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The use of RDP funds

This submission to the Department of Agriculture is made on behalf of the Carbon Cycles and Sinks Network (www.carboncyclesandsinks.org) which has been established with Department of the Environment funds to provide policy advice to government on the best ways of reducing greenhouse gas emissions from agriculture and other types of land use. The CCS Network's ultimate aim is to find ways to turn the Irish land-mass into an emissions sink rather than a source. A list of the members of the Network is supplied as an appendix.

The CCS Network believes that the bulk of any additional funds available for rural development should be applied to the development of biomass-based fuels. This is because the demand for such fuels is currently running ahead of supply and is likely to increase further as the use of fossil fuels is restricted both by measures to reduce greenhouse emissions and the depletion of fossil fuel sources. It is very important that this market- and EU-directive-driven demand for biomass-based fuels be channelled in ways that bring maximum benefit to rural communities and to the environment. The development the Network envisages would do this. It could proceed in four stages:

Step 1. Increase the production of energy crops and develop a market for them.

Substantial greenhouse gas emission savings are possible if energy-crop biomass is co-fired with peat and coal in existing power stations. Accordingly, Ireland's White Paper on Energy, March 2007 set a target of 30% co-firing at the three peat power generation stations by 2015. The National Climate Change Strategy, April 2007 re-stated this aim. Some co-firing trials have been carried out by Bord na Mona at its pilot project at Edenderry Power Station.

At the moment, most of the main energy crop grown in Ireland, miscanthus, is pelleted and used for wood burners. Ireland will only meet the power-station fuel target if adequate biomass feedstocks are grown, which in turn depends on an adequate incentive being given to farmers. A supply network to deliver biomass to the power stations is also required.

It takes a number of years for miscanthus and short-rotation coppice to reach full production after the crops are established. Consequently, the 2015 co-firing target will be unattainable unless a plan is developed to ensure planting begins on time and that a market exists for the initial production. Increased incentives to farmers prepared to grow energy crops may also be required to get the required production. It is the responsibility of the Government's Bioenergy Working Group to

develop these plans but some Network members believe that the Group has not yet carried out adequate stakeholder consultations both national and local level to develop its plans properly.

Step 2. Set up a country-wide network of anaerobic digesters to treat animal slurry and vegetable waste.

Anaerobic digestion (AD) of organic wastes is a proven, well-trying and tested technology that converts organic matter to biogas in the absence of oxygen. In temperate environments the microbiological process of digestion is normally accelerated by heating to either mesophilic (20-40°C) or thermophilic (50-60°C) temperatures. Products of AD are biogas [a mixture of methane (60-80%), carbon dioxide (20-40%) plus low levels of hydrogen sulphide (0-3%), ammonia and nitrogen (0-5%)] and a solid and liquid digestate. The liquid is typically spread on agricultural land and is a source of plant nutrients. The solids can either be composted or pyrolysed to produce a valuable biochar (see section 3). Typically 40-60% of organic matter is converted to biogas with a typical calorific value of 17-25 MJ/m³ (20 MJ/m³ at 70% methane content). Biogas can be utilised by combustion in modified gas boilers to produce heat or in a combined heat and power unit to produce electricity and heat. Biogas can also be used as a vehicle fuel (Frost, 2005).

Because slurry is bulky, it should not be carried far from the farm where it is produced to the place it is processed. Accordingly, just as each parish had its co-operative creamery a century ago, we see a network of local anaerobic digesters being established around the country which would carry out the digestion of the slurry to produce biogas. In addition to slurry, the AD units could be used to treat the organic matter in municipal solid waste, generating an income from gate fees.

The biogas could be compressed and used as a transportation fuel displacing petrol and diesel. Another option is for the AD units to be established close to users of gas such as creameries and the district heating systems that Bord na Mona is planning to set up to serve a target of 250,000 houses around the country¹. Alternatively, they could be connected to the national gas grid. Biogas is already fed into the gas grids in several European countries and this is proposed for Britain².

An investment of RDP funds in the development of localised AD managed by local communities would transform a disposal problem into a profit opportunity. As the technology continues to develop, AD is becoming a key method for the reduction of waste and the production of renewable fuel, a high-grade liquid fertilizer and compost that can reduce the use of peat as a compost base.

