AECB

PO Box 32, Llandysul, SA44 5ZA Tel: 0845 4569773 www.aecb.net

Discussion Paper

Biomass - a burning issue

Nick Grant
Alan Clarke

The use of biomass as a 'low or zero carbon fuel' is increasingly being adopted as the default solution to meet emission targets for new buildings. This approach is fundamentally misguided and is leading to increased UK carbon emissions[1].

This paper demonstrates that there is a crucial distinction between viewing biomass as a renewable fuel - in that plant matter can be self-renewing - and as a low carbon fuel. This is because the amount of plant matter that can renew itself each year is finite, and plant matter burnt for heat reduces the amount available for other sequestered uses, for example as a building structural material or insulant.

This mistaken assumption that biomass is low carbon, combined with the use of a carbon rather than energy metric for buildings, is undermining efforts to achieve large-scale carbon reductions in the UK. David Olivier did not mince his words when he said 'Biomass boilers are an expensive way to make climate change worse and reverse over a century of public health improvements'. In our view they are one of the least sensible uses for wood.

Perhaps ironically, both of the authors live in homes heated by wood stoves and have friends who run businesses selling and installing biomass-heating systems. It would have been much easier not to write this.

[1] This paper uses 'carbon emissions' as shorthand for 'carbon dioxide emissions'.

The dash for biomass

Because the carbon emitted when plants are burnt is equal to that absorbed during growing, it seems self-evident that biomass is a zero carbon fuel. This assumption has led to biomass boilers being seen as the easiest way to meet building carbon reduction targets with the lowest capital cost - although not the lowest running cost; wood costs more than natural gas.

According to a survey by the UK Forestry Commission, the use of biomass boilers has increased 25% in two years[2]. New schools can attract additional funds if their design can demonstrate a calculated 60% carbon saving. Perhaps this is why, despite widely reported problems with maintenance and reliability, 86 per cent of new Building Schools for the Future schemes are installing biomass boilers[3] - the easiest way to qualify for the funding[4]. If it goes ahead, the recently announced Renewable Heat Incentive (RHI) will further encourage this rapid trend[5] and industries that depend on timber for manufacture are already expressing concern about prices and availability of their raw material, trees[6].
There are other criticisms levelled at the use of biomass concerning issues of pollution, and

[2] Reported in Utility Week, 16th February 2010.
[3] Although these are not always actually used since gas backup is usually also installed.
[4] Waite, Richard Architect's Journal. Rethinking Biomass Boilers 11 February 2010.
[5] AECB response to DECC consultation document on Renewable Heat Incentive. http://www.aecb.net/publications.php April 2010.
[6] John Clegg Consulting Ltd. 2010 Wood fibre availability and demand in Britain 2007 to 2025. Confederation of Forest Industries www.confor.org.uk/

other 'externalities' in sourcing, processing and transport. Some experts have raised serious concerns over NO_x and particulate emissions as well as human carcinogens, whilst others are concerned about sustainable sourcing of timber, soil carbon balance and the transport of what even as pellets is a very bulky fuel. The authors believe that these criticisms are valid, but they are outside the scope of this paper, and not central to the case being made here. For the purposes of this paper, the authors are willing to accept that these additional problems might be solved, through a mix of unprecedented political will and clever technology but argue that the fundamental case remains.
The fundamental issues that this paper raises are:

1. Biomass is not in itself a low carbon fuel – burning biomass does produce carbon – more than most fossil fuels.

2. If biomass is grown and not burnt, and an equivalent amount of gas burnt instead, then lower carbon emissions result.

3. Defining biomass as low-carbon, and then setting carbon-based energy standards leads to relaxation of building energy efficiency, and ultimately, higher carbon emissions.

Is biomass really low carbon?

The popularly accepted system boundary for a biomass boiler includes an imaginary area of land that is exactly sufficient to provide the required fuel sustainably. Using this boundary it is then assumed that since burning biomass emits the same amount of carbon as was sequestered when it was grown, it is a zero carbon fuel. Typical values used in SAP[7] to calculate the CO_2 equivalent emissions due to burning biomass allow for transport and losses in processing. The resulting factors range from 0.015 kg/kWh for woodchip to 0.037 kg/kWh for wood pellets and these figures imply that whilst not quite zero, carbon emissions are around a tenth of those from burning gas.

