.

We can reduce our CO2 emissions by making greater use of renewables. In 2006, only 1% of Scottish domestic energy came from renewable sources, by far the largest proportion came from gas (62%)[i]. There is an opportunity for you and your community to have an impact on Scotland's overall mix of power supply and use.

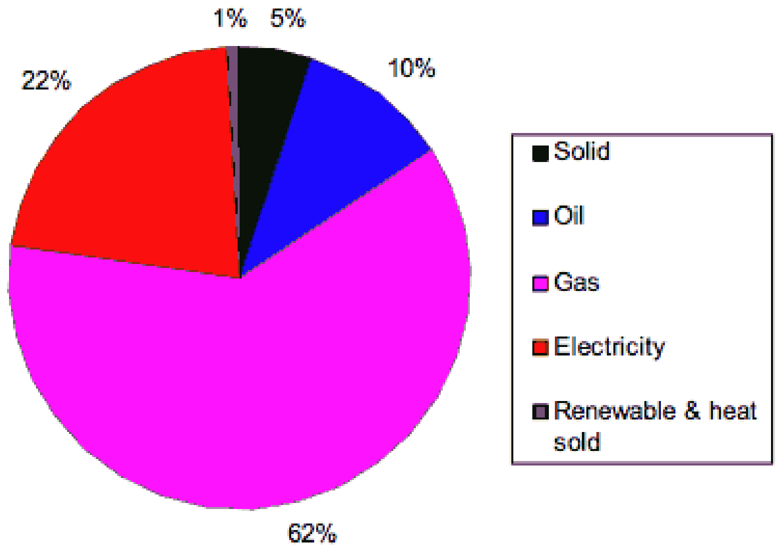


Figure 1: Scottish Domestic Sector Energy Split[ii]

There are three approaches to reducing emissions associated with energy generation and use:

- **Behaviour Change**: Change our habits and expectations so that we choose lower carbon options and avoid using energy when it's not necessary;
- **Install Efficient Technologies**: Use energy much, much, more efficiently by insulating buildings and using more efficient equipment and transport;
- **Generate Renewable Energy**: Increase the amount of renewable and low carbon energy we produce. (Note that the capital elements of projects to install energy generation equipment are excluded from the Climate Challenge Fund but not the preparation for energy generation as part of a wider CO2 emissions reduction plan.)

Energy efficiency

Energy efficiency can be greatly improved by behaviour change and by installing efficient technologies – they often go hand in hand, so we consider them together. Community projects will also often address both aspects.

We all use energy at home to provide heat and light and to power our computers, televisions and other equipment. Small changes in behaviour can result in big savings. Some examples of energy efficiency activities:

- When boiling a kettle only boil the water you need. This means that you use less power each time you boil the kettle, resulting in less emissions of CO_2.. You could reduce emissions of CO_2 by 17.5kg per annum if once per day you boil only one cup rather than a full kettle.
- Children can be encouraged to make a positive contribution too. If they have a games console, when they have finished playing encourage them to switch it off at the wall rather than leaving it on stand-by. For example, a Playstation 3 switched off rather than left on standby could save a massive 604.2 kg of CO_2. (Games equipment often require large power transformers that draw power even when on standby).

As well as these easy changes you can also make buildings more efficient. These improvements can be made to both homes and community buildings. For example:

- Draught proofing the windows and doors in a house can reduce emissions by 130kg per annum.
- Cavity wall insulation can reduce emissions of CO_2 by a further 610kg per annum.

By making just the four simple changes illustrated above over a tonne of CO2 emissions could be saved per year. However, these are only a small number of the changes you might make. By looking online, particularly at websites like the Energy Savings Trust, you can learn about other activities that can reduce your carbon footprint. Remember the average household is responsible for 5.5 tonnes of CO2 emissions per year so one tonne is a significant reduction. Add together all the households taking part in a community project and you're making real progress.

Generating renewable energy

Sources of renewable energy come in a variety of broad categories. We describe five types here: wind, wave, solar, biomass and geothermal. Below, we identify the principal ways in which the sources of renewable energy can be used by communities and householders (often called micro-generation).

Wind

How it is used

Wind energy is captured by a turbine and the rotational motion is converted to electricity by a generator (although the energy can be used, for example, to operate a pump to pump water).

Community scale renewables

Typically a single or a number of turbines are used to generate electricity for local needs or sold into the grid with communities sharing in profits with a developer.

Micro-generation options

Typically a small turbine under 50Kw or so contributing to replacement of household electricity consumption.

Water

How it is used

Moving water (this can either be in the run of a fast flowing river or a large dam) drives a turbine for electricity generation.

Community scale renewables

A local run of river scheme might be a joint venture with a developer, or may provide power for a local community or estate.

Micro-generation options

Rarely used for micro-generation, but was one of the earliest forms of small scale domestic power - water wheels were used for milling and pumping water.

Solar Hot-water

How it is used

Sunlight heats water passing through a panel.

Community scale renewables

Typically will be used on the roof of a community building to provide heated water for central heating or other uses.

