building opportunities for business

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7

LOW CARBON DOMESTIC RETROFIT

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Institute for Sustainability

Technology Strategy Board
Driving Innovation

European Union
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Investing in your future

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- Photovoltaic panels supply renewable electricity
- Efficient hot water production needs careful planning
- Waste water heat recovery is available for showers
- Not all modern gas boilers are as efficient as one might think
- Good, user-friendly controls are essential
- Unless the householder understands the systems, the potential benefits can be lost
- Ground or air source heat pumps have potential for off-gas-grid properties

Business Opportunity

Integrating the technologies together can be a complex task and there are many opportunities for engineers and technicians, designers and installers to satisfy the demand for a holistic approach to designing, installing and maintaining the low carbon building services.

7.1 Introduction

This guide provides information on business opportunities associated with building services in low carbon domestic retrofit. It covers:

- ventilation
- heating and hot water services
- electric power.

It is building services that are actually responsible for using the energy in the home. Often they are given insufficient thought and left to installers, which can result in inappropriate, oversized and poorly controlled solutions. As a dwelling becomes better insulated and more airtight, the reduced load should result in simpler building services solutions. But the opposite seems to be happening; building services are becoming more complicated and difficult to understand – both for the designer or builder and for the householder. See Guide 6 for more information on reducing air leakage in retrofit.

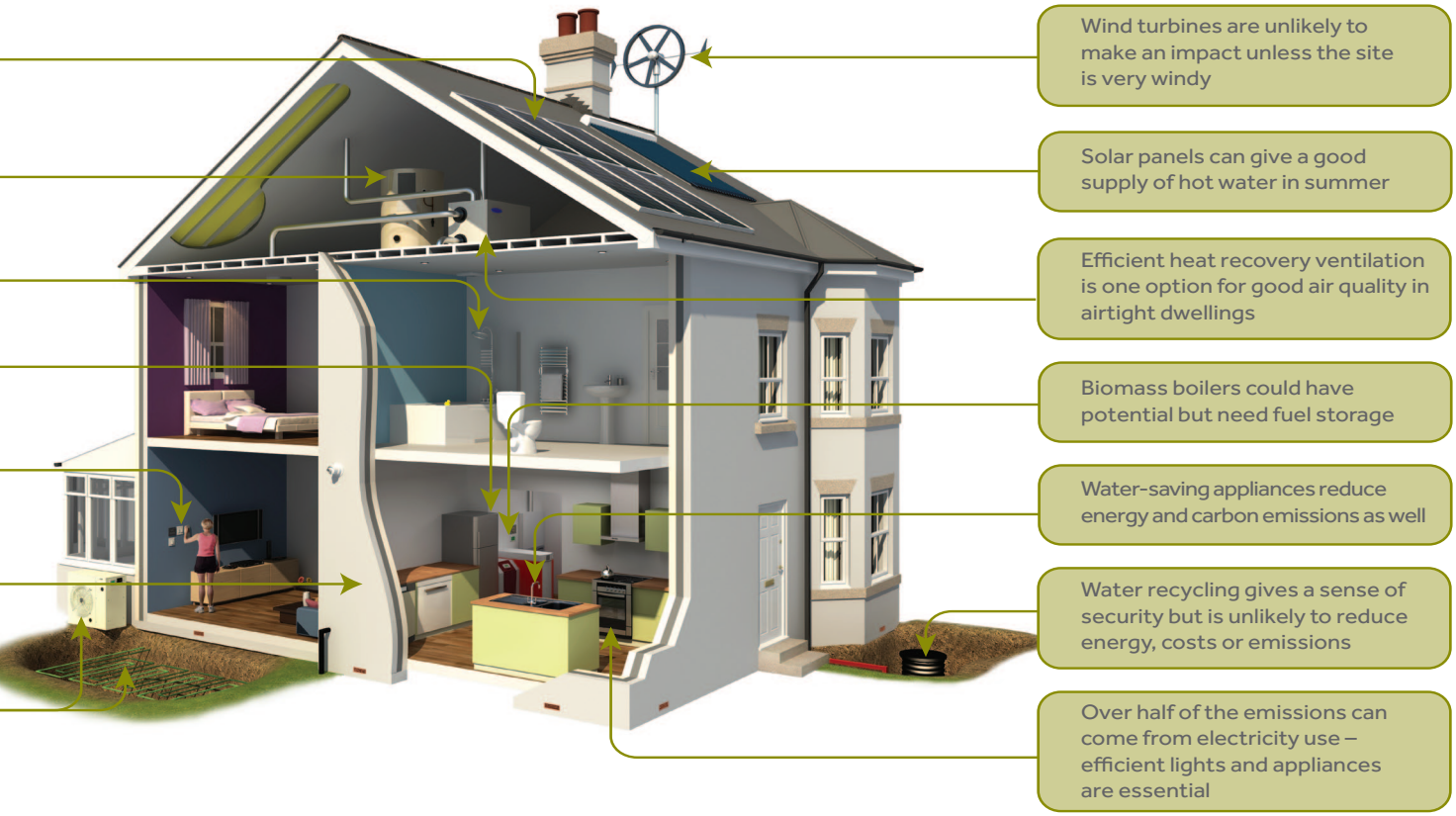

Figure 7.1 Building services are becoming more and more complicated.

