Low and zero carbon technologies (LZCs) provide space and water heating and electricity through renewable technologies or combined heat and power (CHP), which are retrofitted or integral to the building or community. This chapter explores what those technologies could be, how they could come about and the major issues (technical and regulatory) that would need to be addressed along the way. It synthesises what is known about each of these emergent technologies and then brings them together to show what could be achieved under the 40% House scenario. The policy implications to deliver this change are then discussed.

7.1 The low carbon house scenario in 2050

Under the 40% House scenario, by 2050, space and water heating requirements (i.e. useful heat provided) have been substantially reduced from 375 TWh in 1996 to 318 TWh in 2050, through improvements to the building fabric in both existing dwellings and highly efficient new build (Chapter 5). Electricity consumption in residential lights and appliances (RLA) has decreased from 73 to 53.4 TWh through the use of more efficient technologies (Chapter 6). Households have, on average, almost two LZCs, equivalent to a total installed capacity of 55.6 GW. This is sufficient by 2050 to generate 82% of total space and water heating demand and meet total residential electricity demand, with around 15 TWh exported back to the grid. By 2050, more than 20% of homes will have very low space heating demand (1,500 kWh pa useful energy) with no need for central heating. All homes are expected to need around 4,000 kWh useful energy for water heating. Around 75% of homes have either community heating (with CHP or biomass), micro combined heat and power (micro-CHP), biomass or heat pumps, as the basis for their heating system. Around two-thirds of homes will have solar hot water heating and around 30% will have photovoltaics (PV).

Whereas it is relatively easy to foresee some of the improvements in fabric construction, or improvements in lights and appliances, the revolution which could be LZC (Table 7.1) has hardly started. In 1950 central heating was virtually unknown. Within five decades, 90% of homes have central heating. In five decades from now most central heating systems will have been replaced three times, most power stations twice, and probably the majority of the electrical and gas distribution network. Whilst no new technology is envisaged, significant development of existing technologies (e.g. PV and fuel cells) is expected to drive down costs. Investment decisions on the infrastructure for the provision of heating, cooling and electricity over this timeframe will be hugely affected by climate change, political change and regulatory change.

7.2 Current picture

The majority of UK homes (69%) have gas central heating and 9% electricity. Average space heating demand is 14,600 kWh pa, with an additional 5,000 kWh pa for hot water delivered energy. Installation of LZC technologies is low, for example, only around 1% of UK homes are connected to a community heating scheme. Continued high penetration of boilers and central power-only generation (however high efficiency) will not deliver a 60% reduction in carbon.

Proposals for amending part L of the Building Regulations (ODPM 2004a) stated that "if we are to achieve a 60% reduction in carbon emissions by 2050, we are likely to need renewables by then to be contributing 30% to 40% of our electricity generation and possibly more... We have therefore included in the proposals measures that will encourage greater uptake of low or zero carbon (LZC) energy generation systems. This is also in line with Article 5 of the Energy Performance of
The consultation document therefore proposed that, in addition to "what might be achieved by a typical package of conventional energy efficiency measures, there should be an additional reduction in carbon emissions of 10%. This 10% can be seen as a 'notional' LZC contribution, but leaves the developer to decide how best to achieve the improvement.".

If implemented as proposed, the 2005 regulations are expected to deliver a 27% carbon saving in new build housing, of which more than a third, 10% carbon savings, will come from LZC technologies (Ted King pers. comm.). The question is, therefore, given an expected revision to the regulations perhaps every 5 years, what might be the opportunity for LZC technologies to generate heat as well as electricity by 2050? And what might be the effect if Building Regulations were to apply to refurbishments as well as new build?

### 7.2.1 Current support for LZCs

The main mechanisms for supporting uptake of household renewables at present are Clear Skies (England and Wales), and the Scottish Community and Household Renewables Initiative. Community energy and PV are supported through the Energy Saving Trust (EST).

