The Efficiency of Ireland's Renewable Energy Feed-In Tariff (REFIT) for Wind Generation

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Abstract: Ireland's Renewable Energy Feed-In Tariff (REFIT) for wind generation has some unusual features making it different from other REFIT schemes around the world. By utilising an annual floor price element the scheme presents an option value to the contract holder, which to date has gone unnoticed or unvalued in the market. By employing an option pricing framework, this paper has quantified for the first time in the public domain the expected costs and value of the Irish REFIT support scheme for wind generation. While the cost of the REFIT scheme to the electricity consumer appears to be lower than the cost of schemes in other countries, significant inefficiencies exist as a result of the structure of the scheme. The Irish REFIT scheme is contrasted with a single Fixed Price support scheme and the analysis suggests that the Fixed Price scheme can provide a similar or greater incentive to the wind sector at half the cost to the end electricity consumer, and may also prove more compatible with consumers desire to reduce inter-year electricity portfolio cost volatility.

Keywords: Renewable Energy, Energy Policy, Renewable Support Scheme, Option Pricing, Feed-In Tarrif

1. Introduction

While much of the recent drive towards renewable energy and wind energy is as a result of issues that are integral to the international discourse on energy and climate policy, to date there has been very little direct policy action on an international scale in the area of renewable energy (Hirschl, 2009). As a result there are numerous and varied approaches to wind energy policy around the globe. Each individual country adopts an approach which it deems to be appropriate to its local circumstances and ideological approach to market intervention (Saidur et al., 2010). Investment and production tax incentives are used in many countries, but seldom in isolation from other market support schemes.

These market support schemes broadly fall into three categories. The two most significant categories are characterised by (Toke and Lauber, 2007) as the “neoliberal” market based approach, including renewable energy portfolio standards and tradable green certificates, and the more traditional “command and control” Renewable Energy Feed-In Tariff (REFIT) type schemes like that operating in Germany. REFIT schemes typically involve a single or indexed fixed price for the purchase of energy from renewable projects. The third category, and now generally less favoured, is competitive tender schemes.

Proponents of the market based approach claim that this system fosters more intense competition resulting in a reduced cost of achieving renewable energy targets. On the other hand, advocates of the REFIT style system argue that it results in a less bureaucratic system with a lower risk profile for investors, while also fostering a greater degree of local ownership than the market based systems (Toke and Lauber, 2007). Several reviews of the performance of each system of these supports in different markets suggest that the REFIT type schemes provide a more cost effective support regime (Elliott, 2005),(Toke and Lauber, 2007) . One of the most high profile market based support schemes is the Renewable Obligation (RO) scheme in the UK. This scheme is currently under review by the Conservative/Liberal Democrat coalition government, with a view to replacing it with a Contract for Difference (CfD) based REFIT scheme (Pöyry, 2010a).

Ireland had originally introduced a competitive tender scheme called the Alternative Energy Requirement (AER) which it was believed could achieve a low cost way of incentivising renewable energy, provided no strategic bidding took place in the auctions (Huber et al., 2007). However, it appears that those early competitive tender schemes were relatively unsuccessful due speculative bids that were often too uneconomic to actually execute the project. Similar behaviour was seen in similarly unsuccessful schemes in the UK (Mitchell, 2000). After the AER schemes, in 2006 Ireland adopted a REFIT type scheme for the promotion of renewable energy. Ireland’s REFIT scheme has many attributes of a classic REFIT scheme but also has some unusual features including a floor price/option element and a direct payment to cover the “balancing costs” of renewable generation.

This paper is focused on examining the Irish REFIT scheme and in particular the more unusual aspects of the scheme in order to foster a debate on its efficiency in the Irish market. To do this, a basic market forecast and option pricing model is implemented in order to achieve for the first time in the public domain an estimate of the total expected cost and value of the REFIT scheme for a wind project in Ireland. This initially puts in context the costs of the REFIT scheme in Ireland against the costs of schemes elsewhere in the world. Further discussion and commentary on the use and appropriateness of the REFIT scheme in the Irish market follows.

Section 2 of this paper outlines the existing structure of the Irish REFIT scheme and includes some commentary on how the scheme has been viewed by wind industry to date. Section 3 sets out to quantify the cost and value of the REFIT scheme by taking a view of the electricity market and the value of wind in the market in the future. The option value of the REFIT scheme is then found by applying a basic option pricing model. Section 4 presents the results of the quantification and examines some of the implications. The discussion in section 5 further analyses the appropriateness of the REFIT scheme and presents some alterations to the scheme to increase its effectiveness. Other desirable aspects of schemes, like their suitability to the capital profile of the wind projects and their ability to decrease aggregate portfolio price volatility are also touched on in section 5, before conclusions in section 6.

2. Ireland’s REFIT Scheme

2.1 Structure of the REFIT Scheme

The original REFIT Scheme in Ireland was initiated on 1st May 2006 with the aim of supporting 400 MW of renewable generation to fulfil a 1450 MW target by 2010 (DCENR, 2011). Since then the scheme has been extended in terms of eligible capacity. The original REFIT scheme expired in 2010, however, in early 2011 work was underway to establish a follow-on scheme of a similar structure which would include off-shore wind generation and other sources of generation. The work presented in this paper is based on the structure of the original REFIT scheme that was available for applications from 2006 to 2010. The cost of the REFIT support scheme is covered by a Public Service Obligation (PSO) which also supports other market interventions such as peat generation and the provision of peaking plant. These PSO costs are then levied on all customers. (CER, 2011a)

The REFIT support scheme is a 15 year support scheme which is made available to supply companies with the assumption that the supply companies will then efficiently contract with REFIT qualified renewable generation projects through a Power Purchase Agreement (PPA).The REFIT scheme provides varying levels of support for 4 different types of renewable energy projects, namely On-shore Large Wind (projects >5MW); On-shore Small Wind (projects <5MW); Hydro and Biomass, and Landfill Gas.