Many people see low carbon solutions purely in terms of bolt-on renewable technologies such as solar panels and wind turbines. Some of these technologies have a role to play but need to be evaluated in terms of the overall package of improvement measures.

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Business Opportunities

Options for ventilation are complex and poorly understood. There is an opportunity for people to give impartial advice on strategies for air sealing and design and installation of efficient ventilation systems.

The supply chain for components associated with advanced retrofit is currently underdeveloped in this country. An opportunity exists to develop quieter decentralised whole-house extract systems and Passive Stack Ventilation (PSV) techniques to the retrofit market.

The current range of single-room ventilators has low-powered fans and efficient heat exchangers. An opportunity exists to develop units that are quieter and have improved airflow.

7.2 Ventilation

We spend a great deal of time indoors in the company of many indoor pollutants (see Figure 7.2). Ventilation has a key role to play in diluting and removing these pollutants. Air tightness is a prerequisite of a low energy retrofit but if a house is made airtight without an adequate ventilation system, it can be an unhealthy place to live. Conversely, installing ventilation systems in leaky houses can add to heat losses and carbon emissions. It is important to build tight and ventilate right.

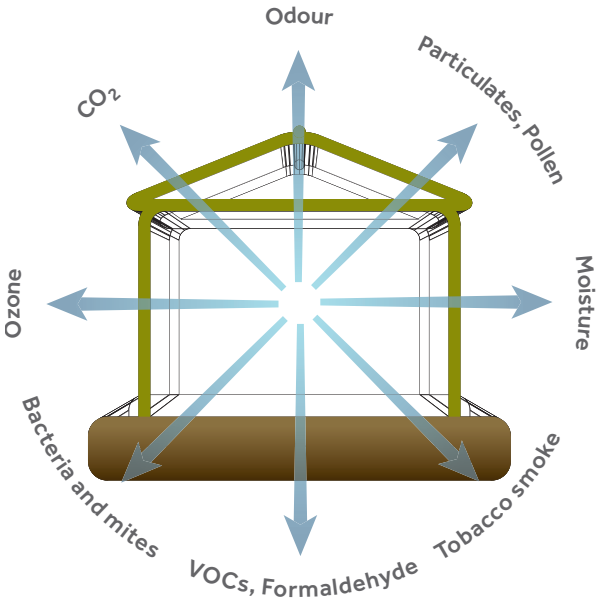

Figure 7.2 Sources of pollution in the home.

Ventilation options

Most homes in the United Kingdom rely on uncontrolled infiltration for background ventilation. Windows are opened or extract fans are used for intermittent purge ventilation. When air tightness issues have been addressed, a more controllable ventilation system should be considered. Options include: whole-house extract, passive stack ventilation, heat recovery room ventilators, hybrid heat recovery systems and whole-house heat recovery ventilation systems.

Mechanical extract ventilation (MEV)

In airtight houses air quality can be improved by using a continuous extract system. Air is taken from the wet rooms and trickle vents are used to admit fresh air into living rooms and bedrooms (see Figure 7.3). Extract rates can be boosted with switches or presence detectors. Further improvements can be made by using low-watt fans and humidity-controlled trickle vents. The preferred option is a single central extract fan unit with ducts to the wet rooms. If the air tightness of the house is being improved, it is important to provide sufficient trickle ventilators for fresh air supply – one in each window head may not be enough – and it may be necessary to fit some ventilators in walls. Good quality humidity-controlled trickle ventilators should be used; poor quality ones often leak air even when they are closed.

Figure 7.3 Mechanical extract ventilation.

Decentralised mechanical extract ventilation (DMEV)

A new range of fans has become available which are intended to be installed in each wet room and to run continuously. These systems are referred to as "Decentralised whole-house extract". Where centralised whole-house systems can be difficult to integrate into a retrofit, decentralised fans may be a simpler solution. These decentralised units can be window or wall fans, or can be ducted. It is unlikely that wall or window fans would be quiet enough to be left running continuously so ducted systems with silencers might be the preferred solution.

Passive stack ventilation (PSV)

Passive stack ventilation has the ability to ventilate the house without the use of electric fans. Ducts link the bathrooms and kitchens to terminals on the ridge of the roof. Humidity-controlled inlet vents in the wet rooms control the extract rate, while humidity-controlled vents in living rooms and bedrooms control the fresh air supply. In refurbishment schemes, using PSV will require a considerable amount of careful planning to accommodate the passive stacks. Sometimes it may only be practical to serve the upper floor.

Heat recovery ventilation

All the above ventilation systems throw away expensive warm air. In poorly insulated houses, heat losses via ventilation are a small part of the total heat loss. But, as shown in Figure 7.4, in better insulated, airtight houses ventilation losses can be more significant. Heat recovery systems help to address this issue by recovering some of the heat in the exhaust air. At present this can be done on a room-by-room basis or with a whole-house system. But there is an opportunity to develop hybrid systems tailored for the retrofit market (see page 7).

Business Opportunities

Mechanical ventilation with heat recovery (MVHR) systems are relatively unusual in the United Kingdom. In new build their design needs to be painstaking. In retrofit the design, planning and installation is even more challenging. There are many opportunities for services offering the design, supply and installation of efficient, low-power MVHR systems.

