Review of the Irish Government's Strategy for Compliance with the European Directive 2009/28

By

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1) Executive summary:

- **Changes in biomass technology and the international supply chain since 2011 mean biomass co-firing at coal and peat power stations or conversion to biomass now represent real options for meeting Ireland's 2020 renewables target.**

- **Conversion from coal to biomass at Moneypoint, Ireland's largest power station, would meet 2020 targets at a single stroke – avoiding the need for additional expensive wind power and pylon infrastructure.**

- **Converting Moneypoint would add another 28% of electricity generation from renewables, which combined with the 18% already in existence in 2012, would exceed the 2020 target of 40%.**

- **The conversion of Moneypoint would make €3.8 billion of wind power related costs unnecessary. The €3.2 billion Grid25 project and €0.6 billion additional interconnector to stabilise the power network would no longer be required.**

- **At an estimated cost of €380 million, conversion of Moneypoint could meet the renewables targets for 10% of the cost of upgrading the transmission system to accommodate additional wind.**

- **Choice of the Biomass conversion option will lower additional costs to domestic customers. In terms of "green economics", moreover, the Biomass conversion option presents an opportunity for carbon savings nearly double those associated with wind power.**

2) Introduction:

BW Energy Limited's January 2014 evaluation of the EirGrid Grid Link Project 'Stage 1 Report' suggested that the initial justification for the project, namely that it was essential in order for Ireland to meet its "2020" targets, may no longer be valid. In particular, the study noted that the case for Grid Link was driven by the Irish Government's 2005 assessment that the most economic way to meet its renewables targets in the power sector was to generate 40% of all electricity from wind power.

The consequences of that decision, such as the difficulty of accommodating such a large variable source of supply and the cost of managing the increased risks to the power network, were not made apparent when the wind strategy was adopted in 2009. Higher network risks can only be solved by a combination of upgrading the transmission network (Grid25 at €3.2 billion), building an additional interconnector (€0.6 billion) to the UK or France and constraining already paid for wind power ('curtailment').

There is no evidence that these additional costs were systematically taken into account in 2009 when assessing the alternative strategies for meeting Ireland's EU targets for 2020. Moreover, BW Energy's initial review highlighted the risk that the absorption of 40% of electricity generation from wind power could threaten the stability of the whole power network and cause extended national 'blackouts'.

Renewable energy technologies, their costs and associated supply chains have evolved significantly since 2009. Since 2011, the biomass sector (wood pellets) in particular, has seen fundamental change with the evolution of more efficient boiler combustion technologies and the development of an established international biomass market. This is very relevant to Ireland, given the scope to convert existing coal and peat power stations either to co-firing or to full conversion to biomass (wood pellets).

A proper evaluation of the net cost of renewable energy generation technologies requires an assessment of the marginal cost of the different forms of power generation (in €/MWh), the associated investment costs,

and the emission reduction effectiveness, in terms of cost of emission saving (in €t/CO_2).

Using those criteria, this report analyses the potential impact on Ireland's ability to meet its 2020 target of the recent changes in biomass generation technologies and international biomass market.

It also revisits the costs of Irish wind energy – taking into account the additional power system costs that directly result from the decision to double Irish onshore wind capacity. Hence the report compares both the cost effectiveness and emissions reduction performance of Irish onshore wind to biomass.

This report concludes that there is a strong case for reconsidering Ireland's "all wind" strategy. Ireland now has the opportunity, through renewable biomass power generation, to rebalance its renewable generation mix much more cost effectively.

3) 2011 IAE perspective on alternative forms of Irish renewable generation:

The Irish Academy of Engineers (IAE)[1] recognised that renewable forms of generation are, in the main, more expensive than fossil fuel power generation such as coal, peat and gas. In order to compare these different forms of power production the IAE in its February 2011 report 'Energy Policy and Economic Recovery 2010 – 2015' calculated the cost to consumers of the associated reduction in carbon emissions (€t/CO_2). The results are shown in Table 1 on page 5 overleaf.