Micro-generation options

Relatively well established but still rare; potential for domestic roof based systems to provide contribution to heating and domestic hot water.

Biomass

How it is used

Taking the energy contained in biological material (including waste) and burning it to create heat energy which is either used directly, or for generating electricity. It involves various forms of combustion, and also includes anaerobic digestion of wastes to create gas which can then be burned.

Community scale renewables

A typical application might be for a combined heat and power (CHP) unit, generating both heat and electricity. CHP units can replace existing large boilers, such as those found at schools and hospitals.

Micro-generation options

Wood burning stoves, and wood chip or pellet stoves, to provide room heating and hot water, are the most common domestic scale applications.

Heat pump

How it is used

Takes advantage of temperature differences and works on the same heat exchange principle of domestic fridges. Typically the temperature difference utilised is small but constant.

Community scale renewables

Ground source heat pumps supplying heat for public buildings / swimming pools or similar applications. Typically expensive to install initially but relatively cheap to operate.

Micro-generation options

Domestic scale ground source heat pumps are considered effective for under floor and background heating systems. Similar air source heat pumps are also available and qualify for additional grant support in cases of fuel poverty in areas with no gas supply.

Other benefits

Environmental

Combustion of fossil fuels is associated with other pollutants as well as CO_2, in particular, oxides of sulphur (SO_x) and nitrogen (NO_x). Reducing this pollution can lead to improvements in air quality and a reduction of acid rain.

Social

Reduction in pollution can have local health benefits. Projects can benefit vulnerable people who may be suffering from fuel poverty. Projects – especially those involving volunteers – can also help build a stronger sense of community and reduce isolation. It may lead to other local activities with wider social benefits.

Economic

Energy saving and local generation can help people save money, and can reduce costs for community buildings. Large projects can generate considerable income for further community projects.

Key players

There are a number of groups and organisations that will be able to advise and assist you with your project. This can include expertise, funding and local knowledge. See the Project Planning Route Map for advice about working with other organisations. See Signposts for links to these organisations.

Community Energy Scotland (CES)

Community Energy Scotland is a charitable organisation that provides advice, expertise and potentially funding to community groups interested in establishing a community energy scheme. A source of information to those across Scotland, CES also manages a series of Scottish Government initiatives (these change from time to time so check the web pages regularly).

Local authority

Planning consent is required for the vast majority of community scale renewables schemes. Many householder scale installations will fall under what is known as permitted development and may not require planning consent to be granted. A good relationship with your local planning authority will help you avoid problems. There are 32 local authorities in Scotland and policies and practice are governed by Planning Advice Notes but interpretations on the ground do vary. Many authorities have staff available to help with these kinds of proposals.

Environmental regulators

Environmental regulators such as the Scottish Environment Protection Agency (SEPA) and Scottish Natural Heritage (SNH) may require you to have a licence to operate a renewable energy facility and may impose conditions on the way in which the facility is operated.

Local people and businesses

By discussing your ideas within the community you will be able to gain an understanding of the community's energy requirements. As well as participants in your development, local people and businesses may be a source of volunteers and funds. Local businesses may advertise events and meetings in shop windows or notice boards or even provide sponsorship or charge reduced rates.

Funding partners

Organisations such as the Energy Savings Trust are open to community organisations looking to take measures to cut CO2 emissions and have practical advice as well as small amounts of funds available. The Energy Savings Trust is keen to provide practical support and advice to community groups and has a dedicated community officer.

Technology partners

Technology firms will be able to advise your group about the most efficient and effective technologies available to your community organisation. However, do bear in mind that some of these potential partners are trying to find markets for their technology or their particular process. You should investigate a selection of partners before deciding which one to work with. You should ensure that spare parts will be available for your chosen technology and that the technology provider is committed to ongoing maintenance or support in the event that the technology does not perform as expected or requires servicing. You will also want to explore issues of feedstock availability with the technology partner for biomass systems.

Commercial Partners

Particularly for larger schemes there may be a case for having a commercial partner who can make certain the appropriate licences and consents are in place. They can also ensure that a suitable grid connection is available and a contract in place with the grid to receive the electricity generated and a suitable re-seller of electricity is available to market your renewable energy. There is currently a UK / Scottish Government scheme of Renewables Obligations Certificates (ROCs) and your commercial partner should undertake to secure these. Commercial partners may also be owners or holders of technology and these roles may be combined. Do bear in mind that their commercial interests are not always aligned with your own, even though you share a desire to develop a local project.

Environmental organisations

Environmental organisations such as the Royal Society for the Protection of Birds (RSPB) may also have to be consulted over siting of facilities such as wind turbines to ensure that important or protected species are not put at risk by the proposed development. Environmental organisations may also be sources of volunteers or participants in your energy scheme so maintain good relations with the environmental organisations in your area.

Choosing your route

When developing a community carbon reduction project with a focus on energy there are three approaches you could adopt:

- Encouraging – and supporting – people to reduce energy use and improve energy efficiency through ***behaviour change*** – perhaps supported by some simple tools like energy monitors.
- Encouraging – and supporting – people to install ***household infrastructure*** to either improve energy efficiency or generate renewable energy.
- Installing larger scale ***community infrastructure*** to generate renewable heat and/or electricity.