The financial support provided by the REFIT scheme is comprised of in 3 distinct elements:

1. **Floor Price Element** – The floor price element provides qualifying projects with an effective floor price on their annual energy market revenue. This floor price applies on an annual basis for each year of a 15 year term covered by the REFIT contract. If in any year the energy market revenue of the project is below that which would be yielded by the floor price the relevant supply company will be refunded the difference from the PSO mechanism. In years when the energy market revenue of the project is above that which would be yielded by the floor price, no payments are made and the relevant supply company keeps the total market revenue. In 2006 the floor price was fixed at 57 €/MWh for projects with an Irish inflation index, known as the Consumer Price Index (CPI), to apply to adjust the floor for future years. This indexation applies in a positive direction only and in 2010 the floor price stood at 66.35

€/MWh. The original REFIT scheme was introduced in 2006, before the establishment of the Single Electricity Market (SEM) in Ireland in November 2007. At that time an annual regulated average market price called the Best New Entrant (BNE) price provided a proxy for the market and a reference for the energy market revenue of the REFIT projects. In the current SEM the reference price is the total per MWh revenue that would be received by the wind generation in the market. It will be referred to throughout this paper as the wind weighted market price. The floor price element is the only element of the REFIT scheme that is referenced to the market.

2. **Balancing Payment Element** – The balancing payment element is an additional payment to the relevant supply company to cover notional costs of "balancing" the variable wind energy in the energy market. This element was designed during a time when the pre-SEM market arrangements included penalising imbalance prices called "top-up" and "spill". It is likely that this payment was based on the cost of achieving a base-loaded or customer profiled energy position in the market with a variable wind output profile and the prevailing imbalance prices at the time. With the onset of the SEM market, where there are no direct imbalance penalties associated with wind generation, the balancing payment element of the REFIT scheme looks rather ill-defined and dated. The balancing payment comprises a payment of 15% of the indexed floor price per MWh for all technology categories. This amounted to 8.55 €/MWh in 2006 and 9.95 €/MWh in 2010.

3. **Technology Difference Element** – the technology difference element is a payment to categories other than the large wind category aimed at delivering a higher level of support to higher cost technologies. In 2006 the technology difference element amounted to 2

€/MWh for the small wind category, 15 €/MWh for the hydro and biomass category and 13 €/MWh for the landfill gas category.Similar to the floor price element and the balancing payment element, the technology difference element is indexed to the CPI.

Table 1 below outlines the minimum level of support available through the REFIT scheme to the various technology categories in 2010. From this point on, the paper will only examine the REFIT scheme in terms of how it applies to the most significant, i.e. Large Wind category.

Table 1: Minimum level of REFIT support for each technology category in 2010

Tech Category	Floor Price (€/MWh)	Balancing Payment (€/MWh)	Technology Difference Payment (€/MWh)	Total (€/MWh)
Large Wind	66.35	9.95	0.00	€76.30
Small Wind	66.35	9.95	2.33	€78.63
Hydro and Biomass	66.35	9.95	17.46	€93.76
Landfill Gas	66.35	9.95	15.13	€91.44

2.2 Experience of REFIT in the Market

Anecdotal evidence to date suggests that wind projects and other REFIT qualified projects are assessed based on the minimum level of support available through the REFIT scheme (Harte, 2010). Industry sources openly suggest that €76.30 is the revenue available to a large wind project. However, the nature of the REFIT scheme is such that the floor price element, the most substantial element of the payment, is in fact a series of 15 annual energy market put options given at no cost by the consumers through the PSO to the REFIT qualified project. The scheme is analogous to a series of put options in so far as, if the project (or holder of the REFIT PPA) does not achieve an adequate price in the market each year for its output they are entitled to the financial equivalent of having the put option counterparty (i.e. the PSO mechanism) purchase their output at the agreed strike price (i.e. the REFIT floor price) (Figlewski et al., 1992). These put options could be categorised as “European Options” since they can be thought of as only being exercisable after the expiration date of the option at the end of each year. The value of these options, i.e. elimination of the potential energy market downside and the retention of the potential market upside, appear to be substantially ignored by the industry so far, and the floor price element put options appear to only be valued at their strike price. This would suggest that utility supply companies are, for the most part, keeping the upside available through the REFIT scheme without passing the benefits on to renewable projects through increased contract prices or on to consumers through lower electricity tariffs. Industry evidence suggests that few, if any, PPAs with utility suppliers are set at prices above the minimum support level fixed in the REFIT contract. If there are arrangements on sharing energy market revenue upside, it is likely that this revenue is not taken into account when assessing the viability of the renewable energy projects or calculating Internal Rates of Return (IRR) versus hurdle rates.

This is a significant element of the REFIT support scheme that is going unnoticed or undervalued. This raises questions as to the efficiency and appropriateness of the structure of the REFIT support scheme. It may be the case that the optionality of this element of the support scheme is overly complicated for the wind developers themselves who with highly leveraged capital intense projects favour simple single value PPAs with suppliers. In this contractual structure, excess (above the floor price) energy market revenues would accrue at times of high market prices to the supply business which signed the REFIT PPA. With no evidence that many PPAs are signed above a level based on the floor price, which would reflect the possibility of this excess revenue in the future, we are left to surmise that the supply businesses are undervaluing this potential revenue. There may be two reasons for this. Firstly, this type of revenue may be too sporadic and uncertain to be compatible with suppliers’ business models which are typically based on low margin, high volume operations with a 6-12 month planning horizon. Secondly, the complexities in quantifying the option value may also create a barrier to valuing the REFIT contract. An alternative possibility is that the supply businesses are tacitly colluding in order to keep this revenue in their sector of the market. However, given that there are more than 5 supply companies operating in the PPA market at present, this possibility seems unlikely.

The option value of the REFIT support scheme is either poorly understood or undervalued by the renewable energy projects, or by the PPA suppliers, or by both. However, the electricity consumers are underwriting the cost of the REFIT scheme, including the option element, which thispaper argues is clearly not effective at incentivising wind generation. The following sections will aim to analyse and quantify this phenomenon.

