



# Findings from a time-dependent carbon footprint analysis of a biomass renewable energy plant

## The focus of the study

The study, “Time-dependent carbon footprint analysis of a biomass renewable energy plant”, compared the amount of carbon<sup>1</sup> emitted into the atmosphere from a proposed biomass-fuelled renewable energy plant and the amount of carbon emitted from generating the same amount of electricity from fossil fuel alternatives. It is generally accepted that biomass energy generation results in reduced long-term carbon emissions when compared to fossil fuels. The key difference examined here between the use of biomass – accompanied by re-planting – and fossil fuels, is the extent to which they result in a short-term net change to carbon in the atmosphere.

## The need for the study

Our environment – the land, the air and water – must be in balance. Within the environment there are various “cycles” which are powered naturally, such as by the sun. The carbon cycle involves the capture of carbon dioxide from the atmosphere by the plant kingdom, turning carbon dioxide into biomass (trees, branches, leaves, vegetation, etc.) and releasing oxygen into the atmosphere through photosynthesis. The carbon in the biomass is then converted back into carbon emissions through digestion and subsequent respiration by animals, or by decay, or through combustion.

Similar cycles exist for water and nitrogen. All these cycles – water, nitrogen and carbon – operate within the timescales of human lifetimes. In a stable environment the amounts of water, nitrogen and carbon dioxide in the environment remain broadly the same. But they can be disrupted, and with undesirable consequences. The use of fossil fuels – sources of carbon stored deep in the earth many millions of years ago – is a source of such disruption. It should be no surprise that adding more and more carbon into the environment will result in undesirable and potentially catastrophic effects. That is what is happening today. On the other hand, the use of biomass has a broadly neutral effect in terms of net additions to the carbon cycle; if more biomass is planted after it is harvested it regrows in a relatively short time period and recaptures the same amount of carbon dioxide that was released when the fuel it is replacing was burned.

Rather than adding more and more carbon into the atmosphere through the continued use of fossil fuels, this use of “short cycle” carbon from biomass is environmentally sustainable. Nevertheless it is still important to understand the short-term impacts of biomass energy generation, which is the driver behind this study, to focus on how biomass electricity generation can contribute to short-term carbon reduction targets and the reducing carbon intensity of the UK grid.

Clearly biomass must be produced with due care for environmental and social sustainability. For example, forests must be managed in such a way as to protect biodiversity, carbon stocks and livelihoods. Externally verified standards and internationally accepted sustainability certification systems help to ensure that these concerns are addressed. Forth Energy laid out its commitment to stewardship and sustainability of fuel in the Sustainability Statements that accompanied each of the four applications submitted under Section 36 of the Electricity Act 1989 for Dundee, Grangemouth, Rosyth and Leith. The proposed biomass plants will generate heat as well as electricity, resulting in carbon savings on top of those presented here, which are related only to electricity.

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<sup>1</sup> In this document ‘carbon’ is defined as the six greenhouse gases stipulated in the Kyoto Protocol (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub>) expressed in terms of equivalent amounts of carbon dioxide (CO<sub>2</sub>e) weighted over 100 years

## The Approach

The study was conducted by SISTech (The Scottish Institute of Sustainable Technology) and adopted two distinct methodologies.

The first, “**EC Methodology**”, is the methodology recommended by the European Commission that was used in previous studies completed by SISTech looking at various sustainability aspects of the proposed Forth Energy plants (Sustainability Statements, 2010). It is the methodology that is adopted to determine the carbon intensity of electricity from biomass and is used to determine eligibility for the UK’s financial incentive mechanism, the Renewables Obligation. The same methodology is used here to determine the carbon intensity of electricity (expressed in CO<sub>2</sub>e/MWh) from biomass fuels, presented later in this document.

The second methodology, “**Time-dependent Methodology**”, was developed specifically for this study and includes all the sources of emissions stipulated in the EC Methodology PLUS both the emissions from biomass combustion and carbon absorption through biomass growth. Including these two elements in this study allows an analysis of the short-term gains achievable by generating electricity from biomass. Using this methodology allows a year on year comparison of the amount of carbon that will be in the atmosphere whether electricity is generated by biomass or by fossil fuels. The same approach was adopted in the Manomet study.<sup>2</sup>

The Time-dependent Methodology included the following sources of carbon emissions: Direct emissions from **burning** the biomass at the renewable energy plant; carbon emissions removed from the atmosphere during the **growth** of the biomass; emissions from **construction** of the biomass plant; emissions associated with **changing the land** to produce the biomass if it is expected to come from a new or expanding plantation; all **transport** emissions from the origin of the fuel to the biomass plant; carbon emissions associated with **processing** the biomass (including fertilizers, forestry practices, chipping, pelletisation, etc.). Emissions associated with **alternative use** were also assessed, such that any emissions avoided (such as avoided disposal) were removed from the carbon balance and any absorption that was avoided (such as preventing continued growth due to harvesting) was added to the carbon balance. In this way a comprehensive account of the carbon emissions resultant from the generation of electricity from the proposed biomass plants could be calculated and compared with alternative energy sources.