The REFIT tariffs represent the price at which EirGrid was obliged to pay for these different forms of energy in 2010 prices. The estimated additional costs are the result of the assessment made by the IAE of the costs of accommodating the variable, 'non-dispatchable' forms of energy; namely wave, tidal and wind, on the electricity transmission system.

[1] Energy Policy and Economic Recovery, 2010-2015; Irish Academy of Engineering, February, 2011

These estimated additional costs result from transmission costs, suppliers' costs and the need to keep reserve; i.e. other forms of production whose output may be changed on demand, called "dispatchable". Such back up of 'dispatchable' generation is necessary as wind power is totally weather dependant and 'non dispatchable' .

The final renewable power generation option listed in Table 1, namely biomass used in existing peat stations, was shown to involve no additional costs. This is because all the electrical connections required were already in place and biomass used as a fuel in existing peat stations delivers power that is 'dispatchable' (i.e. not reliant upon variable weather patterns).

As a result, biomass used in existing Irish peat stations was clearly the lowest cost form of emissions saving of the five generation technologies analysed. In fact, according to the IAE, the cost of emission saving in biomass used in existing peat stations was just over $1/3^{rd}$ of the equivalent cost to be delivered by Ireland's current 'all wind' strategy (€43t/CO_2 cost of emission saving for biomass used in existing peat stations compared to €114t/CO_2 for onshore wind).

Costs to the energy consumer from an emissions abatement perspective were calculated and compared using an industry standard and widely accepted metric: the estimated cost of carbon emission saving (€t/CO_2). These carbon costs, specifically the costs (€) of lowering emissions by 1 tonne (t) of CO_2, were calculated on the assumption that renewable electricity would displace power generated at gas fired stations.

Since one MWh of gas generation was estimated to cost €42 and emit 0.4t of CO_2, the costs of reducing carbon emissions ('renewable energy abatement costs') for each renewable power generation technology were easily calculated.

Table 1[2]
Irish renewable energy abatement costs

Technology	REFIT tariff	Estimated (system) additional cost	Marginal cost of displaced CCGT	CO_2 reduction from generation displaced	Cost of emission saving
	€/MWh	€/MWh	€/MWh	t/MWh	€t/CO_2
Ocean energy	220	53	42	0.4	578
Offshore wind	140	41	42	0.4	348
Biomass CHP	120	20	42	0.4	245
Onshore wind	66.4	30	42	0.4	114
Biomass in existing peat stations	90		42	1.12	43

Table 1 shows the results of considering renewables solely as a means of reducing CO_2 emissions in electricity generation. Clearly, renewables also improve the security of supply and reduce exposure to volatile fossil fuel prices. These strategic benefits were not directly evaluated by the IAE in the February 2011 report and are not considered in this report.

4) Rising attractions of Irish biomass power generation- the Moneypoint option:

[2] See IAE, 2011.

The IAE analysis contained in Table 1 on page 5 indicates that the re-firing of peat stations with biomass was by far the cheapest option given the state of development of alternative renewable power generation technologies in 2011.

However, two options not considered in 2011 were the co-firing of biomass with coal or the conversion to biomass of the existing Moneypoint coal station.

Moneypoint, the largest fossil fuel power generator in Ireland (915 MW generation capacity), currently supplies around 25% of power generation demand and in 2012 represented 28% of Ireland's GHG emissions. It therefore plays a key strategic role in the Irish power system with associated implications for how the 2020 renewable power generation target is met.