3. Quantifying the Value and Cost of the REFIT Scheme.

Quantifying the minimum guaranteed price available from the REFIT scheme is a simple task as already presented in Table 1. However, quantifying the option value and cost of the floor price element of the REFIT scheme is much more challenging as it relates to the likely future revenue and possible spread of future revenues available to a wind project in the SEM.

There are two significant elements which must be dealt with in order to quantify the option value:

1. **Forecasting the level and possible spread of the yearly average electricity market prices in Ireland.** This will be substantially driven by the variances in the international fuel and carbon markets as well as being influenced by the evolution of the Irish generation portfolio and annual capacity margins.

2. **Forecasting the proportion of the average electricity market price that wind generation will extract in Ireland.** It has been well established (Sensfuß et al, 2008), (Munksgaard and Morthorst, 2008) that as wind capacity increases in a system the average price the wind

generation will extract from the market will decrease due to the depression of prices in the hours when there are large volumes of incrementally “free” wind energy. The magnitude of this effect will depend on the evolution of the Irish generation portfolio, the level of wind capacity and the market structure.

Each of these topics represents large fields of research worthy of more detailed investigation in their own right. The intention of this paper, however, is not to pursue these issues in great depth, but rather to make some assumptions based on existing data and industry experience to present initial findings and foster a debate on the appropriateness of the REFIT support scheme in Ireland.

3.1 Level and spread in the expected yearly average electricity market prices in Ireland

This section aims to make some basic assumptions about the level and spread of possible yearly electricity prices in Ireland over the next 20 years. As experienced electricity price commentators and analysts know the "forecast is always wrong" (Schweppe et al., 2000), but the act of compiling forecasts in essential. Several leading industry service providers like Poyry, IHS Global Insight and Wood MacKenzie, provide various fuel and electricity market modelling and forecasting services. However, few if any will provide probabilities or distributions associated with their forecasted scenarios. These are required to value the option in a scheme such as REFIT. All forecasts, no matter how intensely modelled, are at their most fundamental level, simply an analyst's view of the market. This is what will be provided in this section, an analyst's view of the possible level and spread of outcomes in the market[1].

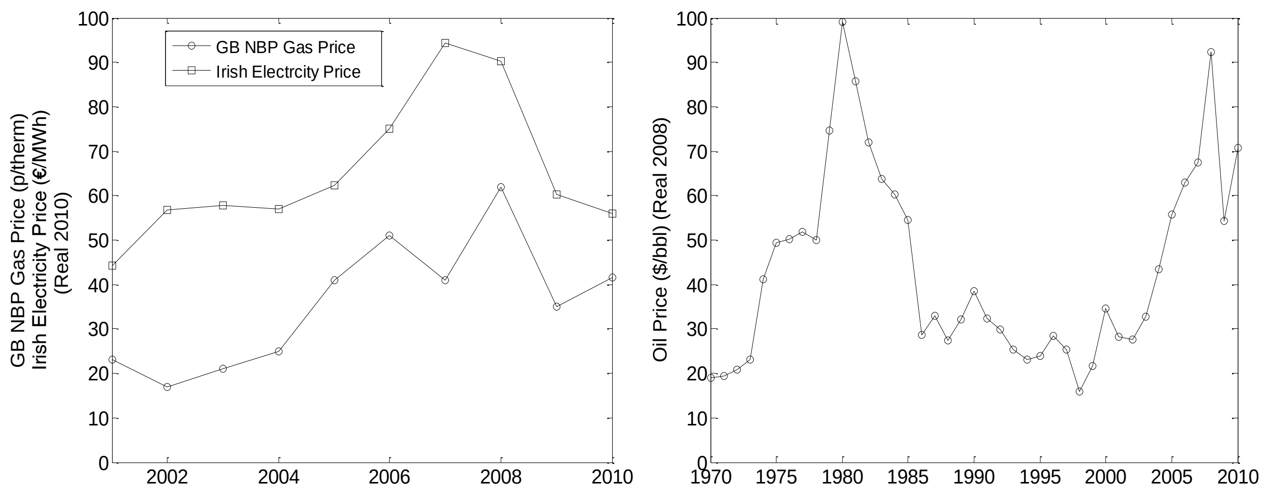

Figure 1: Example of Historic Oil, Gas and Electricity Price Movements[2] (Pöyry, 2010b), 2001 (CER, 2011b), (SEMO, 2011), (Inflationdata, 2010).

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[1] For clarity the forecast contained in this paper is derived for academic purposes and does not purport to represent a reliable basis for investment in the electricity sector. The authors give no warranty or assurances as to the accuracy of the forecasts or any other work in this paper.

[2] Electricity prices are shown for Tariff Years .i.e. Oct - Sept

In order to assess the value and cost of the option offered by the REFIT floor price element, distributions of the likely annual average electricity market price is required for each of the next 20 years. As Figure 1 illustrates annual fuel and electricity price movements appear to be asymmetric. The potential upside volatility appears to vary further from the average than the downward variances, which tend to be more stable and sustained. In addition, there are several elements in the structure of the energy and electricity markets which point to this tendency towards asymmetry. Hugely price insensitive demand in the fuel and electricity markets are one obvious potential driver to upside volatility, while the structure of some of the fuel markets, where groups like OPEC have significant price setting ability will tend to limit the periods of significantly low price. In the electricity markets it is hard to imagine sustained prices achieving levels significantly lower than that required by a marginal thermal plant plus a cost based fuel price element. On the upside, it is hard to for an observer to identify a similar basis for a limiting upper threshold on price, given the possible impact of fuel price spikes and periods of tight system capacity margin.

Reviewing historic data, and based on this asymmetric view of possible future price movements, the following 3 scenarios are forwarded here as this analyst's characterisation of the future electricity market in Ireland. These 3 scenarios along with historic Irish electricity market prices since 2001 (CER, 2011b) (SEMO, 2011) are shown in Figure 2.