However if we draw our boundary around the building and boiler we see that, when wood is burnt, the combustion process actually results in CO_2 emissions similar to burning coal, both figures being around 0.46 kg/kWh of delivered heat[8]. This can of course be measured in the flue gas; wood itself is not a low carbon fuel. Burning natural gas or LPG[9] by contrast releases about half as much CO_2 as burning wood to provide the same heat output. This is in part due to the fact that more of the energy in gas comes from hydrogen rather than carbon, but also because it is physically easy to burn gas more efficiently than solid fuels.

As figure 1 illustrates, biomass energy is a closed carbon cycle driven by solar energy so the CO_2 released is later taken up by trees. But why should we assume that CO_2 released from a gas boiler will cause climate change, whilst CO_2 released from a biomass boiler is simply food for trees? The trees can't tell where the CO_2 came from.
If we decouple tree burning from tree growing, we get two independent activities, which is a more accurate reflection of the actual situation.

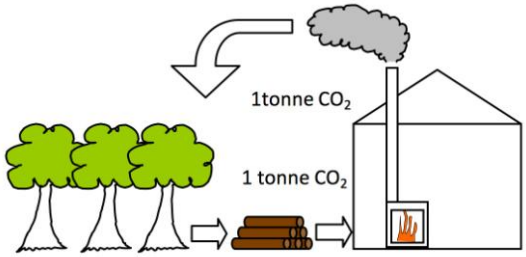

Figure 1. Burning biomass as carbon neutral.

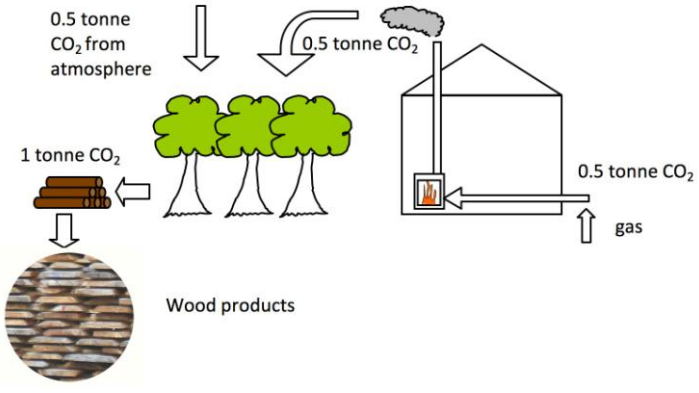

Figure 2. However, growing the biomass and not burning it is carbon negative - even if we burn natural gas instead.

[7] The Standard Assessment Procedure, Revised emission factors for the National Calculation Methodologies, March 2009. BRE.

[8] Figure from the table 'CO_2 footprints for Energy Supply Options' Orchard Partners Ltd. Assumes 78% boiler efficiency.

[9] Around 0.21kg/kWh for natural gas and 0.25 kg/kWh for LPG.

The key assumption underpinning the 'zero carbon biomass' claim is that if the trees were not burnt they would die and rot down, releasing their sequestered CO_2 anyway[10]. But letting them rot is obviously not the only option. We could take the view that trees (and other biomass) are too valuable to burn and choose to 'lock up' the carbon in them by turning them into building structures, insulation materials, furniture, windows, flooring and other long life products. Indeed, contrary to popular belief, even old-growth forest continues to absorb CO_2 from the atmosphere, albeit at a slower rate, whilst newly felled or planted forest emits more CO_2 than it sequesters[11]. More exotic solutions include biochar but the fact is that for every kilowatt hour worth of biomass grown, and then sequestered in some way - we could burn around two kilowatt hours of natural gas and still claim to be carbon neutral.

Of course we might choose to heat our building and water with windows (passive solar gain), solar thermal panels, district CHP or other much lower carbon technologies than gas. But the point is that even standard gas boilers, burning fossil fuel, are lower emitters of carbon dioxide than biomass boilers.

It would be possible to provide incentives for planting more forest and to make more things out of wood rather than paying us to burn more wood. However all the mechanisms to promote biomass as renewable heat reward the installation of boilers to burn wood rather than the planting of forest for the sequestration of carbon. Rather than encouraging the use of timber, current incentives are stimulating competition for a finite resource and raising prices. Another possible perverse outcome is that we may end up using more energy-intensive materials such as clay brick, concrete and steel if timber prices soar due to runaway demand for biomass to burn.

[10] In fact rotting wood releases CO_2 rather more slowly than burning wood – even after 100 years, perhaps 10-15% may still be lying on or within the soil, stabilised to such an extent by the natural processes of decomposition that it can be considered to be permanently sequestered. (Waste Management Options and Climate Change: Final Report to European Commission, DG Environment Alison Smith, Keith Brown, Steve Ogilvie, Kathryn Rushton and Judith Bates AEA Technology July 2001)

[11] Luyssaert, Sebastiaan *et al* Old-growth forests as global carbon sinks. Nature Vol 455|11 September 2008.