Step 3. Install pyrolysers beside the anaerobic digesters

Many agricultural scientists, farmers and commentators are concerned about the potential impact of biomass harvesting on soil and water quality. Crop residues are a vital component of soil agro-ecosystems as they contain substantial amounts of plant nutrients (primarily C, N, K, P, Ca, and Mg). As a result, if they are taken away from the land every year the nutrients in them have to be replaced by increased fertilizer use (Laird, 2008). The residues are also important for building and maintaining soil structure, maintaining water infiltration, and reducing soil erosion. Consequently, if a lot of above-ground crop residues are removed year after year, soil quality rapidly deteriorates (Wilhelm et al., 2004). More fertilizer, more tillage, and more irrigation water are needed to produce the same crops, and the quality of the ground water deteriorates. Furthermore, any carbon credit claimed for bioenergy production would have to be significantly discounted because of the

1 http://www.bnm.ie/files/20080722034947_Press%20Release%2021%20July%202008.pdf

2 <http://www.nationalgrid.com/corporate/Media+Centre/Press+Releases/Global+Press+Releases/020209.htm>

loss of soil organic carbon and the substantial energy required for increased fertilizer manufacture and tillage (Laird, 2008).

Ireland's Rural Development Plan should therefore focus on the design of integrated agricultural biomass-bioenergy systems that build soil quality and increase productivity so that both food and bioenergy crops can be produced sustainably. One such system involves processing agricultural residues/AD digestate/biomass through a distributed network of pyrolysers. .

Pyrolysers heat biomass to ~500°C and thereby thermally transform biomass into bio-oil, syngas and biochar (charcoal). The energy required to operate pyrolyser is a low percentage of the total energy that can be derived from the feedstock. Modern systems are designed to use the syngas generated by the pyrolyser to provide all the energy needs of the pyrolyser. Bio-oil is an energy raw material (17 MJ kg⁻¹) that can be burned directly to generate heat energy or easily shipped to a refinery for processing into transportation fuels and various co products (Bridgwater et al., 1999).

While the biochar could be burned for energy, incorporating it in the soil replicates the soil building techniques used to produce the Amazonian Dark Earths or *Terra Preta*. Biochar was used as a soil fertiliser/enhancer by pre-Columbian civilisations. Native Amazonian Indians burned their domestic waste under restricted air conditions, under a soil cover (Smith, 1980). BioChar formed in that way greatly increased the fertility of the soils where applied. These are now called "*Terra Preta de Indio*" (TP) or Amazonian Dark Earth (ADE). TP soil have up to three times more N and P and have C contents up to 9% more than adjacent non-char amendment soils (Glaser, Lehmann et al. 2002). Also, the TP have high cation exchange capacity values and nutrient availability (Smith, 1980). Based on these discoveries, application of chars from pyrolysis processes may provide feasible ways to generate sustainable fertile soils similar to the *Terra Preta*.

Biochar is an excellent adsorbent which increases the soil's capacity to adsorb plant nutrients and agricultural chemicals and thereby reduces leaching of those chemicals to surface and ground water. It also contains many nutrients (depending on feedstock) and has the capacity to slowly release those nutrients to growing plants. The Network therefore expects that a high proportion of the biochar produced by the pyrolysers will be used to absorb the nutrients in the liquid digestate before being applied to the land and will thus complete the nutrient cycle.

Biochar is a relatively low density material that helps to lower the bulk density of high clay soils, increasing drainage, aeration, and root penetration, and charcoal increases the ability of sandy soils to retain water and nutrients. Biochar is also a liming agent that will help off set the acidifying effects of nitrogenous fertilizers, thereby reducing the need for liming. Because of the positive aspects, substantial crop yield increases have been reported for the few trials where charcoal has been added to agricultural soils (Glaser et al., 2002). The half-life of carbon in soil charcoal is in excess of 1000 years (Glaser et al., 2002). This means that soil-applied biochar will make both a lasting contribution to soil quality and act as a carbon-sink as the carbon in the biochar will be removed from the atmosphere and sequestered in the soil for at least a millennium. This presents the potential for carbon-neutral and carbon-negative energy from agricultural residues/AD digestate/biomass.

Pyrolysers can be scaled to match locally-distributed sources of agricultural residues/AD digestate/biomass, thus minimising transportation costs. Ideally they should be located on the same sites as the digesters to allow the solids left after the digestion is completed to be pyrolysed. Pyrolysers are relatively inexpensive and could easily be financed by funding from the RDP. A distributed network of pyrolysers will bring jobs and opportunities to rural communities and allow a greater proportion of the revenue generated by the process to be retained there.

It will probably be necessary to reward the farmers for the application of the carbon-sequestering biochar on their land. This could be done by payments from the RDP fund or through the sale of carbon sequestration credit contracts to those wishing to offset their fossil fuel emissions. Buyers would know exactly how many tonnes of carbon had been locked away for at least 1000 years. Failing this, direct government payments to farmers for charcoal applications could easily be justified, as the farmers would be providing critical environmental and ecosystem services to the rest of the nation (Laird, 2008).

