CPL RENEWABLES

Biomass Heat in the UK beyond 2020

Paper by CPL Renewables

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ecuity

Prepared with input from Ecuity Consulting LLP

Foreword by Alan Whitehead MP, Chairman of Parliamentary Renewable and Sustainable Energy Group

Generating heat accounts for 44% of our energy usage and, one way or another, accounts for around a third of our annual greenhouse gas emissions. Facing the growing certainty of anthropogenic climate change and its impacts, it is essential that we address the way we generate and consume heat in this country.

Although we have seen promising progress in renewable heating deployment under the Renewable Heat Incentive, choosing the right pathway to low carbon heating is not a simple challenge. The uncertainties of prices, technology and fuel availability increase the complexity of this issue beyond 2020. We must therefore now address all evidence which is currently available to ensure that we meet our heat demand as sustainably and cost-effectively as possible.

The role of biomass in meeting our heat demand has been open to significant debate. Current modeling and scenarios seem to show the technology as having a rather limited role in long term heating strategies. However, despite these gloomy predictions, I believe that carefully managed biomass heating has an important role in our energy system; this report is therefore a welcome contribution to the debate.

Alan Whitehead MP

Executive Summary

Bioenergy is expected to play a significant role in meeting the UK's legally binding decarbonisation targets to 2050. Policymakers have set out via a number of key strategy documents their view that available sustainable bioenergy resources are limited and therefore usage should be prioritised to a number of key sectors. For space and hot water heating, bioenergy usage is expected to play a major role in off gas grid heating up to 2020 but faces a less certain future beyond this point.

This paper reflects on the substantial benefits of building a long-term biomass heating sector beyond 2020 – one that is reflective of the progress made to date and very real constraints on the existing plans for heat decarbonisation which may necessitate a re-evaluation of the role of biomass for heating beyond 2020.

Many existing approaches to heat decarbonisation are based on the decarbonisation of the electricity grid and electrification of a large part of the UK's heat requirements. If implemented this will require a larger and much cleaner grid by 2050 – an ambition supported by many but which may prove to be more expensive and more challenging to realise than first thought. Additionally these plans are based on consumer and investor uptake of new and occasionally disruptive technologies with higher capital costs and longer payback compared to conventional alternatives.

Given the uncertainty over the likely availability of low carbon electricity, the need to meet the requirements of a diverse building stock and desire for consumer choice, a more mixed technology approach in the heating market may be essential during the 2020s and beyond.

Factors supporting a re-evaluation of the contribution from biomass for heating are structured into five areas within this paper.

These five areas or forces are summarised as follows:

1. Growing adoption and falling costs:

- The volume of installations under the Renewable Heat Incentive demonstrate biomass's popularity with consumers and investors.
- Market growth has triggered capital cost reduction, a trend expected to continue.

2. Retrofit ready:

- Biomass heating systems are particularly suitable from a cost and carbon standpoint for off-grid buildings including those unsuitable for thermal insulation or heating system modification.

3. Wider energy system benefits:

- A portfolio of heating technologies which includes biomass could alleviate stress on the grid and can lower costs for electric heat consumers.

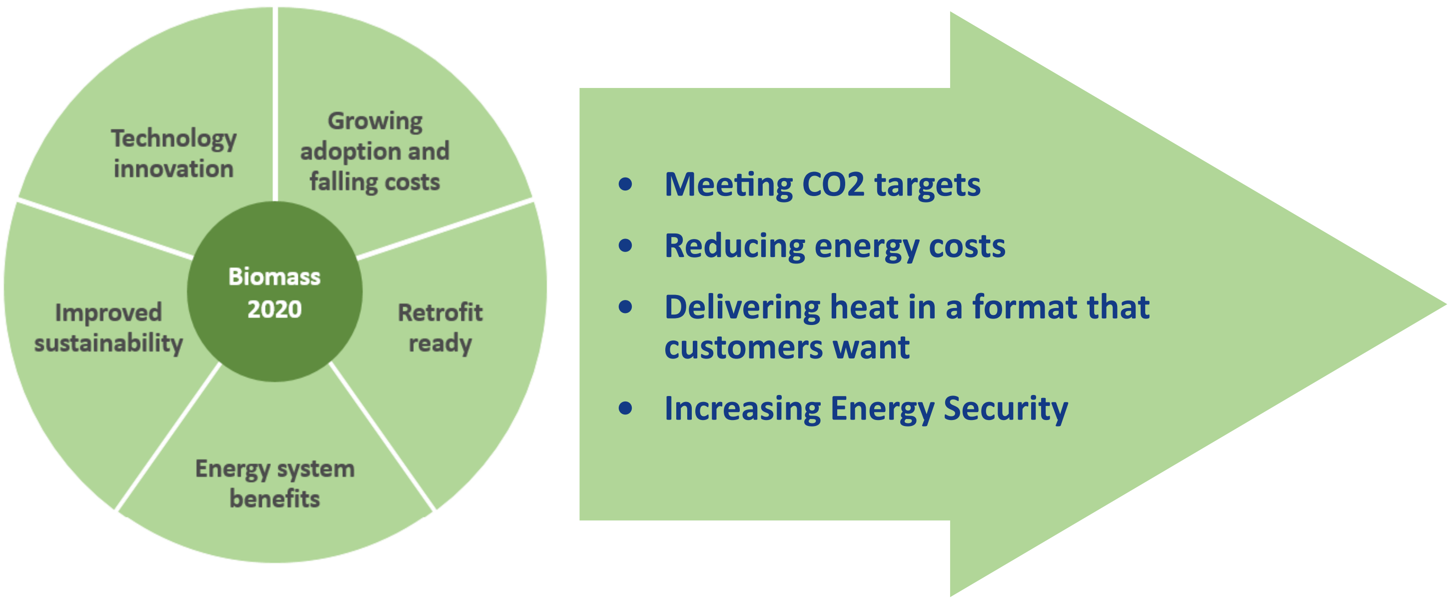
4. Improved Sustainability

- Sustainability issues are being tackled by policymakers working with academics, NGOs and business at an international scale.
- Instruments to tackle key issues including reporting, resource management and Indirect Land Use Change are under development in order to manage greater volumes of biomass mobilisation.

5. Technology Innovation

- New technologies such as torrefaction will help to unlock additional feedstock opportunities, increasing overall supply, reducing pressure on alternative uses for bioenergy.

Forces driving a greater role for Biomass Heating beyond 2020



About the authors of this paper

CPL RENEWABLES

This paper has been produced by CPL Renewables with the aim of encouraging a fresh look at the role for biomass in heating in the UK beyond 2020. CPL Renewables, part of CPL Industries, is focused on the development and distribution of wood pellet heating solutions for residential, commercial and public sector organisations within the UK.

CPL Industries is the UK's leading distributor of solid fuels. Our heating fuels provide energy needed by homes and businesses across the UK. With a turnover in excess of £140m and over 500 employees we have invested in renewable fuels through our WoodPellets2U brand to become a UK market leader in sustainable biomass and the UK's first EN Plus A1 certified wood pellet distributor.

The views set out here are our own however we have consulted with a broad range of stakeholders in preparing the report, including policymakers and industry colleagues. The paper has also been prepared with the support of Ecuity Consulting LLP, experts in sustainable energy policy.

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Introduction

Energy and political imperative to act to reduce GHG emissions

In October 2014, EU leaders agreed to reduce greenhouse gas (GHG) emissions by 40% relative to 1990 levels by 2030. The newly announced target sits within the broader context of the EU 2030 policy framework, which aims to make the energy system more secure, sustainable and competitive. In the UK, legally binding targets extend to delivery of an 80% reduction in GHG emissions by 2050.

An uncertain role for Biomass Heating

It is recognised that bioenergy will be essential for meeting GHG targets cost-effectively towards 2050[1]. However, the volume of bioenergy which can be deployed has been subject to debate. Current constraints on the UK's domestic forest biomass supply include a limited forested area, the lack of storage and transport facilities, the dispersed nature of the resource, and convincing private landowners' to manage forests for biomass[2]. Internationally, global stocks of biomass are also limited from competing alternative land use options – predominantly food production. The increasing global population and the changing diet of developing nations could require an increase in agricultural production of 70% by 2050, thus limiting the land available for growing energy crops[3]. Furthermore factors associated with Direct and Indirect Land Use Change (ILUC), could reduce or in some cases eliminate GHG savings and harm biodiversity.

Given potential restrictions on the availability of sustainable feedstock it has been a priority of policymakers that bioenergy resource is used in ways which deliver genuine carbon savings at greatest contribution to energy policy objectives.