Behaviour change projects

As we suggested earlier, changing behaviour and becoming more energy aware can be the most cost effective means of reducing a community's carbon footprint. The Energy Savings Trust and Going Carbon Neutral Stirling, among other organisations, provide information about possible actions and the savings that can be achieved. Key to success will be getting a sufficient number of people to participate, change their behaviour – and to keep on making the changes.

Understanding what leads people to make – and continue to make – changes will be important to your project's success. The Project Planning Route Map has information on behaviour change.

Projects aimed at changing behaviour at a community level are potentially very effective in their own right. Where there is a proposal for a community infrastructure project it can be very powerful to combine this with energy efficiency and behaviour change projects as well. There are a number of other actions that people can take to improve the energy efficiency of homes, offices and community buildings (see also the Community Buildings Route Map) in your project area that lend themselves to being co-ordinated at a community scale.

Monitoring and controlling energy consumption

There are a number of devices which allow energy consumers to understand and see how they are consuming energy. These help to inform users about the nature and pattern of their energy use and can be very helpful as part of a campaign of supported behaviour change within a community. These lend themselves to bulk purchase (or donation) and to 'mass' installation as part of a community led project. Portable monitors can easily be shared with neighbours or members of a community group can take turns in using one in their own homes.

Monitors and smart-meters

The split between monitors and smart-meters is a little arbitrary. Monitors include devices householders can install and use themselves to provide real time readings of electricity use.

Monitors are simple devices placed over the cables near to your electricity meter which provides information on current energy use. These can be purchased for around £30 but may also be available more cheaply or free through electricity suppliers. Most of these monitors come in two units: one that attaches to the outside of the electricity supply cable and another about the size of a travel alarm clock which gives the readouts. The monitor responds very quickly to changes in demand making it possible to illustrate the difference in electricity used when the equipment is switched off.

Smart-meters are electronic devices fitted by electricity and gas suppliers which provide feedback to householders and the supplier. Unlike traditional electricity and gas meters it is possible for you to see your energy consumption in real time. The Government has announced that all homes in the UK will be equipped with smart-meters by 2020.

Smart-meters have been trialled in Sweden and the USA. It was shown that by making energy consumption clear to the consumer household energy bills were reduced by between 5 and 10%[iii]. However, there is now some evidence that the demand reduction associated with smart-meters does begin to fade after six months or so and it is important to refresh commitment to them on a regular basis.

Timers, thermostats and programmers

There are a number of devices that can be used to control heating and hot water systems in homes and community buildings. These devices control the temperature of water and heating, and make sure that water and heating is only turned on when it is needed.

A room thermostat allows control of the temperature of each room in the home or building. This allows heating to be turned down or off depending on what is required for the activities taking in place in a particular room. Generally, rooms occupied for living or working in can be kept slightly warmer than those which are occupied less. This can have a significant effect on reducing energy consumption although the savings will vary depending on how the system would be used without these additional controls.

'Power down' or 'anti-stand-by' devices detect when a piece of equipment is not being used or is in standby. The device then switches off the power to equipment. Care is needed when using these devices but they can be very effective in the right circumstances.

Household infrastructure projects

In this section we consider the options for household ***energy saving*** installations and domestic scale renewables infrastructure. Domestic renewables splits into two broad categories: ***low carbon heating*** and ***micro-generation***. Although there are some overlaps between the two, we consider technologies that replace or complement existing gas, electricity or oil based heating systems as low carbon heating. Under micro-generation we include systems to generate electricity on a domestic scale such as solar and wind.

Organising the installation of 20 domestic wind turbines or solar panels is likely to be far easier and cost effective than 20 individuals trying to arrange their own (especially if your project attracts funding to carry this out).

Individual householders can be intimidated by uncertainty about the suitability, applicability, and reliability of individual pieces of kit and can be concerned about local planning conditions and whether or not they have the skills to install it. Community projects can overcome those uncertainties of behalf of groups of householders. With many of these technologies, collective action wins on cost as well because a specialist installer can reduce travel and waiting costs by undertaking a number of installations in the same street at the same time.

Energy saving

Draught proofing

Draughts arise from poorly fitting doors, windows and skirting boards. In older buildings it's not uncommon to be able to see daylight around the doorframe.

The Energy Saving Trust (EST) states that in a typical home, 20% of heat is lost due to draughts and ventilation. Spending £300 (installed) or £90 (DIY) on draught-proofing can save 150kg of CO2. This provides an indication of the levels of savings possible when lots of households take part in a project, or when larger buildings are improved. Draught-proofing materials are readily available and can be easily installed.

Draughts around sash and case windows can be more tricky to deal with. Draught-proofing strips can be fitted, but these tend to come off with wear and tear. Specialist contractors can restore windows of this type, but this work costs more and as a CO2 reduction measure this is likely to be relatively expensive. That said, there are other benefits from extending the life of timber windows.