An opportunity exists to develop training and accreditation for mechanical ventilation installers.

An opportunity exists to develop a suite of MVHR products designed for the retrofit market.

An opportunity exists to offer integrated planned maintenance services for MVHR systems as part of an overall maintenance package.

Secondary opportunities exist to carry out training of maintenance technicians and develop systems such as online maintenance records (like the car MOT).

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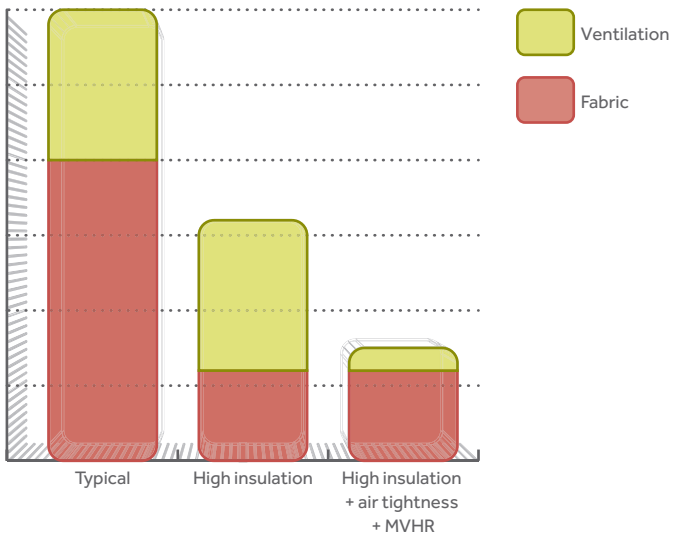

Figure 7.4 If building fabric improvements are made without attention to infiltration and ventilation, ventilation heat losses can dominate.

Room ventilators with heat recovery

These systems combine supply and extract ventilation with heat recovery in compact through-the-wall units (see Figure 7.5). Heat recovery efficiency can be as high as 80% with fan power as low as 2 W.

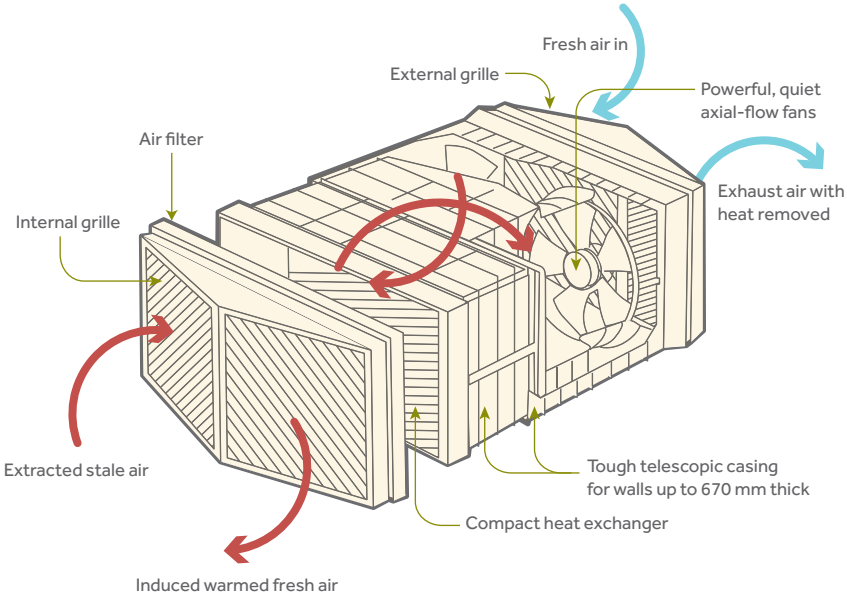

Figure 7.5 Room ventilator with heat recovery.

Mechanical ventilation with heat recovery (MVHR)

Whole-house MVHR systems extract from wet rooms and supply to other rooms (see Figure 7.6). Typically, half an air change per hour is supplied, which is sufficient to give good air quality. Carefully designed heat exchangers can recover up to 90% of the heat in the extract air. It is important to select systems with high efficiencies because some systems recover as little as 60% of the heat. The other essential consideration in the selection of an MVHR unit is the fan power. If high wattage fans are used the fuel costs and emissions associated with running them continuously can outweigh the heat recovery savings. The fan power is expressed in terms of the total wattage per litre per second of extract air (W/(l/s)). Some systems use as much as 1.5, while the best performing are as low as 0.5 W/(l/s).

Warm moist air is extracted from kitchens and bathrooms and passed over a heat exchanger (1) where it preheats incoming air supplied to living rooms and bedrooms.

Figure 7.6 Whole-house heat recovery ventilation.

Fan power and heat exchange efficiency are not the only issues needing careful specification. With low fan powers, it is essential that ducts are large in diameter (eg 150 mm), smooth bore and rigid, with very few bends. Flexible ducts should only be used for the final terminations to air diffusers.

It is clear that using MVHR systems in refurbishment requires a lot of careful planning. The fan unit and all the ductwork should be within the insulated airtight envelope. This is where insulating the roof at rafter level can come into its own – a warm loft space can accommodate the MVHR unit and the ductwork. See Guide 6 for more information on insulation.

