Microgeneration from renewable and other sources

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Introduction

Microgeneration is the production of low-carbon heat and/or power by individuals to meet their own needs. Several technologies enable homes to become energy producers with much higher efficiency than centralised power stations, and can allow a move to lower carbon fuels.

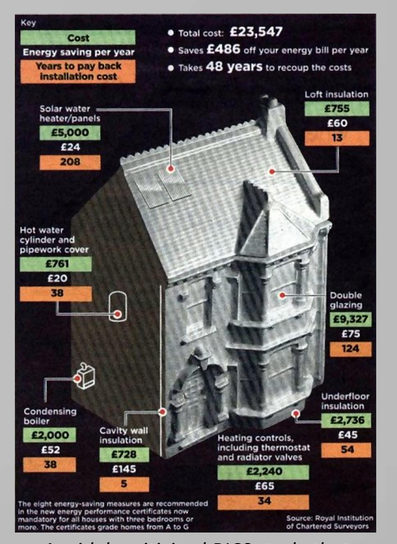
Renewable technologies have been well promoted and achieved significant market shares in Europe and Japan. Other low-carbon technologies could achieve similar or greater savings, given the same levels of promotion and uptake. Together, these could greatly reduce carbon emissions from the domestic sector (24% of UK total).

The UK Energy Research Centre commissioned an interdisciplinary project to assess microgeneration technologies – integrating behavioural and policy issues with technology reviews, simulations and economic appraisal.

Motivation

It is difficult to assess the economic and environmental potential of these technologies from previous studies. Opinion is divided on their relative merits, with each study recommending a different technology. At the extremes, microgeneration is considered a key element of UK energy policy, or branded an expensive mistake – depending on who does the calculations.

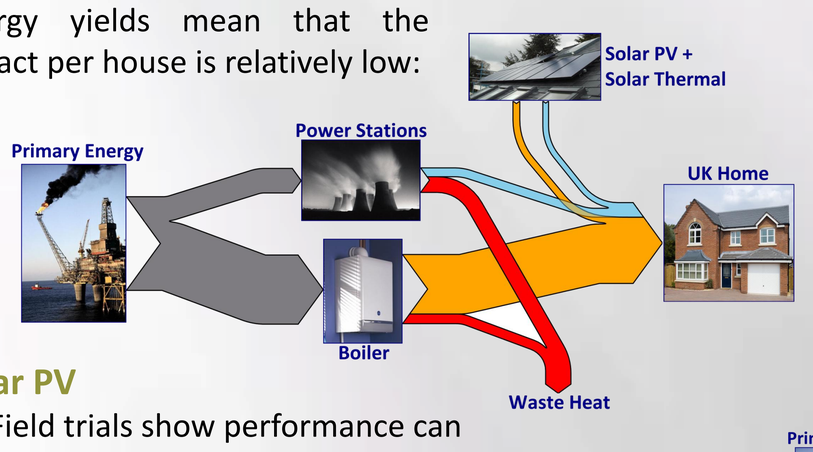
In this work, each technology was reviewed individually, focusing on the real-world performance achieved when installed in houses and actual installed costs in the UK. Device simulations and field trial data were used to produce a cross-technology comparison of the sector, estimating the carbon savings and costs in the UK residential sector.



A widely criticised RICS study that suggested 50-100 year payback times for PV, and 150-200 for solar thermal

Renewables

Harnessing the sun and wind gives zero-carbon energy with zero fuel costs. The embodied energy of construction is quickly paid back, however the high installed costs of roof-mounted technologies make financial payback slower. Small energy yields mean that the impact per house is relatively low:



Solar PV

- Field trials show performance can be better than expected from the overcast British skies.
- However, poor installation and lack of system monitoring lowers energy yield substantially in >2/3 of installations.

Solar Thermal

- The most widely used microgeneration technology: over 30 million installed worldwide, ~100,000 in the UK.
- In boiler integrated systems, energy yield depends strongly on consumer behaviour *(see previous poster)*

Micro-Wind

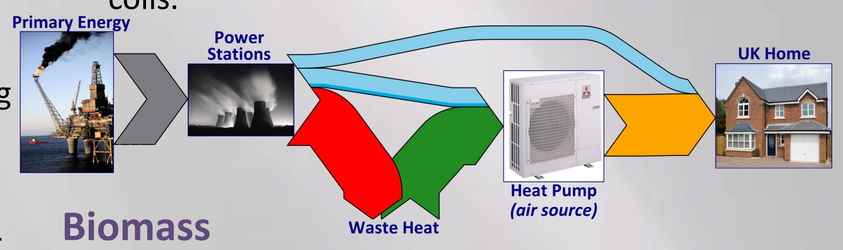
- Much bad press in the UK after recent trials showed urban sites produce just 1/10 of claimed energy yields.
- Isolated rural areas (10% of UK homes) with high wind speeds should be chosen, where it is financially viable.

Low Carbon Heating

Biomass boilers and heat pumps can meet the entire heat demand with sustainable energy from the natural environment. 85% of the energy demanded from UK homes is heat, meaning these technologies can offer the greatest carbon savings.

Heat Pumps

- Natural gas heating is substituted with higher cost and higher carbon electricity, but the majority of energy comes from the air or ground.
- Specifications can be misleading as performance varies strongly with external temperature.
- Costs vary significantly between designs, particularly with installation of ground heating coils.



