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THE CO-FIRING EXPERIENCE: THE USE OF PEAT AND BIOMASS FOR ELECTRICITY GENERATION IN IRELAND

Charles Shier

Bord na Móna, Ireland

**Corresponding author: Charles.Shier@bnm.ie*

SUMMARY

Peat has been used as an energy source for power generation in Ireland since the 1950s. However, peat produces electricity with a comparatively high carbon footprint. This paper discusses the experience of using biomass co-fired with peat in a condensing, bubbling fluidised bed power plant in Ireland as a means of mitigating the carbon emissions. It describes Ireland's underlying climate and energy policy; it examines the sources and types of biomass utilised for co-firing and highlight the key quality parameters; and it explores some of the limitations imposed by the Irish regulatory environment. The European Union's approach to biomass sustainability is discussed, and the greenhouse gas emissions created by the supply chains of the main biomass types utilised to date are quantified. The paper also examines some of the challenges associated with the co-firing of peat and biomass in the years ahead.

***Keywords**: peat, biomass, co-firing, electricity, sustainability*

INTRODUCTION

Energy policy in Ireland has supported the use of indigenous peat for the generation of electricity since the 1950s. The production and use of local peat fuel has contributed to the security of energy supply and it has also had a major positive socio-economic impact on the Irish Midlands region. Ireland currently has three peat-fired condensing generating stations with a combined gross electrical output of 378 MW. These stations operate as baseload generators and require 3.1 million tonnes of milled peat, or 23.7 PJ of primary energy, per annum. However, recognising that the use of peat as a primary energy source leads to comparatively high carbon emissions, the Irish Government sought a pragmatic way to mitigate these emissions and introduced a target of 30% co-firing with biomass materials for the peat stations by 2015.

In line with the rest of the European Union (EU), Ireland has a long term goal to reduce its carbon emissions by at least 80% by 2050. This will be achieved by a progressive decarbonisation of the energy sector, with the gradual phasing out of peat and coal, and ultimately also natural gas, in favour of renewable energy sources (DCENR, 2015). As a member of the EU, Ireland has been given a mandatory target to ensure that 16% of its final energy consumption is supplied from renewable energy sources by 2020, as its contribution towards an overall 20% EU renewable energy objective.

The use of biomass as a co-fuel not only reduces carbon emissions, but it also leads to the production of dispatchable renewable electricity. While Ireland has an excellent renewable energy source in the form of wind, which in 2015 contributed 20% of our electricity mix, biomass is capable of delivering dispatchable, synchronous power and also of providing a greater range of electricity system services. This paper describes Bord na Móna's experience of co-firing peat with biomass at the Edenderry power station over the period since 2008, it explores the emerging issue of biomass sustainability and it discusses some of the challenges that lie ahead.

CO-FIRING EXPERIENCE

The Edenderry power station is a 128 MW, bubbling fluidised bed, condensing generating unit that was commissioned in 2000. Following biomass co-firing trials in 2002, the commercial co-firing of biomass with peat commenced in 2008, and a range of biomass materials have been utilised over the intervening years. Suitable biomass materials fall into three main categories:

a) Forest Materials – woody residues arising directly from activities such as harvesting or thinning; or indirectly from sawmills and other wood processors; or treated materials such as wood pellets;

b) Energy Crops – purpose grown, short-rotation, woody species such as willow (*Salix*) and poplar (*Populus*), or high-yielding grass species such as *Miscanthus* or Reed Canary Grass (*Phalaris*);

c) Agro-industrial Residues – co-products produced by the food- or feed-manufacturing industry, such as almond shells, sunflower husk pellets, shea nut pellets and palm kernel shells.

The Edenderry power station was designed to utilise milled peat with an optimum moisture content of around 50%. While the bubbling fluidised bed technology is capable of handling a wide range of biomass materials, with moisture contents ranging from 10% to 60%, it is important to ensure that an adequate moisture balance is maintained in the boiler combustion zone. This is achieved by fuel scheduling and mixing through an intermediate buffer store which can hold over two days' fuel supply.