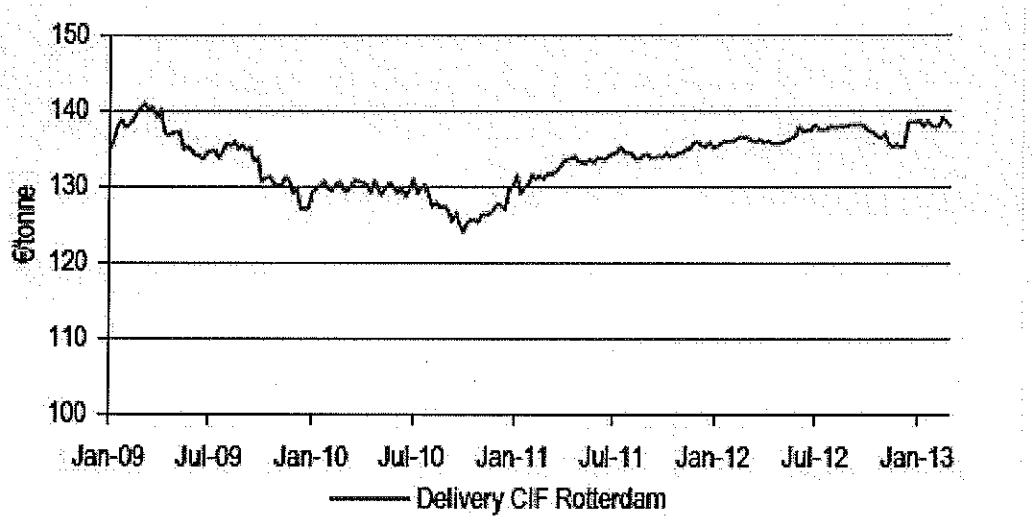
In 2011, it was entirely understandable that these two options at Moneypoint were not considered. This was because biomass power generation technologies and the international biomass market were not sufficiently developed.

Today, biomass boiler technologies and the international biomass market are well established. Both biomass co-firing and full conversion are proven as technically viable and economically attractive for large coal fired power stations such as Moneypoint. Following the scaling up of the international biomass market and technical advances in boiler design, co-firing with biomass or conversion to biomass generation at the key Moneypoint coal station should now be evaluated as real options to meet the 2020 target.

Indeed, since the IAE's report was published in February 2011, the international biomass market and supply chain has blossomed, partly driven by the European Directive 2009/28 and also by the German Government's decision (announced in May 2011) to close their nuclear fleet by 2020.

The international biomass supply chain has responded effectively to the degree that despite the marked pick-up in demand expectations, the price of woodchip delivered to Europe has remained reasonably stable over the past four years.

Figure 1
Wood pellet prices delivered to Rotterdam



Source: Liberium, Edex, Bloomberg

Since 2010, the UK has developed a large capability to co-fire biomass at its coal fired power stations, based on an incentive scheme. Early technical concerns that the power station boilers would be damaged have been assuaged to such an extent that some stations have operated with 25% biomass input.

Developments have focused on the coal fired Drax power station in North Yorkshire. Drax is the largest power station in Western Europe with a generation capacity of 3,960 MW, and contributes around 7% of UK power supply. It was solely coal-fired until 2010.

Furthermore, in 2012, after the successful introduction of biomass co-firing with coal in 2010, Drax announced it was going to convert three of its six 660 MW generator units to operate solely on biomass – most of it

sourced from North America and supplemented by a local straw pelletising facility.

Given the changes in the biomass supply chain and developments in boiler technology, Moneypoint would be an obvious candidate for either co-firing biomass with coal or conversion to biomass. Its location on the coast with existing coal handling facilities would enable it to take deliveries directly, without the need to encounter multiple handling costs (as in the case of Drax, which requires transhipment to rail).

Furthermore, co-firing could also be introduced at the two Irish peat fired stations at West Offaly (150MW generation capacity) and Lough Ree (100MW generation capacity), and further extended at the Edenberry peat fired station (120 MW generation capacity), which already has 9% biomass co-firing. Indeed, the particular design of these stations (bubbling fluidised bed technology) might allow them to operate at full output on wood.

Critically, co-firing or full conversion to biomass would make a major contribution to meeting the Irish 2020 renewable target.