Insulation

Insulation is such a good idea that it shouldn't need mentioned. In a home, half the heat is lost through the walls and loft, so insulation has potential to cut emissions substantially. There are several different areas for insulating:

- Walls, by means of cavity insulation (if your building has one), or insulating the internal or external wall.
- Floors, by installing new insulated boards, and stopping up gaps between skirtings and flooring.
- Loft spaces, by installing or adding to the insulation material already there, in the form of quilts, boards or blown insulation.
- Water tanks and pipes, where heat loss can be reduced and frost damage reduced.

Different materials can be used for insulation, ranging from glass and rock-spun fibre quilt, to paper and sheep's wool. The EST has a list of materials it recommends. Indicative figures are available on EST's web site[iv] showing costs, CO2 savings and likely payback times, which vary according to the size of the project and the materials used.

Caution: If you are intending to do this work yourself, take care to check any risks before you start and plan out how you will deal with these. Also ensure you have suitable tools, equipment, including protective clothing, when working within lofts and other spaces within your building.

Lighting

This is a no-brainer. For most purposes, low energy light bulbs (sometimes called CFLs) are perfect substitutes for the old-fashioned incandescent type. Replacing just one 60 watt bulb with an 11 watt low energy alternative saves 80 kilograms of CO2 annually (based on lights being on 8 hours per day). The CO2 saving is considerable (up to 80%) .

Low carbon heating

There are three low carbon technologies worth active consideration – biomass, groundsource heat pumps and solar.

Biomass

Biomass is probably the most straightforward replacement for an existing heating system. Biomass can generate high temperatures and supply a central heating system in much the same way as gas or oil based systems. There is a significant capital cost in replacing a gas boiler with a biomass boiler; so this is most suitable for new build or the like for like replacement of an old system.

Biomass when burned creates CO2 emissions but wood and other plants absorb CO2 during their life, making the emissions 'carbon neutral'. However, there are CO2 emissions associated with the transport of biomass fuel. See the Travel Route Map for how to take account of transport related emissions.

Biomass boilers come in a variety of forms, mainly they burn logs, wood chips or wood pellets. The advantage of pellets (provided a reliable source can be found) is that their energy and moisture content is likely to be fairly consistent and the performance of the boiler therefore higher. Larger systems (typically non domestic scale systems) can be more tolerant of variations in input fuel.

Typically biofuel is burned to heat water which is then pumped around a central heating system. Suitable flue arrangements must be in place. Certain boilers and fuels are certified for smokeless zones.

With all these systems it is essential to identify appropriate sources of fuel, have a dry safe area for storage of fuel and have maintenance, regular servicing and technical support arrangements in place. You will also need to have suitable arrangements in place to dispose of waste ash (logs are likely to generate the most ash and wood pellets the least).

Ground-source (and air-source) heat pumps

Heat pumps rely upon the temperature differential between the ground and the inside temperature. The simplest description of the process is that it is like a refrigerator in reverse. A temperature gradient (difference) is established by installing an outside loop containing a mix of antifreeze and water which collects the energy and is pumped back to the heat exchange elements. A reasonable length of loop is required which can be buried vertically in bore holes, or horizontally where area allows; alternatively a pond or river can be an ideal place for a loop to be installed. Horizontal loops are cheaper to install because they only require shallow excavation but are only suitable where a large area is available. Vertical loops are typically more expensive to install but require a much smaller area for installation.

Operation of the system requires electrical energy for the operation of a pump and the efficiency of the system is often described in terms of the ratio of input energy to output energy – ratios as high as 1:4 are not impossible. Air source systems are typically a little less efficient but easier to install..

Heat pumps can provide a constant source of low level heat and are suitable for background heat and under-floor heating. Heat pumps continue to work even in very low temperatures because there is consistently a temperature differential between the underground and the surface temperatures.

Heat pumps take several hours before they provide reliable heat and are therefore not suited to uses requiring rapid heating. Heat pumps are often considered ideal for local swimming pools and church halls.

Heat pumps are quite complicated installations and incorrect installation can significantly impair performance. It is important to ensure the installer provides appropriate guarantees of workmanship and performance.

Ground-source heat pumps have recently been brought within the permitted development regime for planning purposes and will normally be permitted for household installation without the need for a planning application. It is nevertheless advisable to seek guidance from local planning authorities. A community led project could clarify with the planning authorities what restrictions or conditions would apply, saving both the authority and householders from repeated individual enquiries.

Solar hot water

Solar hot water systems (sometimes referred to as solar thermal systems) have been available for a considerable time and in spite of our relatively low temperatures and lower levels of sunlight than many other parts of Europe, they can nevertheless be a good option for some people. There are two main types of panel system to consider: evacuated tube systems and flat plate systems. Evacuated tubes are generally a little more efficient than flat plates but also a little more expensive. Typically they are recommended for areas with lower sunlight. Cheaper flat plates can be designed with a higher surface area and are less susceptible to wind damage.

Panels are usually roof mounted and you should ensure that the roof is sufficiently robust to support the additional weight and provide a suitable anchor for the system (including during high winds).