The Clear Skies programme provides grants as well as lists of manufacturers and installers. Data from the first 20 months of the Clear Skies grant programme shows that 92% of projects funded are solar thermal. At present only about 100 grants for heat pumps are awarded per year. To date, the EST solar grant programme has installed around 600 residential systems. In terms of community energy, the EST has £60 million to invest in refurbishing or extending community heating, which is expected to deliver around £240 million in total investment (EST website). PowerGen is the first of several manufacturers and suppliers to offer micro CHP on a commercial basis (micro-CHP website) but whilst field trials of a range of designs are ongoing, programme support is yet to be developed. PowerGen also has a programme to install 1000 heat pump systems over several years, principally in social housing as part of their Energy Efficiency Commitment (EEC) programme.

Whilst these measures are important and beneficial, there is insufficient cross-programme and cross-sectoral learning in terms of programme design. These programmes are at a small scale compared to what is needed and are not adequate to enable the uptake of technologies required to achieve the 60% reduction target.

### 7.3 LZC technologies

Table 7.1 summarises the LZC technologies considered, from simple, heat based renewables, to technologies that supply both electricity and heat, to those that supply electricity only. These are discussed in more detail below. LZC technologies that supply cooling (eg Riffat and Zhu 2004) are additional and not discussed further here.

<table>
<thead>
<tr>
<th>Types of LZC considered, 40% House scenario</th>
<th>Heat only</th>
<th>Heat and electricity</th>
<th>Electricity only</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low carbon</strong></td>
<td>Heat pumps</td>
<td>Gas fired CHP in community heating</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas fired micro-CHP (Stirling engine)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas fired micro-CHP (fuel cells)</td>
<td></td>
</tr>
<tr>
<td><strong>Zero net carbon</strong></td>
<td>Solar hot water</td>
<td>Energy from Waste or biomass CHP in community heating</td>
<td>Photovoltaics</td>
</tr>
<tr>
<td></td>
<td>Biomass</td>
<td>Biomass in micro-CHP (eg Stirling engines)</td>
<td>Wind</td>
</tr>
<tr>
<td></td>
<td>Geothermal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Geothermal</td>
<td></td>
</tr>
</tbody>
</table>

*Table 7.1: Types of LZC considered*
Chapter 7: Provision of heating and electricity through low and zero carbon technologies

7.3.1 Heat pumps

Heat pumps can provide space heating, cooling, water heating and in some cases recover heat from exhaust air. Heat pumps can be designed for individual dwellings or as a heat source for a heat network, often in conjunction with CHP (Section 7.3.4). There are currently only a few hundred installations in the UK, although the market is mature in Scandinavia and the US (IEA Heat Pumps website).

Heat pumps work like a refrigerator, moving heat from one place to another. To move heat takes energy, either electrical (vapour compression heat pumps) or thermal energy (absorption heat pumps). Up to five units of heat can be provided for one unit of electrical energy used. The efficiency of a heat pump depends on the relationship between the energy used to move the heat and the amount of heat recovered from the heat source, eg the ground. Air to air heat pumps are expected to find the coldest UK days difficult to provide for. Heat pump efficiency shows significant seasonal variation. A heat pump operates most effectively when the temperature difference between the heat source and distribution system is small (EEBPP 2000). Thus heat distribution systems need to be low temperature and therefore large surface area (eg underfloor heating systems). Consequently, the highest efficiency units (and therefore the largest carbon reductions) are limited to new build since installing such units in existing buildings would require major internal disruption. Refurbishment with lower efficiency units is possible, although with lower carbon savings. It is unlikely that this technology could provide all UK homes with heat.

Consumer barriers to this technology include unfamiliarity, uncertainty about continuing maintenance and service availability, and noise, although these have been tackled successfully elsewhere.

Heat pumps are only appropriate under certain conditions:
- The large surface area required for the heat distribution system and the disruption to land external to the dwelling during installation means that many existing properties with mature gardens or insufficient land would not be suitable.
- With a low distribution temperature and highly efficient heat pump, a long on-time is required to ensure an adequate indoor temperature. This would not be well suited to poorly insulated properties or intermittently occupied dwellings.