P50 Price Series : This price series characterises the 50th percentile, i.e. price that in each year of the series is equallylikely to be exceeded by the average electricity market price as it is to exceed market price itself. The average electricity market price for the 2010 tariff year of 56.56 €/MWh was taken as a starting point. This was assumed to rise to 80 €/MWh by 2030 in real terms. This suggests that electricity market inflation will run head of general CPI inflation by around 1.8% per annum.

P10 Price Series : The 10th percentile series of prices describe the level at which there is only a 10% probability that the average market price in each year will outturn at a level lower than the relevant price in this series. This price is set here at 40 €/MWh in each year in real terms. Over the past 10 years only one year produced a price close to this level. In 2001 the regulated market price was set at 44.32 €/MWh.

P80 Price Series : The 80th percentile series of prices describes the level at which there is an 80% probability that the average market price in each year will outturn at a level lower than the relevant price in this series. This price series is set at 80 €/MWh in 2010 rising to 120 €/MWh in 2030 in real terms. In the past 10 years, 2 years have had an average market price greater than 80 €/MWh.

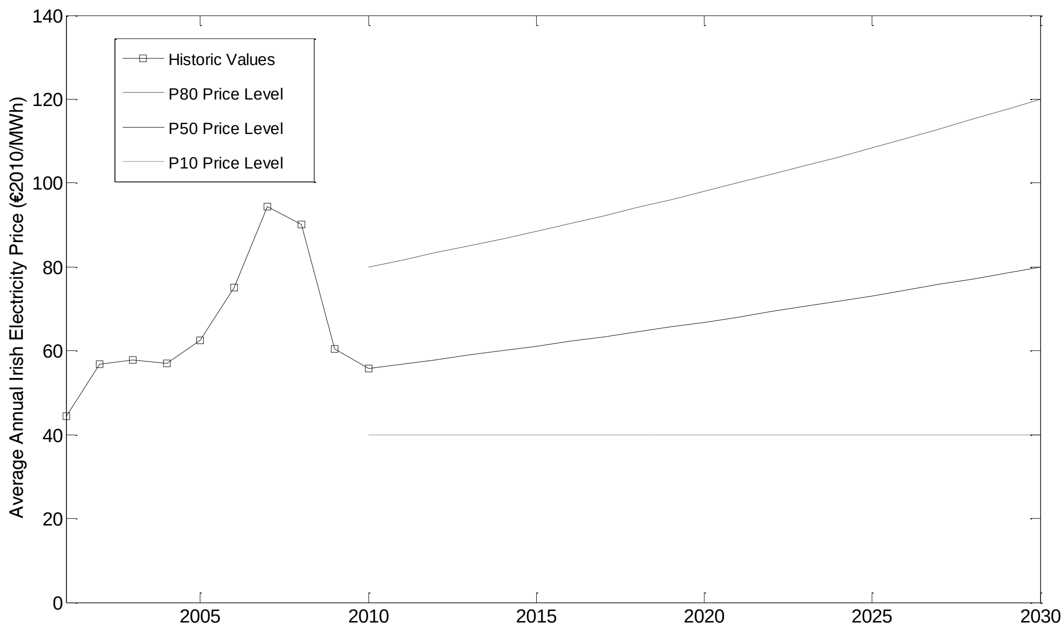

Figure 2: Historic Irish electricity market prices and projected future price scenarios

3.2 Proportion of the average electricity market price that renewable energy will extract

There are many studies focused on the effect of wind energy on electricity market prices. (Sensfuß et al, 2008), (Munksgaard and Morthorst, 2008). What is clear is that wind generation will depress the general electricity market price and in so doing will disproportionately suppress the wind weighted price that it itself would receive in the market. This is a complex topic requiring the analysis of the portfolios mix, the level and capacity of renewable and interconnection in the system, as well as international fuel prices and any changes in the wholesale market structure itself. A detailed analysis of this topic is clearly beyond the scope of this paper.. Consequently, some basic assumptions around the issue are made.

Data was compiled (SEMO, 2011), (Eirgrid, 2011) consisting of the 3 years of available active market data and corresponding wind generation in Ireland. Analysis was carried out with the aim of getting an approximate indication of what wind generation would be worth in the market if it were not to effect market price. This price can be used as a starting point, reflecting the value of the first MW of wind capacity in the portfolio. This price is found here by applying the wind profiles of a particular year to price profiles of other years (e.g. applying 2008 and 2010 wind profiles to 2009 market prices) and multiplying to find the value of the wind generation in the market. Using this approximation, it was found over all the scenarios tested that the value of wind in the market, were it not to effect the market prices, is 1.4% greater than the time weighted average market price in each year.

Further analysis was carried out to assess the actual effect wind generation had on its own price in the market. Table 2 highlights the actual average market and wind weighted market prices from the 3 years of available data. It can be seen that the wind weighted market price was on average 5.5% lower than the time weighted average price in the market. Adjusting for the level of installed wind generation would suggest that 1 GW of wind capacity will receive approximately 4% less than the time weighted market price. Assuming a +1.4% starting point outlined above and a -4% end point, it would appear that the first GW of installed wind capacity on the Irish system suppressed its own price by around 5.4% relative to the time weighted market price.

Table 2: Summary of time and wind weighted market prices

Year	**Average Market Price €/MWh**	**Average Wind Weight Market Price (€/MWh)**	**% Difference**	**Installed Wind Capacity (MW)**	**Implied % Difference per GW Installed Wind Capacity**
2008	88.57	83.92	5.25%	1220	4.30%
2009	61.20	58.54	4.34%	1562	2.78%
2010	56.56	52.41	7.34%	1800	4.08%

In the absence of a detailed portfolio study and without knowledge of the future changes to the wholesale market rules a basic assumption is made that wind generation will suppress its own price at a rate of 4% per GW of installed wind capacity with respect to the time weighted average price in each year. Finally, this paper assumes that the installed wind capacity in the SEM will grow from around 1800 MW in 2010 to 5800MW in 2030 (SEI, 2009).