The UK Government's Bioenergy Strategy[4] published in April 2012 outlines four principles for appropriate use of bioenergy:

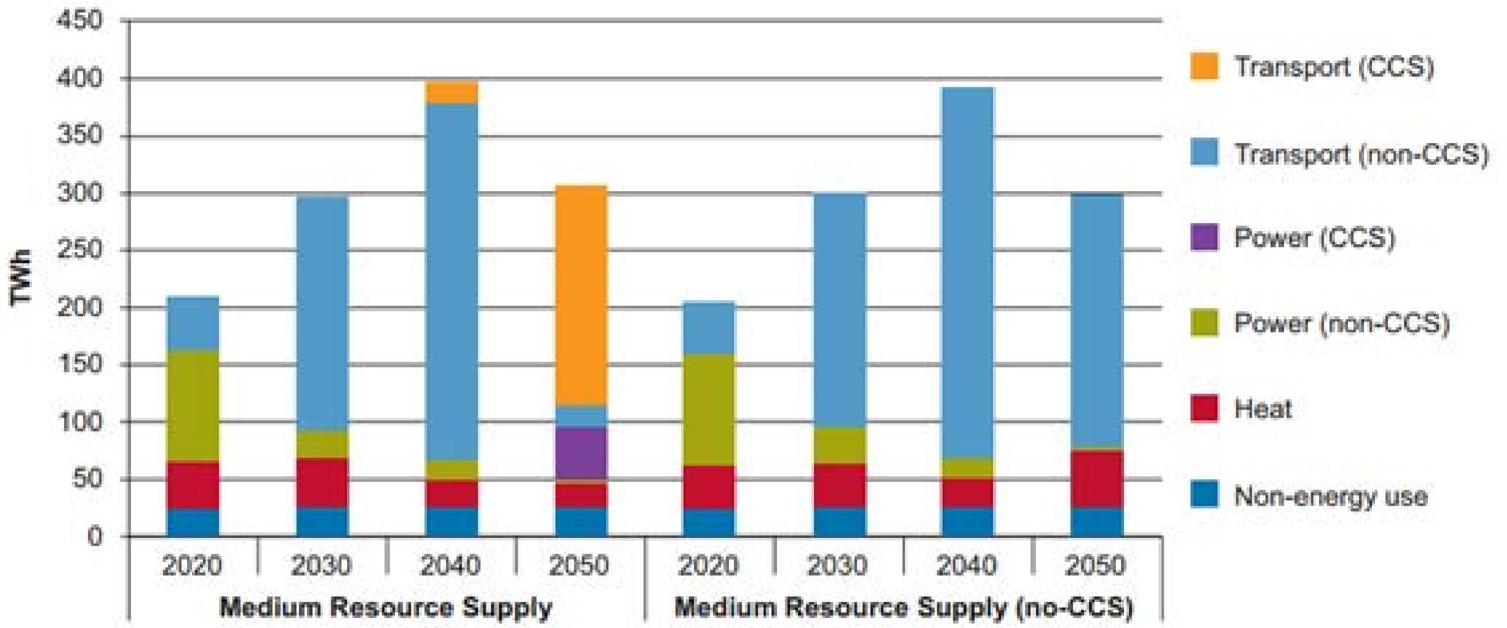
1. **Bioenergy uses should deliver genuine carbon savings**
2. **Use should be cost effective within overall energy and decarbonisation goals**
3. **Support should maximise net benefits across the economy**
4. **Implications of bioenergy demand on other biomass sectors must be assessed and addressed by policy makers**

[1] HM Government, 2010. 2050 Pathways Analysis.

[2] Committee on Climate Change, 2011. Bioenergy Review.

[3] UNEP, Division of Technology, Industry, and Economics, 2011. The Future of Food and Farming: Challenges and choices for global sustainability.

[4] DECC, 2012. Bioenergy Strategy.



Source: DECC analysis based on Redpoint

Notes: "Non-energy uses" refers to new potential biomass deployment opportunities from use of wood in construction that could deliver cost effective carbon savings. This is being included as an illustration of potential non-energy uses of biomass. Other sectors have not been included due to data limitations[48]. Transport CCS refers to CCS with hydrogen production (including gasification of biomass to generate negative emissions).

Figure 1 Anticipated use of biomass resources available to the UK towards 2050 (DECC, 2012: Bioenergy Strategy)

In accordance with these guidelines, the Bioenergy Strategy suggests that biomass will only serve a transitional role in the heating sector. While resource availability will grow significantly from 2020 to 2040, the biomass used for heat will be squeezed as transport applications take a growing portion (figure 1). Meanwhile, the Heat Strategy proposes that heating will largely be electrified with heat pumps or demand met by gas fuelled heat networks.

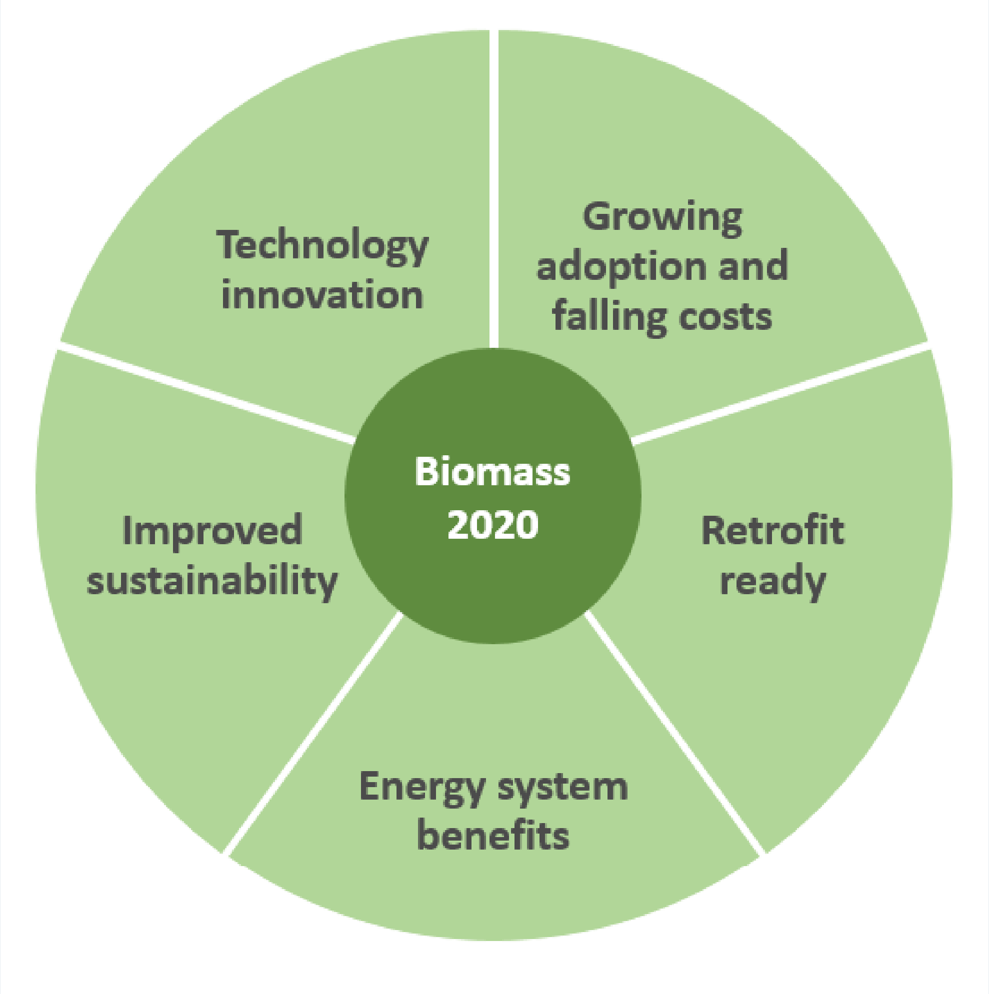
In this paper we seek to review emerging forces in the bioenergy sector and suggest that a re-evaluation of the role of bioenergy in the future of heating may be required. In doing so we note the Bioenergy Strategy authors' willingness to review policy in the light of new information.

"Given the complexity of issues associated with bioenergy, significant uncertainty will remain about the future impacts of increased demand. Therefore, it will be important to continue to monitor impacts and review policies and measures periodically in the light of information gained from monitoring policy impacts and the outputs of continuing research"

...We will review how the totality of UK bioenergy policies meets the direction and principles set out in this strategy in at least 5 year intervals.''

UK Bioenergy Strategy, page 7

By exploring five drivers of benefits, the paper highlights how bioenergy for heating sits comfortably within the principles outlined in the Bioenergy Strategy. Economic modelling demonstrates that falling capital costs will prevent resource costs from becoming prohibitive in the future. Meanwhile there are numerous markets where, on account of the specific characteristics of heat demand, biomass is technically and financially the most appropriate type of heating technology, and a more balanced portfolio of heat generators could limit stress on the electricity grid. Furthermore bioenergy applications which can best utilise low-grade, end-of-life woody materials reduce environmental harm. Ongoing research and policy implementation are strengthening sustainable land management for bioenergy feedstock. Finally, several innovative technologies and processes will enhance sustainability throughout the supply chain whilst increasing the availability of low-risk wastes for heating applications and improving the performance of biomass heaters.

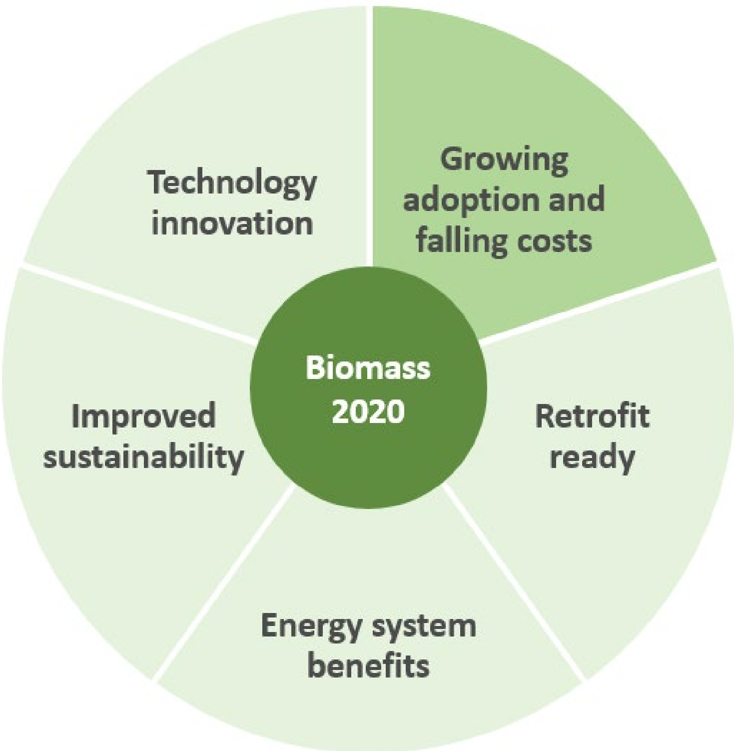


Few in the Bioenergy sector suggest that all heat demand should be met by biomass. However many argue that the type of heating technology should be chosen on account of the specific characteristics of the heat demand and that a one size fits all approach is not appropriate. This more balanced approach could create significant benefits for the individual heat consumer, the UK's carbon targets and the wider energy system.

