The co-firing challenge: the use of biomass in peat-fired generating stations in Ireland

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Summary

The Irish Government, as part of the national greenhouse gas emissions reduction strategy, has set a target of 30% co-firing with biomass for Ireland's three peat-fired stations by 2015. The co-firing target will require the supply of 7.1 PJ of biomass energy each year. This paper discusses the range of suitable biomass materials currently available; the supply-chain requirements to ensure the delivery of biomass with an adequate quality; the volumes presently available and the likely delivered prices. It also examines the amount of subvention required, at varying carbon prices, in order to ensure that the co-firing target can be achieved.

Key index words: co-firing, peat, biomass, electricity generation, carbon price

Introduction

As a member of the European Union, Ireland has obligations under the Kyoto Protocol and has an emissions target of 63 Mt CO_2e per annum for the First Commitment Period 2008-12. Ireland's projected annual emissions, taking account of existing measures, are expected to average 71 Mt CO_2e over the period to 2012. The distance to target will be met by a combination of additional measures and credits purchased under the Kyoto flexible mechanisms (DEHLG, 2007). As part of the additional measures, the Irish Government has introduced a target of 30% co-firing with biomass materials for the peat-fired generating stations by 2015.

Ireland has three peat-fired, condensing generating stations with a combined gross electrical output of 378 MW. These stations operate with a planned annual load factor of 81% and consume 3.08 million tones of peat fuel, or 23.7 PJ of primary energy, per annum. The 30% co-firing target will require the supply of 7.1 PJ of biomass material each year. This paper examines how the co-firing challenge could be accomplished, given the range of suitable biomass materials available, their likely volumes and delivered prices.

Biomass materials

Unlike many of its European neighbours, Ireland does not have a large forest base. The most recent national forest inventory concluded that coniferous and broadleaved forests cover 698,000 ha, or just 10% of the land surface (Forest Service, 2007). Many of the Irish forests are comparatively young, with over 60% of the total stocked area being less than 20 years old. The total standing volume is estimated at 70 million m^3, and the annual harvest for processing purposes is circa 3 million m^3.

On the agricultural front, the majority of Ireland's farmland is under permanent grassland, with around 350,000 ha, or 8% of the farmed area, under cereals and other crops. Both the small land area under forest, and the low proportion of farmland used for growing crops, limit the potential availability of biomass materials for co-firing purposes.

Forest Based Materials

Roundwood: The production of roundwood from Irish forests is forecast to increase substantially, as areas planted from 1980 onwards reach the thinning stage (Gallagher & O'Carroll, 2001). However, many of the young forests are privately owned, and there is no legal obligation on owners to thin. The recent national inventory discovered that some 240,000 ha were at a development stage where thinning could have taken place, but the majority (69%) of this area had not been thinned. Small stand sizes and the high costs of installing road access can result in negative returns from thinning. The National Council for Forest Research and Development, COFORD, has recently revised its estimate of the proportion that is likely to be thinned to 50% for conifers and 40% for broadleaves. This will reduce the volume of small roundwood available for co-firing, especially in the initial years.

Forest Residues: Residues, such as branch material and tops with a diameter of less than 7 cm, have traditionally been left in the forest following clearfell activities. While this will continue to be the practice on certain sites, for nutrient return or trafficability reasons, other forest sites may yield residues that could be used for co-firing purposes. Coillte, the State owned forestry company, has initiated a series of studies to quantify the volume of residues that could become available, and the delivered price. Their current estimate of annual forest residue availability is 80,000 to 100,000 m^3. Not all of this material will be available for co-

firing, as higher economic returns may be available from supplying the commercial heating and biomass CHP markets.

Sawmill Residues: In 2006, 2.18 Mm^3 of timber was processed by the sawmill sector in Ireland. From this total input, 1.1 Mm^3 of sawn timber was produced along with 1.08 Mm^3 of co-products, including bark, sawdust and woodchips. The co-products were mainly used for horticultural purposes, for boiler fuel and for panel board manufacture. However, some 50,000 m^3 of sawdust and 46,000 m^3 of woodchips were exported (Knaggs & O'Driscoll, 2007). It is very likely that some or all of these exported sawmill residues could be used economically in the peat-fired power stations.

Wood Pellets: Only one wood pellet manufacturing facility has been established to date on the island of Ireland by Balcas at Enniskillen in Northern Ireland. The facility has an initial capacity of 50,000 tonnes of pellets per annum, with output expected to increase to 70,000 tonnes p.a. over the next few years. A number of other solid fuel suppliers are importing wood pellets for distribution to the domestic heating market. Considering the high humidity levels that prevail in Ireland, and the hygroscopic nature of wood pellets, it is anticipated that both pellet screenings and a quantity of degraded pellets will become available for co-firing.

Land Based Materials

Energy Crops: The production of energy crops in Ireland is at a very early stage of development, with mainly research and pilot plot scale plantations having been installed during the past 20 years of low energy prices. In spring 2007 the Irish Government introduced a Bioenergy Scheme, which provided grant aid for the establishment of willow (*Salix*) and *Miscanthus* energy crops. The scheme was designed to encourage alternative land use options, to provide rural development and employment and to produce biomass suitable for use as a clean and renewable source of heat and energy. Some 1,400 ha were planted under the scheme in 2007, and it is anticipated that an additional 1,600 ha will be planted in 2008.

