Energy Action Scotland Advisors Toolkit

Chapter VI. Renewables

"Working to end fuel poverty and achieve warm, dry homes for all."

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Renewable Technologies and Planning

There are a number of microgeneration renewable technologies now available that can be incorporated into both new developments and existing homes. These can reduce greenhouse gas emissions (which contribute to climate change) and save money by providing cheap energy and reducing the impact of gas and electricity price rises. Anyone intending to install domestic renewable technologies should be advised to first install 'traditional' energy efficiency measures such as cavity wall or loft insulation where possible.

The Town and Country Planning (General Permitted Development) (Domestic Microgeneration) (Scotland) Amendment Order 2009 grants rights to carry out certain limited forms of development on the home, without the need to apply for planning permission. The scope of the TCP (GPD) in Scotland now extends to the following technologies:

Solar PV and solar thermal (roof mounted) is permitted unless:

- panels protrude more than 200mm when installed
- installed on any part of the external walls of the building if the building contains a flat
- panels, when installed on a flat roof, are situated within 1 metre from the edge of the roof or protrude more than 1 metre above the plane of the roof
- panels, when installed, project higher than the highest point of the roof (excluding the chimney)
- the building is within a conservation area and the solar PV or solar thermal equipment is installed on a roof which forms the front of the building and is visible from the road.

The solar PV or solar thermal equipment must, as far as is reasonably practical, minimise its effect on the amenity of the area and be removed when it is no longer needed or used for domestic microgeneration.

Solar PV and solar thermal (stand alone) is permitted unless:

- more than 4 metres in height
- above a maximum area of array of $9m^2$
- installed a distance from the boundary of the curtilage of the dwelling house which is less than the height of the array
- within the curtilage of a listed building
- results in more than one free standing solar
- the building is within a conservation area and the solar PV or solar thermal equipment is installed on a wall or roof which forms the front of the building and is visible from the road.

The solar PV or solar thermal equipment must, as far as is reasonably practical, minimise its effect on the amenity of the area and be removed when it is no longer needed or used for domestic microgeneration.

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Wood burning boilers and stoves, and micro-CHP is permitted unless:

- the flue exceeds 1m above roof height (excluding the chimney)
- installed on the principal elevation and visible from a road in buildings in Conservation Areas
- the flue is situated within an Air Quality Management Area (when CHP is wood fuelled)

Ground source heat pumps:

Permitted

Water source heat pumps:

Permitted

Micro and small wind

TCP (GPD) does not cover micro or small wind. Further legislation is expected later this year and it is expected that roof mounted and free standing wind turbines will be permitted at detached properties that are not in conservation areas. Consult with the local authority regarding planning permission.

Air source heat pumps

TCP (GPD) does not cover air source heat pumps. Further legislation is expected later this year and it is expected that air source heat pumps will be permitted developments. Consult with the local authority regarding planning permission.

Note that permitted development rights are not extended to Listed Buildings which are covered by other planning regulations.

Most renewable technologies must be installed by an appropriately qualified/registered/approved installer.

Always check with the local authority to find out whether planning permission is required or not.

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Solar PV

Solar Photovoltaic is a technology in which daylight is converted into electrical power. The most common systems comprise a number of semiconductor cells (the cells comprise one or two layers of a semi conducting material, usually silicon, which converts solar energy into electrical energy) interconnected to form a solar panel or module. A number of modules are usually connected together in an array.

Solar PV can either be roof mounted or free-standing in modular form, or integrated into the roof or façades of buildings as solar shingles, solar slates or solar glass laminates. Solar PV can be connected to the national grid or used as a stand-alone system.

Solar PV:

- Does not generate greenhouse gases or cause pollution when in use. Each kilowatt-peak (kWp) of electricity produced can save approximately 455 kilograms of carbon dioxide emissions compared with electricity generated from fossil fuels
- Has no moving parts, and is low maintenance
- Can be integrated into the building fabric
- Does not require direct sunlight.

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The cost of a solar system varies depending on the type of system used and the size of the array installed. A typical array on a family home would produce 1.5 to 3kW peak output (providing approximately half of the household's electricity needs every year). In grid-connected solar PV systems any surplus electricity can be sold back to the local distribution network with the agreement of the network operator and an electricity supplier.