In this paper the authors assert that given major budgeting decisions affecting the Renewable Heat Incentive are due to be undertaken at the next Comprehensive Spending Review (autumn 2015), an early re-evaluation of the role of bioenergy in buildings is appropriate in early 2015.

1. Growing adoption and falling costs

Across Europe biomass has been adopted more readily than any other renewable heating technology, and at current growth rates, it looks unlikely that alternative heat technologies will meet their sought after share of demand by 2020. Furthermore the rapid uptake of biomass is decreasing capital costs with significant reductions in system cost across the UK during 2014.



The growing biomass market

The Renewable Heat Incentive (RHI) deployment statistics demonstrate that with current subsidy support biomass is a desirable heating technology. Since the domestic RHI was launched in April 2014, biomass has comprised 56% of applications. In the commercial sector, the preference for biomass over alternatives has been even more evident; 95% of non-domestic RHI installations so far are biomass boilers[5]. This is represented in figure 2, which shows the growth in different heating technologies for the RHI scheme from the last six months of 2014.

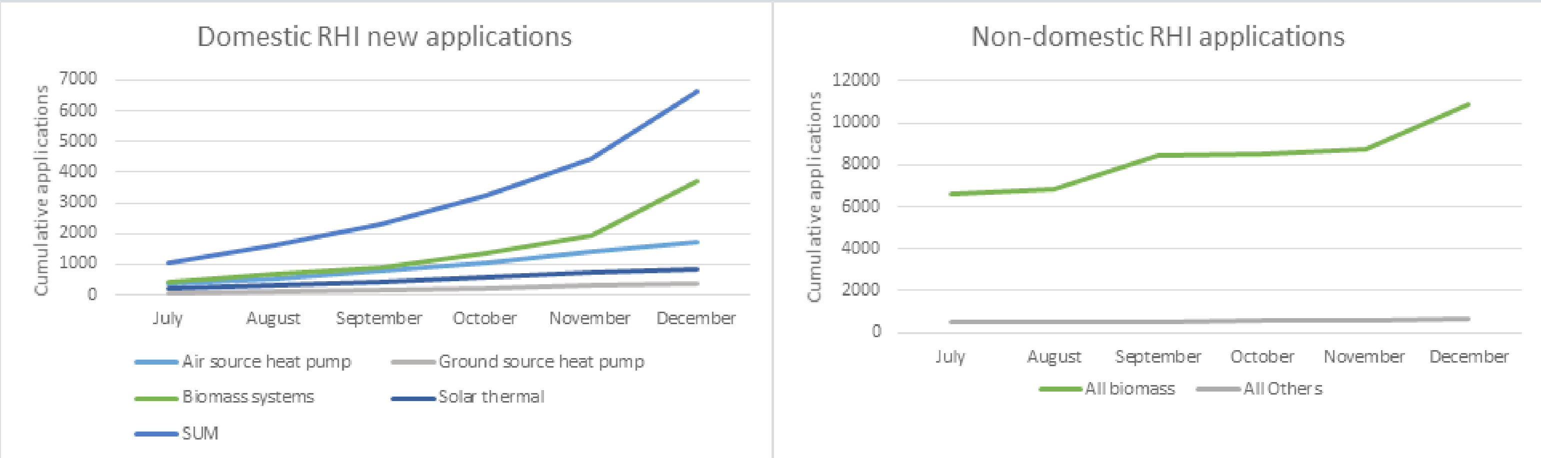


Figure 2

Across the UK, heat consumers, installers and investors are keen to deploy biomass systems.
RHI supported growth is having and will continue to have the desired effect: costs are falling and biomass heating systems are becoming increasingly competitive with conventional fuels. Lifecycle analysis suggests that even though pellet prices are expected to rise the capital cost reductions associated with scaling equipment manufacturing installation are leading to decreasing lifecycle or levelised costs (figure 3).

Biomass heating systems command comparatively large capital costs, but offer savings in the form of cheaper fuel costs (p/kWh).

Modelling by the Low Carbon Innovation Coordination Group (LCIG) indicates cost reductions will be more significant towards 2050[6]. Across the supply chain, levelised costs can be expected to fall by 14% for small scale systems and 12% for larger systems. These reductions will only be possible if the market develops, driving conversion efficiency, installation method and distribution system improvements. Longer term certainty for the role of bioenergy in heating beyond 2020 could help to provide private investors with the assurance they need to deliver innovation and scale benefits.

[5] Up to December 2014. Data from: DECC, 2015. Non-Domestic RHI, Domestic RHI and RHPP and Deployment monthly data

[6] Low Carbon Innovation Coordination Group, 2012. Technology Innovation Needs Assessment: Bioenergy Summary report

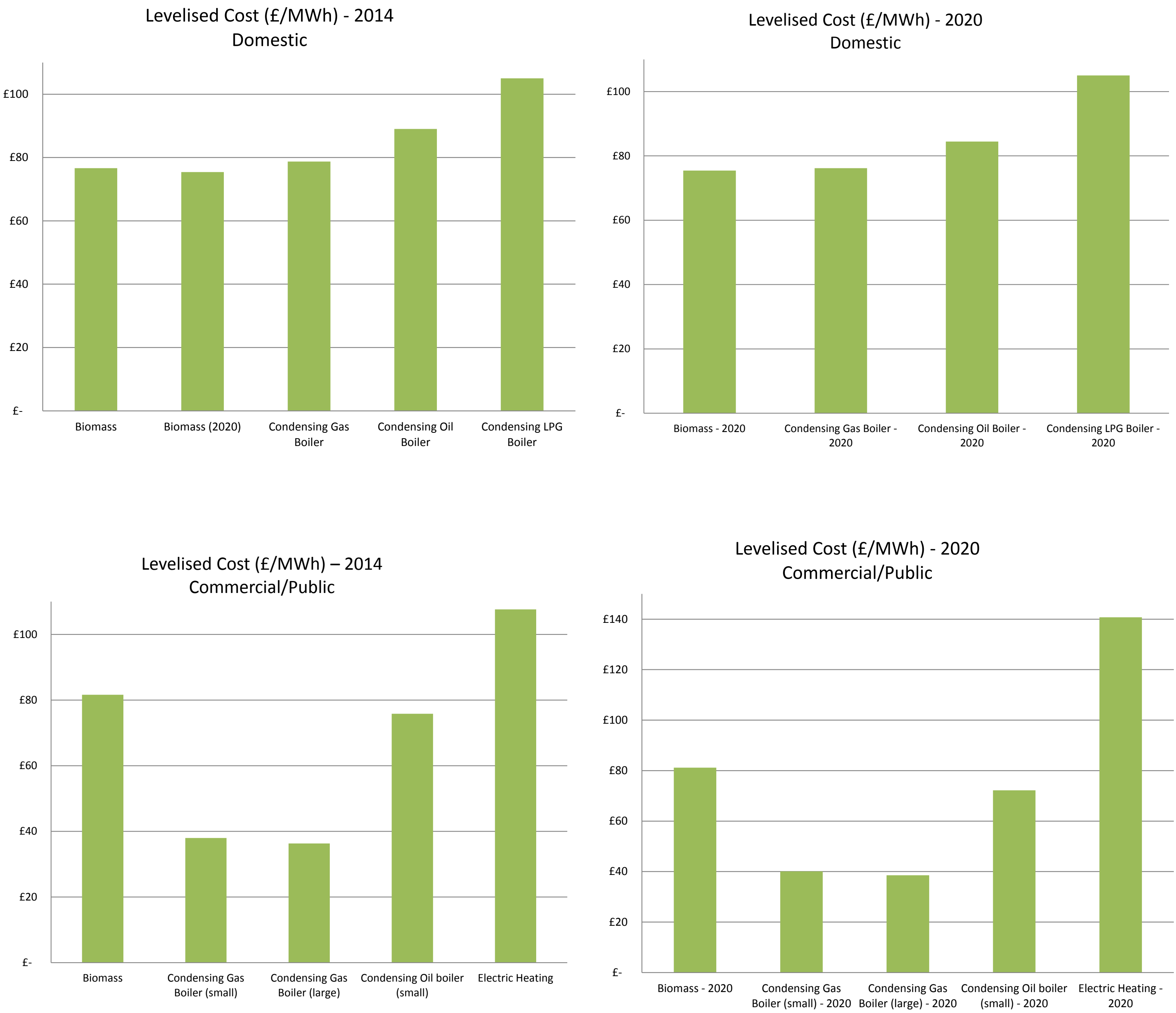
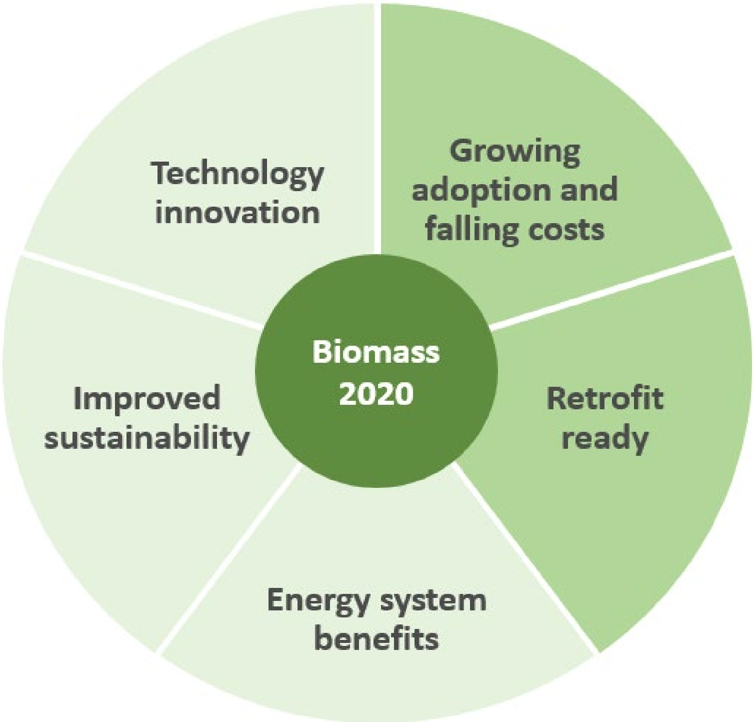