### “Time-dependent Methodology” inclusions:

- Emissions from burning biomass
- Absorption/sequestration from growing biomass
- Construction
- Land use change
- Transport
- Processing
- Alternative use (e.g. wood-based products, landfill, incineration)

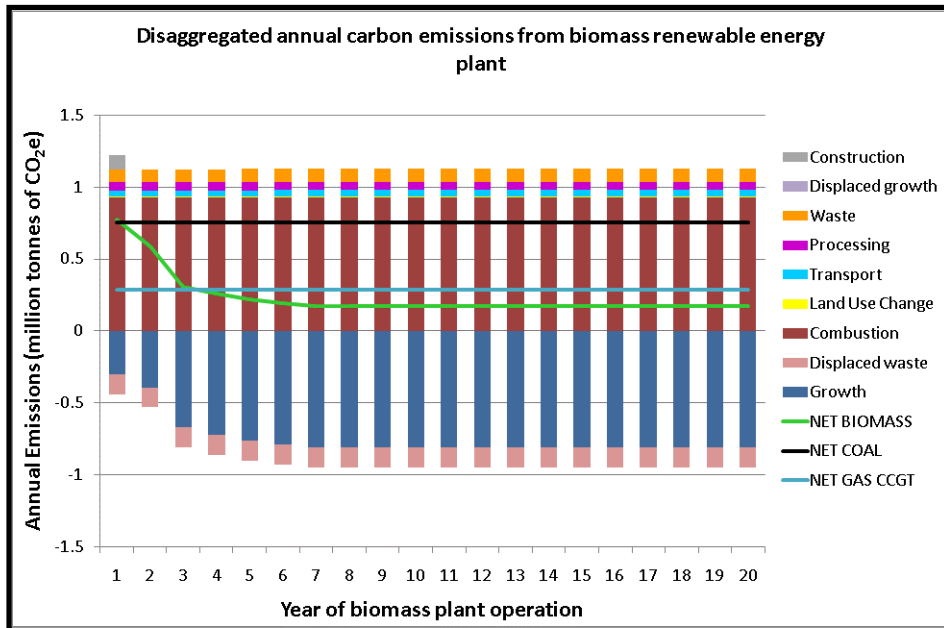
A range of fuelling scenarios based on realistic fuel sources were developed following consultation with suppliers. Data for each of the sources of carbon emissions named above were researched with assumptions made where data was lacking. The fuelling scenarios included a mixture of: fast growing crops to get the benefit of fast carbon absorption; by-products from industry and forestry to avoid carbon emissions from disposal (both decomposition and burning); and local wood and forestry thinnings. A broad range of fuels were considered to highlight the relative contributions of transport, rate of growth, and all the other elements to the total carbon emissions.

<sup>2</sup> Walker, T., Cardellicchio, P., Colnes, A., Gunn, J., Kittler, B., Perschel, B., and Saah, D., 2010. 'Biomass study and carbon sustainability policy'. *Manomet Center for Conservation Sciences*.

## What we found

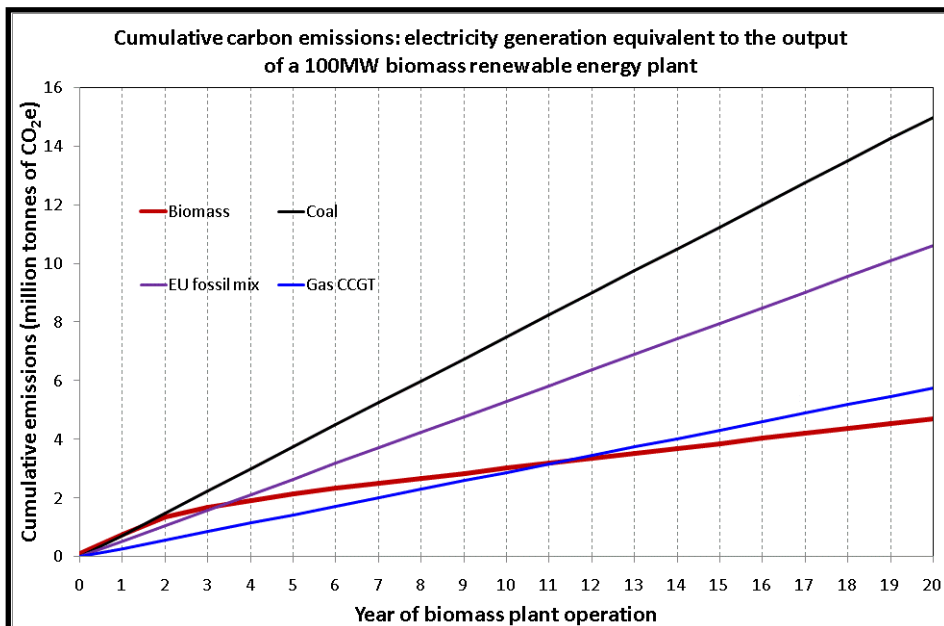
Figure 1 shows the disaggregated contributions of each element to the overall annual carbon emissions from one of the fuelling scenarios, utilising a proportion of fast growing biomass. Adding together each of the coloured bars gives the “NET BIOMASS” green line. The contributions to the net emissions of construction, displaced growth, waste, processing, transport, land use change, and displaced waste are relatively small. Clearly net emissions are dominated by the contributions from the combustion and growth. When the growth of the biomass replaced after the first harvest increases, the annual net emissions of biomass falls rapidly below the net annual emissions of the fossil fuel comparators (coal and gas<sup>3</sup>).