Quality control of the biomass materials used is extremely important, particularly in relation to potential boiler corrosion and fouling problems. In order to manage the quality issue, Bord na Móna has developed a Biomass Materials Register which uses a simple „Traffic Light' system as an initial materials screen. This register has been compiled from numerous laboratory analyses of a wide range of biomass materials, and it classifies the materials into three categories: ok for use (green); maybe (amber); and not suitable (red). Biomass specifications have also been developed for different material classes, with particular attention paid to particle size, chlorine content and ash melting behaviour.

In general, forest-based woody materials present very few problems, provided that the leaves or needles are left in the forest. Materials derived from the family Poaceae, such as *Miscanthus x giganteus* or *Phalaris arundinacea*, can be difficult to manage, principally due to their high and varying chlorine content. Edenderry station has managed this problem by limiting the proportion of such materials in the daily biomass materials mix. Agro-industrial residues need to be examined on a case-by-case basis, and samples are analysed to confirm suitability prior to purchase and shipping.

Unlike some of its European neighbours, Ireland does not have a large forest base. Recent inventories indicate that coniferous and broadleaved forests cover around 750,000 ha, or just 11% of the land surface. Many of the Irish forests are quite young, with over half (56%) being less than 20 years old. The total standing volume is just under 100 million m^3, and annual roundwood production is forecast to increase steadily from the current 3.1 million m^3 over the next decade. The proportion of wood fibre potentially available for energy use, including recycled wood, is estimated to increase from 1.1 million m^3 today to round 1.7 million m^3 by 2028 (Phillips, 2011). There will be competition for this energy fraction, especially if the Irish Government introduces incentives to promote the use of renewable heat in commercial and industrial installations.

In the agricultural sector, the majority of Ireland's farmland is under permanent grassland, with around 352,000 ha, or 8% of the farmed area, under cereals and other crops. The Irish Department of Agriculture introduced a Bioenergy Scheme, which provided grant aid for the establishment of willow (*Salix*) and *Miscanthus* energy crops, in 2007. Bord na Móna also promoted the establishment of short rotation coppice willow for a number of years, and offered prospective growers long-term offtake contracts. Despite these initiatives, the area planted with energy crops has remained quite modest, with a maximum of 2,400 ha under Miscanthus and 1,020 ha planted with willow.

The lack of an adequate supply of indigenous biomass has meant that we have had to import a range of biomass materials to co-fire with peat at the Edenderry power plant over the past eight years. The principal materials imported include wood pellets, sunflower husk pellets, shea nut pellets and palm kernel shells. An overview of the balance between indigenous and imported biomass utilised, along with the greenhouse gas (GHG) emissions avoided and the renewable electricity produced, is presented in Table 1.

Table 1: Biomass utilised for co-firing at Edenderry Station, CO_2 emissions avoided and renewable electricity produced: 2008-2015

Year	Biomass Materials Used		GHG Emissions Reduction (t CO_2)	Renewable Electricity (GWh_e)
	Indigenous (TJ)	Imported (TJ)		
2008	145.6	1.6	16,951	15.2
2009	511.2	2.0	59,126	51.9
2010	683.2	170.0	93,229	84.4
2011	903.1	227.1	126,525	112.4
2012	1,268.1	250.4	169,781	147.6
2013	908.8	1,060.4	220,290	193.8
2014	1,053.2	1,251.1	260,920	229.9
2015	884.9	804.0	188,922	168.9

The use of biomass instead of peat at Edenderry station has resulted in a considerable reduction in emissions of carbon dioxide, and also a significant contribution to Ireland's renewable electricity supply. Both of these positive impacts were lower in 2015, when Edenderry station had a prolonged outage for boiler and turbine renovation.

IRISH REGULATORY IMPACTS

In Ireland, peat-generated electricity qualifies for priority dispatch and receives support through a 'public service obligation' levy on electricity consumers for the first 15 years of a peat station's life. After that, it must survive in the electricity market. However, the peat stations were designed to operate as baseload plants, running constantly throughout the day. While they can ramp output up and down, they are not suited to the stop/start regime that would be required for a merchant plant operating in a market like Ireland's, which has a high proportion of intermittent generation from wind.