Figure 3 Levelised costs of domestic and commercial heating technologies in 2014 and 2020

Source Ecuity Modelling

2. Retrofit ready



The UK has a huge variety of buildings and the sheer range of potential requirements and heating profiles means that a scaled biomass sector (alongside other low carbon and energy efficiency technologies) makes sense. Biomass can be an appropriate source of heat in many buildings, and there is likely to be a significant portion of demand which will be best served by biomass beyond 2020.

Heat in buildings

The existing DECC Heat Strategy does not foresee biomass meeting a significant proportion of space and water heating demand towards 2050[7].

A large proportion of buildings are projected to be served by heat pumps. High efficiency electric heating will certainly have a key role to play however, there are coherent environmental and economic cases for a more diverse portfolio of heating technologies. There are several applications in which biomass may be the more appropriate heating system for the consumer, and if these opportunities are realised, there are broader energy system benefits associated with the portfolio.

Efficient heating in poorly insulated buildings

While buildings with lower energy efficiency will never improve the environmental or economic performance of any heat generator[8], the implications for carbon and the consumer are not uniform across heating technologies.

In the case of a biomass boiler, greater volumes of heat will need to be generated to meet thermal demand if a house has worse thermal efficiency. However, the efficiency of energy conversion – chemical energy in biomass to heat energy – is not affected.

[7] DECC, 2013. The Future of Heating: Meeting the Challenge

[8] The economic case for combined heat and power units may be improved in low efficiency houses as more high priced electricity can be sold.

Meanwhile in the case of heat pumps, there may be compounding performance reductions. If a building is not well insulated, the low temperature output of heat pumps may not be sufficient to heat the space without large heat emitters, which may not be appropriate in all buildings. As biomass is capable of delivering suitably high temperature low carbon heat, there is a case for ensuring it is widely available option considering that a potentially significant proportion of the building stock may not be able to be as well insulated as desired towards 2050.

At least 70% of the housing stock in England which will exist in 2050 has already been built[9]. Most of these 27 million homes were built before 1976, and thus before energy efficiency regulations were enforced. As a result, 43% of the housing stock is defined as hard to treat[10], i.e. those which cannot accommodate cost-effective energy efficiency measures.

In addition to 27 million houses in the UK there are 1.8 million non-domestic buildings occupying an extremely diverse range of sectors, from small shops to airport terminals. Heating and cooling these buildings accounts for over 10% the UK's total energy consumption. Nearly a quarter of these were built before World War 2 and thus are typically poorly insulated. However, DECC expect half of these buildings will still be in use by 2050[7], representing approximately 220,000 buildings.

The Committee on Climate Change (CCC) states that recent Energy Performance Certificates and Display Energy Certificates data show there has been little progress in the non-domestic sector to improve energy efficiency. Meanwhile they argue that recent changes to the Carbon Reduction Commitment for non-domestic buildings render the policy little more than a modest carbon tax, which is unlikely to incentivise further major energy efficiency improvements[2]. Therefore it is reasonable to expect that a significant proportion of the building stock by 2050 will not be particularly energy efficient. Appropriate heating technologies should be made available for these consumers to reduce carbon and costs.

Process heat

The Heat Strategy identifies industrial heat as one of the most suitable pathways for biomass due to the high energy density and temperatures required. In the 2020s biomass could meet around half of industrial demand, though industries have stated that they would need a secure supply of competitively priced biomass and clear policy signals before they would invest in fuel switching measures. DECC state that deployment at a meaningful scale will require addressing the sustainability issues.

Heat networks

A critical component of DECC's Heat Strategy is the deployment of heat networks which are expected to expand significantly towards 2050. Poyry estimate that it is economically feasible for 14% of the UK's heat demand to be met by heat networks while DECC project that by 2030 this figure will be 20%. However, it is anticipated that natural gas will provide the majority of this heat; the contribution of biomass is projected to stagnate from 2020[7].

Large energy centres (as opposed to smaller commercial or domestic boiler set-ups) can often provide the space required to facilitate the use of woodchips. Although less energy dense, woodchips are cheaper than pellets per kWh[11]. Securing investment in this sector can help to bring down the capital costs and improve system efficiency to lower the levelised cost of heat delivered further.

Benefits are not reserved for the use of woodchips. As the heat production is centralised, fewer deliveries of biomass are needed to meet heat demand for a given number of customers. This can drastically reduce required transportation distances, which make up approximately 17-25% of lifecycle pellet emissions.

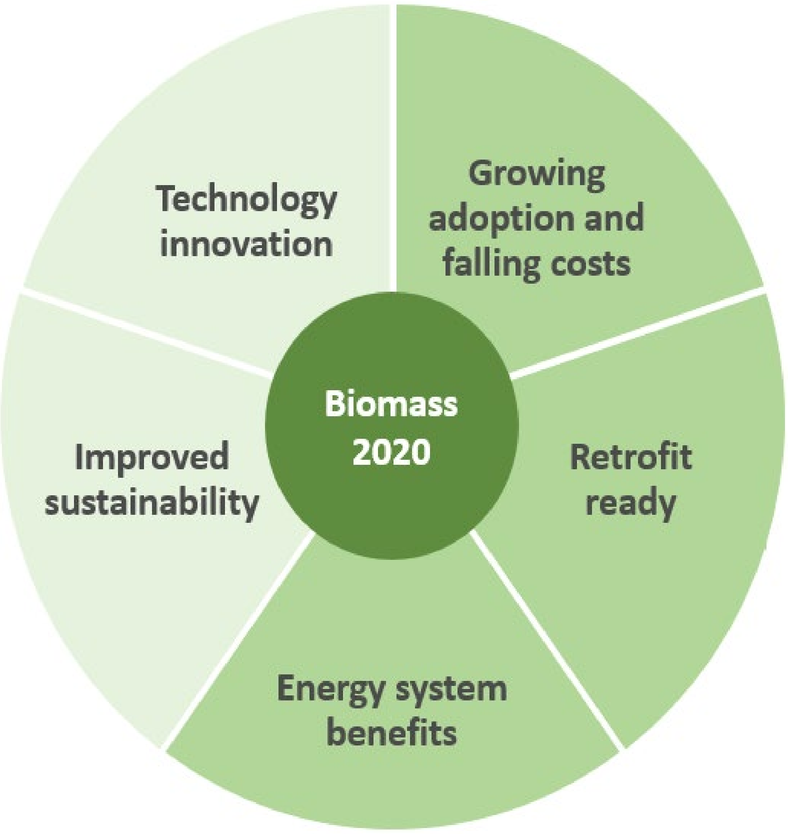
Heat networks can utilise the heat produced from highly efficient large combined heat and power systems, which can achieve total efficiencies of over 90%.

[9] Sustainable Development Commission, 2006 'Stock Take': Delivering improvements in existing housing

[10] BRE, 2008 A study of Hard to Treat Homes using the English House Condition Survey

[11] Biomass Energy Centre, 2011. Fuel costs per kWh

3. Energy system benefits



Wider energy system benefits may be accessed by employing a broad portfolio of heating technologies. These benefits include alleviating electricity peak generation requirements during periods of high heat demand. Application of CHP systems could also help provide the grid with low carbon electricity during these peak times.

Grid Decarbonisation

The relationship between electricity grid emission factors and carbon emissions of heat for different heating types is illustrated in figure 4. The heat pump SPF figures are derived from average values found in field trials conducted by Energy Saving Trust (EST)[12].

The pellet emissions are based on lifecycle analysis of a typical UK biomass supply chain[13]. Wood pellets with CHP refers to biomass which is pelletised using biomass CHP at the production stage – a process with economic as well as environmental benefits. From this data we can assess the current carbon saving potential of heat pumps compared to biomass.

At a 2014 emissions factor of 0.504kgCO2e/kWh of electricity consumed domestically, heat pumps will typically emit between 0.22-0.31 kgCO2e/kWh, compared to 0.03-0.05kgCO2e/kWh for sustainably sourced wood pellets. The carbon intensity of the grid is anticipated to fall improving the environmental case for electric heating systems. Using DECC's emissions factors projections for domestic consumption, the emissions associated with current heating technologies towards 2050 have been plotted in figure 5. At current efficiencies, ground source heat pumps will not match the carbon performance of a current wood pellet system until 2030, and not that of pellets produced with CHP until 2033.