Teagasc, the Irish Agriculture and Food Development Authority, has examined the product price needed to encourage farmers to enter energy crop production and the factors influencing the adoption decision at farm level. The assessment concluded that the current farming activities, the level of agricultural education and the existence of a successor all impact on the decision to switch to energy crop production. The price model demonstrated that for a 15-year scheme, *Miscanthus* planting would commence at an ex-farm price of €4.4/GJ; and *Salix* planting would commence at an ex-farm price of €5.6/GJ. The ex-farm prices required to supply all 7.1 PJ of the biomass for co-firing were €6.50/GJ for *Miscanthus* and €11.00/GJ for *Salix*, based on a 15-year scheme and maintaining current levels of grant aid.

Cutaway Peatlands: Following peat harvesting activities, some of the cutaway peatlands may be suitable for the production of biomass materials. Three approaches are being taken to examining the potential of these areas for biomass production: i) the growth of energy crops; ii) the harvesting of naturally regenerating (feral) birch (*Betula*); and iii) the planting of fast-growing tree species suited to Irish cutaway peatland conditions.

Trial plots have shown that neither *Salix* nor *Miscanthus* produces a viable yield on cutaway peatlands in Ireland. Reed Canary Grass (*Phalaris arundinacea*) has been grown with considerable success on cutaway peatlands in Finland, but trial results to date in Ireland using seed sourced from Northern European ecotypes have been disappointing. It is expected that *Phalaris* seed from native or Mid-European sources should have a longer growing season and may yield better results.

Some areas of cutaway peatland, which have adequate drainage and at least a moderate minerotrophic status, will naturally recolonise with birch copses, mainly *Betula pubescens*. A harvesting trial will be carried out during 2008 to determine both the biomass yield from these feral birch copses and also the delivered cost of this biomass material to the power stations.

Intensive research conducted under the BOGFOR programme demonstrated that site assessment, careful species selection, site preparation and specific management practices are all required in order to successfully establish and grow forest species on Irish cutaway peatlands (Renou *et al.*, 2006). Trial plantations of alder (*Alnus spp.*) are being established, and coniferous species such as Scots pine (*Pinus sylvestris*) and Corsican pine (*Pinus nigra* var. *maritima*) may also be planted at close spacing on more ombrotrophic sites in order to determine their longer term potential for biomass supply.

Waste Based Materials

Waste Wood: In 2006, Ireland generated 219 kt of wood waste in the municipal sector, of which 204 kt was recovered (EPA, 2007). The industrial sector produces around 250 kt of wood waste per annum, the majority of which is recycled. Ireland also generates around 2.9 Mt of non-soil construction and demolition (C&D) waste per annum, but no fractional analysis of this C&D waste is available. In order to be suitable for combustion in peat-fired power plants, wood recovered from the various waste streams needs to be "clean", i.e. it must be free from coatings, varnishes and glues and must not have been treated with preservatives containing halogenated organic compounds or heavy metals.

Waste management companies have indicated that they are willing to invest in separation systems which would recover the clean wood from mixed waste streams, but the licensing and approval of such separation systems by the Irish Environmental Protection Agency is critical to this investment.

Green Waste: Green waste composting facilities, which take in clean biomass materials from local authorities, landscape contractors and the agri-food sector, normally end up with a woody fraction which does not break down during the 3 or 4-month composting cycle. This woody material can be screened out from the green compost and used for co-firing in the peat power stations.

Meat and Bone Meal: Category 3 meat and bone meal (MBM) was declassified as a waste in Ireland in November 2006, and therefore its combustion no longer comes within the scope of Directive 2000/76/EC on the incineration of waste. Ireland produces around 100 kt of Category 3 (low risk) MBM each year which would be suitable for co-firing in the peat stations.

Imported Biomass: A wide range of biomass materials are traded internationally, and could potentially be imported for co-firing in the peat stations. These include chips and pellets from the forest products industry and residues from the food processing industry such as olive stones, peanut husk and sunflower husk pellets and palm kernel shells. In general, these materials have been processed specifically to reduce transport costs, have low moisture contents (10% - 15%), high bulk densities and good net calorific values (15 - 17 GJ/tonne).

Volumes and prices

While a wide range of biomass materials appears to be available for co-firing in Ireland, competition from other users will significantly reduce the volume of materials readily obtainable. These competitors include the four existing panel board mills, which utilised 1.7 Mm^3 in 2006; wood pellet manufacturers; the domestic and commercial heating market; and industrial facilities that come within the scope of the European emissions trading scheme and therefore benefit from the use of carbon neutral fuels.

The largest sectoral demand is likely to arise from the heating market, which has been set a 12% renewable heat target by 2020 (DCMNR, 2007). This target will require an additional 16.7 PJ of renewable energy, of which some 12-14 PJ is likely to be from solid biomass. This is double the renewable energy required for 30% co-firing in the peat power stations. The likely volumes available for co-firing in the initial years, along with the estimated delivered prices, are set out in Table 1.