To bring a distributed network of pyrolysers about, RDP funds should be spent on demonstration projects that validate the benefits of biochar applications to the soils and develop new agricultural management systems that incorporate biochar application. They should also be spent to research, design, build and demonstrate

- robust and efficient pyrolysers with effective emissions control systems,
- bio-oil refineries, and
- agricultural equipment for handling and incorporating biochar.

Step 4. Develop the combined digester-pyrolysis sites into biorefineries

The CCS Network believes that most crops grown as biofuel are too valuable just to burn. Biomass can be processed by second-generation biorefining technologies to produce a variety of products according to the particular biomass used; bio-refineries are therefore somewhat analogous to oil refineries. For example, the dry matter in miscanthus contains plant protein. This can be extracted quite readily by crushing the grass in a weak solution of washing soda. If hydrochloric acid is then added to the liquid, the protein comes out of solution as a curd. It can then be used as an animal food or eaten by humans as a tofu-substitute. The liquid left still contains sugars which can be converted to methane in an AD. The cellulose and hemicellulose polymers in the remaining solids can be cleaved using hydrolysis technologies, liberating their component monosaccharides as free sugars. These sugars can then be fermented to ethanol or converted to other products such as butanol or the platform-chemical levulinic acid. Furans and lignin are also produced

Hydrolysis can be achieved using enzymes, acids or other solvents. The lignin component usually remains largely unchanged and can be utilised as an energy source to fuel the process or can be pyrolysed to produce biochar. Some of the biochar can then be heated with steam to produce water gas – carbon monoxide and hydrogen - and the hydrogen can then be used to turn the furans into a synthetic diesel fuel. The rest of the biochar can be used to absorb the nutrients contained in the liquor from the digester – primarily nitrates and phosphates – and returned to the land as a soil improver. The application of char treated in this way will not only improve the fertility of the land on which it is spread but lower emissions from it and lead to the plants growing on it sequestering carbon as well.

Conclusions

The biorefining process we have outlined above for miscanthus is not, as far as we are aware, being carried out in its entirety anywhere in the world, although the individual components are all in use. For example, the ProGrass consortium is extracting protein from grass in the Netherlands. We should emphasise that we mention the process only as an example. Other processes need to be explored. Certainly, different processes will be needed in different parts of the country because different crops will be available – miscanthus can only be grown satisfactorily on good land. Hemp, which also produces a large amount of dry matter per hectare per year, is more tolerant but would need to be processed differently to ensure that the raw materials it contains were put to best use.

Willow and poplar grown in short-rotation coppice would need a different process again.

As we have already stressed, because biomass is bulky, it should not be carried far from the place it is grown to the place it is processed. Accordingly, we see a network of local bio-refineries, with accompanying AD and pyrolysis units, being established around the country which would carry out the basic, bulk-reducing, processing work on the biomass from its area and would send on the concentrates – in the miscanthus example, the protein curd, the levulinic acid, the furans and the lignin – for further processing at a regional refinery. The char would then come back to treat the biodigester liquor and return the local nutrients to local land.

Our suggestion is therefore that, in addition to financing Steps 1-3, some of the RDP funds should be used to establish prototype local biorefineries. These should be regarded as action research, the start of a series of iterations in which refineries are built, studied and improved. While the technologies involved are ready to move out of the laboratory, their development is still necessary on real-world scale. Denmark used this successive iteration approach to development its anaerobic digestion technologies and became a world leader in the field. It did not expect that the prototype would be right first time.

Gussing, a town of 3,500 people in Austria, is probably the best example in the world of how a rural community can progress by developing its local bio-energy resources using local refineries. Over 1,000 people are employed there as a result. Significantly, the development would not have been possible without regional, national and EU funds. Ireland should invest its national and EU funds the same way.

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Budget for the next four years, with a list of benefits that spending might bring.