[12] DECC, 2013. Detailed analysis from the second phase of the Energy Saving Trust's heat pump field trial

[13] Ecuity, 2014. Delivering the UK's renewable heat objectives through wood fuel

For the least efficient heat pumps, these thresholds will not be passed until 2033 and 2040. While it can be expected that the emissions performance of both biomass and heat pumps systems will improve in the current decade, this initial analysis suggests there should be a longer term role for biomass as an environmentally appropriate option.

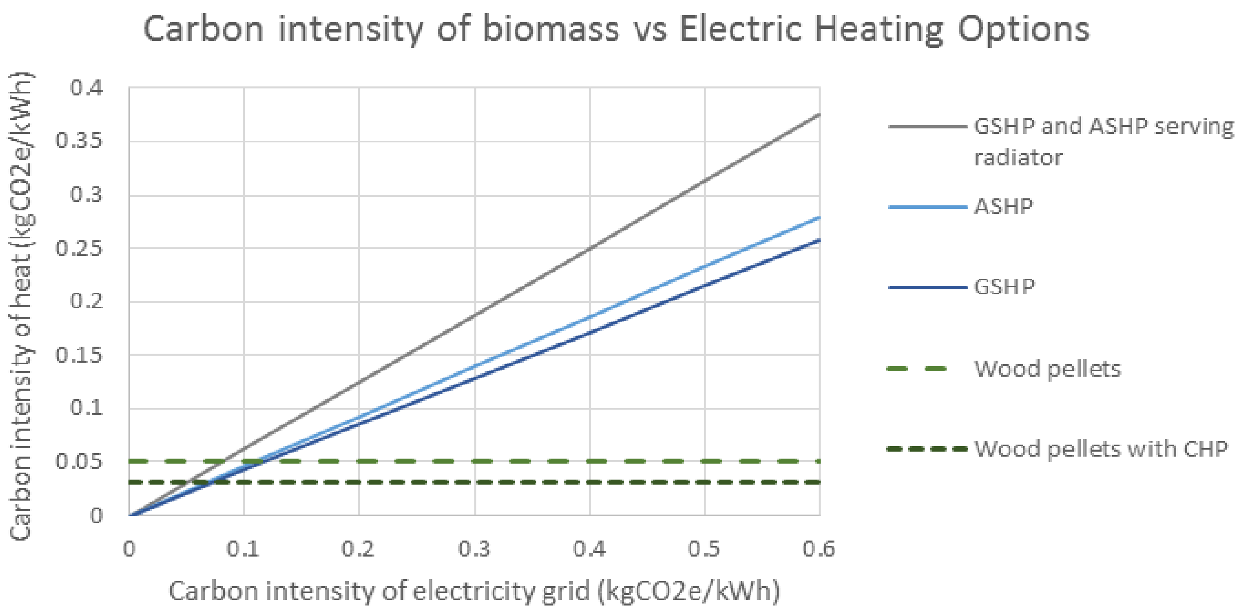


Figure 4 A comparison of the average carbon emissions associated with producing 1 kWh of heat at different carbon intensities of the electricity grid with wood pellets, air source heat pumps (ASHP) and ground source heat pumps (GHSP). Source: Ecuity modelling. SPF values and pellet emissions from EST[12]and CPL/ Ecuity[13] respectively.

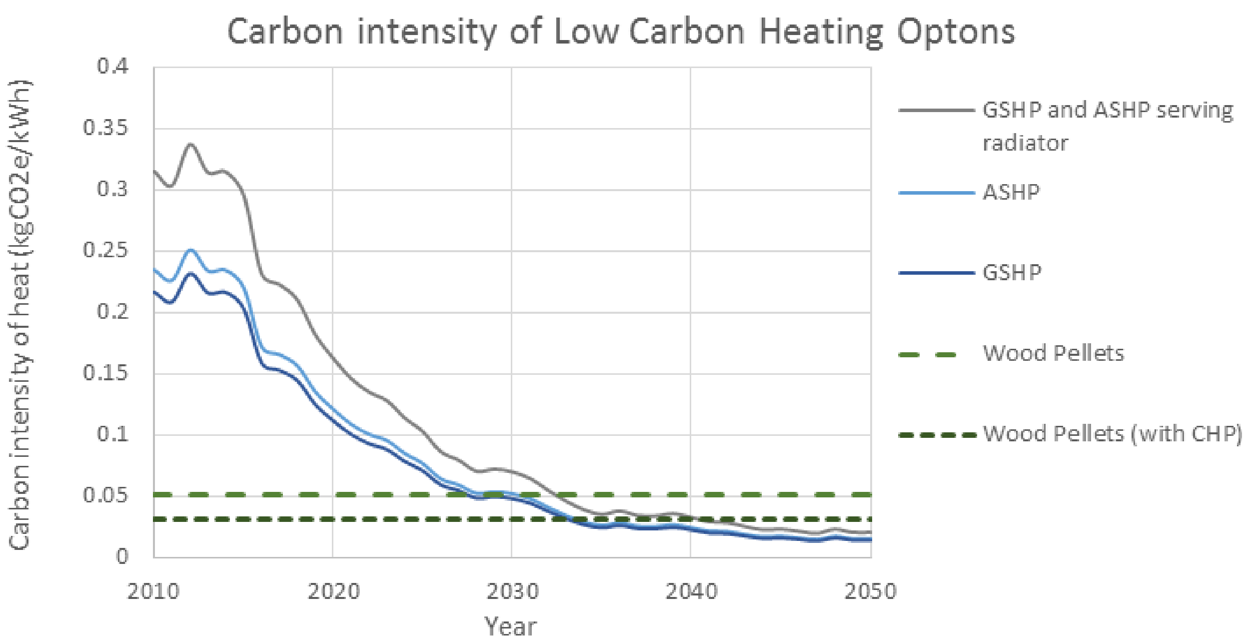


Figure 5 Carbon emissions of current heat pumps and biomass technologies as the grid decarbonises towards 2050. Source: Ecuity modelling

Projections for decarbonisation of the electricity system may be optimistic. A recent study from Imperial College London[14] showed nearly half of current coal-fired generating capacity may still be operating by 2030. Modelling an array of scenarios based on existing policies, the researchers found no instance where coal is not playing a role in generation by 2030 and emissions targets are not missed.

Electricity peaks

In October 2014 National Grid released a warning that winter power capacity is at a seven year low[15] reinforcing the importance of considering the additional stress large volumes of electric heating and transport may place on upstream electricity generation. Heat consumption patterns are fairly uniform as consequence of societal behavioural patterns and weather conditions. Given that thermal demand is a significant proportion of total energy demand, future electricity peaks in the morning and afternoon may require significant additional upstream electricity generation. Assuming all houses were using heat pumps by 2050, these peaks would result in a 33GWe addition to peak electrical load even if all houses were highly insulated.

Biomass heating could serve two beneficial roles in combatting this challenge. Firstly by providing heat in the least thermally efficient buildings which would, if electrified, place the highest requirement on the grid. Secondly by reducing the extra capacity required on the grid there is a reduced need for investment in electricity generation required to run at low capacity or frequency.

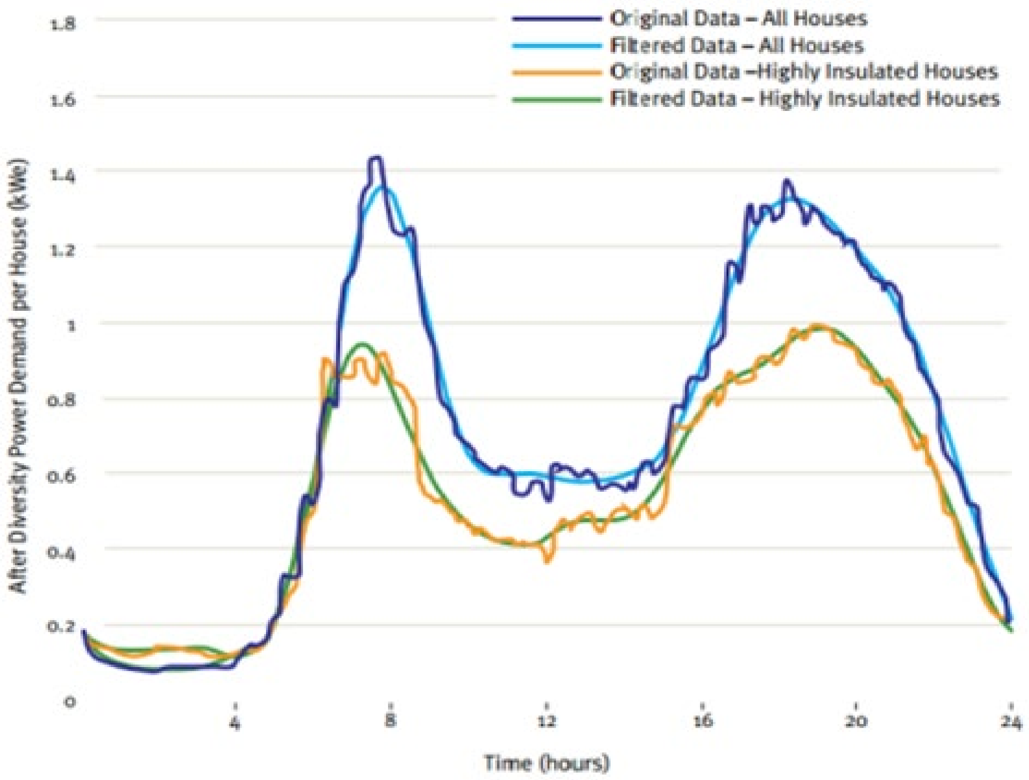


Figure 6 Power demand for existing 66 residential ASHP systems on a cold day in the UK. After diversity refers to the average per-installation impact when there are large numbers of installations. Source: Hawkes, Munuera and Strbac (2011) p. 1016

[14] Gross et al. 2014. Could retaining old coal lead to a policy own goal?