7.3.2 Solar water heating

Solar water heaters are simple, reliable, well known and widespread (Greenbuilder undated). They are probably the LZC technology closest to being commercially viable. The most efficient designs concentrate solar radiation onto a small diameter tube to maximise heating efficiency. Usually an installation of around 4 m² is needed for solar hot water, producing sufficient to keep a 200 litre tank topped up. Water heaters can provide all of summer demand and around 50% of current year round demand in an average house, but this could increase to over 60%. It is conceivable that in the most efficient dwellings, a wood burning stove and a solar water heater could provide all space and water heating requirements.
7.3.3 Biomass

Biomass can be used to generate heat in individual dwellings or as part of a community heating scheme. At the household level, a biomass boiler can provide space heating for the whole house as well as water heating on a timed daily basis, with automated fuel feeding from a hopper. This technology relies on a ready supply of fuel, such as woodchip, pellets or logs. The main potential is in rural dwellings (around 10% of households) and some suburban areas.

Biomass in heat networks can be more diverse and complex, serving both local rural and urban schemes. In addition to crop-based products, use of biomass in heat networks may also include tree wastes from council services; energy from waste; anaerobic digestion of food wastes or farm wastes to produce gases for combustion; landfill gas; or methane from pyrolysis.

7.3.4 Community heating using LZC technologies

A community heating scheme provides heat from a central source to more than one building or dwelling via a network of heat mains. Significant carbon savings are available if heat is supplied from biomass, geothermal heat, or the waste heat from power generation (known as combined heat and power or CHP). A community heating scheme may also provide cooling via an absorption chilling plant. A network is ‘future proofed’, in that the introduction of a single installation can switch a whole portion of a city over to a new lower carbon fuel, such as biomass, combined cycle gas turbines or fuel cells. Indeed the first fuel cell in operation in the UK was in a community heating scheme in Woking (DTI 2004d).

In the UK, less than 1% of homes are served by community heating, but in Scandinavia around half of homes are heated in this way (Euroheat undated). Community heating schemes can vary in size, from a small block of say half a dozen flats to individual tower blocks or whole portions of a city with tens of thousands of homes connected, as is the case in Southampton, Sheffield, or Nottingham. Schemes can start with a single tower block with additional buildings connected over time.

Community heating is most appropriate in the following circumstances:

- Dense housing: there are around 4 million dwellings in low and high-rise housing.
- Off-gas communities, where oil, solid fuel heating, or electricity is displaced (EST 2004a and b).
- In new and dense build, typically over 50 dwellings per hectare (Wiltshire pers. comm.), where electrical and gas network infrastructure is not already installed.
- Where there is decision making on behalf of a group, eg a strong residents association or new build developer.

7.3.5 Micro-CHP

Micro-combined heat and power (micro-CHP) units provide sufficient heat for a single dwelling, similar to a conventional boiler. Indeed, units are physically similar to boilers and are designed as drop-in replacements. However, the heat is provided as the by-product of the generation of electricity in the home – this is more efficient than the generation of heat in a boiler and import of electricity via the electrical network.

The power generation unit can be a Stirling engine, reciprocating engine, or fuel cell, each with different power and heat efficiencies: around 20% for larger Stirling engines (with up to 70% provided as heat) and up to around 35% for fuel cells (net of reformer and DC to AC conversion losses, with up to 55% of fuel converted to heat). Micro-CHP is capable of operating in condensing mode and thus at a high overall efficiency. In the longer term, fuel cells offer the greatest carbon saving potential, but there are a number of significant issues that need to be addressed first. For example, major cost reductions would be needed for large scale uptake, but the underpinning materials are themselves very expensive. DTI is investing significantly in fuel cell
Chapter 7: Provision of heating and electricity through low and zero carbon technologies


The carbon savings from micro-CHP are strongly dependent on electrical efficiency as well as the operating strategy. As with conventional boilers, micro-CHP units operate to match heat demand, but it is also possible to turn them on at other times, for instance, to generate electricity when prices are high. The heat generated could then be stored in a high pressure water vessel contained within the unit for later supply to the dwelling.