Co-firing at Moneypoint and the three peat stations could produce 6,850 GWh of "renewable energy", representing 28% of electricity generation in 2012[3].

Alternatively, this could be achieved with full conversion of Moneypoint as it is currently the largest single emitter of greenhouse gases within Ireland, capable of generating 6,800,000 MWh each year, i.e. around the same 28% of the Irish electricity production, were the co-firing option adopted including the three peat fired stations.

5) Potential economics of biomass co-firing and biomass conversion at Moneypoint:

a) Biomass co-firing potential economics:

[3] SEAI, 2013

Figure 1 on page 7 shows that woodchip prices have remained within a band of €125-140/tonne for a considerable period. Based on a calorific value of woodchip of 17GJ/tonne, this equates to around €7.80/GJ, or ~€75/MWh for electricity, assuming Moneypoint would have an efficiency of 36% when burning wood chip.

Thus the current REFIT tariff suggests that co-firing at Moneypoint would represent a financially attractive proposition at ~€75/MWh and certainly a better deal for customers than wind at ~€100/MWh (including IAE estimated additional system costs).

The biomass option also looks very attractive compared to onshore wind based upon estimated costs of carbon emissions savings. The cost of emissions savings for biomass co-firing would be less than half the equivalent costs for onshore wind. This is because, the current cost of generating power from coal at Moneypoint is driven by the European coal price which has been in the range €70-95/t[4] for the past four years. This implies a generating cost, excluding carbon costs, of €26-36/MWh. Therefore, the ~€75/MWh generating cost for woodchip suggests that the cost of emissions savings would be around ~€55/tCO_2[5] for biomass co-firing, as opposed to ~€114€/tCO_2 for onshore wind (including IAE estimated system additional cost).

b) <u>Biomass full conversion potential economics:</u>

The power sector's renewable generation target could also be achieved if Moneypoint were totally converted to biomass power generation (as opposed to the partial conversion of Moneypoint and the three peat fired stations).

If instead of co-firing at Moneypoint and the peat stations the boilers at Moneypoint were converted entirely to biomass the capital cost would be substantial. Using the Drax power station as a conservative benchmark, the

[4] API2 price at 6,000kg/kg or 25.1GJ/t calorific value.
[5] This assumes that the woodchip would displace coal which emitted 0.82tCO_2/kWh

three 660 MW units at Drax are expected to cost £700m to convert to burn wood and Drax's management anticipates this will reduce their output by 10%.

A stage by stage conversion of Moneypoint using a similar approach to that used at Drax is estimated to cost around €380m. A gradual conversion of the plant taking advantage of seasonally lower demand periods would ensure security of power supply during the conversion process.

The conversion of Moneypoint would lead to a financing cost of around €420/kW for the power station. Assuming that capital could be raised at 7% real pre-tax, this would lead to a financing cost €6/MWh, were the station to operate at a 85% load factor for a further 15 years.

Taking these capital costs and marginal costs together, and conservatively assuming that other costs do not change significantly on account of the switch from coal to biomass, a switch to wood pellets would lead to an operating cost of ~€80/MWh.

On the key metric of the comparable cost of emissions savings, full conversion of Moneypoint compares very favourably to the onshore wind strategy. The estimated cost of carbon savings from biomass conversion at Moneypoint is €60/tCO_2, just more than half the cost of carbon savings delivered by the onshore wind strategy at €114/tCO_2,.

The comparison of the three different Irish renewable generation strategies – biomass co-firing in the three peat stations and at Moneypoint, full biomass conversion at Moneypoint and continuing with the onshore wind strategy are set out in table 2 on page 13.

On the key metrics of generation cost and emissions abatement costs, the plan to double onshore wind capacity is markedly the least attractive strategy. Customers would, of course, be exposed to changes in the price of wood pellets. However, Drax has managed to secure contracts of up to 9 years duration. There remains capacity in North America to produce more

biomass under long term supply contract ensuring long term security of supply and price.