[15] National Grid, 2014. Winter Outlook 2014/15 published

[16] Hawkes, Munuera and Strbac, 2011. Low Carbon Residential Heating. Grantham Institute for Climate Change Briefing Paper.

Time of use tariffs

The anticipated wider roll out of time of use tariffs[17] may result in fluctuating electricity prices. The price variation is a consequence of the merit order of the UK electricity market, in which electricity generators are typically turned on in ascending order of their marginal cost of generation. Therefore, during peak periods, each unit of electricity costs more than average. This can be problematic for electric heat consumers as heating peaks typically coincide with electricity peaks. Figure 7 shows how thermal demand profiles of different sectors correlate to electricity load. Most of the sectors represented display a peak thermal demand in the evening period between 17.00 and 22.00 where electricity load is greatest and thus prices are highest. Perhaps more significant is the morning thermal peak between 6.00 and 10.00 which is more uniform amongst sectors. As we move away from gas, and more heat is electrified, the positive correlation between heat demand and electricity demand will grow stronger, and thus the morning peak electricity demand could increase substantially. This would mean consumers in nearly all sectors will pay very high prices in the morning.

[17] Richards and White, 2014. Simplifying energy Tariffs. House of Commons Library

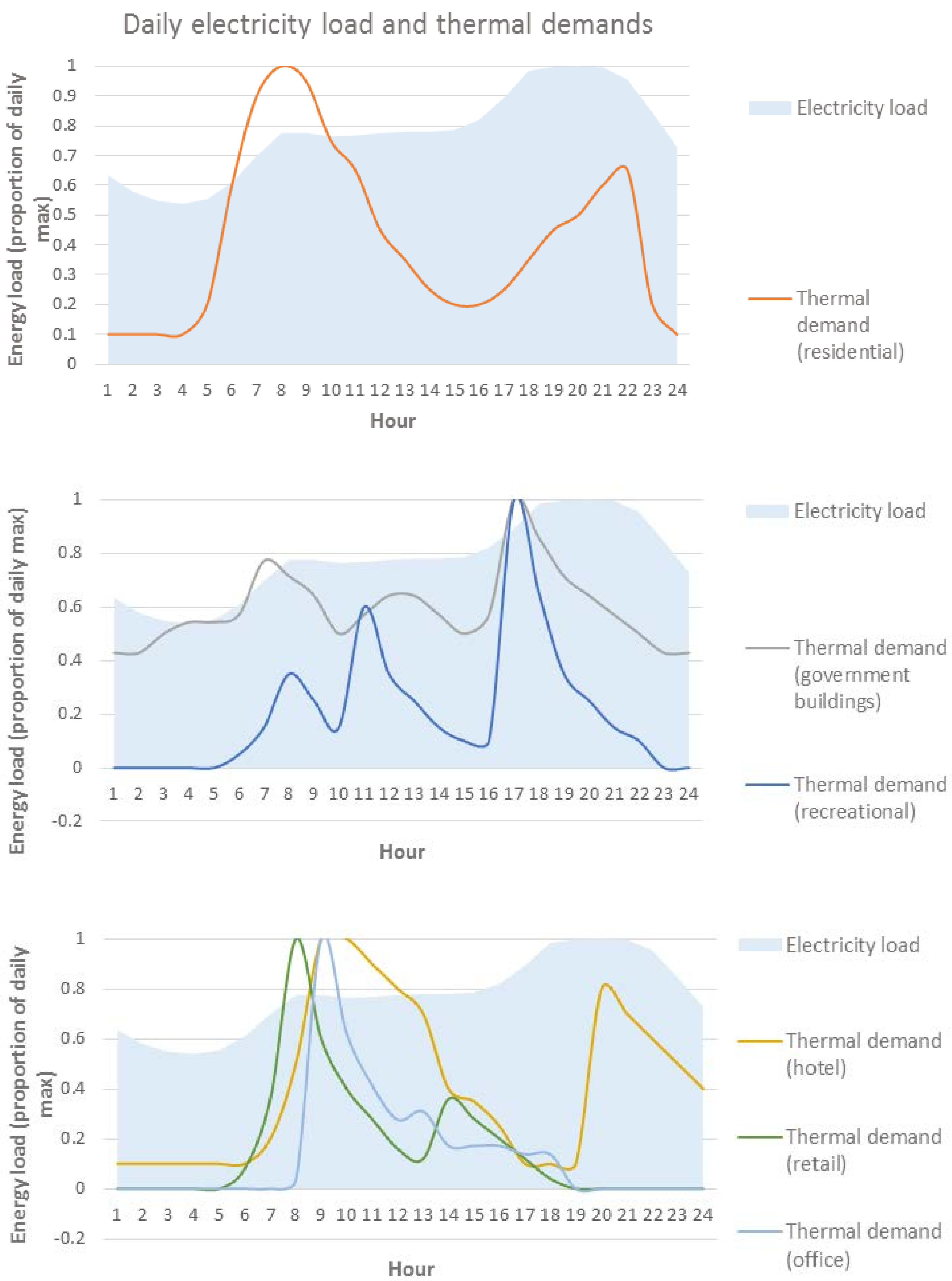
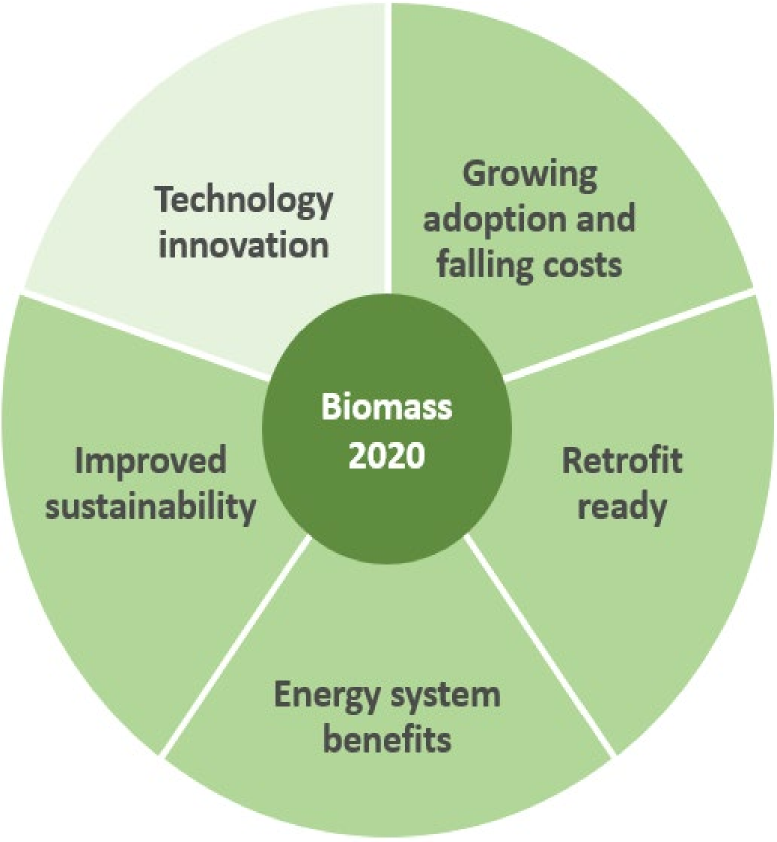


Figure 7 The relationship between electricity load profiles and thermal demand profiles in different sectors. Note that most sectors exhibit peaks at similar times, especially 6-10am. The thermal peaks are likely to drive up electricity load at these times as more heat is electrified. Electrical load from National Grid, thermal profiles from CSE

4. Improved Sustainability



The sustainability of bioenergy resources for the UK is a crucial issue affecting desirable uptake. Supply chain analyses from industry actors and government research indicate GHG saving criteria are being exceeded but concerns remain over the potential impact of scale deployment beyond 2020. It is therefore important that tools and standards are put in place at national and international level to ensure sustainable feedstock is used and genuine GHG achieved.

Some of the initiatives employed by private and public sectors from a national to international scale are described below.

UK practice and regulatory environment

RHI biomass sustainability requirements and current supply chain practices

From autumn 2015, all biomass users claiming RHI will have to demonstrate that the fuel meets sustainability criteria addressing the two core issues of the debate: GHG emissions and land use practices. Lifecycle GHG emissions must not exceed 34.8g CO_2 per MJ (125.28g per kWh) of heat produced, or 60% of the EU fossil fuel average. The land criteria is defined in the UK Timber Standard for Heat & Electricity and is designed to ensure that woodfuel originates from a legal and sustainable source. In practice this means that biomass must be sourced in compliance with the EU Timber Directive (see below) and that suppliers include measurable outputs which describe their performance in regards to maintaining ecosystem health and forest productivity.

While self-suppliers will have to report to energy regulator Ofgem on the sustainability of their fuel, most consumers can ensure they are meeting the criteria by sourcing their biomass from the Biomass Suppliers List[18].

In a study of the sustainability of their own supply chain, CPL Renewables, in conjunction with Hoval, Verdo and Land Energy, conducted an analysis of the lifecycle GHG emission associated with their product[13]. Emissions from harvesting, transport, pelletisation and conversion amounted to 30.4-50.4gCO_2 per kWh (the smaller value when a CHP system is used for pelletisation). The range of emissions is well below the 125.28g CO_2 required by RHI biomass sustainability requirements demonstrating that current industry practices are already exceeding the criteria.