Hybrid heat recovery ventilation systems

Heat recovery ventilation has a lot to offer in terms of indoor air quality and energy conservation, but designing and retrofitting a whole-house MVHR system is a significant challenge. Only in the most extreme retrofits is the MVHR option likely to be implemented. Room heat recovery ventilators tend to be noisy, so a hybrid system could be developed specifically for the retrofit market. This system would be in between a room ventilator and a whole-house system. It would serve adjacent rooms – extracting from a wet room (kitchen or bathroom) and supplying to one or more other rooms (living rooms or bedrooms). The system would be quiet, have an efficient heat exchanger and an extremely low fan power.

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Figure 7.7 Heat recovery ventilation systems need maintenance. (Source: Envirovent)

Business Opportunity

There is general confusion about low carbon heating systems. There is an opportunity to give clear impartial advice on low carbon heating systems through a quality assured advice process.

Maintenance

The need for maintenance of MVHR systems should not be underestimated. The units can become very dirty (see Figure 7.7) and if the filters are dirty, fan power and/or performance will be adversely affected. In addition, if the heat exchanger becomes dirty the heat transfer rate will be reduced. In the owner-occupied sector, the simple maintenance routines should be within the capabilities of the homeowner, provided easy access to the MVHR unit has been designed into the installation. In the private and social rented sector, however, maintenance can be a critical issue. The routine maintenance and repair needs to be part of a planned programme and carried out at the same time as other maintenance such as the boiler service or a check on the solar system. At present there is no workforce trained to carry out these integrated maintenance tasks.

7.3 Heating and hot water

91% of British homes have central heating; 87% have gas central heating. This is in marked contrast to 1970, when only 31% of homes had central heating. 40% of boilers are now combination types, or "combis", providing heating and "instant" hot water from the same boiler (without a hot water storage cylinder).

Heating systems

Heating systems are defined as a "controlled service" under Part L1B of the Building Regulations. Work on heating systems should comply with the Domestic Building Services Compliance Guide and a Building Control Body should be notified of the work. This can be done by an application for approval under the Building Regulations before work starts or by a Building Notice. Alternatively the work can be "self certified" by a "competent person" (ie a registered Gas Safe, Oil Firing Technical Association (OFTEC) or Heating Equipment Testing and Approval Scheme (HETAS) fitter).

Fuel choice

The choice of fuel affects running costs and carbon dioxide emissions. Figure 7.8 shows running costs and carbon dioxide emissions for a typical three-bedroomed house, with various heating fuels.

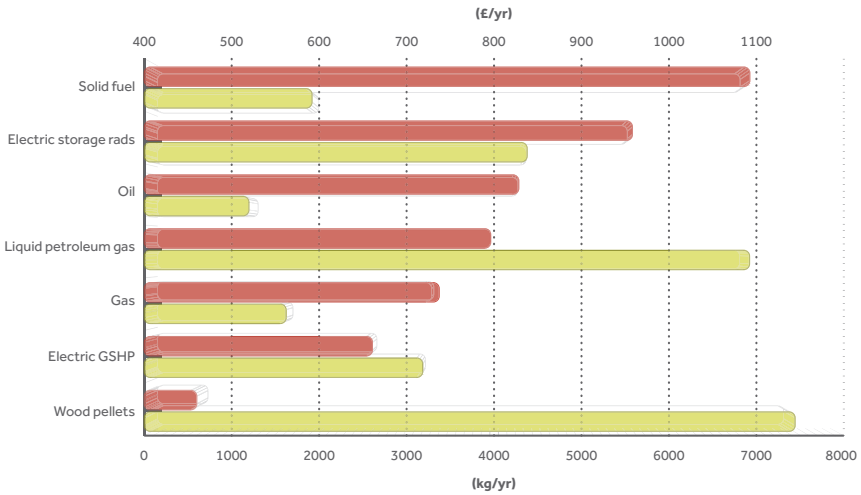

Figure 7.8 Carbon dioxide emissions and annual fuel costs for a typical three-bedroom semi-detached house.

The chart is arranged in order of carbon dioxide emissions. Solid fuel (anthracite) is the most polluting, while a wood pellet boiler is the least. In terms of fuel costs, oil, solid fuel and gas are cheapest, while wood pellets and LPG are the most expensive.

Gas-fired central heating

Standard gas-fired central heating systems are well understood, but there are many opportunities to improve performance with better zoning of heating temperatures and controls throughout the dwelling.

It is always worth reassessing the level of heat loss from the dwelling before installing a replacement boiler. The existing boiler is likely to be oversized and very often energy efficiency measures will reduce the heating requirements so that it can be met by a smaller boiler.

Gas-fired heating systems have relatively low carbon dioxide emissions and are relatively cheap to run but it may well be worth considering alternatives that have the potential to reduce emissions further.

Heat pumps

Heat pumps use refrigeration technology to provide heat from a condensing unit. The evaporator side of the heat pump absorbs energy from outside the house. The evaporator typically uses outside air or the ground as the source of heat. Air source heat pumps (ASHP) are cheaper and easier to install than ground source heat pumps (GSHP), which use horizontal coils or vertical boreholes as the source. Heat pumps are a promising option for properties that are off the mains gas supply network.

Figure 7.9 Ground or air source heat pumps need careful installation.

All heat pumps require specialist installation. Very often they are installed by untrained heating installers who do not understand the principles and subtleties involved in heat pump installations.