Micro-CHP only generates a portion of household electricity demand, the balance being imported from the electrical network. At certain times, more electricity may be generated than is required by the home, allowing export back to the network. This represents a significantly different proposition for distribution companies and energy suppliers compared to the current situation, and there are a range of issues about connection, metering and the value of such electricity exports (FaberMaunsell et al 2002, Harrison and Redford 2002, Cogen Europe 1999 and 2004).

The most likely scenario for large-scale implementation is for units to be installed on an energy services basis (Section 7.5.2), in other words, financed, owned, operated and maintained by a supplier, with the household buying heat and electricity on a combined tariff (Harrison 2001, 2004).

The opportunities for community heating with CHP and micro-CHP are different and additional. Micro-CHP is best suited to:

- detached and semi-detached dwellings with a higher heat demand, where the micro-CHP unit will run for a sufficient length of time to generate enough electricity to make it cost effective;
- individual decision making, eg by owner-occupiers.

7.3.6 Photovoltaics (PV)

Photovoltaics (PV) convert light directly into electricity. Whereas the UK has around 600 installations, Germany has close to 100,000 because of support through electricity tariffs (Wustenhagen and Bilharz 2005). A typical current residential installation of 12m² could generate around 1,300 kWh pa with a peak of around 1.9 kW, though larger and more efficient installations are possible. Different materials can be used to give different efficiencies, with amorphous silicon efficiencies around 4-6% and crystalline efficiencies at around 15% and potentially up to 20%. The output from PV depends on the particular installation: shading can reduce output severely and orientation is also important (Jardine and Lane 2003). There may be an upper limit of PV on UK roofs (domestic and non-domestic) imposed by UK electricity summer peak demand (currently 20-25 GW) and network management issues if sufficient electrical storage is not available on the local distribution network.

7.3.7 Wind turbines

Wind in urban areas or around buildings is unpredictable with significant disturbance. A cleaner more concentrated flow can be achieved by channelling or ducting wind into a turbine, most suited to high rise blocks with stronger winds and higher load factors. However, these technologies are still in development and may have some associated noise management issues. In rural areas, only a small percentage of dwellings could support a wind turbine as a stand-alone device (without the need for ducting).

7.4 40% House scenario

Under the 40% House scenario, the aim is to reduce heat and electricity demands, and then to meet remaining heat demands from LZC to the maximum extent possible, and to meet or exceed the demand for electricity in households. This strategy is similar to the approach adopted when considering CHP for any given site.

Many of the available technologies may be perceived to be either in competition (eg PV and solar thermal competing for roof space) or
Producing electricity at the same time as providing heat is efficient either in the home or for a local community.

Complementary (e.g., PV and micro-CHP both need similar metering and remunerative arrangements for exported electricity). However, the savings are not dependent on the success or failure of any one technology – it is the achievement of the portfolio that is challenging and necessary. Each technology is appropriate to a different portion of the housing stock. In addition, each technology has a contribution to make at a different part of the load curve (Chapter 8), therefore a diverse portfolio of technologies will require fewer back-up fossil fuel plants.

The following assumptions were made under the 40% House scenario (Table 7.2):

- **Heat pumps** are best suited to large dwellings not on the gas network, or in new build. This is assumed to give 2.7 million installations by 2050, consistent with other estimates (Hitchen 2004).

- **Solar water heating** is assumed to be installed in around two thirds of homes by 2050. Installation occurs at the same time as roof replacement (to avoid the biggest installation cost which is scaffolding) or boiler replacement (to reduce plumbing costs). These assumptions, combined with volume, are expected to make it cost effective in most situations.

- **Biomass** boilers are assumed to remain a specialist product for rural areas.

- **Community heating** using a combination of CHP, biomass, and heat pumps is focused in dense urban areas in both new build and refurbishment. 4.1 million homes are refurbished with community heating by 2050.