Heat from the sunlight warms water in tubes which is then fed into the hot water system. Supplementary heating will usually be required. In public buildings there have been concerns about the potential for legionella to thrive if high enough temperatures are not reached.

The positioning of the panels can have significant impact on both the total energy accumulated and time of day when hot water will be available; appropriate advice should be sought to ensure that your requirements are met.

Because solar panels are highly visible it is advisable that even though they may be within permitted development for planning purposes (outside of conservation areas) suitable advice should be sought from the planning authority.

You should also bear in mind that solar systems will provide different amounts of heat at different times of year. A system that is sufficient during summer may require topping up with an additional system during winter months.

Micro-generation

Micro-generation (micro-gen) is the small scale generation of electricity: solar PV (photovoltaic) cells and micro wind turbines.

Solar Photo-voltaics (PV)

Solar PV is very similar to solar hot water but generate electricity, not hot water. Typical applications of solar PV are off-grid locations where a battery is charged in order to store and supply electricity when needed. The cost of panels is relatively high and the amount of electricity generated in Scotland will be relatively low.

Care has to be taken with siting and the structural integrity of roofs where panels are fitted.

Local authorities have had some success in using Solar PV to power street furniture such as parking meters and road signs where power demands are low and failure has few significant consequences.

Micro Wind Turbines

Wind turbines capture the energy in the wind. Wind causes the blades to turn and the motion is converted to electricity in a generator. The amount of electricity generated is a function of the wind speed and the area of the turbine blades. Most wind turbine blades are vertical like a propeller of an aeroplane but horizontal systems are also available. Turbines with an energy rating up to about 500w that can be fitted to the roof can be found and will supply electricity to the householder supplemented by electricity from the grid. The rating of a wind turbine is the maximum energy supply and the actual performance will depend a very great deal on wind conditions and location. In high winds it may be necessary to shut down your system to avoid damage and you should ensure that this can be done easily.

Public acceptability of wind turbines is high but costs can be prohibitive and payback periods can be quite long.

Not all areas are suitable for micro wind turbines and care should be taken to identify suitable sites. The presence of other buildings often reduces the useable wind resource. If a turbine is to be attached to a building structural integrity must be considered. A community project could carry out surveys for householders to assess the potential for interested householders to ensure that systems are not purchased for areas with poor wind resources.

Community infrastructure projects

In this section we consider options for communities to create community owned infrastructure to generate electricity and/or heat for use locally. This should be read in conjunction with the Feasibility Studies Route Map. The information provided here is a starting point and these kinds of projects should only be undertaken after considerable thought and preparation.

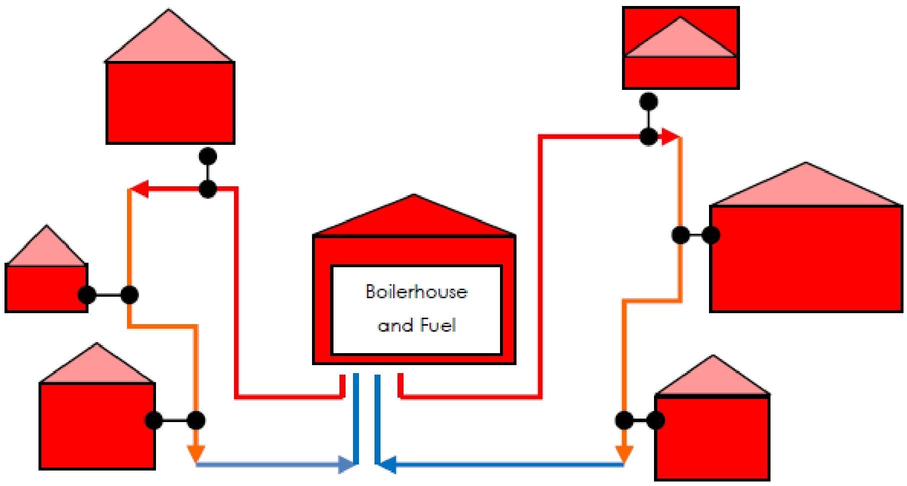
Community scale wind and hydro

In essence these projects are simply enlarged versions of the domestic scale schemes described above and many of the same constraints and issues apply. However, at a community scale there are important issues of organisational structure and governance. Advice is available from Community Energy Scotland – see Signposts.

Combined heat and power

Combined heat and power plants can use a variety of fuels (gas, biomass, and waste being the most likely.) Heat in the form of hot water is then distributed to the participating households, offices and factories in a loop with cooler water returned to the boiler house for re-heating and re-pumping. There may also be a supply of electricity to households or the grid.

This is a large and complicated proposition and not to be undertaken lightly. Thought needs to be given to the appropriate legal structure and ownership arrangements for all projects but a shared service system based on significant capital investment and with a lifespan of many years needs particular attention.



This kind of system is most easily installed in a new build development. Retro-fitting is possible, but the disruption and costs associated with laying pipes and modifying individual heating systems can make it expensive.