Biomass heating

In the domestic setting, biomass heating usually involves burning wood logs or pellets in stoves or boilers. Other biomass crops include wood chip, miscanthus grass or coppiced willow, which are usually burnt in larger heating appliances, perhaps serving several dwellings. "Processed" fuels such as wood chips and wood pellets involve slightly more carbon dioxide emissions than logs, but they are often easier to manage and store.

There is a debate about the benefits of wood as a low carbon fuel and whether it is better to lock the carbon up by using timber in construction rather than burning it. It is doubtful if the recent rush to install wood burning heating will lead to a more sustainable future. Where supplies are plentiful, wood heating represents a viable low carbon solution. However, there is not enough land available to grow sufficient wood to heat more than a small proportion of homes in the United Kingdom.

Figure 7.10 Wood heating has a small role to play in a sustainable future. (Source: John Willoughby)

Business Opportunities

There are many opportunities to improve the performance of central heating systems, particularly the controls. Installers can offer better control systems, which enable more flexible heating patterns. There are opportunities to develop simple electronic devices such as relays in wiring centres to facilitate zone control and hold-open control valves to ensure that heat from the boiler is passed to the space rather than the by-pass circuit.

Unless heat pumps are installed correctly their performance can be disappointing. An opportunity exists to develop a quality assured environment in which heat pumps can be installed to a high standard of performance.

There are opportunities for independent advice on the sizing, supply and installation of heat pumps in the retrofit market through a quality assured advice process.

There is a significant need to train designers and installers of heat pump technologies.

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Business Opportunities

With the increased use of solar hot water systems, there is a benefit in using solar heated water in washing machines and dishwashers. With the implementation of the Renewable Heat Incentive (RHI), there is an opportunity to source and supply a range of appliances that are not only energy and water efficient but also use hot fill.

Many retrofit techniques are innovative and not widely adopted in the industry. There is an opportunity for training programmes to speed the uptake of new energy saving techniques.

The performance of many solar systems is not obvious to the householder. There is no feedback to indicate how the solar system is performing and often the boiler is used as the first priority to heat the water and the solar contribution is minimised. There is an opportunity to develop low-cost heat meters and better feedback systems for solar hot water systems.

If it were possible to capture half of the energy in waste water, the contribution to household energy could be similar to that of a solar system. There is an opportunity to develop such systems.

Micro-CHP

A domestic combined heat and power (CHP) unit generates heat and electricity in one unit (see Figure 7.11). The heat can be used for heating the house and the electricity can be used in the house or exported to the grid. Micro-CHP units are best suited to large dwellings with high demand for hot water throughout the year. Small hotels or guesthouses are ideal situations to exploit this technology.

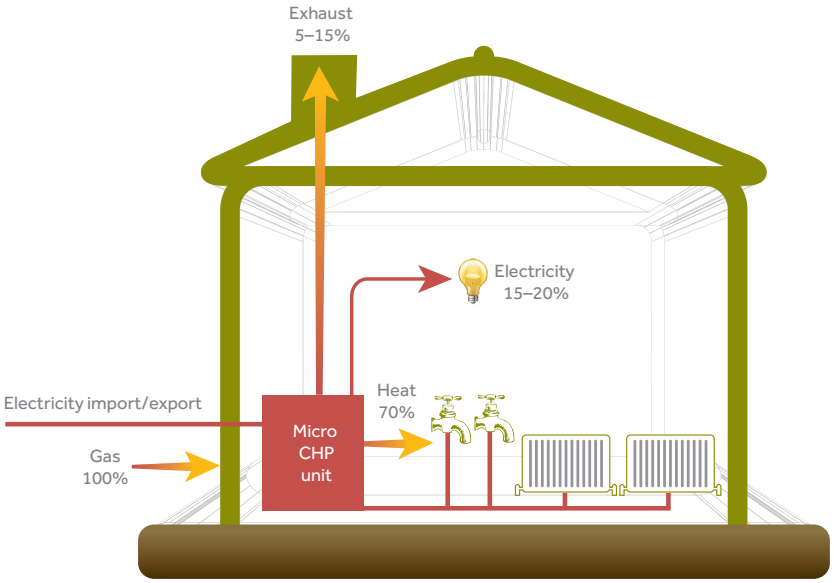

Figure 7.11 The micro-CHP concept. (Diagram courtesy of EA Technology)

Hot water systems

In well-insulated homes, energy costs and emissions connected with hot water use can be greater than that used for heating. This is graphically illustrated in Figure 7.12. This shows that, in a well-insulated three-bedroomed semi-detached house, hot water costs exceed heating costs, electricity costs are more than twice as much as heating and hot water and, remarkably, cold water costs are more than all the energy costs put together. (The water costs assume that three people use 150 litres each per day and they are paying for metered water in the South West.)