### Table 7.2: Uptake of LZC under the 40% House scenario, 2050

<table>
<thead>
<tr>
<th>Ownership</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas boilers</td>
<td>10%</td>
</tr>
<tr>
<td>Electric heating</td>
<td>10%</td>
</tr>
<tr>
<td>Community heating (using CHP and biomass)</td>
<td>20%</td>
</tr>
<tr>
<td>Stirling micro-CHP</td>
<td>21%</td>
</tr>
<tr>
<td>Fuel cell micro-CHP</td>
<td>17%</td>
</tr>
<tr>
<td>Heat pumps</td>
<td>8%</td>
</tr>
<tr>
<td>Biomass (wood boiler rather than stove)</td>
<td>5%</td>
</tr>
<tr>
<td>PV</td>
<td>30%</td>
</tr>
<tr>
<td>Solar water heating</td>
<td>60%</td>
</tr>
<tr>
<td>Wind</td>
<td>5%</td>
</tr>
<tr>
<td>Total number of LZC installed</td>
<td>53.6 m</td>
</tr>
<tr>
<td>Electricity generated by LZC (TWh pa)</td>
<td>100.9 TWh</td>
</tr>
<tr>
<td>Heat generated by LZC (TWh pa)</td>
<td>260.9 TWh</td>
</tr>
</tbody>
</table>
which is within the cost effective potential (EST 2003). An additional 2.2 million new homes have community heating by 2050; a proportion of these will only provide hot water and a very small space heating load (like BedZED). By 2050, most schemes will be non-gas based (eg biomass CHP, energy from waste), or converted to higher electrical efficiency generation, such as combined cycle gas turbines or fuel cells, with biomass boilers for back-up and top-up heat.

- **Micro-CHP** is a suburban technology for semi-detached and detached owner-occupied homes. It is installed in some 12.4 million homes (around 40% of households) by 2050, similar to other estimates of the potential in this sector (Harrison 2001, 2004, EST 2002, FaberMaunsell et al 2002). Whilst the majority of CHP units will utilise gas, a proportion of Stirling engines could utilise biomass or bio-diesel. The electrical efficiency of the stock improves with time, and fuel cell micro-CHP emerges by 2020, with most uptake after 2040, resulting in 9.3 GW of fuel cell capacity installed by 2050. This compares with the 10 GW target Japan has set for fuel cells by 2020 (H2FC website).

- **Photovoltaics.** The period to 2020 replicates what has happened in Germany already, with hundreds of thousands, rather than millions, being installed. By 2050, 9.4 million units are installed, amounting to 28.3 GW in the residential sector, which is in excess of current summer daytime demand. Power storage on the local distribution network is therefore assumed. Around a quarter of homes will have the main roof facing between South East and South West, which retains output within 95% of maximum. West or East facing roofs still achieve 80% of peak output. South facing walls receive 70% of the maximum potential solar radiation, but are more subject to shading. The majority of the installations are assumed to occur after 2040, when costs are assumed to be well within product lifetime.

### Table 7.3: Comparison of 40% House scenario with PIU and RCEP studies

<table>
<thead>
<tr>
<th></th>
<th>40% House</th>
<th>PIU</th>
<th>RCEP (scenarios 1-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community heating with CHP or biomass</td>
<td>4.9 GW (25% are not gas fired)</td>
<td>Report states that “by 2050 all low temperature heat could be provided from CHP units of an appropriate size … However, these are more likely to be micro units than community heating.” Therefore assume 114 TWh generated by an expected 28-57 GW of mchp</td>
<td>3-20 plants 8-60 MW fuelled by MSW (average of 0.4 GW) 42-2900 plants between 0.5 and 10 MW fuelled by biomass (energy crops and wastes) (average of 7.9 GW)</td>
</tr>
<tr>
<td>Stirling engine micro-CHP</td>
<td>12.8 GW</td>
<td>1.7-2.4 million at 2 kW (average of 4.1, max 4.8 GW)</td>
<td></td>
</tr>
<tr>
<td>Fuel cell</td>
<td>9.3 GW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>28.3 GW</td>
<td>0.75 -15 million roofs at 4 kW (average of 31.5, max 60 GW)</td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>0.2 GW</td>
<td>not building integrated</td>
<td></td>
</tr>
<tr>
<td>Total LZC capacity</td>
<td>55.6 GW in households</td>
<td>171 GW across the UK economy</td>
<td>44 GW average across several sectors</td>
</tr>
</tbody>
</table>