Table 3 below shows the assumed installed wind capacity and the assumed wind weighted market price series for the P50, P10 and P80 cases for each year. Figure 3 below shows the projected future average and wind weighted market price scenarios.

Table 3: Assumed future wind weighted price scenarios

		Wind Weighted Market Prices (€/MWh)		
Year	**Wind Capacity (MW)**	**P50**	**P10**	**P80**
2010	1800	51.84	37.12	74.24
2011	2000	52.32	36.80	75.11
2012	2200	52.81	36.48	75.98
2013	2400	53.29	36.16	76.85
2014	2600	53.78	35.84	77.73
2015	2800	54.26	35.52	78.62
2016	3000	54.75	35.20	79.51
2017	3200	55.23	34.88	80.40
2018	3400	55.72	34.56	81.29
2019	3600	56.20	34.24	82.19
2020	3800	56.69	33.92	83.09
2021	4000	57.17	33.60	83.99
2022	4200	57.65	33.28	84.89
2023	4400	58.13	32.96	85.80
2024	4600	58.61	32.64	86.70
2025	4800	59.09	32.32	87.61
2026	5000	59.56	32.00	88.52
2027	5200	60.04	31.68	89.43
2028	5400	60.51	31.36	90.34
2029	5600	60.97	31.04	91.25
2030	5800	61.44	30.72	92.16

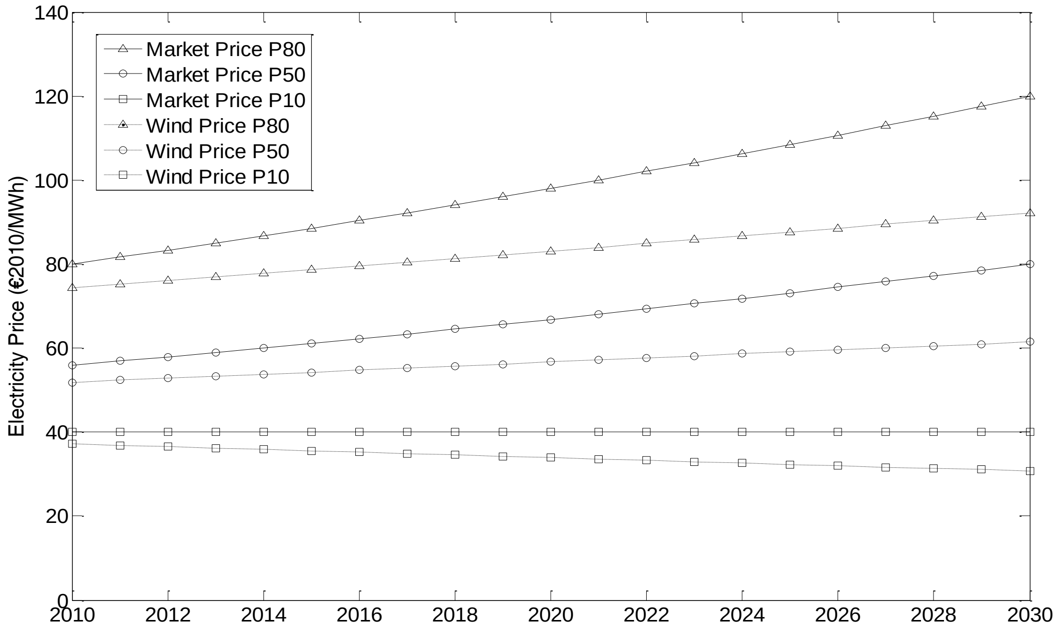

Figure 3: Projected future average and wind weighted market price scenarios.

3.3 Distributions Fitting

In order to estimate the option value of the REFIT floor price element a distribution must be fitted to the range of forecasted possible outcomes for the wind weighted market price in each year. Given the low probability of zero values and the asymmetric view of the market price movements, a Generalised Extreme Value (GEV) distribution was chosen to describe the range of possible market outcomes in each year. While this type of distribution is usually used to model the statistics of extreme events and "tail risk" (Cole, 2001), the flexibility of its 3 fitting parameters and the overall shape was deemed useful and reflective of this analyst's view of the market. The probability density function of the GEV distribution (*pdfgev*) is given below, where μ is the location parameter, σ is the scale parameter, and k is the shape parameter.

$$pdfgev = f(x \mid k, \sigma, \mu) = \left(\frac{1}{\sigma}\right) \exp\left(-\left(1 + k\frac{(x-\mu)}{\sigma}\right)^{-\frac{1}{k}}\right)\left(1 + k\frac{(x-\mu)}{\sigma}\right)^{-1-\frac{1}{k}} \quad (1)$$

The GEV distribution was fitted to the corresponding P50, P10 and P80 prices for each year and presented above using the array of functions available in the Matlab Statistics Toolbox. The corresponding parameters for the fitted distribution in each year are given in Table 4. All fitted distributions where found to have a positive shape parameter *k* which characterises the distributions as Type II, or Fréchet. Predictability all distributions' *k* values are less than 1 which is the criterion for a finite mean. Figure 4 shows the resulting probability density functions for each year. From these yearly distributions the expected mean value of the wind generation and the impact of the option in the floor price element can be assessed.

