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The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region

The Scottish Government
Edinburgh
Scotland

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Towards a Low Carbon Economy for Scotland: Discussion Paper, The Role of Biochar

1. We welcome the preparation of the Discussion Paper and agree with the sentiment that Scotland can and must play a key role in the transition to a low-carbon energy system. One area that was not mentioned in the Paper is the concept of biochar. *Our preliminary work suggests that biochar could contribute between 0.5 and 4.7 MtCO_2 equivalent per year. This represents 1 – 10 % of the CO_2eq reduction needed to meet the 80% reduction target by 2050.* Biochar can help meet the Government's stated ambitions related to enhancing energy security (page 11), reshaping waste management into resource management (page 12), greenhouse gas reduction and carbon sequestration (pages 14 & 19) and minimizing emissions from agricultural and other land use businesses (page 19).

2. **Biochar** is the solid remains of any organic material that has been heated (to at least 250^{o}C) in a zero-oxygen or oxygen-limited environment, which is intended to be mixed with soils for carbon storage and often also to improve the soils.[1] Production and use of biochar serves a number of vital functions: greenhouse gas abatement, renewable energy generation, agronomic gain and sustainable waste management. Biochar is generally produced using pyrolysis (burning in depleted oxygen); and a PBS chain includes the configuration of the feedstock, pyrolysis plant, transport and storage infrastructure and the biochar 'sink', usually suitable agricultural land.

3. Biochar contains up to **90% fixed or stabilized carbon**: it remains in a stable form for hundreds to thousands of years, hence contributing to removal of CO_2 from the atmosphere over a time period that is relevant in tackling climate change (>100 years). PBS can also be a net energy exporter, hence there is an avoided carbon emission from the substitution of fossil fuels. A third source of CO_2 equivalent savings arises from the indirect impacts of biochar in soils, with the possibility of N_20 and CH_4 suppression and reduced fossil fuel use in farming operations and inputs.

4. **Biochar Carbon Abatement Potential from Virgin Feedstocks in Scotland**: Hammond (2009) provided estimates of carbon abatement from PBS using clean (virgin) biomass in

[1] More technically, it has been defined as: 'the porous carbonaceous solid produced by thermochemical conversion of organic materials in an oxygen depleted atmosphere which has physiochemical properties suitable for the safe and long-term storage of carbon in the environment and, potentially, soil improvement' (Shackley, Sohi, et al., 2010).

Scotland assuming existing levels of feedstock availability. A low feedstock availability scenario gave a carbon equivalent abatement of 0.6 $MtCO_2eq$ per year (yr^{-1}) while a high feedstock scenario provided a value of 1.2$MtCO_2eqyr^{-1}$ and a very high feedstock scenario delivers 2.4 $MtCO_2eqyr^{-1}$ abatement. Therefore PBS could contribute between 1 – 5 % of the CO_2eq reduction needed to meet the 80% reduction target by 2050. The majority (84%) of the biochar produced would be from woody feedstocks (residue from sawmills and forestry, small round wood and short rotation coppice) with the rest being derived from straw.

5. **Biochar Carbon Abatement Potential from Non-Virgin Feedstocks in Scotland**. Biochar can also be produced from urban wastes (non-virgin feedstocks) such as wood from the construction and demolition or commercial and industrial sectors, as well as from sewage sludge, food, or garden and green waste. Ibarrola estimated that a low feedstock availability scenario for Scotland could give a carbon equivalent abatement of 0.5 $MtCO_2eq\ yr^{-1}$, while a high feedstock scenario could provide a value of 1.0 $MtCO_2eqyr^{-1}$ and a very high feedstock scenario delivers 2.3 $MtCO_2eqyr^{-1}$ abatement. Of all the urban wastes mentioned, wood waste would be the most suitable feedstock for biochar production due to its high calorific value and low moisture content, and due to the fact that PBS would not be competing for the treatment of this feedstock with other technologies such as composting or anaerobic digestion, as it would for the treatment of sewage sludge or garden and green waste.

6. **Future potential given increased forest cover.** Under a scenario of increasing reforestation, afforestation and some expansion in the use of marginal land for growing energy crops such as willow, reed canary grass (RCG) and short rotation forestry (SRF), we estimate that substantially more suitable feedstock could become available. Based upon analysis of other studies and scenarios (e.g. Wood Fuel Task Force, 2008, Read et al., 2009) a very preliminary estimate is that the quantity of additional woody feedstock that could be produced per year is c. 1.2 Mt by about 2030, which in turn represents about 1.2 $MtCO_2eq$. abatement. This would increase the overall abatement from virgin feedstocks to c. 3.6 $MtCO_2eqyr^{-1}$ or a total (all feedstocks) of 5.9 $MtCO_2eqyr^{-1}$ by c. 2030.