This analysis also indicates the role for an expanding biomass market in furthering carbon reductions. Delivery distances are currently high at c. 200 miles per delivery. This transport to the final customer also currently represents about 25% of carbon emissions within the supply chain. As the market develops (with the support of the RHI), and customers and suppliers are more abundant, it can be expected that these distances will reduce significantly, with a direct correlation to the reduction in emissions from this stage of the supply chain.

Forestry Commission Woodfuel strategy

Support for the UK bioheat industry has been extended by several conservation and ecological groups. Wildlife and Countryside Link* whose high profile members include RSPB, Friends of the Earth and the Wildlife Trust. A number of these organisations have released a position statement advocating the Forestry Commission's 2020 Woodfuel strategy. They believe that sustainable development of a bioenergy economy could address the need for positive forest management, adding character and diversity to the UK's woodlands. These organisations urge the government to commit to delivery of woodfuel targets through investment in appropriate infrastructure, whilst ensuring safeguarding mechanisms are in place to maintain sustainability. Such targeted evidence based support could reinvigorate the rural economy and provide major gains for wildlife, landscape and cultural heritage. Wildlife and Countryside Link advocate the use of local biomass in high efficiency boilers as the most appropriate end use of the growing production.

[18] Biomass Suppliers List, 2015. Biomass Suppliers List

* Wildlife and Countryside Link, 2009. Position Statement by Wildlife and Countryside Link on the Forestry Commission's Woodfuel Strategy for England

Sustainability requirements across the European Union

The EU has been keen to address the concerns which have been raised over sustainability. The carbon debt (i.e. the time difference between the combustion of the biomass and the sequestration of the same amount of carbon via regrowth) is an often cited criticism of bioenergy. In response the Independent Joint Research Council conducted a review of the evidence on carbon accounting[19]. Their findings state the significance of distinguishing between different biomass sources; dedicated stemwood growth may not accrue savings for several decades, though for residues and agriculture, savings can be immediate. Excepting stemwood, all listed feedstocks should be expected to achieve carbon reductions within 50 years. The EU is also looking beyond carbon towards the sustainable management of the resource.

Although there has been concern that there are no specific EU directives to address the sustainability of bioenergy, there are numerous Directives and Regulations, outlined in Table 1, which contain strategies to ensure all biomass resources are managed sustainably.

Table 1 EU policies for domestic biomass production

EU Timber Regulation[20]
Entered into force in 2013, the EU Timber Regulation is designed to prevent illegal harvesting. Operators and traders must exercise due diligence when placing biomass on the EU market; they are required to have access to information describing the wood type, quantity, location of harvest and compliance with national legislation. As of July 2014, 24 of the 28 Member States have the sufficient competent authorities to implement the Regulation; only Hungary is not in the process of fulfilling this obligation [21].
EU Forest Strategy[22]
The EU Forest Strategy provides a framework to address the risks associated with the growing demand for biomass across all sectors. The objective is to ensure sustainable forest management principles – concerning economics, local environment and climate – are practiced in all forests. The European Commission is currently developing objective criteria for Member States.
Common Agricultural Policy[23]
Recent (2014) CAP reforms offer greater environmental protection in agricultural practices (including energy crops). Subsidy levels received by farmers are dependent upon their environmental credentials, whilst further funding is available for voluntary action. These policies lay the foundation for sustainable energy crops towards 2020 and beyond.

[19] European Commission, 2013. Carbon accounting of forest bioenergy

[20] EU Regulation, 2010. Laying down the obligations of operators who place timber and timber products on the market

[21] European Commission, 2014. State of implementation of EU Timber Regulation in 28 Member States

[22] European Commission, 2013. A New EU Forest Strategy

[23] European Commission, 2013. Overview of CAP Reform 2014-2020

Imports from outside the EU

As EU demand is expected to exceed domestic supply by 2030[25], the bioenergy industry will be increasingly reliant on imports from further afield. This has raised two primary concerns: first, are biomass production practices in these regions sustainable? And second, do these imports still deliver GHG reductions once the transport has been taken into account?

In South East USA where a significant amount of biomass production is expected, net forest growth exceeds net removals by 35%[24] despite harvest volumes increasing – a result of years of research, investment and commitment to sustainable land management. In Canada, mill and logging residues from the huge timber industry provide a low risk pathway for biomass imports to the EU. Formerly these were burned without energy capture, and thus they were not providing a role as a carbon stock[24].

Several studies have demonstrated that biomass sourced from North America can make a contribution to carbon savings in the heating sector. The EU Commission's Joint Research Centre calculated GHG reductions relative to a fossil fuel heating comparator. Biomass transported from South East USA achieves savings of around 70-80%, while that from Western Canada can deliver approximately 60% savings (up to 75% when residues are used)[25].

The EU is also working to address sustainability issues of biomass production in less developed countries through its FLEGT Action Plan. Published in 2003, the EU Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan targets illegal logging at a global scale, particularly in developing regions. In 2008 the regulation was implemented through Voluntary Partnership Agreements (VPA) with timber producing countries across the world. These are bilateral legally-binding commitments made from both regions to halt illegal trade. As of 2014, six countries are implementing VPAs, whilst a further nine are in negotiation, and discussions have begun with an additional eleven. As the EU is one of the largest customers of timber in the world, such developments will help to drive the demand for sustainable timber and thus improve the supply from responsibly managed forests.

[24] AEBIOM, USIPA, BC Bioenergy Network and Wood Pellet Association of Canada, 2013. Forest Sustainability and Carbon Balance of EU Importation of North American Forest Biomass for Bioenergy Production

[25] European Commission, 2014. State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU

Managing Indirect Land Use Change

Indirect Land Use Change (ILUC) occurs when new cropland is developed at a natural site to match the gap created between supply and demand as a result of former cropland production being displaced by new bioenergy feedstock production. ILUC emissions occur because natural lands store carbon in their soil and vegetation; conversion to agricultural land will change the carbon stock of the site.

Quantifying the extent of ILUC and its impacts has been made difficult by the sensitivities of models to the underlying assumptions. The degree of intensification of production, distance between site of crop displacement and replacement, increasing food demand and a range of time horizons contribute to the variation in estimations of ILUC extent. Estimated ILUC emissions for biofuels (not bioheat feedstocks) range from zero to "very large"[26]. Similarly, the JNCC[27] finds a range of 0.1 to 1.9Mha extra cropland per extra Mtoe of biofuel production.

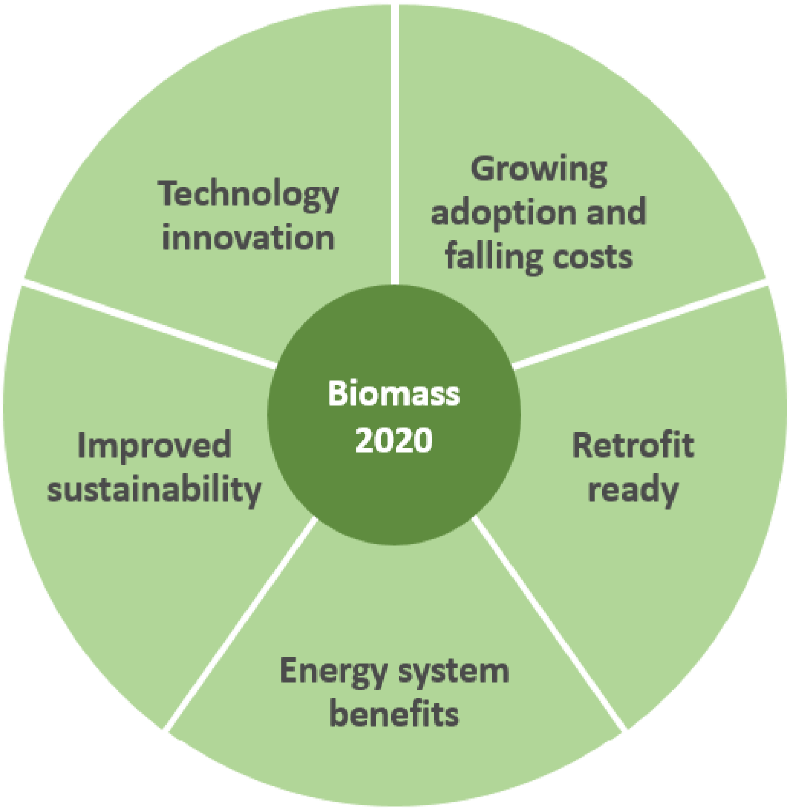
What has received more consensus in academic work undertaken so far is that utilisation of waste materials reduces the risk of ILUC. As most bioheat feedstocks are currently and projected to be based on by-products and waste materials, the ILUC environmental impacts for bioheat can be significantly lower than biofuels. The use of wastes is a consequence of an economic argument: biomass for heat demands a significantly lower price than high-grade wood products or agriculture. As demand increases, a range of innovations will be needed to maximise the availability of end-of-life materials for the bioheat sector. Emerging technologies are supporting waste use and increasing efficiency throughout the supply chain.

[26] Forestry Research, 2014. Review of literature on biogenic carbon and lifecycle assessment of forest bioenergy.

[27] Joint Nature Conservation Committee, 2011. Indirect Land Use Change from biofuel production: implications for biodiversity.

5. Technology Innovation

There are already significant environmental and economic advantages to using biomass for heat with existing mature technologies, however future innovation will further lower carbon emissions and improve heating performance.