Table 4: Fitted GEV parameters for each year

Year	**GEV Parameters**		
	k	σ	μ
2010	0.4077	13.3750	46.5765
2011	0.3793	14.0048	46.8132
2012	0.3498	14.6531	47.0800
2013	0.3230	15.2915	47.3401
2014	0.2974	15.9342	47.6098
2015	0.2745	16.5689	47.8714
2016	0.2521	17.2070	48.1429
2017	0.2317	17.8368	48.4070
2018	0.2118	18.4700	48.6809
2019	0.1939	19.0966	48.9461
2020	0.1762	19.7272	49.2212
2021	0.1599	20.3548	49.4868
2022	0.1448	20.9717	49.7560
2023	0.1308	21.5912	50.0205
2024	0.1166	22.2115	50.2927
2025	0.1036	22.8302	50.5615
2026	0.0918	23.4423	50.8219
2027	0.0799	24.0588	51.0918
2028	0.0691	24.6688	51.3531
2029	0.0596	25.2749	51.6044
2030	0.0500	25.8631	51.8746

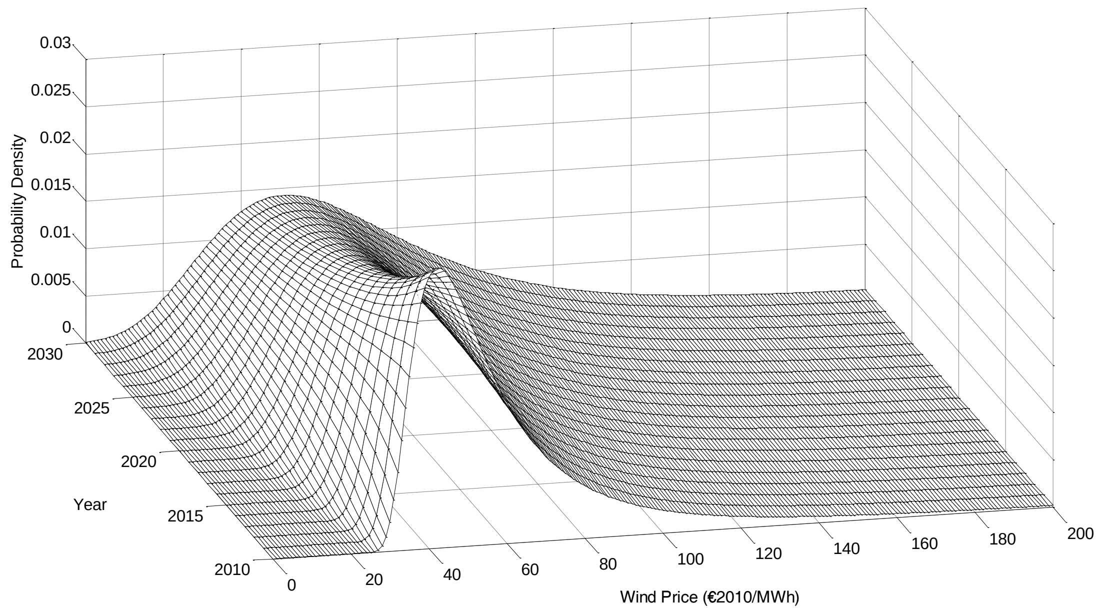

Figure 4: Probability density function for wind weighted price in each year

4. Results

Using the distributions defined in the previous section and the array of functions available in the Matlab Statistical Toolbox the results presented in Table 5 are derived. All results outlined in this section are in Real 2010 euro terms. Table 5 shows the mean expected value of wind generation in the market. This is simply the mean of the distributions in each year and has an average value over the range of years of 65.05 €/MWh.

Also shown in Table 5is the value of the put options with a strike price at the REFIT floor price of 66.35 €/MWh. The average value of these annual put options over the period in question is 12.92 €/MWh. The mean expected value of the wind generation in market with the floor price in place equates to the mean market value plus the value of the annual put options. On average the mean expected market revenue with the floor price applied is 77.97 €/MWh (65.05 + 12.92 €/MWh).

With the inclusion of the 9.95 €/MWh balancing payment the mean expected total revenue to the wind project is 87.92 €/MWh. This figure is 11.62 €/MWh higher than the minimum guaranteed price of the REFIT scheme of 76.30 €/MWh. Figure 5 shows a contour plot of the distributions which reflect the view of the future value of wind in the market. Also shown is the distribution of the wind weighted market price in 2020 along with the level at which the REFIT strike price is set.

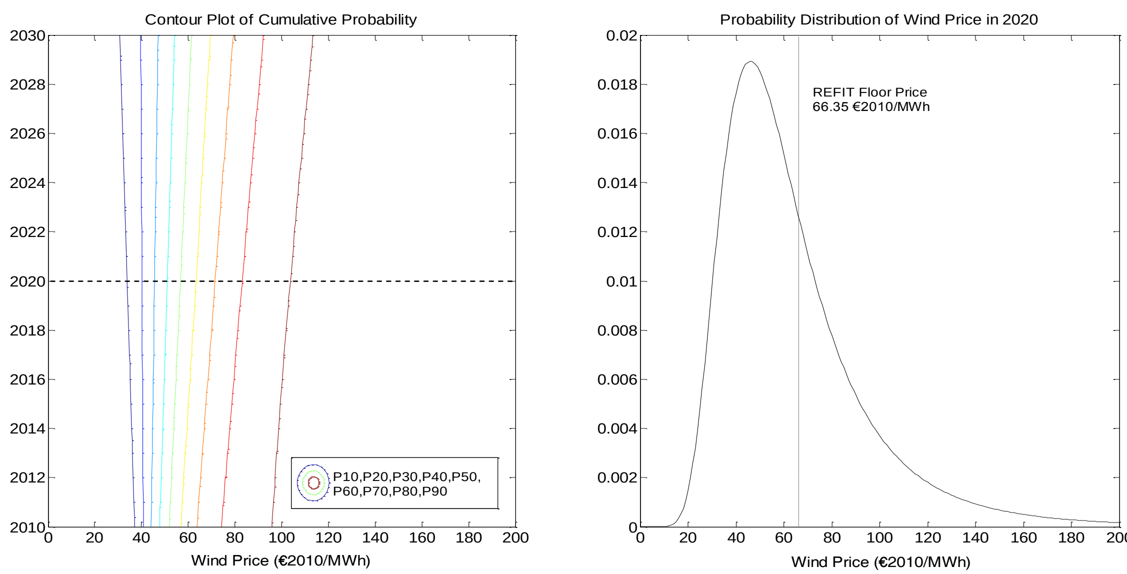

Figure 5: Contour plot of CDF of annual distributions and example distribution from 2020