A metering system for charging or cost sharing and a billing system will be needed. Collecting payments can be a particularly difficult task. It is essential that the system for billing is robust and efficient because even small delays in payment can cause considerable difficulties for the community operator which will have wages and bills to pay.

In developing a system like this attention needs to be given to the supply of input fuel which needs to be both local and reliable to maximise CO2 savings. In addition the equipment needs to be robust and supported with a reliable service arrangement.

Case studies

Here are a few examples of community led projects that have been developed demonstrating how other community groups have already taken this journey. You should refer to the Feasibility Studies Route Map for further information about conducting your own locally relevant feasibility study.

Ardvasar Community Hall Solar Water Heating Project[v]

Ardvasar Community Hall is used for a variety of community activities, from hosting the local playgroup to dances and parties. The Community Hall Committee were looking to run their building in a more sustainable fashion.

In 2007 they received a grant from what is now Community Energy Scotland of £4410 which covered 81% of the costs of installing a Solar Water Heat Pump. It is believed that the installation of this new system saves the community 1760 Kw (and 945 kg of CO_2) which would otherwise have to be bought from an electricity supplier.

Boyndie Windfarm Cooperative[vi]

The Boyndie Windfarm Cooperative bought a stake in a seven turbine wind farm situated on a former World War II airfield. There are 716 stakeholders with the minimum stake being £250 and the maximum £20,000. The seven turbines are capable of producing 14Mw of electricity (7.5 tonnes of CO2). Providing electricity for around 7,000 homes

Members of the cooperative receive a number of benefits. As well as receiving an annual interest payment based on their stakeholding, members also receive expert advice on how to reduce energy usage.

Ayrshire Energy Agency[vii]

In 2007 The Energy Agency began providing advice to the communities in Ayrshire and Dumfries and Galloway. The aim was to create warmer, more energy efficient, sustainable communities. The Energy Agency provides free on the doorstep advice to the local community and also makes free insulation available. This is not dependent on the household fulfilling any particular criteria. Traditionally, uptake of free insulation and advice is normally 10%. Take up for this scheme is substantially higher at 63%.

Planning your journey

Key data

Activity	kWhs Saved Annually	Kg of CO_2 Saved Annually
Turn lights off in your home at night	28	15.7
Reduce the amount of TV that you watch by 3 hours per week	42.1	23.7
Turn off electrical equipment at the wall when not in use (compared with standby mode)	Desktop Computer	6.4
	Laptop	1.6
	Stereo Amplifier	19.3
Draught proof windows and doors		130
Insulate your hot water tank		195
When replacing your boiler, replace with a condensing boiler		875

Table 1: CO2 savings from selected activities.

Additional data for similar activities is available from Going Carbon Neutral Stirling – see Signposts.

Fuel Type	Units	kg CO2 per unit
Grid Electricity	kWh	0.430
Natural Gas	kWh	0.206
	Therms	6.023
Gas	Tonnes	3190
	kWh	0.265
	Litres	2.674
Diesel	Tonnes	3164
	kWh	0.263
	Litres	2.63
Petrol	Tonnes	3135
	kWh	0.252
	Litres	2.315
Fuel Oil	Tonnes	3223
	kWh	0.282
Burning oil	Tonnes	3150
	kWh	0.282
	Litres	2.518
Domestic Coal	Tonnes	2523
	kWh	0.313
Wood Pellets	Tonnes	132
	kWh	0.026

Table 2: Emission factors for selected fuels[viii].

Estimating potential savings

All of the projects and technologies described here can provide considerable CO2 savings compared to the alternative of using grid electricity or fossil fuels. The general formula to use is as follows:

Emissions by existing system – emissions from new system = emissions saved.

Infrastruture projects

A simple method of calculating savings of CO2 is to find the amount of fossil fuel or electricity saved or replaced and multiply this by the CO2 conversion factors in Table 2.

This gross amount is then adjusted (reduced) to reflect the additional CO2 associated with the project activities such as delivery of input fuel, CO2 embodied in equipment purchased and so on.

Below is an example of how you can estimate the CO2 savings from replacing an electric heating system with a wood pellet boiler:

First: Calculate existing electricity use over the last year from the meter readings shown on electricity bills:

Current meter reading – meter reading at same time last year = electricity used over the year

Say, 23,432 kWh (kilo Watt hours) of grid electricity.

Second: Calculate CO_2 emissions associated with generating that electricity:

Electricity used x emissions factor for grid electricity = CO_2 emissions

Eg: 23,432 kWh [from above] x 0.43 kg CO_2/kWh [from table X] = 10,076 kg CO_2

Third: Calculate emissions from new system (in this case the number of tonnes of wood pellets required to operate the system. If you are just comparing the efficiency of the system you should use the number of tonnes required to provide the same level of heat output as before. However, if part of your project is to increase the level of comfort and therefore the heat output you should use the amount of fuel that will be used for the new system.

Tonnes of wood pellets x emissions factor for wood pellets = CO_2 emissions

Eg: 8 tonnes x 132 kgCO_2/tonne = 1,056 kg CO_2

Fourth: Subtract new from old giving the gross annual savings.