Figure 1.



All of the scenarios examined in the study will result in lower levels of carbon emissions within 20 years of the plant starting to generate electricity when compared to fossil fuel alternatives. Figure 2 shows the cumulative carbon emissions from the same scenario as illustrated above. The point at which the (red) biomass line goes below the comparator line is when carbon savings are being realised.

Figure 2.



The Time-dependent Methodology was used to get the above results because it is important to take into account the combustion emissions and absorption from regrowth when considering carbon savings.

## Carbon Intensity

Aside from Forth Energy's own sustainability commitment there is a requirement to comply with Government targets for the carbon intensity of biomass electricity generation. Central to this is a requirement that biomass electricity generation must have a maximum carbon intensity of 285.12 kg CO<sub>2</sub>e per MWh. To calculate the carbon intensity of individual biomass fuels as well as the fuelling scenarios, the EC Methodology is adopted, which does not account for combustion emissions and absorption from growth, to be consistent with this figure.

The fuels evaluated in this study were found to have carbon intensities ranging from:

125.15 – 355.36 kgCO<sub>2</sub>e/MWh

One of the fuels exceeded the threshold stated above from the Renewables Obligation and so was discounted from the fuelling scenarios. The fuelling scenarios had carbon intensities ranging from:

193.58 – 230.78 kgCO<sub>2</sub>e/MWh

The average carbon intensity of the UK grid electricity in 2008 was 571 kgCO<sub>2</sub>e/MWh. This is targeted to decrease to approximately 300 kgCO<sub>2</sub>e/MWh by 2020 and between 120 kgCO<sub>2</sub>e/MWh to 260 kgCO<sub>2</sub>e/MWh by 2030 dependent on factors including carbon price and the availability of commercially viable energy-generation technologies. To put the above figures into context, the carbon intensity of electricity generation from coal is 1007 kgCO<sub>2</sub>e/MWh and gas CCGT<sup>3</sup> is 387 kgCO<sub>2</sub>e/MWh.<sup>4</sup> In order to meet the decarbonisation targets for the UK, carbon intensive forms of electricity generation must be replaced by less carbon intensive forms of electricity generation.

## Conclusion

The 'Time-dependent carbon footprint of a biomass renewable energy plant' study compared the amount of carbon emissions in the atmosphere from biomass energy generation and fossil fuel alternatives. As illustrated in the graphs, one of the realistic fuel sourcing scenarios could lead to **less carbon** in the atmosphere **within two years** of the biomass plant generating electricity than if the electricity had come from coal power. In comparison to gas, carbon savings could be realised **within twelve years**.

Sustainably sourced biomass can provide a means of lowering the carbon intensity of the UK grid and this study has shown that there is the potential to realise carbon savings in the short term.

### Key conclusions from the study:

- **Less carbon in atmosphere than if fossil fuels used to generate electricity**
- **Carbon savings within the anticipated 20-year lifetime of the plant compared to fossil fuels**
- **Fast growing biomass can lead to carbon savings despite long transport distances**
- **Fuel mix can result in short term and long term savings**

<sup>3</sup> CCGT (Combined cycle gas turbine) is one of the most efficient forms of fossil fuel energy generation.

<sup>4</sup> These comparator data were sourced from EC (2010) and Defra / EA (2010). They each include emissions from the extraction (e.g. mining), processing and transport of the fuels, as well as emissions from the generation stage, and so provide comparable life-cycle carbon footprints to the results presented here.