Table 5: Results of the mean expected value of wind in the market, option value and total expected wind price

All Values in Real Terms €2010	Mean Expected Value of Wind in Market (€/MWh)	Value of Put Options with Strike Price of 66.35 (€/MWh)	Mean Expected Value of Wind in Market with Floor Price at 66.35 (€/MWh)	Mean Expected Total Wind Price with Balancing Payment of 9.95 (€/MWh)
2010	63.18	13.89	77.08	87.03
2011	63.19	13.76	76.96	86.91
2012	63.21	13.63	76.85	86.80
2013	63.29	13.50	76.78	86.73
2014	63.39	13.38	76.72	86.67
2015	63.51	13.27	76.75	86.70
2016	63.74	13.16	76.90	86.85
2017	63.94	13.06	77.00	86.95
2018	64.21	12.97	77.17	87.12
2019	64.45	12.88	77.34	87.29
2020	64.74	12.80	77.54	87.49
2021	65.01	12.73	77.75	87.70
2022	65.26	12.66	77.96	87.91
2023	65.66	12.60	78.26	88.21
2024	66.03	12.55	78.55	88.50
2025	66.30	12.50	78.81	88.76
2026	66.69	12.45	79.14	89.09
2027	67.04	12.41	79.43	89.38
2028	67.36	12.38	79.76	89.71
2029	67.72	12.35	80.10	90.05
2030	68.18	12.31	80.48	90.43
Average	**65.05**	**12.92**	**77.97**	**87.92**

Several observations stem from the analysis. Firstly, if a comparison is made between the total mean expected revenue per MWh to the wind farm and the mean expected worth of the wind generation in the market (87.92 versus 65.05), one can for the first time in the public domain estimate that the Irish electricity consumer will on average expect to subsidise wind generation to the tune of 22.87 €/MWh. The appropriateness of this level of support is not the topic of this paper and depends on the perceived benefits of renewable generation for security of supply, local economic growth and environmental sustainability. What can be observed is that the current level of subsidy in Ireland appears to be below that of other European countries such as the UK and Germany, where the RO certificates and REFIT tariffs appear to subsidise wind energy to a greater extent (OFGEM, 2010),(Bundestag, 2004). The reason for the lower level of subsidy provided in Ireland may be predominantly due to the attractive wind speeds at Irish wind farm sites and the higher average wholesale electricity market prices.

The second observation is that the access to the market upside provided by the put options, which this paper argues is going unnoticed or undervalued in the market, at 11.62 €/MWh, comprises a not insignificant portion of the total expected revenue available to a wind project. In percentage terms, this equates to approximately 15%. If this additional revenue were to become understood and valued it may have a noticeable impact on project returns and consequently the level of renewable generation capacity the REFIT scheme is effective in incentivising. The following example is derived to emphasise this point.

Example Project: A project is assumed to be built in 2010 and has an operating life of 20 years running from 2011 to 2030 inclusive. The first 15 years are assumed to fall under the REFIT scheme of which 2 valuations scenarios are presented below. The capacity factor is 35% and the availability is 95% throughout the life of the project. The capital costs are 1.7M €/MW, and the annual O&M costs are 2% of the capital costs in each year (Harte, 2010). The results in Table 6 show that the increased project valuations that result from properly valuing the option value of the REFIT are significant and would result in increased levels of renewable energy being incentivised in the market.

Table 6: Project Internal Rate of Return and Net Present Value (NPV) with and without valuing the REFIT option element

	Project IRR	**Net Present Value per MW Installed with Discount Rate of 8%**
REFIT Valued with Floor Price (ave 76.30 €/MWh)	8.64%	€75,293
REFIT Valued with Option Value (ave. 87.92 €/MWh)	10.74%	€326,536

Sensitivity analysis is not undertaken in this paper. The distributions used here already reflect the assumed uncertainly that prevails in future electricity market prices. Clearly differing views on the level and, more importantly, the uncertainty in the market will alter the option valuations. It is evident that few analysts have undertaken this type of analysis in the Irish marketplace and few forecasting organisations have associated distributions or probabilities with their price forecast scenarios. Therefore, it is difficult to establish objectively the range over which any sensitivity analysis of other analysts' market perceptions could be undertaken. It is worth noting that the REFIT floor price falls quite centrally with respect to the future market view taken here, as illustrated in Figure 5. This would tend to suggest that the option valuation will not be overly sensitive to slightly modifications of the market forecasts used in this paper.

5. Discussion

5.1. Alternative REFIT Scenarios

This section will examine in more detail the component parts of the REFIT scheme and their effectiveness in incentivising wind generation in Ireland. This will be done by examining the existing REFIT scheme relative to five alternative scenarios. Three of these schemes will be modifications of the existing REFIT scheme where the floor price element and balancing payment element are present. The final two schemes examined will be basic fixed price schemes, with a single guaranteed price paid to the project. The analysis is built on the metrics presented in Real 2010 terms in Table 7 below.

Scenario 1 – Current REFIT Scheme: As highlighted in the previous section the valuation in this paper suggests that a wind project could expect a mean per MWh revenue of 87.92 €/MWh. However, wind projects in the market are only being valued at the level of 76.30 €/MWh. This would suggest that the support scheme is effectively wasting €11.62 of electricity consumers' money for every MWh of wind energy produced in the REFIT scheme. With a 35% capacity factor and 95% availability each GW of REFIT supported wind generation would be expected to waste around €34M per annum of Irish electricity consumers' money.