- See Feed-in Tariffs, Chapter IV. A (2)

The optimum location for PV panels is facing south and at a tilt of 35 - 40˚. Direct sunlight is not needed but care must be taken to avoid overshadowing from buildings, trees and other structures. If the roof surface is in shadow for parts of the day, the output of the system decreases.

Solar PV installations should always be carried out by a trained and experienced installer. Solar PV is low maintenance, however wiring and components should be checked regularly by a qualified technician.

Stand-alone systems, i.e. those not connected to the grid, need maintenance on other system components, such as batteries.

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Solar Panels (Thermal)

Solar collectors are panels containing fluid that absorb the sun's energy and use this to heat water contained within a storage tank for use within the home, normally for domestic hot water heating.

Solar water panels come in two main forms: flat plate (the collectors are in a box which is usually glazed and insulated behind); and evacuated tubes (where vacuum glass tubes enclose each pipe and its associated absorber plate acts as the insulation). Flat plate tends to be cheaper to buy but evacuated tubes are more efficient.

Solar panels:

- can meet almost all domestic hot water requirements during the summer months (approximately half all total annual requirements) for an average household
- have no moving parts (excluding plumbing system parts) and are low maintenance
- produce energy even with diffused sunlight.

The cost of a solar system varies depending on the type of system used and the amount of hot water required. A collector area of 3-5m² is typically installed for a family of four.

For solar energy collectors the optimum location is facing slightly west of due south and at a tilt of 30 - 40˚. If the roof surface is in shadow for parts of the day, the output of the system decreases. Solar panels are heavy and the roof must be strong enough to take their weight.

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Wind Turbines

Wind turbines convert the power in the wind into electricity, using rotating blades to drive a generator. The electricity produced can be used directly, used to charge batteries or linked directly into the national grid.

The power of a wind turbine increases exponentially in relation to the speed of the wind, and the diameter of the blades. This makes larger turbines with higher wind speeds more cost effective e.g. the energy payback for larger turbines in windy places is multiplied.

There are two types of domestic-sized micro wind turbine:

- mast mounted: these are free standing and are erected in a suitably exposed position
- roof mounted: these are smaller than mast mounted systems and can be installed on the roof of a home

If a micro wind turbine eligible for feed in tariffs (FiTs) is connected to the grid in a location with high wind speeds, consumers can sell excess or surplus generated electricity to an electricity supply company, and earn an added export tariff. If a wind turbine is not connected to the grid, surplus electricity can be stored in a battery. Wind turbines need to be appropriately sited on or off the electricity grid. The issue of intermittency has to be taken into consideration, as well as amenity issues in terms of noise and visual amenity.

NB - Field trials have demonstrated that small wind turbines need to be sited in appropriately windy and usually exposed locations to operate optimally. Approved installers can advise on the best locations and should be able to provide fairly accurate predictions on energy outputs. Energy outputs for wind are very site-specific, so at least a three month period of advance wind speed testing is recommended, as well as certified products and installation.

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Ground Source Heat Pumps (GSHP)

Ground source heat pumps (GSHP) transfer low-temperature heat from the ground into the home to provide space heating and in some cases, to pre-heat domestic hot water. Beneath the surface, the ground stays at a fairly constant temperature, so a ground source heat pump can be used throughout the year.

GSHP needs electricity to run, but it should use less electrical energy than the heat it produces.

A GSHP system comprises a ground loop and a heat pump at ground level. The ground loop is a network of pipes sunk in a borehole or buried in a straight or horizontal (‘slinky coil’) trench. It is a closed circuit and filled with a mixture of water and antifreeze, which is pumped round the pipe absorbing heat from the ground. The heat pump raises the temperature (through a process of evaporation, compression and condensation) for supplying a heating system.

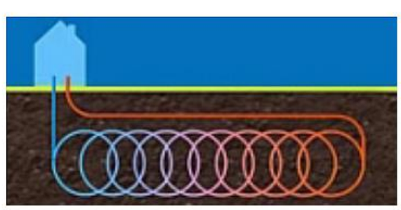
The heat produced by GSHP is at a lower temperature than other forms of heating – making it best suited to underfloor heating, which requires lower temperatures, rather than radiators (or, if radiators are used, they should be properly-sized). Those installing GSHP need to consider whether a back-up system will also be required.