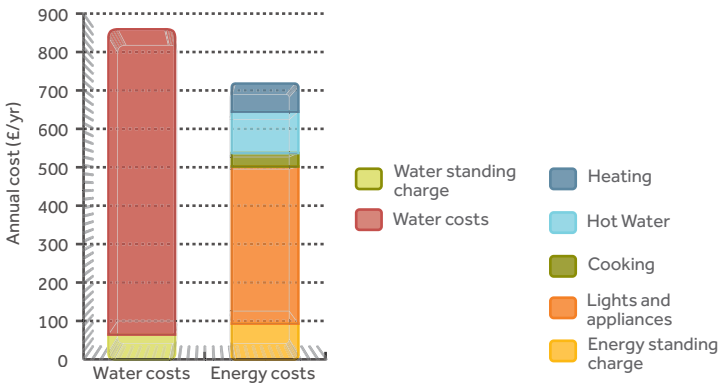

Figure 7.12 Water and energy costs for a well insulated three-bedroomed semi. In a low energy home hot water costs and emissions can exceed those from heating, while water costs can be more than all fuel costs put together.

The largest proportion of carbon dioxide emissions is for hot water use in the kitchen sink and bathrooms. Savings can be made by choosing the most efficient appliances. Further savings can be gained by using solar pre-heated water in these appliances but the availability of hot-fill appliances is becoming scarce.

Hot water is most commonly produced by either a combination boiler (supplying "instant" hot water directly to the taps) or a regular boiler supplying via a hot water storage cylinder. When using a combi boiler there is much that can be done to reduce fuel use.

- Ensure that the boiler is of a type that condenses in hot water mode; the efficiency of many combi boilers is low when producing hot water only.
- Make sure the combi is positioned near to the water-using appliances, particularly the shower and the kitchen sink.
- Microbore pipework serving each appliance separately can be used to reduce the "dead leg" between the boiler and the appliance (see Figure 7.13).
- Beware of "keep-hot" facilities on combi boilers.

When using a regular boiler and cylinder, energy use can be reduced:

- Make sure that the cylinder and associated pipework are well insulated.
- Use a "high performance" cylinder that contains a heat exchanger with a larger surface than normal.
- Avoid the use of secondary hot water circulation around the building.

Figure 7.13 Distributing in microbore pipework can reduce dead legs, saving energy and water. (Source: John Willoughby)

Solar water heating

Solar hot water systems can make a significant contribution to reducing carbon dioxide emissions. In summer most of the hot water can be supplied and over the year a well designed system should reduce the emissions associated with water heating by approximately half.

Flat plate panels or evacuated tube arrays can be connected to a dedicated solar cylinder or to the lower coil of a dual coil "combined" cylinder. Figure 7.14 shows a typical open vented system with a large combined cylinder containing an additional solar heat exchanger, usually referred to as twin-coil.

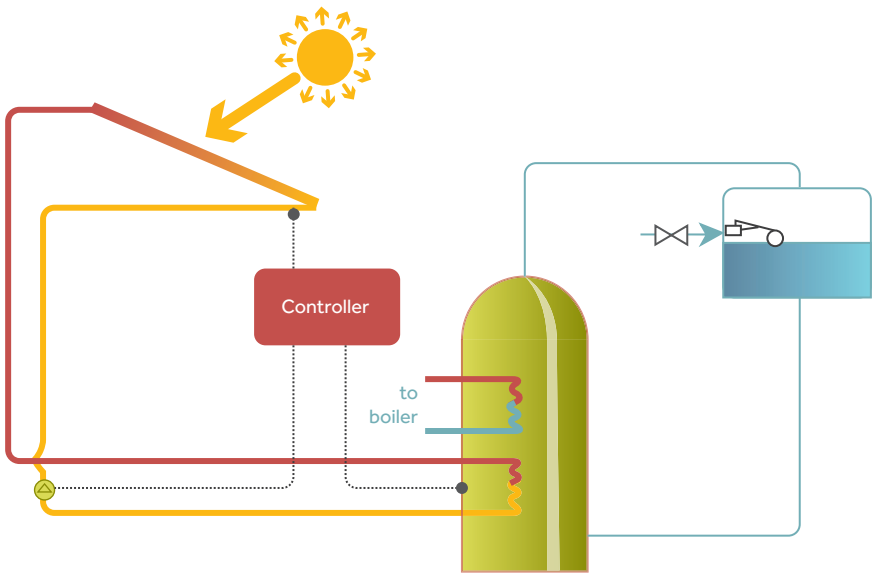

Figure 7.14 A typical solar water heating system.

Figure 7.15 A simple runback timer allows the boiler to be used to top up the solar system if the temperatures displayed on the solar controller require it. (Source: John Willoughby)

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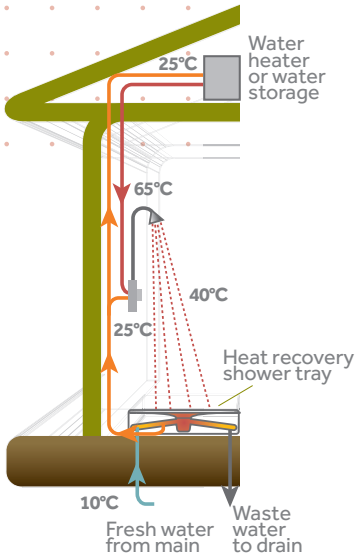

Figure 7.16 Waste water heat recovery could have potential.

Business Opportunities

There is an opportunity to develop a well designed attractive range of light fittings to take compact fluorescent lamps (CFLs) and light emitting diodes (LEDs).

An opportunity exists to offer a design and installation service, which provides well designed, energy-efficient lighting systems with very low electricity use.