Step	Budget	Benefits
<p>Step 1. Increase the production of energy crops and develop a market for them.</p>	<p>Further funding is needed in crop establishment and harvesting machinery to reduce investment risks for farmers. At least 2,000 ha of energy crops need to be established per annum. Current establishment grants are available at € 1,450/ha. Increasing this to € 2,000 may lead to increased establishment of energy crops. 2,000 ha @ €2,000/ha = € 4M per annum Total over 4 years: € 16M</p>	<ul style="list-style-type: none"> ▪ Development of an indigenous rural bioenergy industry with major employment and economic benefits for rural communities. ▪ Development of a market and supply chain for indigenous energy crops: feedstock security avoiding importation of feedstocks e.g. soya thus avoiding potential food vs fuel issues. ▪ Reduction in reliance on imported fossil fuels leading to increased fuel security. ▪ Reduction in greenhouse gas emissions through displacement of fossil fuels. ▪ Increase C in soil if C-sequestering crops are used. ▪ Compliance with targets.
<p>Step 2. Set up a country-wide network of anaerobic digesters to treat animal slurry and vegetable waste.</p>	<p>AD units capable of handling slurry from 1,000 head of cattle cost approximately € 1M. At least 10 AD units per annum: € 10M. (50% could be grant aided through the RDP with the remaining 50% from private investment) Total over 4 years: € 40 M (50% RDP, 50% private investment).</p>	<ul style="list-style-type: none"> ▪ Employment and economic benefits for rural communities. ▪ Production of renewable fuel: biogas which could displace petrol and diesel/be used for CHP, leading to greater fuel security. ▪ Waste Reduction/Pollution prevention as energy, compost and nutrients are recovered from organic waste thus avoiding landfill.
<p>Step 3. Install pyrolysers beside the anaerobic digesters.</p>	<p>Pyrolysis units can range from € 1 to 1.5 M for a 1000t/annum installation. At least 5 pyrolysers per annum (capital cost plus maintenance): € 10 M (50% could be grant aided through the RDP with the remaining 50% from private investment). Total over 4 years: € 40M (50% RDP, 50% from private investment).</p>	<ul style="list-style-type: none"> ▪ Employment and economic benefits for rural communities. ▪ Protection/Enhancement of soil and water quality. ▪ Sustainable production of energy crops and food. ▪ Waste Reduction/Pollution prevention as agricultural residues/AD digestate are transformed into energy and Biochar. ▪ Potential for carbon-neutral/carbon-negative energy/biofuels as the soil applied biochar acts as a carbon-sink. ▪ Economic gain for farmers through the development of financial rewards for C-sequestration through Biochar application. ▪ Reduction of greenhouse gases (N₂O and CO₂) from agriculture through Biochar application which sequesters C and reduces the need for fertilizer application.

<p>Step 4. Develop the combined digester-pyrolysis sites into biorefineries.</p>	<p>This will require longterm investment of RDP to establish prototype biorefineries. This should begin with the establishment of a biorefining competence centre in collaboration with a research centre which will allow a pilot scale biorefinery to be constructed, studied and improved.</p> <p>Investment of € 10M needed for this. This would be 100% funded from public finances and could include contributions from Enterprise Ireland, SFI, EPA-STRIVE and EU Framework funding.</p>	<ul style="list-style-type: none"> ▪ Development of an integrated agricultural biomass-bioenergy system which will make a significant contribution to the solution to both global warming and rapidly declining oil supplies while enhancing soil and water quality. ▪ Major employment and economic benefits for rural communities and Ireland as a whole. ▪ True value of biomass utilised as it its biorefined rather than burnt. ▪ Production of valuable products from Biorefining. ▪ Production of a liquid transport fuel which will is extremely important for fuel security and to build reliance against the impacts of peak oil. ▪ Reduction of greenhouse gases and increased C sequestration.
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Appendix 2

Advisory Panel Members	
Name	Organisation
Bob Wilson	CELT
Bruce K. Darrell	Feasta
Dr. Catherine Farrell	Bord na Mona
Dr. Catherine O'Connell	Irish Peatland Conservation Council.
Dr. Christoph Mueller	UCD CarbonRestore BOGLAND
Dr. David Wilson	UCD
Dr. Florence Renou	UCD
Dr. Gary Lanigan	Teagasc
Emer O'Siochru	Feasta
Ian Lumley	An Taisce
Joe Barry	Crann
Joe Condon	Organic growers
John Enright	ICMSA
Mark Rutledge	Feasta
Michael Delaney	Coillte www.raisedbogrestoration.ie
Mike Holden	Irish Natural Forestry Foundation
Neil Foulkes	Hedge laying association
Prof. Mike Jones	TCD
Prof. Nick Holden	UCD
Prof. Shane Ward	UCD BOGLAND: Protocol for sustainable Peatland Management in Ireland. http://www.ucd.ie/bogland
Rowan Fealy	Irish Climate Analysis & Research Unit (ICARUS) Maynooth
Siobhán Egan	Birdwatch Ireland
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Tom Roche	Just forests
Vicky Heslop	Bioenergy Association
Prof. Michael Hayes	University of Limerick