Advanced conversion technologies

A range of thermo-chemical processes are under development which can improve the quality of the biomass fuel provided to end users. Some of these treatments are referred to as Advanced Conversion Technologies (ACTs) with the most well-known processes being pyrolysis and gasification. These processes are typified by increasing homogeneity and energy density of feedstocks. This facilitates a wider range of sources for feedstocks; previously unsuitable materials, such as food wastes, can be converted to a high quality useable fuel. The Low Carbon Innovation Coordination Group Bioenergy Technology Innovation Needs Assessment (TINA) suggests ACTs are essential to allow flexible bioenergy technologies to decarbonise a wide range of sectors.

The Green Investment Bank (GIB), set up by the UK government to attract private funding, has made significant investments towards more advanced biomass technologies. In 2014, GIB invested £64 million to a waste management plant in Derby which will use gasification to convert low value household waste to renewable energy[28]. This project is significant in demonstrating the investment potential of innovative conversion technologies. If similar support could be made available for torrefaction, CPL is ready to develop the technology at an industrial scale.

[28] Green Investment Bank, 2014. UK Green Investment Bank investment in new green power plant in Derby

Figure 7 Illustrative outline of the inputs and outputs associated with torrefaction

Torrefaction, a biomass upgrading pre-treatment process, has received interest due to its ability to improve efficiencies and environmental performance throughout the supply chain. A mild form of pyrolysis, torrefaction involves heating biomass to approximately 200-320oC in the absence of oxygen. The resulting torrefied wood has properties somewhere between wood and coal; moisture content falls from around 10% to 0-3% and the amount of heat released during combustion increases by 5-25%29. The material can be densified to give a fuel with an energy density about twice that of typical wood pellets, reducing transport emissions by approximately 50%, as well as minimising the amount of fuel storage space required for consumers. Numerous handling benefits are associated with torrefaction; its hydrophobic properties facilitate open air storage, whilst no biological activity prevents decomposition and minimises the risk of fire.

Wet torrefaction (also referred to as hydrothermal carbonisation) is a lower temperature thermal treatment which torrefies the biomass product in water or dilute sulphuric acid solution. There is significant promise in this technology as laboratory tests have demonstrated its ability to convert a wide array of feedstocks into an energy dense homogeneous bio-char. This allows utilisation of low value wastes and other non-edible biomass products such as grasses and straws30. This minimises the risk of displacing food production, and serves as an environmentally sound waste management procedure. The plant operator may be able to offset the higher capital costs through gate fees paid by the waste producer.

Torrefaction has been explored as a pre-treatment not only to solid combustion but also gasification. This pre-treatment can increase the thermodynamic efficiency of gasification, and reduces tar production while facilitating use of a broader range of feedstocks. Gasification offers applications in electricity, heat and transport, and can be upgraded to biomethane for injection into the natural gas grid. This last application is one which has seen significant developments in the past year. RHI payments for energy delivery have increased over 1,600% in the six months from May to October 201431. As of December 2014, biomethane plants have contributed more than 73 million kWh to the grid32, an output second only to the solid biomass plants. This is primarily a consequence of the large size of the installations which received payments calibrated to much smaller units. In response, DECC launched a public consultation, from which they decided to tier the tariffs to avoid overcompensation33. Nevertheless, the lower than anticipated costs and large output are indicative of the potential for biomethane to contribute towards renewable targets. Encouraging the development of torrefaction holds potential for further cost reductions in this growing sector as cheaper feedstocks become available and more efficient energy conversion is possible.

These applications show promise yet are at present under-researched and under-developed; industrial scale costs and energetics are yet to be determined. Recognising the potential to further reduce their supply chain emissions and improve product quality, CPL is ready to develop industrial scale torrefaction. However, as is recognised in the Bioenergy Strategy34 advanced conversion technologies require government support. Therefore appropriate financial backing or policy signals are required from government to demonstrate to investors that there is a clear role for torrefaction and advanced biomass in the future.

[29] Prins, Ptasinki and Janssen, 2006. 'More efficient biomass gasification via torrefaction' Energy, 31(15), pp. 3458-3470

[30] Chen, Ye and Sheen, 2012. 'Hydrothermal carbonization of sugarcane bagasse via wet torrefaction in association with microwave heating' Bioresource Technology. 118, pp.195-203

[31] DECC, 2014, RHI mechanism for budget management: estimated commitments

[32] Ofgem, 2014. RHI Installations Report

[33] DECC, 2014. RHI Biomethane Injection to Grid Tariff Review: Government Response

[34] "Government needs to continue to support UK technology research, development and demonstration to provide the fullest range of options that will enable the deployment of the low-risk pathways" Bioenergy Strategy, p. 9.

Biomass cascading

Less a technological development, but a methodological innovation, biomass cascading could minimise impacts on other biomass sectors while maximising resource availability. Biomass cascading refers to using the biomass resource more than once, typically with applications moving down the value chain overtime to where lower-grade material is permissible (figure 8).

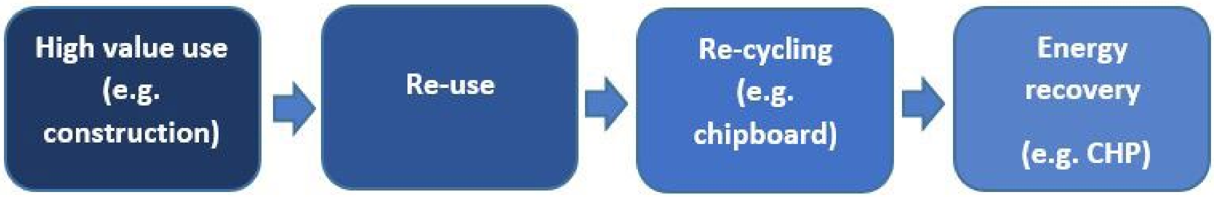


Figure 8 Example chain of biomass cascading

Biomass cascading tackles the carbon debt by allowing the wood products to remain as a carbon stock for potentially many years after harvest. Maximum value of assets can be achieved as waste is minimised, enhancing economic efficiency as well as minimising land use requirements. However, the potential is largely untapped at present. Further research is required to explore optimum uses across the cascading chain to maximise value whilst minimising net carbon increases or environmental damage.

The principles of biomass cascading are not new; the process is in line with the Waste Framework Directive hierarchy for waste management, and end-of-life materials are described as a low-risk option in the Bioenergy Strategy. However, what is needed is the academic research to identify best practice, and stronger, holistic policies which incentivise biomass industry stakeholders throughout all value levels to utilise re-used wood rather than dedicated crops/forestry where appropriate.

Conclusions

- It is widely recognised that bioenergy will be an essential component in the UK's future low carbon economy. However current policy does not suggest a significant role for biomass in heating applications beyond 2020. Government strategy states that as biomass is a limited resource, it should be used in alternative sectors. However, as outlined here, emerging factors suggest that biomass could be a long-term, low carbon heating technology in many applications that should be supported accordingly. Given this evidence, the government should consider re-evaluating the role for biomass heating in its bioenergy strategy.

- Biomass has by far contributed most towards the UK's renewable heating targets. Across the domestic and non-domestic sector, solid biomass boilers account for 80% of all applications (as of December 2014). As the market matures there is a need for continuing government support to allow biomass to continue contributing towards the UK's low carbon heating targets. Market trends suggest that pellet price increases will be offset by falling capital costs, which overtime will lower the overall levelised cost of heat. However, in order for this to happen, manufacturers and consumers need the government to show commitment to this technology.

- There is not a one size fits all solution for heat supply. In poorly insulated buildings, biomass can be preferable from an economic and environmental standpoint over alternative renewable heating technologies due the higher temperature of heat it supplies. Whilst there are numerous energy efficient buildings strategies, the nature of the building stock and current progress indicate many properties are unlikely to be well insulated by 2050. A portfolio of technologies will be required to meet the UK's diverse heat demands.

- A portfolio of heating technologies can also help to minimise energy system issues. A growing electric heating market will increase electricity peaks in the winter, potentially requiring additional generating capacity. Biomass use will displace this electricity demand, whilst biomass CHP systems will help deliver low carbon electricity during these peaks.

- Lifecycle emissions analysis suggests biomass, whether domestic or imported, is delivering genuine, significant carbon savings. Recent research attention means more emphasis is being placed on net carbon accounts of biomass supply chains; monitoring is enabling identification of lower risk pathways. Existing and emerging national and international legislation is ensuring that as more biomass is mobilised, sustainability standards are maintained. It is important to maintain and improve this legislation.

- Finally, there are several technologies on the horizon which will improve the economics, technical performance and environmental credentials of biomass heating.

Heat and the bioenergy strategy

Drawing from the evidence presented, it is clear that heating sits within the appropriate use of biomass criteria described in the Bioenergy Strategy:

Bioenergy Strategy: Appropriate use criteria	**Biomass heat characteristics**
Bioenergy should deliver genuine carbon savings	Industry and EU analyses demonstrate carbon savings of up to 90% compared to fossil fuels are achievable.
Use should be cost effective within overall energy and decarbonisation goals	In many permanently poorly insulated buildings biomass boilers can be more cost effective and lower carbon than alternative renewable heating systems.
Support should maximise net benefits across the economy	Biomass for heat can ease the requirements for extra electrical capacity needed on the grid to account for peaks associated with electrified heating; Biomass CHP efficiently provides low carbon electricity at times of high demand; A developed biomass industry can invigorate the rural economy.
Implications of bioenergy demand on other biomass sectors must be assessed and addressed by policy makers	International biomass sustainability standards and tools are reducing risk to other sectors; Waste utilisation and more comprehensive biomass cascading maximises resource efficiency, reduces competition with other sectors and minimises indirect land use change; Advanced conversion technologies such as torrefaction allow lower risk feedstocks to be utilised.

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