Decoupling energy use from generation and biomass emissions from sequestration allows a more holistic approach to carbon accounting that is better suited to inform national climate change policy.

What is the potential resource?

The amount of biomass available to sequester per annum is limited. If biomass supplies *were* actually unlimited then we could offset all emissions through sequestration, meet all of our needs for renewable raw materials *and* have enough left over to burn.

Clearly though this is not the case. Estimates of the sustainable biomass energy potential for the UK or EU vary but it is certain that the figure is closer to 10% than 100% of total energy use. Furthermore biomass supplies appear to be declining. For the world as a whole, carbon stocks in forest biomass decreased by an estimated 0.5 Gt annually during the period 2005–2010[12]. Clearly burning more of it won't improve this situation.

Whilst we have demonstrated that burning gas instead of biomass results in around half the net CO_2 emissions, this does not mean that we can offset our gas heating by planting trees - we simply can not grow enough to do this either. Our point is that biomass is a lot worse than we thought, not that gas is a lot better.

UK regulations

The UK emphasis on using CO_2 rather than energy consumption as the metric to drive building design is problematic since it is undermining the potential for demand reduction measures. Budgets and design time are always stretched and on all projects something 'has to give'. Whilst energy efficiency is often said to be at the top of the zero carbon hierarchy, this is not the way client or design team decisions are generally being made. If we mistakenly consider biomass to be a zero carbon fuel then the efficiency argument is seriously weakened. Once biomass has been chosen there is far less incentive to invest in additional thermal efficiency of buildings. It is argued, wrongly, that since biomass heat is 'carbon free' the embodied carbon in thicker insulation results in higher emissions over the building's life. High

[12] The Global Forest Resources Assessment 2010, FRA 2010.

backstop U-values[13] then appear to be the most sensible choice in terms of build-cost.

Ironically the fact that many of these buildings actually run on "back-up" gas boilers from day-one, means they emit less carbon than if the biomass boilers were being used as they were supposed to. Of course it would be better still if they had also been insulated properly.

Energy security

Given the limited biomass resource it does not appear to offer a solution to concerns that gas will become scarcer. If the renewable heat feed in tariffs start to achieve what they set out to do – i.e. fast track the uptake of such biomass burning technologies, expect to see stories about 'peak wood', a recurrent problem since prehistoric times[14], last solved in the UK with the grudging acceptance of coal as a replacement for biomass.

Already those of us who heat our homes with wood are noticing that prices are increasing and previous supplies such as sawmill waste are drying up. Suddenly Russian gas feels like the secure option! The only sure source of energy in an uncertain future is what Amory Lovins called Negawatts - that is 'energy conserved or not required thanks to radical efficiency measures'. We would include in efficiency measures the use of reject power station or industrial heat to heat buildings via district heating systems. By contrast the occupiers of far less efficient buildings with woodchip boilers are more exposed to the vagaries of the market, and saddled with high and rising fuel bills and ongoing maintenance and repair costs.

Conclusions

By incorrectly defining biomass as a low carbon fuel we are actually increasing global carbon emissions.

There is a finite and limited supply of Biomass, compared to the many demands being made on the available resource. We would like to see proper analysis as to how best to use this precious resource before rushing into policies based on creative (carbon) accounting. Should we grow biomass to lock up carbon in structures, products and soil; convert it into high grade fuel for transport; use it to replace coal in district CHP plants; or just burn it to heat a few buildings? We are a very long way from addressing this question at the strategic level in the UK. Instead we have the large-scale installation of biomass heating in an attempt to meet theoretical carbon targets. This policy is misguided. In attempting to decrease UK carbon emissions it will not only fail, but in fact lead to the exact opposite. As even this simple paper demonstrates, further uptake of biomass in the UK will mean significantly increased carbon emissions[15].

Acknowledgements

The authors do not claim the insights in this paper to be their own and would like to thank the many people who have contributed to this discussion over many years and in particular to those who took the time to critically review early drafts of this article. Any errors or bad writing remain our responsibility.

[13] See Table 4 of the Approved Document L2A; Conservation of fuel and power, 2010.

[14] http://tobyspeople.com/anthropik/2005/10/peak-wood/

[15] We have focussed on buildings as they are our daily concern, but the most significant emissions will be from biomass fuelled power stations and co-generation in existing ones.