7. **Biochar sinks in Scotland**. Scotland has approximately 550,000 ha of arable and horticultural land. If 2.5 Mt biochar could be produced a year, then 10t/ha could be applied to all arable + horticultural land in two to three years. There is also 1.2 million ha of grassland in Scotland and biochar could also be incorporated into at least a proportion of this. Higher application rates than 10t/ha are also feasible, for the purposes of both carbon storage and agronomic benefit. Finally, very large land areas of rough grazing and marginal land could be utilized as a sink for biochar, as can forest soils at the time of tree harvesting and replanting. It is unlikely therefore that insufficient land-area is available for storing biochar in Scottish soils. Export to agricultural areas of England is a further possibility.

7. **Agronomic benefits of biochar.** Most research on crop yield response to biochar has taken place on depleted soils in the tropics (Verheijen et al., 2010). Three sets of

experimental biochar field trials are now underway in Scotland however (East Lothian, Fife and Angus). The first was set up in 2009 by Jason Cook and Colin Hunter in East Lothian and a statistically-significant 8% increase in spring barley yield was reported for the 2009 harvest. Further results from spring barley, oil seed rape, potatoes, carrots and beetroots will become available during 2010 and measurements will continue in subsequent years.

8. **Life Cycle Assessment of biochar.** Life cycle assessment of PBS has demonstrated that it is an effective way of abating carbon and, expressed in terms of land-use, is far more efficient than conventional bioenergy systems in the UK (c. 7 – 20 $tCO_2eqha^{-1}yr^{-1}$ compared to 1 - 7 $tCO_2eqha^{-1}yr^{-1}$ for biomass used in combustion for electricity generation). The detail of this analysis is set out in Hammond et al (2010), Hammond (2009), Ibarrola (2009) and in a report for Defra and DECC (Shackley, Sohi, et al., 2010). PBS is not, however, the most efficient way of generating electricity from biomass, though it can be a net energy exporter. If there is a localized demand for the heat, then the net energy efficiency of the PBS can be greatly improved, however.

9. **Key Barriers to deployment of biochar.** A number of issues hamper the development and deployment of PBS, which the Scottish Government could partially alleviate, through policy development, regulation and incentivisation. These issues are:

- Availability of feedstock;
- Lack of a dominant design in pyrolysis technology;
- Lack of a carbon credit for the carbon that is fixed within the biochar;
- Lack of a clear unambiguous risk and regulatory regime for biochar production and incorporation into soils.

10. **Utilisation of waste (non-virgin) feedstocks.** Feedstocks can be made available at much lower, or even negative, costs where non-virgin organic materials can be used to produce biochar. Many wastes incur a tipping fee if disposed of in landfills hence it is possible that a pyrolysis unit could charge a tipping fee, thereby raising a revenue stream. Use of organic residues, particularly non-virgin waste, will raise legitimate concerns about contamination and environmental risks, requiring a clear approach to risk assessment and regulation (see 13).

11. **Need for a dominant pyrolysis design**. To address the lack of a robust technological design, greater support from the public and private sector is sought. While a number of major companies have expressed an interest, most of the development is occurring in small operations that are funded on a ‘shoestring’. A more concerted effort is required to establish a cost-effective and efficient design that can be readily manufactured and exported internationally.

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12. **Creating a carbon credit for stabilized carbon in biochar.** Without a carbon credit for the stabilized carbon in biochar, the production and use of biochar are unlikely to be economically feasible. At present, the incentives are geared towards renewable electricity generation; pyrolysis by its nature is less efficient than alternative use of the biomass in combustion, even though PBS may well deliver higher overall carbon abatement than combustion. We therefore urge the Government to examine the inclusion of biochar within carbon trading arrangements. Since the EU ETS is probably not the appropriate instrument, Governments in Holyrood and Whitehall may wish to give consideration to the inclusion of biochar within the Carbon Reduction Commitment Energy Efficiency Scheme (CRC EES). While the CRC EES is not currently designed for inclusion of offset emissions or of stabilised carbon storage, it is a tradeable scheme that aims to reduce the carbon emissions of SMEs. Just as CO_2 capture and geological storage (CCS) is now included with the provisions of the EU ETS, soil carbon storage could be included within the CRC EES. If this is not considered to be feasible, an alternative soil or land-based carbon crediting scheme may need to be developed.

13. **Risk assessment and regulation.** The final problem identified above is the lack of a clear regulatory framework for biochar. The complex regulatory and risk assessment issues are dealt with in part in chapter 5 of Shackely, Sohi et al. (2010). While the issues are complex, there is a high level of expertise on the underlying science in Scotland and the UK. There are also good precedents for dealing with risk assessment and regulation of amendments to soils in an effective way – e.g. the PAS 100 for compost applications and the sewage sludge regulations & quality protocol. What is urgently needed now is a small level of support (£20-30k) to allow a regulatory committee of experts to be formed to come to a view on the risk assessment and appropriate analytical methods and to move towards devising a quality protocol. Scotland, as HQ's of the UKBRC, is ideally placed to lead the UK on developing a biochar PAS or quality protocol.

We would be delighted to provide more information to the Government, or discuss any of the issues raised here, on request.

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