Solar photovoltaic (PV) arrays perform better when cool. There have been developments that attempt to cool PVs and use the heat to deliver hot water or heating. There may be opportunities to develop these so-called PVT (combined PV and solar thermal) systems but care is needed to ensure that the added complexities do not result in unrealistic costs.

Waste water heat recovery

Over the years there have been many attempts to develop waste water heat recovery systems. The main problem has been the time lag between the heat recovery and the next use of hot water. Simple shower heat recovery devices address this issue by capturing the heat from the waste water and pre-heating the shower water simultaneously.

7.4 Electric power

Using a unit of electricity in the home produces about three times as much carbon dioxide emissions as using a unit of gas. A unit of electricity is also about four times more expensive than a unit of gas. Therefore energy-saving electrical appliances and good housekeeping can make a significant impact on household fuel costs and emissions. Figure 7.17 shows that as more is done to reduce fuel used for heating, the more significant emissions are from electricity use.

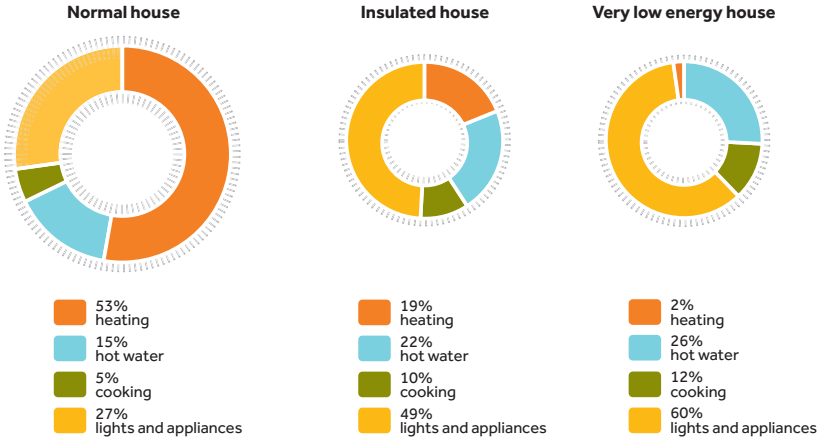

Figure 7.17 As insulation standards improve, the emissions from electricity use increases.

Electricity use in similar houses with different occupants can vary enormously. Figure 7.18 shows a ratio of over 3 to 1 in electricity use in similar houses. This suggests that there is a large potential for cutting electricity use by lifestyle changes.

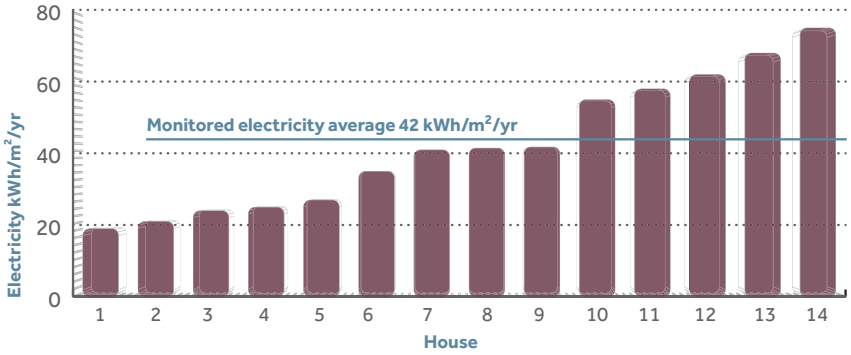

Figure 7.18 Monitored electricity use per square metre of floor space, in similar houses.

Low energy lamps

Low energy lamps are a very cost-effective investment. The extra cost of the lamp is paid for many times over during its life.

As 100 W and 60 W tungsten lamps become more difficult to find, the wider range of compact fluorescent lamps (CFLs) will become more readily available (see Figure 7.19). The range of light fittings is also developing to accommodate CFLs.

Figure 7.19 CFLs are available in many different shapes and sizes. (Source: Greenled Light)

Light emitting diodes (LEDs)

Over the past few years, LEDs have overtaken CFLs in the lighting efficiency stakes. With quoted lifetimes of 50,000 hours, LEDs are an attractive alternative. Colour rendering is now much improved,- although the cost of the lamps can still be high.

Domestic appliances

Energy labelling of electrical appliances has been a major success in promoting energy efficiency over the past two decades. Awareness among consumers has increased but the main success has resulted from manufacturers vying for pole position in the electrical retailers' showrooms. Such has been the success that many electrical goods are now not on an A++ to G scale. Consumers now need to be aware that buying an "A-rated" appliance does not necessarily mean that it is the best available.

Photovoltaics

Electricity generated by domestic photovoltaic (PV) installations qualifies for the Feed in Tariff (FiT), ie for payments significantly greater than the tariff the householder pays for electricity purchased from the grid. See Guide A for more information on the Feed in Tariff.

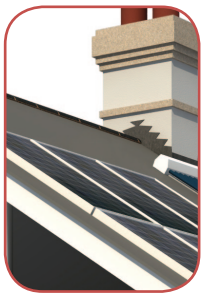

Figure 7.20 Generous feed in tariffs make PV more attractive.