Electricity CO_2 – Wood Pellet CO_2 = Gross Savings

10,076 – 1,056 = 9,020 kg CO_2 (ie just over 9 Tonnes)

Fifth: Factor in additional CO_2 – in this case we will include the delivery of wood pellets from 22 km away by lorry (using DEFRA factors for heavy goods vehicle: 0.132kg per tonne km – see the Travel Route Map for other transport emission factors). This accounts for the emissions from the fuel used in transporting the pellets to your facility.

Delivery Tonnes x distance x emission factor = additional CO_2

8 tonnes x 22 km x 0.132 kg CO_2/tkm = 22.2 kg CO_2

If there are several additional sources of CO_2 add them together.

Finally: Subtract additional CO_2 from gross savings (calculated in 3 above)

Gross Saving – additional CO_2 = net CO_2 savings

9,020 – 22.2 = 9,997.8 Kg

Behaviour change projects

Calculating the CO_2 savings from a behaviour change project can be achieved by comparing energy bills over time (although you will need a complete year of electricity use before and after the change to get a meaningful result) and simply multiplying the difference in KWh by the Grid Electricity figure in Table 2.

However, if you want to estimate savings of CO_2 without having such a detailed record or before bills arrive, the methodology is a little more complicated but basically the same as in the example above. You need to compare the electricity use before the behaviour change with electricity use after the behaviour change (and then multiply by the grid electricity figure). Here is an example:

Your project has succeeded in encouraging three types of behaviour change, switching to low energy light bulbs, switching TVs and associated equipment off, rather than leaving them on standby and only washing full loads of clothes in the washing machine. In this example we will use average values but if you have smart meters or monitors you could get even more precise calculations.

First: Collect information from your group about what they have changed over a set period of time (let's say a week for this example).

Your results will look something like this:

Action	Number of times done	Notes
Switch to low energy light bulb 60w to 11w	250	Add up the total number of bulbs changed
TV switched off not left on standby	75 nights	Not everyone will do it every night so it makes sense to record each night separately
Wash only full loads	50 loads saved	Number of loads saved

Second: Multiply up for the week using a reputable source of information such as the carbon crib sheet. The procedure looks something like this:

Action	Number of times done	Multiplier[ix] Kg	CO2 Saving Kg
Switch to low energy light bulb 60w to 11w	250	1.5	375
TV switched off not left on standby	75 nights	5.6	420
Wash only full loads	50 loads saved	.31	15.5
Total			810.5

You have now calculated the carbon saving for the week.

Third: To convert this into an annual saving you can multiply by 52.

810.5 x 52 = 42,146 Kg (42.146 tonnes) of CO2 per year.

However, you need to appreciate that not all people will stick to these changes so you will need refresh people's commitment and of course repeat your survey. You can find out more about 'stickiness' of behaviour change in the Project Planning Route Map. Changes such as switching to low energy bulbs will tend to stick because people rarely change back to old incandescent bulbs, but changes like switching equipment off need to be regularly reinforced so that people keep on doing them.

Note: You can also use this method to estimate the carbon savings from a project that you plan (simply use the planned changes rather than the results of your survey).

And also…

There are a few more issues to take account of:

Embodied energy / CO_2 in the technology used

Embodied energy is a measure of the energy used in the manufacture of equipment that you use, it can include the energy required to extract the minerals used in production, manufacture and installation. The calculations of CO_2 emissions from grid electricity do not include the embodied energy (and therefore CO_2) in the construction of power stations so unless your technology is particularly energy intense in production the convention is that it should be ignored. It may also be very difficult to find out what the embodied energy / CO_2 of your equipment is but it is a good question to ask your supplier. If you can establish the embodied energy you might like to calculate how long it will take to repay the embodied CO_2 emissions in your project with the CO_2 savings your project will deliver. The procedure is simple – divide the embodied CO_2 by the annual CO_2 savings and the result is the number of years your equipment needs to operate before the CO_2 is 'repaid'.

Transport emissions of input fuels (in the case of biomass)

Where you feel this might be significant you can readily account for this in your calculation. It is included in the example above. However, note that CO_2 from grid electricity does not include the CO_2 used in extracting or transporting coal or gas that might have been used in its production.

Increased energy use

In some systems (heat pumps for example) there might be a greater level of overall comfort from heating than there would have been had the original system been retained. In some cases, therefore, the saving in CO_2 might be lower than if you had made a comparison between CO_2 emissions before and CO_2 emissions using the same system for the same level of comfort. It is worth noting this increase in comfort when you report emissions reductions. See information on rebound effects in the Project Planning Route Map.

