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A cost-benefit analysis of generating electricity from biomass

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HIGHLIGHTS

► This paper considers the long term effects of cofiring with biomass in Irish peat stations.
► Ireland has only half the necessary resource to meet the target.
► Imports will be required in large quantities to meet the national cofiring target.
► It is found that in all cofiring scenarios, the estimated total NPVs are negative.
► Cofiring is never the least cost option, thus the focus of Government policy may need to be revisited.

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ABSTRACT

A key challenge internationally is the design of future electricity systems which will bring about emissions savings and fuel security at least cost. Peat is used to generate electricity in several EU countries, mainly to take advantage of indigenous resources and increase fuel mix diversity. The Irish government has introduced a target of 30% cofiring of peat and biomass by 2015. This paper assesses the feasibility of achieving this target by calculating the available indigenous biomass resource capable of being cofired; the cost of meeting the target; the benefits in terms of carbon abatement; and finally the present value in economic terms of meeting the target. Results demonstrate that Ireland has only half the necessary resource to meet the 30% target and that the net cost of doing so is greater than the cost of what is currently being paid for peat, in all of the scenarios considered. Thus, it is concluded that while it may be technically possible to meet the target by combining national resources with imported biomass this is never the least cost option, and as a result the targeted focus of Government policy may need to be reconsidered.

1. Introduction

A key challenge internationally is the design of future electricity systems which will bring about emissions reductions and fuel security at least cost. The substitution of conventional energy sources with renewable energy sources offers considerable potential for reducing a nation's carbon emissions and meeting national and international policy targets (DCENR, 2007; European Commission, 2009a, 2009b). One method of increasing a country's level of renewable generation is by cofiring existing fuel sources with biomass. The potential of cofiring biomass for electricity generation in emissions terms is significant, especially as all forms of biomass are considered by the EU to be carbon neutral, due to the fact that all carbon emitted during combustion has been taken from the atmosphere during their relatively short lifetime (European Commission, 2005).

Biomass can be defined as all the earth's living matter; materials such as wood, plant and animal wastes, which – unlike fossil fuels – were living matter until relatively recently. Biomass is an appealing source of renewable energy for several reasons. The direct benefits associated with cofiring include a reduction in greenhouse gas emissions, not only in terms of a reduction in carbon dioxide (CO_2) but also methane (CH_4) which also contributes to global warming (Sami, Annamalai et al., 2001; De and Assadi, 2009). As noted by Domac et al. (2005), "Millions depend upon bioenergy as their main source of fuel not only for cooking and heating but also more importantly, as a source of employment and incomes". As all countries have their own biomass supplies, it offers an opportunity to reduce fuel imports and

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increase fuel mix diversity simultaneously, particularly in those countries without large fossil fuel resources (Domac, Richards et al., 2005).

The socio-economic benefits of utilising bioenergy, such as regional economic gain, security of supply and employment gains, can unmistakably be identified as a significant motivation for increasing its share in the total supply of energy (Domac, Richards et al., 2005). Biomass, for its part, could significantly reinforce sustainable security of supply, considering that it is a widespread and versatile resource that can be used just as easily for heating, electricity production or as transport fuel. On a global scale, biomass ranks fourth as an energy resource, providing approximately 14% of the world's energy needs (Bain, Overend et al., 1998).

With particular reference to cofiring for electricity generation, using indigenously sourced materials will enable countries to reduce the level of energy which they import and increase their energy mix diversity. With regards to waste residues, such as wood wastes and meat and bone meal (MBM), these residues, if used for cofiring, have the potential to reduce the amount of waste either being sent to landfill or exported, further reducing absolute carbon emissions. However, biomass also possesses several challenges; for one it must be sourced responsibly, as transporting vast quantities over larger distances negates any CO_2 mitigation benefits from its combustion. Also with reference to energy crops, biodiversity must be maintained so as not to have lasting impacts on global natural habitats and food resources.

Experience in Germany (Hartmann and Kaltschmitt, 1999) has found that overall the cofiring of biomass provided benefits both in terms of emissions mitigation and also economic benefits in comparison with other renewable energy sources, meaning that in the future biomass could make a substantial contribution to a more environmentally efficient energy supply system. In Holland, Verbong and Geels (2007) found that while the cofiring of biomass in existing coal stations had positive benefits in terms of emissions and other environmental factors, it was still met by widespread opposition from local groups in relation to the types of biomass being used and as a result many cofiring plants encountered problems in permit procedures. This has already been an issue in Ireland, with many residents groups wanting clarification of what types of biomass will be used and the general public being opposed to incineration for waste disposal (Gormley, 2008; South East Waste Management Region, 2010).