GSHPs differ in size and complexity, so cost and payback are difficult to specify. Payback is also influenced by: efficiency of the system; the type of system being replaced by GSHP; energy efficiency of the home; whether GSHP is also being used for heating the domestic hot water supply.

The efficiency of a GSHP system is measured by the Coefficient of Performance (CoP). This is the ratio of units of heat output for each unit of electricity used to drive the compressor and pump for the ground loop. Typically, for every unit of electricity used to pump the heat, 3 to 4 units of heat are produced.

In addition to planning requirements, consideration needs to be given to the area and type of land and access for machinery.

The Energy Saving Trust has just completed field trials of ground and air source heat pumps, in order to get a better idea of how they perform and the savings they achieve in real life environments. Read the final report ‘Getting warmer: a field trial of heat pumps’ on their website at www.energysavingtrust.org.uk



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Air Source Heat Pumps (ASHP)

Air source heat pumps (ASHP) absorb heat from the outside to heat buildings. There are two types of air source heating systems. Air-to-air systems provide warm air, which is circulated to heat a home. Air-to-water systems heat water to provide heating to a home through radiators or an underfloor system. ASHP can extract useful heat from air at temperatures as low as minus 15°C.

ASHP needs electricity to run, but it should use less electrical energy than the heat it produces. Typically, for every unit of electricity used to power the pump, 3 to 4 units of heat are produced.

ASHPs extract heat from the outside air, and use it to heat your home and hot water. An air source heat pump has three main parts: an evaporator coil which absorbs heat from the outside air; a compressor which drives the refrigerant through the heat pump, compressing it to increase its temperature and; a heat exchanger which transfers the resulting heat to air (for warm air convection systems) or water (for radiators, underfloor heating or pre-heating water in a storage tank).

ASHPs differ in size and complexity, so cost and payback are difficult to specify. Payback is also influenced by: efficiency of the system; the type of heat distribution system being installed (underfloor heating tends to be more effective); the type of system being replaced by ASHP; energy efficiency of the home; whether ASHP is also being used for heating the domestic hot water supply.

In addition to planning requirements, consideration needs to be given to the installation site (space and air flow).

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Water Source Heat Pumps

Water source heat pumps (WSHP) absorb heat from a source of groundwater to heat buildings. There are two types of WSHP, water-to-air systems provide warm air, which is circulated to heat a home and water-to-water systems heat water to provide heating to a home through radiators or an underfloor system.

A water source heat pump system extracts heat from a local water source and usually operates exactly like ground source heat pumps within a 'closed loop' system. In a closed loop system, the pipe work will simply be sunk to the bottom of a water course. However in some instances a water source heat pump can operate using an 'open loop' system. This involves water being abstracted from a borehole and discharged via a heat exchanger to a river or sewer. These systems can be very efficient because of consistent water temperatures.

The Coefficient of Performance (the units of heat generated for each unit of electricity used) – COP - of water-to-air heat pumps will depend on the temperature of the source water, but typically lies between 2.8 and 3.7. The COP of water-to-water heat pumps will depend on the source water temperature and the temperature to which it is being raised, but is typically in the range of 3 and 5.

Possible water heat sources are:

- **Ground water** is available with stable temperatures (4-10°C) in many regions. Open or closed systems are used to tap into this heat source. In open systems the ground water is pumped up, cooled and then re-injected in a separate well or returned to surface water. Open systems should be carefully designed to avoid problems such as freezing, corrosion and fouling. Closed systems can either be direct expansion systems, with the working fluid evaporating in underground heat exchanger pipes, or brine loop systems. Due to the extra internal temperature difference, heat pump brine systems generally have a lower performance, but are easier to maintain. A major disadvantage of ground water heat pumps is the cost of installing the heat source. Additionally, local regulations may impose severe constraints regarding interference with the water table and the possibility of soil pollution.

- **River and lake water** is in principle a very good heat source, but has the disadvantage of low temperatures in winter (close to 0°C). Great care has to be taken in system design to avoid freezing of the evaporator.