*Source: PIU (2002, Table 6.1), RCEP (2000, Table E7)*
Table 7.4: Installations of LZC by decade (thousands), 40% House scenario

<table>
<thead>
<tr>
<th></th>
<th>2004 to 2010</th>
<th>2010 to 2020</th>
<th>2020 to 2030</th>
<th>2030 to 2040</th>
<th>2040 to 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total installed</td>
<td>650</td>
<td>6,972</td>
<td>11,974</td>
<td>16,064</td>
<td>17,966</td>
</tr>
<tr>
<td>the decade</td>
<td></td>
<td>currently</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumulative</td>
<td>37</td>
<td>688</td>
<td>7,660</td>
<td>19,634</td>
<td>35,698</td>
</tr>
<tr>
<td>installations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>53,665</td>
</tr>
</tbody>
</table>

- Wind turbines are assumed to be installed in 10% of dwellings, half being ducted turbines in tower blocks with good wind speeds and high load factors, and the other half being either freestanding or ducted devices in rural areas.

7.4.1 Comparison with other studies
Table 7.3 compares the 40% House scenario to work done by the Cabinet Office (PIU 2002) and the Royal Commission on Environmental Pollution (RCEP 2000). In summary, the 40% House scenario is considerably more challenging than the average of the RCEP scenarios, but equivalent in uptake to the future foreseen by the PIU for the residential sector alone.

7.4.2 Competitive markets
The 40% House scenario equates to an installation industry that grows at 30% per annum (Table 7.4). This is challenging, particularly given that, so far, renewables in the UK have only increased at 15% per annum since 1996 (DTI 2004d). This is a huge step requiring changes in infrastructure, householder perception, manufacturing, and employment, education and training of installers. It is the creation of a new industry, in line with the goal of the Energy White Paper to promote competitive markets. However, the UK lags behind many OECD countries, for example, Germany for PV, Scandinavia in community heating and heat pumps, the US in community heating, PV and heat pumps. The technology is available, but needs the right market framework to grow.

7.5 Cost and finance issues
7.5.1 Cost issues now and in future
Few LZC technologies are commercially cost effective at present or as cost effective as energy efficiency. Many struggle to pay back within their lifetime. However, technologies and markets for LZC are not mature and current cost-effectiveness is no guide to future cost-effectiveness. Even technologies which are considered mature (if little understood), such as community heating with CHP, can strongly benefit from increased market volumes to bring down costs. Hitchen (2004) suggests that for heat pumps, UK costs appear to be higher than those overseas, so increasing market size and the consequent more efficient use of resources and increased skill levels could lead to cost reductions.

‘Technology learning’ – reductions in cost through learning by doing and examining the underlying cost trajectory of a technology – is a well understood concept (Kobos et al in press). Achieving cost reductions depends on technologies being developed, economies of scale being achieved, the market for installers being expanded to a state of full competition and the costs of connection to the electrical network standardized with appropriate metering in place.

One technology that will particularly be affected by a change in costs is PV, the cost of which is commonly estimated to halve every ten years, with current costs at around £7250/kW peak. Greenpeace and EPIA (2001) estimate costs in 2020 to be a third of costs now, although this is clearly dependent on the international policy framework. Such a reduction in costs would bring
payback within product lifetime and therefore increase installation rates. However, to payback in a timeframe competitive with other investments (e.g., five years) and increase installation further, costs need to be 16 times less, which may take four decades. Over half the cost of installation is labour, requiring good competition and training to bring it down. A good portion of the cost is scaffolding, which can be avoided if installation is required at the time of roof replacement.