While most cofiring to date internationally is in conjunction with coal, as can be seen in Baxter (2005) and Molcan et al. (2009), this paper will focus on the cofiring of biomass with peat in Ireland. This is for several reasons; firstly because it is a higher emitter of CO_2 than coal, secondly because peat is a more expensive fuel than coal and therefore creates an added incentive to reduce its consumption, thirdly more types of biomass can be cofired with peat than with coal as a result of the stations being better suited to dealing with variable moisture levels and thus higher quantities of biomass, and finally due to the fact that peat is an indigenous fuel to Ireland unlike coal and therefore offers job creation benefits and cofiring prolongs the supply of this resource for future generations.

Peat has been a significant source of energy for electricity generation in Ireland since the 1950s, and was possibly the most important indigenous energy resource prior to natural gas coming on stream in 1979 (Bord na Móna, 2001). The bulk of domestic gas has now been consumed, and the majority of natural gas is currently imported. At its peak, peat provided just under 40% of all electricity generated in the State, though this figure has been falling steadily over the last 50 years. Peat is one of the most polluting fuels in use for electricity generation, emitting 1.167 kg of CO_2 per kW h of electricity generated, as can be seen in Fig. 1.

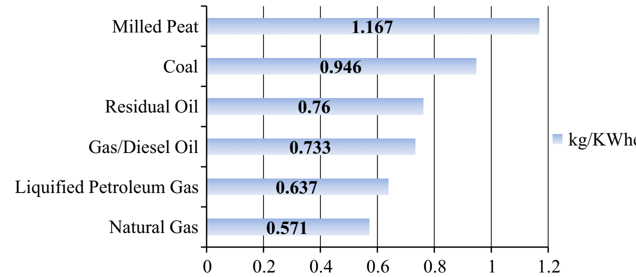

Fig. 1. CO_2 emissions of fuels for electricity generation (SEAI 2011).

While not a significant source of energy in most countries, peat is also used for electricity generation in Sweden and Finland (Schilstra, 2001; Ericsson et al., 2004). Peatlands in Ireland were estimated to be 0.95 million hectares (Mha) or 13.8% of the national land area by Connolly et al. (2007). While peat is indigenous in all three countries, Finland and Sweden are part of the Nord Pool common electricity area alongside Denmark and Norway, rendering them far less dependent on peat for energy security than Ireland. In fact, of the 363.3 TW h of electricity produced in the Nord Pool area in 2003, 24% came from nuclear energy, 46.3% from hydro stations and 1.7% came from wind (Laurikka and Koljonen, 2006). Peat's contribution however is negligible—representing only 1.2% of installed capacity in the Nord Pool area in 2005 (Oranen, 2006). In contrast, peat is subsidised in Ireland to ensure it operates 24 h per day at maximum stable output when available, in an attempt to alleviate import dependency as well as to preserve jobs in the industry (Styles and Jones, 2007). Peat represents 5% of installed capacity in Ireland (SEAI, 2009), and accounted for 6% of its electricity generated in 2010 (CER, 2011).

The remainder of the paper is structured as follows; Section 2 outlines the methods and data used in the study and Section 3 introduces the case study. Sections 4 and 5 will look at the costs and benefits associated with cofiring in Irish peat stations respectively; Section 6 will compare these and discuss the outcomes of this study and Section 7 will conclude.

2. Methods and data

This paper endeavours to value the changes associated with cofiring, considering both the additional costs to the generating stations and the benefits incurred through the emissions savings arising from generating electricity from biomass, a carbon-neutral fuel, relative to the status quo.

Costs considered are the biomass fuel costs, capital costs, and increased operations and maintenance (O&M) costs associated with handling the biomass at the power stations. The transport of biomass fuels to the stations and all farm level costs are assumed to be included in the cost of biomass fuels delivered to the stations. Benefits to be included are the fuel savings in terms of peat and carbon abatement. Qualitative benefits which are not included but are discussed in Section 5 are the changes in employment arising from cofiring and the effects on other plant emissions which are highly dependent on the fuel mix used at each point in time. All costs and benefits are relative to how peat stations are currently utilised. Eq. 1 represents the cost benefit equation used, calculating the net present value (NPV) of additional costs and benefits relative to the current peat station operation.

$$\begin{aligned} \textit{Net present value} &= \textit{annual } CO_2 \textit{ saving} \\ &\quad + \textit{annual peat fuel cost saving} - \textit{capital cost} \\ &\quad - \textit{annual biomass cost} - \textit{other variable costs} \end{aligned} \quad (1)$$