- **Waste water and effluent** are characterised by a relatively high and constant temperature throughout the year. Examples of possible heat sources in this category are effluent from sewers (treated and untreated sewage water), industrial effluent, cooling water from industrial processes or electricity generation, condenser heat from refrigeration plants. The major constraints for use in residential and commercial buildings are, in general, the distance to the user, and the variable availability of the waste heat flow. The heat is then delivered to either radiators or fan-coil units within the indoor space.

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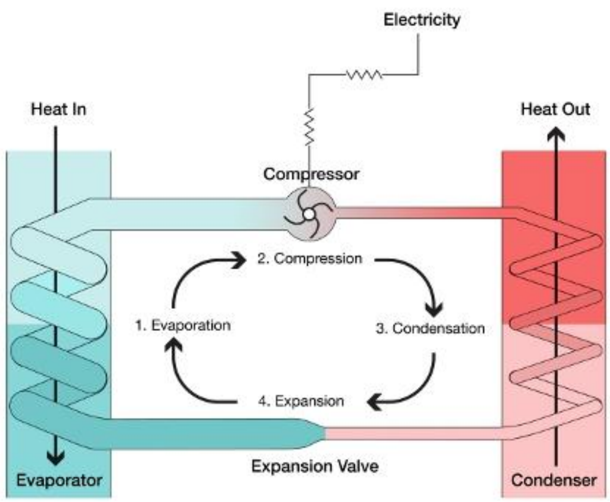
- WSHP needs electricity to run, but it should use less electrical energy than the heat it produces.
- Water source heat pumps are ideal for new builds, highly insulated renovated houses and houses with underfloor heating.
- Installation costs can be slightly higher than other types of heat pumps. The pipes require space and good depth and some flow of water to refresh the heat collection. Lake source heat pumps have lower running costs and can capture better temperatures from "refreshed" water.
- A heat pump consists of three main elements; the evaporator, the compressor and the condenser. A heat pump uses its ‘evaporator’ to pump energy from outside to inside, raising the internal temperature through releasing heat via an internal ‘condenser’. The diagram below shows how this works.



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EAS Advisors Toolkit

Factsheet No VI. 8

Micro Combined Heat and Power (CHP)

Micro-CHP is a specific form of CHP designed for individual households. It replaces a standard domestic gas boiler, generating heat and electricity simultaneously, from the same energy source. A typical domestic system is expected to have the potential to generate up to 1kW of electricity per hour, which would be enough to power the lighting and appliances in an average home. The amount of electricity generated ultimately depends on how long the system is running.

Most domestic micro-CHP systems use mains gas or Liquid Petroleum Gas (LPG) as a heating fuel, although they can also be powered by oil or bio fuels. While gas and oil are not renewable energy sources (they are fossil fuels), the technology is still considered to be a 'low carbon technology' because it is more efficient than just burning the fossil fuel for heat and getting electricity from the national grid.

Micro-CHP systems should always be installed and run to meet the heating needs of the building, rather than to generate more heat than is needed just to meet electricity demand. The electricity generated should be treated as a useful by-product of heat generation. For this reason, electricity will only be generated when there is a heat demand.

Because they only generate electricity when there is a heat demand, micro-CHP systems are more cost effective in houses with large heat demands that cannot be reduced by other means such as upgrading insulation, draught proofing and other low carbon heat technologies such as wood stoves.

Any electricity generated and not used in the home can be exported back to the grid.
Micro-CHP is eligible for Feed in Tariffs (FiTs).

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Wood Fuelled Heating (Biomass)