In order to achieve a more stable operating regime, the Edenderry station has registered as a 'Hybrid Plant' in the Irish single electricity market (SEM). Hybrid Plants, which must use a renewable energy source for part of their energy input, are accorded priority dispatch. The market regulator has decided that, in order to qualify as a Hybrid Plant, a generating station must:

a) Produce at least 10% of its output from renewable energy sources; and

b) Emit fewer carbon emissions than an appropriate reference thermal plant deemed to be displaced. The carbon emissions threshold has been set at 0.7445 tonnes CO_2/MWh up until the end of 2016 (SEMC, 2013).

Biomass as an energy source is generally more expensive than competing fossil fuels. This additional cost has been recognised by the Irish Government and a series of supports have been introduced for electricity generated from bioenergy sources, including biomass combustion, biomass combined heat and power (CHP) and anaerobic digestion (DCENR, 2012). The support tariffs for renewable electricity produced from energy crops and from other types of biomass co-fired with peat are indexed in line with the increases in the Irish consumer price index, if any, and the current tariffs are published on the Irish Department of Communications, Energy and Natural Resources' website (DCENR, 2016).

BIOMASS SUSTAINABILITY

Within the European Union, biomass as a fuel has been classified as 'carbon neutral', i.e. carbon emissions from the combustion of biomass materials are deemed to be reabsorbed by the re-growing plants. This carbon neutral status has been challenged by a number of environmental NGOs, especially in relation to biomass supply chain emissions, land use change and the impacts on both vegetation and soil carbon stocks. The small-scale and local use of biomass for domestic heating is generally regarded as satisfactory, but the large-scale use of biomass for electricity generation has raised concerns, particularly when the biomass used is imported from overseas.

The European Commission first addressed the sustainability of solid biomass in 2010, when it issued a non-binding recommendation on sustainability requirements to Member States (EC, 2010). The sustainability recommendation included:

a) A methodology for calculating supply chain greenhouse gas emissions;

b) A stipulation that wastes, secondary biomass and forestry and agricultural crop residues shall be considered to have zero life-cycle GHG emissions up to the process of collection of those materials;

c) A fossil fuel comparator of 198 $gCO_{2eq.}$/MJ of electricity, against which biomass used for the production of electricity must be compared; and

d) Typical and default emission values for solid biomass pathways.

The Commission's position was updated in a report on sustainability requirements in July 2014, which included an updated GHG emission accounting methodology and a revised fossil fuel comparator of 186 $gCO_{2eq.}$/MJ of electricity that takes account of the likely evolution of the European single electricity market (EC, 2014). The Commission also indicated to Member States that:

"….it is considered to be good practice for existing bioenergy installations to achieve GHG savings of at least 70% compared to the fossil fuel comparators."

Bord na Móna has quantified the GHG emissions associated with the supply chains for the main indigenous and imported types of biomass used at Edenderry power station. This analysis was carried out using the bioenergy pathway methodologies and the default GHG emission values published by the Joint Research Council (JRC, 2014.) The JRC methodology assumes a standard electrical conversion efficiency of 25%. In quantifying the emissions for Edenderry station, we have used the plant's actual conversion efficiency when co-firing of 35.5%. The percentage GHG emission savings, against peat and against the EU fossil fuel comparator (FFC), are presented in Table 2.