Clearly, the operators of Moneypoint would have to monitor the sustainability of its sources, otherwise it could fall foul of changes to regulations concerning wood quality. However, there is certainly a possibility, as at Drax, for the establishment of a pelleting facility which would allow the stations to take deliveries of locally grown material. Ireland has ideal growing conditions for suitable renewable biomass and opportunities to develop a large scale domestic biomass supply chain, with associated jobs and economic benefits to the Irish economy, should definitely be investigated further.

Costs to customers of delivering the renewables targets by wind or by biomass is also, of course, a major concern. For the wind strategy, the IAE assumed that the wind would displace gas fired generation and the additional costs would be around €100-42=€58/MWh. The Grid Link project is intended to support an additional 2,000 MW of wind capacity by 2020. If this operates with a 30% load factor, it would generate 5,260 GWh per annum; suggesting an additional cost of €305m per annum. If these additional costs of wind are spread over all electicity customers according to their consumption, domestic customers, who on average, use 5.4 MWh each year[6], would see their bills rise by around €60 per annum[7]. On the other hand, if intensive energy users are protected from paying these policy costs, as in Germny, and all the costs fall onto the domestic sector, then the 1.6m[8] households would see their bills rising by some €190 per annum.

The costs for the biomass conversion option may be calculated in a similar way. Since the biomass displaces coal, the additional costs are around €50/MWh. So, for the same amount of generation, the additional costs would be €265m. The impact on a domestic customer's annual bill if costs are spread evenly would be €50 per annum. If they are levied only on domestic customers, the cost would be around €165 per annum.

[6] World Energy Council, 2008.
[7] This assumes overall consumption in Ireland is around 28TWh.
[8] UNECE 2011.

The result that the costs to domestic customers are only slightly lower than those of the wind strategy is because wind displaces gas, which is relatively expensive, whilst biomass displaces cheap coal. The fact remains that the carbon savings of biomass are nearly double those associated with wind.

Table 2
Estimated Irish renewable energy abatement costs

Technology	Price/cost of generation	Estimated (system) additional cost	Cost of carbon savings	Additional cost for households
	€/MWh	€/MWh	€/tCO_2	€ per annum
Biomass in existing peat or coal stations	75	0	55	45-145
Biomass conversion	80	0	60	50-165
Onshore wind	70 (REFIT)	30	114	60-190

Source: BW Energy estimates based on IAE system costs.

6) Conclusions:

As explained at the outset of this report, legitimate comparison of renewable energy generation technologies to achieve cost effective decarbonisation requires evaluating two factors:

*the capital and marginal cost of the different forms of power generation (in €/MWh).

*the emission reduction effectiveness of different forms of renewable generation in terms of cost of emission saving (in €t/CO_2).

On both measures, the plan to double onshore wind capacity is markedly less attractive economically than either biomass co-firing at Moneypoint and the three peat stations or simply full biomass conversion at Moneypoint from coal. Indeed, either option would involve customers having to pay more for their electricity. It is difficult to determine exactly how much more, as this depends how government chooses to levy the additional costs. They could amount to as much as €60-190 per annum per household for the wind option, and somewhat less, €50-165, for the conversion of Moneypoint.

Biomass power generation using existing power plants is both flexible ('dispatchable') and delivers emissions savings at much lower cost. By using power stations that are already securely connected to the transmission system, the need to reinforce the existing transmission system is avoided (unlike more wind power).

The conversion of Moneypoint to biomass, at a tenth of the capital cost of the network investment required for wind, offers large scale, cost effective renewable power generation and the opportunity for Ireland to meet its 2020 renewable target at a single stroke.

Recent changes in biomass boiler technologies and the international biomass market mean that – in moving from an "all wind" policy to the biomass option – Ireland now can avoid expenditure on the network, meet its EU targets and potentially create more Irish jobs in a domestic bio energy industry.

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