As highlighted in Chapter 9, the cost of any given technical improvement is strongly dependent on policy. The future cost of LZC technologies is a political decision and depends upon the support framework now. Market transformation policies need to pay close attention to changing the cost structure of LZC, with R&D support targeted at improving efficiency, as well as a range of measures aimed at significant price reductions, including installer training and finance mechanisms.

7.5.2 Financing
The sceptic would read this and point out that it has taken some 20 years to get condensing boilers into 5% of homes. If decisions are left to householders, nothing very much happens. Householders are, by comparison to institutions, ill-informed and do not put a high priority on emissions or cost savings; they only make a decision on boilers once every 15 years or so. Incentives or requirements are therefore more likely to be effective if targeted at installers or energy suppliers or group decision-makers (like councils, housing associations, and house-builders) than at householders.

Indeed, many of the products discussed here are best delivered through an Energy Service Company (ESCo) approach. For example, most schemes under Community Energy are being delivered through ESCos, and many of the benefits of micro-CHP accrue to the supplier, not to the household. ESCos currently serve a very small portion of the housing stock, but could potentially supply more than half of homes, for instance, with CHP at the levels given in the 40% House scenario. Where there is more than one LZC system in each home, the ESCo approach becomes even more important for several reasons: to ensure the best interactions between LZC technologies; to support investment in fabric measures and in efficient lights and appliances; and to deliver appropriate support systems such as metering and billing.

7.6 LZC market transformation
The market transformation approach, outlined in Chapter 1, can support the movement of heating systems away from those based on boilers and electric heating, to one where the provision of heat and electricity is very substantially from LZC.

At the moment, the focus is on transforming the boiler market, through the Market Transformation programme, EST, and the EEC. However, there is a limit to the carbon saving opportunities possible once efficient A or B rated boilers are a Building Regulation requirement. Programmes focused on renewables are supporting the larger scale technologies such as offshore wind, wave and tidal. There is a need to move resources away from condensing boilers onto building-integrated LZC if the substantial carbon savings available are to be realised.

7.6.1 Provision of information
Provision of information on products that deliver a heating service should allow a comparison of boilers with the LZC options such as solar hot water, micro-CHP, or community heating. This includes product labels (although this will not be straightforward) as well as advice to householders and larger decision-makers such as councils, housing associations, and house-builders. Information at the level of the building, through the Energy Performance of Buildings Directive (EPBD), will clearly help to show the improvement that can be gained through LZC.

7.6.2 Financial incentives
Introducing new technologies and techniques to
Chapter 7: Provision of heating and electricity through low and zero carbon technologies

The market is a vital component in building the market for LZC technologies and will be essential if the potential is to be achieved. To create long term investor confidence, there needs to be clarity that support will be maintained for a sufficient period to build the market and establish expertise in every geographical area and specifier group, so that the costs per house have come down, before support is withdrawn.

The Government, along with Ofgem, EST and the Carbon Trust, needs to develop a clear strategy that supports the techniques and technologies during their introduction to market. Indeed, the Government has committed to a micro-generation strategy by 2005 (Green Alliance 2004). LZC technologies are suited to non-domestic as well as domestic applications, therefore a cross-sectoral approach is appropriate. Lessons from the Community Energy, Clear Skies, and Solar PV programmes have shown that it is not only the grant support, but development of guidance and case studies, as well as support for training and approving consultants, specifiers and installers, that has helped begin the process of transforming markets. These programmes could also benefit from being better integrated with schemes involving visits to install energy efficiency measures, resulting in installation of LZCs at the same time.

Options for large scale support include expanding the scope of the Enhanced Capital Allowances scheme (ECA website) to include LZC; reduced VAT for installation needs to be extended to all LZC; and stamp duty rebates for improvements may include LZC. The difficulty is that whilst all these are welcome, they are, individually, small support, and there is a high transaction cost in ensuring consumers understand what support is available. All of these mechanisms need to consider the relative importance of support for the householder and the installer or ESCo. Ultimately, a tariff-based approach is far more effective, as used in Germany to support PV. Amendments to the UK’s Renewable Obligation (RO) could include tariff support for LZC technologies, including electricity generated in natural gas based CHP. The RO could also be extended to include a heat obligation for heat-only renewables.