Table 2: Percentage GHG emission savings from using different biomass materials at Edenderry Station

Biomass Type	**Biomass Supply Chain Emissions ($gCO_{2\ eq.}$/MJ)**	**Biomass Electricity Emissions ($kgCO_{2\ eq.}$/MWh_e)**	**GHG Savings compared to:**	
			Peat (%)	**EU FFC (%)**
Indigenous				
Woodchips - forest residues	6.0	60.8	94.6%	90.9%
Woodchips - thinnings	5.6	56.8	95.0%	91.5%
Woodchips - sawmill resid.	4.5	45.6	96.0%	93.2%
Willow Chips	8.6	87.2	92.3%	87.0%
Wood Pellets	4.0	40.6	96.4%	93.9%
Imported				
Nut Shells - Europe	5.6	56.8	95.0%	91.5%
Agri-pellets - Europe	11.8	119.7	89.4%	82.1%
Wood Pellets - Europe	12.6	127.8	88.7%	80.9%
Palm Kernel Shells - Asia	16.8	170.4	84.9%	74.6%

However, biomass supply chain greenhouse gas emissions are not the only sustainability issue. The illegal harvesting and supply of timber for energy purposes; the sustainability of forest management techniques; the impact of biomass use on biodiversity and on soils with high carbon stocks, including peatlands and wetlands; the potential for direct and indirect land use change; and the socio-economic impact of biomass supply on the local population, are all causes for concern.

In February 2015 the European Commission launched an Energy Union package, which included a framework strategy for energy resilience coupled with a forward-looking climate change policy. As part of this package, the Commission proposed a new approach to the use of renewable energy, including a review of the Renewable Energy Directive 2009/28/EC, and a new policy for sustainable biomass and biofuels that will apply in the period after 2020. The first step in this process began with a public consultation on the existing sustainability policy and the need for additional measures, which was instigated in February 2016.

Bord na Móna expects that, following negotiations with the Member States and the European Parliament, a new bioenergy policy will be introduced in Europe from 2020. This policy is almost certain to include harmonised sustainability criteria for solid biomass that will have to be satisfied in order for any electricity or heat generated from biomass to qualify for Governmental support, or to count towards a Member State's overall renewable energy output.

CHALLENGES FOR THE FUTURE

Looking ahead, there are a number of challenges that both the Edenderry power station and the other two peat-fired plants in Ireland will face in the coming years:

a) Surviving in a progressively lower carbon world. While the co-firing of biomass with peat serves to reduce a power station's net carbon emissions, and leads to the generation of dispatchable renewable electricity, public and environmental pressures could mean that the proportion of biomass that needs to be used is likely to increase as the average carbon intensity of the power sector diminishes;

b) Procuring enough biomass at a commercially viable price. Biomass demands from both the heating and the electricity sector in Ireland will exceed the available indigenous resource. Increased global competition for biomass may serve to push up the price of internationally traded biomass materials;

c) The priority dispatch/renewable support conundrum. The carbon emissions limit, which peat stations will have to achieve to continue to qualify as a Hybrid Plant, may be reduced as the Irish generating fleet changes over time. However, support for biomass co-firing in Ireland is limited at present to 30% of a plant's installed capacity;

d) Tighter sustainability criteria. An increase in the expected GHG emission savings, beyond the proposed 70%, or a lowering of the European fossil fuel comparator for electricity, will serve to rule out certain types and sources of biomass. To help mitigate this risk, Bord na Móna will be examining and quantifying the actual biomass supply chain emissions, rather than using the JRC default values;

e) Lower combustion emission limits. New, non-CO_2 emission limits have been introduced from 2016 for large European power plants by the EU Industrial Emissions Directive 2010/75/EU. These limits will be reduced further by the Best Available Techniques (BAT) Reference Document for Large Combustion Plants (LCP BREF) process currently under way. Capital investment in enhanced flue gas treatment facilities may be required to enable existing plants meet the new emission limit values for SO_x, NO_x, HCl, HF and particulates.

CONCLUSION

The co-firing experience at Edenderry station has been a positive one over the past eight years. The bubbling fluidised bed technology has proven to be very robust and capable of utilising a wide range of biomass materials in combination with milled peat. We have managed to obtain adequate volumes of suitable biomass materials at an acceptable price. Along the way, significant emissions of CO_2 have been abated, and the plant has produced a considerable amount of renewable electricity that contributes towards Ireland‘s renewable energy target. Looking ahead, there are a number of challenges that the peat stations in Ireland will have to overcome in order to continue to co-fire with a mixture of peat and biomass.

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