Biomass

- Wood burning boilers can replace a traditional heating system, or room stoves can augment it.
- Improved supply chains are needed in the UK, giving increased availability and awareness.
- On-site wood storage limited to larger homes.
- Periodical cleaning is seen as inconvenient, but can engage users with their energy consumption.
- LCA suggests a carbon content of 15-30g/kWh for wood pellets – *if* they are sustainably replanted.

Micro-CHP

Combined heat and power generation on the domestic scale is still an emerging field, with each technology having only 1 commercial product available. Natural gas is used at present, but all technologies could use biogas if suitable infrastructure and economic incentives are developed.

Stirling Engines

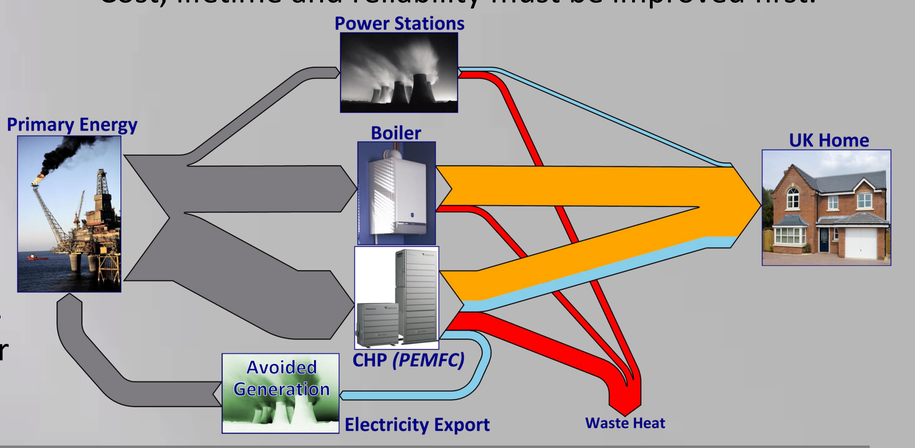
- Popular in the UK in part due to large heat output, however this limits suitability to larger houses.
- Electrical efficiency is very low, and highly sensitive to operating patterns.

Internal Combustion Engines

- Currently only available in Japan and USA at 1kW level.
- Can only run at full power, so do not provide an optimal match between supply and demand.

Fuel Cells

- First products to go on general sale next month in Japan.
- High electrical efficiency promises large benefits.
- Cost, lifetime and reliability must be improved first.



blue denotes unvalidated data	Solar PV	Solar Thermal	Micro-Wind	Ground Source Heat Pump	Air Source Heat Pump	Biomass Boiler	Stirling Engine	IC Engine	PEM Fuel Cell	Solid Oxide Fuel Cell
Capacity	1.6kW$_p$	2.8kW$_p$	1.2kW$_p$	10kW	10kW	15kW	1kW$_e$ + 8-13kW$_h$	1kW$_e$ + 2.8kW$_h$	1kWe + 1.3kWh	1kW$_e$ + 0.8kW$_h$
Installed Cost	£6,500-9,500	£2,500-7,500	£2,000	£10,000-15,000	£2,500-7,500	£5,000-12,000	£3,000	£4,000-6,500	£15,000	£35,000-50,000+
Lifetime (yrs)	25-40	25-40	15-25	15-25	15-25	20-30	10	10	3-5	3-5
Efficiency / Ann. Energy Yield	1,000-1,500 kWh elec	800-1,700 kWh heat	50-1,500 kWh elec depending on site	COP 3.4 - 4.4	COP 3.0 - 3.7	70-80%	4-8%$_{el}$ 66-77%$_{tot}$	20%$_{el}$ 72-77%$_{tot}$	27-30%$_{el}$ 68-72%$_{tot}$	35-40%$_{el}$ 68-72%$_{tot}$
Annual Bill Savings	£110-160	£30-50	Urban: £5-15 Rural: £130-190	£70-220 - *Standard Tariff* - £0-160 £170-360 - *Heat Pump Tariff* - £130-210		Logs: £0-50 Pellets: -£50-150	£0-50	£75-150	£150-250	£150-250

Findings and Conclusions

A Monte Carlo simulation of each technology was made from these validated performance figures in the UK domestic market. The range of carbon savings and costs is evident in the adjacent graph:

- Biomass and *rural* wind offer the largest and cheapest carbon reductions respectively – however both have a limited market due to the available resource.
- Cheaper models of heat pump (esp. air source) are the most cost effective mainstream option.
- The high cost of CHP systems is a problem today, but 50% reductions are expected in 5 years.

- The UK market for many technologies is uncompetitive, as poor consumer awareness allows an oligopoly of installers to apply large profit margins. Installed costs for heat pumps or solar thermal vary by a factor of 5 or more, with little technical reason.
- There are many discrepancies between manufacturers' claims for efficiency, yield and cost and those seen in practice. This could lead to individual technologies (*i.e. wind)* or microgeneration as a whole being given a bad image, and losing consumer trust.

- No single technology is the 'silver bullet', but decarbonising heat supply is the route to the greatest UK savings. Several technologies available now can reduce domestic emissions by >25%.
- Investment in certain technologies can already be considered 'value for money' at under £100/T of CO_2. Incentives can help uptake, but crucially the UK lacks awareness and understanding.