7.6.3 Regulation to increase market share

A range of measures may provide regulation to support LZC in new build, such as the EPBD and the 2005 Building Regulations. The energy strategy of the London Mayor requires planning applications to include renewables, CHP and community heating where viable, and expects the London Development Agency to promote these technologies in its work (GLA 2004). Developers are already taking this on in their thinking, with a range of LZC options built into proposals for new urban communities (BioRegional 2004).

Existing dwellings are more challenging. Heating system replacement needs to become a controlled service, ie bringing it within the scope of the Building Regulations. An easy change might be in social housing by laying out a methodology requiring LZC, or measures achieving an equivalent reduction in carbon emissions, to be installed as electric heating is replaced. A more difficult, and more distant change, might be to require the same of owner-occupiers.

The Sustainable and Secure Buildings Act 2004 (the Stunell Act) may help to support uptake of LZC, two-way metering and fiscal incentives as well as requiring a report on the extent to which own-generation is integrated into the building stock.

7.7 Priorities for action

A complete market transformation to LZC could be achieved over the course of 2005 to 2050, which could be considered as three heating system replacement cycles of 15 years each.

- The first of these could be characterised by technology development, eg through innovation support, grant or preferably tariff support programmes, testing, training and
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• The second period could be characterised by a requirement in Building Regulations to install LZC in new build. Costs should continue to come down through increasing economies of scale.

• Markets take a long time to develop and it is assumed that more than a third of the 53.6 million installations are made in the decade between 2040 and 2050. By 2050, the LZC market could become largely a replacement market, with ownership saturated, much as the central heating boiler market is today.

7.8 Conclusions

This chapter has shown how in the 40% House scenario, over 80% of heat demand and more than 100% of electricity demand could be met by LZC by 2050, with significant carbon benefits. This requires a substantial switch away from gas boilers and turns dwellings from net importers of high carbon content electricity, into net exporters of low carbon electricity. In summary:

• Existing but refurbished homes are expected to need around 6,900 kWh useful energy for space heating. Around 20% of homes (those built after 2020) have very low (1,500 kWh useful energy) space heating demand. All homes are estimated to have around 4,000 kWh pa water useful heat demand.

• 72% of homes have LZC as the main form of heating. 20% have gas boilers or electric heaters.

• 53.6 million LZC installations are expected by 2050. This equates to 1.7 installations per dwelling.

• LZC installations account for 260 TWh of heat generated by 2050, which is 82% of the 318 TWh space and water heating needed in that year.

• LZC installations generate 100.7 TWh electricity, compared to 85.6 TWh needed in homes by 2050, thus 15 TWh is exported in 2050.

• The carbon savings from these measures are assessed in Chapter 8.
Whilst few LZC technologies are cost effective right now, this is not a good guide to the real cost of achieving this change – costs are dependent on uptake and uptake is policy dependent.

Diversity is hugely important, with different technologies making contributions in different types of housing and at different parts of the load curve, thereby providing security and sustainability.

The installation of LZC technologies would need to grow by around 30% per annum, which will be challenging. The technology exists, though improvements will be needed to bring down costs. The UK lags behind many OECD countries in the use of LZC and can import much technical, market and policy know-how.

Market transformation policies have a role in creating the right environment for investment which will be needed to deliver the required annual 30% growth. Investor confidence is key and for this reason, support needs to range from installer training to advice to large-scale decision-makers, to financial support. Stamp duty rebates, enhanced capital allowances, and lower levels of VAT, would all help, but tariff support is the most promising option, based on experience in Germany. In the longer term, Building Regulations need to focus as much on LZC in existing build as in new build.

The strategy outlined here is not meant to be a forecast or a prediction, nor is it about picking technological winners and losers. It is difficult to predict which technology will benefit most from technical or market driven reductions in cost: if one technical route proves difficult, another will fill its place. Some combination of most or all of these technologies is a necessary component of a sustainable energy future a basket of technologies offers diversity and resilience.