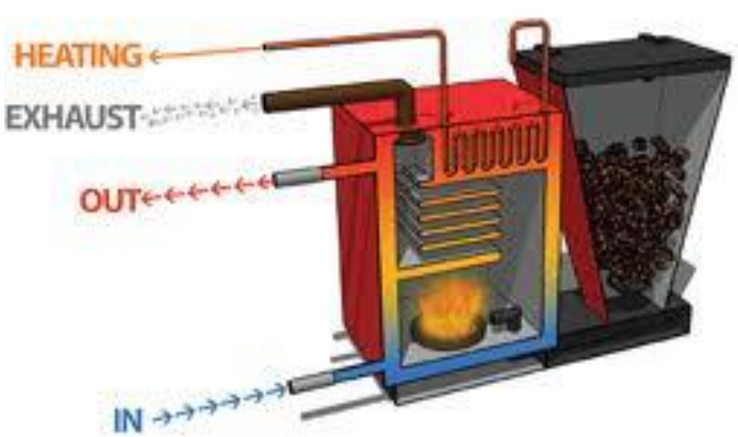
Wood fuel is often referred to as biomass, bioenergy or biofuel. Biomass is produced from organic materials, either directly from plants or indirectly from industrial, commercial, domestic or agricultural products. It is considered to be a carbon neutral fuel. Wood fuel includes forest products, untreated wood products, energy crops and short rotation coppice (SRC), e.g. willow. Small-scale domestic applications of wood fuel usually take the form of wood pellets, wood chips and wood logs.

Homes can either use stand-alone stoves providing space heating for a single room, or boilers connected to central heating and hot water systems. Stoves (which can often be fitted with a back boiler to provide water heating) can be fuelled by logs or pellets but only pellets are suitable for automatic feed. Boiler systems are suitable for pellets, logs or chips. Many boilers will dual-fire both wood chips and pellets, although the wood chip boilers need larger hoppers to provide the same time interval between refuelling. Boilers can be designed with an integral hot water energy storage or accumulator tank that stores water up to 90º C.

The vent material must be specifically designed for wood fuel appliances and there must be sufficient air movement for proper operation of the stove. Chimneys can be fitted with a lined flue. Wood can only be burnt on exempted domestic appliances, under the Clean Air Act. Installation must comply with the appropriate safety, planning and building regulations (e.g. Part J of the Building Regulations).

The cost for boilers varies depending on the fuel choice and payback depends both on the fuel being used and the fuel being replaced.

Consideration must be given to storage space for the fuel, appropriate access to the boiler for loading and availability of local fuel supplies. It is both more cost-effective and sustainable when a local fuel source is used.



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Micro Hydro

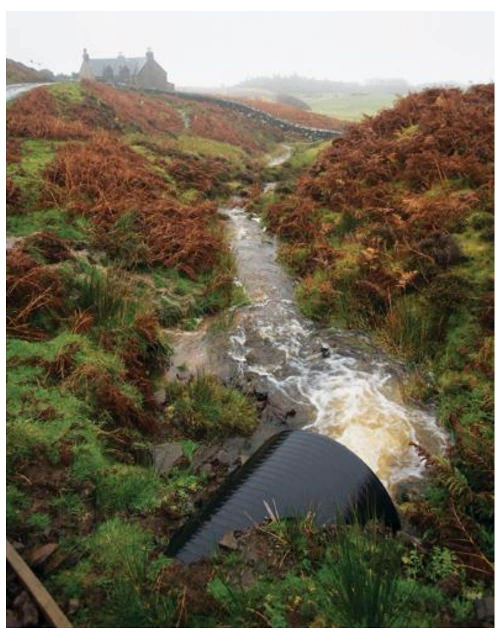
Hydro-power systems convert potential energy from water to kinetic energy (or the energy used in movement) to turn a turbine to produce electricity. Micro hydro refers to generation capacity below 100kW.

Hydro power requires the water source to be relatively close to where the power will be used, or to a suitable grid connection. Hydro systems can be connected to the main electricity grid or as a part of a stand-alone (off-grid) power system. In a grid-connected system, any electricity generated but not used can be sold to electricity companies. In an off-grid system, electricity can be supplied directly to the devices powered or through a battery bank and inverter set up. A back-up power system may be needed to compensate for seasonal variations in water flow.

Energy available in a body of water depends on the water's flow rate (per second) and the height that the water falls from. The actual output will depend on conversion efficiency (the power of the water into electrical power).

Total system costs can be high but may be less than the cost of a grid connection and with no electricity bills to follow. It should be noted that in off-grid applications the power is used for lighting and electrical appliances. However space and water heating can be supplied when available power exceeds demand.

Relevant planning authorities should be consulted to ensure that site and design are acceptable and to identify any other permissions required.



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