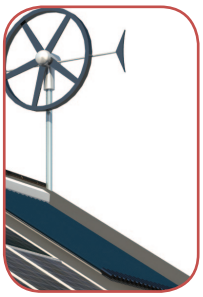

Figure 7.21 Building-mounted wind turbines are seldom likely to be effective.

Wind turbines

Small wind turbines attached to individual dwellings have been heavily promoted in recent years. However, the important thing to understand about wind power is that the power output from a wind turbine is proportional to the cube of the wind speed. So a halving of wind speed will result in a reduction of output by a factor of eight. For this reason, building-mounted wind turbines are not usually a cost-effective improvement measure and are very unlikely to significantly offset the electricity demand of a typical home.

7.5 Summary of business opportunities

This section describes the business opportunities identified above in more detail – including the potential customers, the potential market, any constraints such as requirements for accreditation and any associated risks.

General opportunities

The major business opportunity in the area of building services is in developing a one-stop-shop approach to the design, funding, supply, installation and maintenance of the complex building services systems that modern houses need. A major inhibitor to the take-up of ventilation systems, solar systems, innovative heating systems and other new technologies is that the householder needs to find different people to install the different systems. If they then each need a different person to maintain them, maintenance costs are going to be prohibitive. One visit is required to do the servicing on the ventilations system, the heating system, the solar system etc.

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Integrating the technologies together can be a complex task and there are opportunities for engineers and technicians, designers and installers to satisfy the demand for a holistic approach to designing, installing and maintaining the low carbon building services. There are also opportunities to train installers in the new skills and techniques necessary to integrate building services into low carbon retrofits. There are opportunities to carry out training of maintenance technicians. There are also opportunities to develop on-line fault monitoring and reporting systems.

Ventilation

Options for ventilation are complex and poorly understood. There is an opportunity for people to give impartial advice on strategies for air sealing and design and installation of efficient ventilation systems.

The supply chain for components associated with advanced retrofit is currently underdeveloped in this country. There is an opportunity to develop quieter decentralised whole-house extract systems.

The current range of single room ventilators has low-powered fans and efficient heat exchangers. An opportunity exists to develop units that are quieter and have improved airflow.

The supply chain for components associated with advanced retrofit is currently underdeveloped in this country. An opportunity exists to adapt PSV techniques to the retrofit market.

MVHR systems are relatively unusual in the United Kingdom. In new build their design needs to be painstaking. In retrofit, the design, planning and installation is even more challenging. There are many opportunities for services offering the design, supply and installation of efficient, low-power MVHR systems.

For MVHR, opportunities exist to develop training and accreditation for mechanical ventilation installers; to develop a suite of MVHR products designed for the retrofit market; and to offer integrated planned maintenance services for MVHR systems as part of an overall maintenance package. Secondary opportunities exist to carry out training of maintenance technicians.

Heating and hot water systems

There is general confusion about low carbon heating systems. There is an opportunity to give clear impartial advice on low carbon heating systems through a quality-assured advice process.

There are many opportunities to improve the performance of central heating systems, particularly the controls. Installers can offer better control systems, which enable more flexible heating patterns. There are opportunities to develop simple electronic devices such as relays in wiring centres to facilitate zone control and hold-open control valves to ensure that heat from the boiler is passed to the space rather than the bypass circuit.

Unless heat pumps are installed correctly their performance can be disappointing. An opportunity exists to develop a quality-assured environment in which heat pumps can be installed to a high standard of performance. There are also opportunities for independent advice on the sizing, supply and installation of heat pumps in the retrofit market through a quality-assured advice process. There is a significant need to train designers and installers of heat pump technologies.

Many of these techniques are innovative and not widely adopted in the industry. There is an opportunity for training programmes to speed the uptake of new energy saving techniques.

Solar systems

With the increased use of solar hot water systems, there is a benefit in using solar heated water in washing machines and dishwashers. With the implementation of the Renewable Heat Incentive (RHI), there is an opportunity to source and supply a range of appliances that are not only energy and water efficient but also use hot fill.

The performance of many solar systems is not obvious to the householder. There is no feedback to indicate how the solar system is performing and often the boiler is used as the first priority to heat the water and the solar contribution is minimised. There is an opportunity to develop low-cost heat meters and better feedback systems for solar hot water systems.

If it were possible to capture half of the energy in waste water, the contribution to household energy could be similar to that of a solar system. There is an opportunity to develop such systems.

Lighting

There is an opportunity to develop a well designed attractive range of light fittings to take CFLs and LEDs. There is also an opportunity to offer a design and installation service, which provides well designed, energy efficient lighting systems with very low electricity use.

Photovoltaics (PV)

PV arrays perform better when cool. There have been developments that attempt to cool PVs and use the heat to deliver hot water or heating. There may be opportunities to develop these so called PVT (combined PV and solar thermal) systems but care is needed to ensure that the added complexities do not result in unrealistic costs.

7.6 Next steps

Key references

CONSTRUCTION PRODUCTS ASSOCIATION (CPA) (2010) *An Introduction to Low Carbon Domestic Refurbishment*, **www.constructionproducts.org.uk** [accessed 28/06/11].

HM GOVERNMENT (2010) *Domestic Building Services Compliance Guide*, **www.planningportal.gov.uk**

Key links

Building Regulations information:
www.communities.gov.uk/planningandbuilding/buildingregulations

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