Signposts

Carbon emission factors

DEFRA's emissions factors *– generally recognised as the 'official' figures for calculating emissions – are listed in:*

Guidelines to Defra's greenhouse gas (GHG) conversion factors for company reporting – annexes
http://www.defra.gov.uk/environment/business/reporting/pdf/ghg-cf-guidelines-annexes2008.pdf

Additional background information, including methodology, is also available if required – but unlikely to be necessary for most projects:
http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Going Carbon Neutral Stirling *has a comprehensive list actions people can take showing the CO2 reductions associated with each action:*
http://www.goingcarbonneutralstirling.org.uk/

Background information about micro-generation in Scotland

An alliance of social and environmental NGOs, including Age Concern, Barnados, Friends of the Earth Scotland and WWF promoting the micro-generation.
http://www.microgenscotland.org.uk/

Approaches to micro-generation

Scottish Government Consultation Document: 'Energy Efficiency and Microgeneration: Achieving a Low Carbon Future: A Strategy for Scotland'
http://www.scotland.gov.uk/Publications/2007/03/09144516/0

Scottish Government: 'Community Renewable Energy Toolkit'
http://www.scotland.gov.uk/Publications/2009/03/20155542/0

Renewable Energy Office for Cornwall: Information and approaches to microgeneration in Cornwall
http://www.reoc.info/microgeneration-community-and-domestic-scale

BERR document showing number of micro-generation installations
http://www.berr.gov.uk/files/file49151.pdf

Energy saving and micro-generation advice

Going Carbon Neutral Stirling
http://www.goingcarbonneutralstirling.org.uk/

Funding: Talent Scotland, a part of Scottish Enterprise: web page 'Funding for Micro-renewables' http://talentscotland.com/jobs.aspx?item_id=62314

How to get Microgeneration fitted, information provided by the Energy Savings Trust and The Scottish Government
http://www.energysavingtrust.org.uk/scotland/Scotland/Scottish-Community-and-Householder-Renewables-Initiative-SCHRI/Household-renewables/How-can-I-get-it-installed

Microgeneration Case Studies from the Energy Savings Trust and the Scottish Government
http://www.energysavingtrust.org.uk/scotland/Scotland/Scottish-Community-and-Householder-Renewables-Initiative-SCHRI/Household-renewables/Case-studies

Scottish Biomass Heat Scheme
http://www.scotland.gov.uk/Topics/Business-Industry/Energy/19185/20805/BioSupport/BioSupportIntro

Energy Savings Trust
http://www.energysavingstrust.org.uk

Heating Controls
http://www.energysavingtrust.org.uk/Home-improvements/Heating-and-hot-water/Heating-controls

Existing community micro-renewable projects

Sheffield Community Renewables: Gives an overview of the activities which this organisation carries out.
http://sheffieldcommunityrenewables.org.uk/

CORE - a Social Enterprise which supports local community groups in implementing community microgeneration projects.
http://www.core.coop/site/

E-on Sustainable Energy Fund: Microgeneration
http://www.eon-uk.com/about/2648.aspx

Ecodyfi: A community group which owns and runs wind turbines
http://www.ecodyfi.org.uk/prnewturbine.htm

Community windfarm in Selkirk, Scottish Borders at the feasibility study stage
http://www.thesouthernreporter.co.uk/news/Selkirk-wind-proposal-takes-step.5237871.jp

Orkney Renewable Energy Forum
http://www.oref.co.uk/

Community Energy Scotland
http://www.communityenergyscotland.org.uk/about-us.asp

Boyndie Wind Farm Co-operative Limited
http://www.boyndie.coop/boyndie_aboutus.asp

Sources of funding for community energy projects

DECC
http://www.lowcarbonbuildingsphase2.org.uk/page.jsp?id=5

Scottish Biomass Heat scheme

http://www.usewoodfuel.co.uk/ScottishBiomassHeatScheme.stm

Climate Challenge Fund

http://www.keepscotlandbeautiful.org/ccf.asp

SNH

http://www.snh.org.uk/about/ab-grants.asp

Glasgow Council for Voluntary Sector

http://www.gcvs.org.uk/?gclid=CJmbq6fAkZsCFd0B4wodJAjmpw

Community Energy Scotland

http://www.communityenergyscotland.org.uk/grant-funding.asp

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[i] Scottish Energy Study Volume 1 (Accessed (8/6/09)
http://www.scotland.gov.uk/Publications/2006/01/19092748/5

[ii] Scottish Energy Study Volume 1 (Accessed 8/6/09)
http://www.scotland.gov.uk/Publications/2006/01/19092748/5

[iii] http://www.energysavingtrust.org.uk/Resources/Features/Features-archive/Smart-meters-your-questions-answered

[iv] See Energy Saving Trust, 'Home Insulation & Glazing' section viewed at
http://www.energysavingtrust.org.uk/Home-improvements/Home-insulation-glazing

[v] http://www.communityenergyscotland.org.uk/case-studies.asp?id=21 (Accessed 10/9/2009)

[vi] http://www.boyndie.coop/boyndie_home.asp (Accessed 10/9/2009)

[vii] http://www.energyagency.org.uk/

[viii] DEFRA (2008) http://www.defra.gov.uk/environment/business/reporting/pdf/ghg-cf-guidelines-annexes2008.pdf

[ix] From Going Carbon Neutral Stirling 'crib sheet'

http://www.goingcarbonneutralstirling.org.uk/