The analysis indicates that the 30% co-firing target will only be reached by using significant amounts of imported biomass. This conclusion is supported by a recent assessment of renewable energy resources, completed as part of an all-island study on renewable electricity penetration (ESBI, 2008). The volume of imports required will be reduced if additional biomass materials can be provided from forest thinnings or from energy crops grown by the agricultural sector.

Supply chains and support mechanisms

Both roundwood and forest residues require a 'drying phase' in the supply chain to increase the energy density. Energy crops such as *Miscanthus* are more economically transported in bale form and shredded at the power plant. Robust supply chains need to be developed, which balance materials from differing sources throughout the year, maintain continuity of supply and deliver biomass that meets defined quality standards. This is particularly important in relation to the chemical constituents of the biomass, in order to minimise boiler fouling and to prevent any corrosion damage to the heat recovery elements.

Power generation from peat in Ireland is supported by a levy on electricity consumers, if the cost of the power produced exceeds the average wholesale market price. Taking the current delivered price for peat fuel, and adding a carbon price of €20/t CO_2, a total substitute price of €6.19/GJ could be paid for biomass without amending the present supports. Considering the estimated delivered prices outlined in Table 1, and the additional costs associated with biomass handling, sampling and testing, a biomass fuel price of at least €8/GJ will be required to support the targeted level of co-firing. The actual amount of additional subvention required will vary with the market price of

Table 1. Volume of biomass materials available and estimated delivered price

Biomass Material	Volume (kt/a)	Calorific Value (GJ/t)	Peat Displaced (TJ)	Delivered Price (€/GJ)
Forest roundwood	50 - 100	8.2	820	€5.7 - 7.1
Forest residues	25 - 30	8.2	246	€5.5 - 7.4
Sawmill residues	10 - 20	7.2	144	€4.2 - 5.7
Irish wood pellets	5	16.8	84	€7.90
Energy crops	10 - 50	12.6	630	€7.5 - 8.0
BnM cutaways	10	11.4	114	€8.0 – 9.0
Recovered wood	50	14.6	730	€6.85
Green waste	7.5 - 15	12.5	187	€7.20
Meat & bone meal	51	15	765	??
Imported biomass	200+	16	3380	€6.0 - 7.9
Total			**7100**	

Table 2. Annual subvention required to support a biomass price of €8/GJ

C Market Price (€/t CO_2)	Total Peat + C (€/GJ)	"Top Up" (€/GJ)	Subvention (€M/a)
€20	6.19	1.81	12.9
€25	6.76	1.24	8.8
€30	7.33	0.67	4.7
€35	7.90	0.10	0.7

carbon, as outlined in Table 2. At a carbon price of €20/t CO_2, and a biomass cost of €8/GJ, the effective additional cost of carbon abatement through co-firing is €15.87/t CO_2.

An alternative approach is to apply support mechanisms further back along the supply chains, e.g. for harvesting or transporting roundwood; or for planting, growing or transporting energy crops. These supply chain supports would act to lower the delivered price of biomass and to reduce the level of assistance required through the electricity tariff.

Conclusions

Considering the targets set by the Irish Government for renewable energy penetration, Ireland does not have sufficient biomass material to supply all of the market sectors. In the short term, 30% co-firing of the peat stations will only be possible if some materials are imported. To increase the degree of self-sufficiency, additional incentives will be required to persuade private owners to thin forests and to encourage farmers to grow energy crops. Additional subventions will be necessary to support co-firing when the market price of carbon is below €36/t CO_2.

References

DCMNR (2007). Government White Paper: Delivering a sustainable energy future for Ireland. 68pp. Department of Communications, Marine and Natural Resources. Irish Government, Dublin.

DEHLG (2007). National Climate Change Strategy 2007-2012. 59pp. Department of Environment, Heritage and Local Government. Irish Government, Dublin.

EPA (2007). National Waste Report 2006. 80pp. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

ESBI (2008). All Island Grid Study - Workstream 1: Renewable Energy Resource Assessment. 251 pp. Report prepared by ESB International for the Department of Communications, Energy and Natural Resources, Dublin and the Department of Enterprise, Trade and Investment, Belfast.

Forest Service (2007). National Forest Inventory: Republic of Ireland – Results. 252 pp. Forest Service, Department of Agriculture, Fisheries and Food. Irish Government, Dublin.

Gallagher, G. and O'Carroll, J. (2001). Forecast of roundwood production from the forests of Ireland 2001-2015. 24pp. COFORD, Dublin.

Knaggs, G. and O'Driscoll, E. (2007). Estimated woodflow for the Republic of Ireland for 2006. Coford Connects: Processing/Products No. 12. 8pp. COFORD, Dublin.

Renou, F., Egan, T. and Wilson, D. (2006). Tomorrow's landscapes: studies in the after-uses of industrial cutaway peatlands in Ireland. *Suo* **57**(4), 97-107.