Scenario 2 – Reduced Floor and Increased Balancing Payment: This scenario keeps the sum of the floor price and balancing payment at 76.30 €/MWh similar to the current REFIT scheme. However, with a lower strike price of 56.35 €/MWh on the put options, the value of those options decrease and, accordingly, the balancing payment is increased to 19.95 €/MWh. The lower floor price effectively means that there is a larger portion of the distribution describing the market upside which goes unvalued by the industry. This leads to a larger amount of the total cost of the support scheme being wasted, i.e. being paid for by the consumer but not being valued by the wind projects (15.86 €/MWh), and a greater overall expected cost of the scheme (27.12 €/MWh above market). This example shows that the existence of a balancing payment may tend to force down the floor price in such a scheme and consequently increase the amount by which the scheme may be undervalued.

Scenarios 3 – Floor at 76.35 €/MWh and no Balancing Payment: Having indentified the balancing payment as contributing to the inefficiency of the scheme this scenario examines the case where there is no balancing payment and the floor price is set to 76.30 €/MWh. In this scenario one would expect a similar level of wind generation to be incentivised as the current REFIT scheme, but at a lower expected end cost to the consumer, i.e. a cost of 19.88 €/MWh above market value instead of 22.87 €/MWh. However, due to the unvalued optionality that remains there is still inefficiency in the scheme, quantified here as a wasted support of 8.64 €/MWh.

Scenario 4 – Increased floor to give same costs to the consumer: This scenario shows that the effective level that wind generation can be incentivised to can be increased to 80.27 €/MWh for the same expected cost to the consumer of the existing REFIT scheme, i.e. 22.87 €/MWh above market value. This is simply done by increasing the floor price to 80.27 €/MWh and eliminating the balancing payment. However, despite the increased incentive for wind, inefficiency in the system remains. **Scenario 5 - Fixed Price Scheme at current REFIT guaranteed price:** Scenario 5 shows how a simple fixed feed-in tariff (with no floor price or balancing payment element) increases the efficiency of the entire support system. A Fixed Price Scheme of 76.30 €/MWh would effectively be equally as efficient at incentivising wind generation as the existing REFIT scheme but could do so at half the cost to the consumer, i.e. an expected costs of 11.25 €/MWh above market value. The simplicity and effectiveness of the single Fixed Price Scheme approach is striking.

Scenario 6 – Fixed Price Scheme at same final cost to the consumer: The final scenario highlights that for the same cost as the existing REFIT scheme (22.87 €/MWh above market value) a simple Fixed Price support scheme could incentivise wind projects which are viable up to a level of 87.92 €/MWh. This means that for no extra cost over the existing REFIT scheme a single Fixed Price scheme could provide an added incentive to the wind sector of 11.62 €/MWh. (i.e. 87.92 €/MWh – 76.30 €/MWh)

Table 7 : Results for existing REFIT and alternative schemes

Scenario		Wind Market Value (€/MWh)	Support Scheme Floor/Fixed Price (€/MWh)	Support Scheme Option Value (€/MWh)	Support Scheme Balancing Payment (€/MWh)	Total Expected Support per MWh (€/MWh)	Support Above Market Value (€/MWh)	Wind Incentive in Practice (€/MWh)	Wasted Support (€/MWh)
1	**Current REFIT Scheme**	65.05	66.35	12.92	9.95	87.92	22.87	76.30	11.62
2	**REFIT with Reduced Floor and Increased Balancing Payment**	65.05	56.35	7.16	19.95	92.17	27.12	76.30	15.86
3	**REFIT with Increased Floor and No Balancing Payment**	65.05	76.30	19.89	0.00	84.94	19.88	76.30	8.64
4	**REFIT with Increased Floor and No Balancing Payment to Give Same Overall Expected Cost as Current REFIT Scheme**	65.05	80.27	22.87	0.00	87.92	22.87	80.27	7.65
5	**Fixed Price Scheme at Guaranteed Price in Current REFIT Scheme**	65.05	76.30	0.00	0.00	76.30	11.25	76.30	0.00
6	**Fixed Price Scheme at Total Expected Support of Current REFIT Scheme**	65.05	87.92	0.00	0.00	87.92	22.87	87.92	0.00

5.2 Further consideration of Single Fixed Price schemes versus Existing REFIT scheme

The above analysis highlights the inefficiencies in the existing REFIT scheme and also outlines the benefits that a simpler Fixed Price Scheme would have. While this paper has substantially focused on the valuation of support schemes, there are other aspects that need to be considered when comparing the existing REFIT scheme to any possible alternatives. The follow three sections touch on other aspects of the schemes and highlight further the attractiveness of a Fixed Price scheme over the existing REFIT scheme.

Structure of Scheme: The balancing payment element of the existing REFIT scheme, which was initially designed to financially compensate the contracted supplier for the balancing costs of the variable wind generation is now ill defined given that there are no direct costs of balancing wind in the wholesale market. This outdated element, the unusual upwards only inflation indexation and the generally fragmented nature of the REFIT scheme points towards an overly complicated and engineered support scheme. The alternative scheme presented here, i.e. a single Fixed Price feed-in tariff properly linked to inflation, appears to achieve greater efficiency with a simpler and more understandable structure. The upside which is sporadically available through the REFIT scheme is not easily quantified and is not transparent to the market. This increases the probability that utility supply companies will fail to pass on the benefits to either renewable projects or customers. A transparent Fixed Price scheme would not suffer from this effect.

Matching the Capital Profile of the Project: One of the reasons that REFIT-type schemes appear to be gaining favour over market based schemes like the RO is that the simplicity of the guaranteed price matches the up-front capital intense profile of the wind projects. The market based schemes often result in assumed project revenue being discounted for the uncertainty inherent in the energy market and the uncertainty in the quasi-market that governs the tradable green certificates.

The Irish REFIT system gives total price certainty up to the sum of the floor price and the balancing payment. However, the additional revenue associated with the expected market upside, even if correctly understood and quantified, appears to be too uncertain and sporadic to be compatible with either the highly leveraged capacity intense wind farm investment, or the contracted supply businesses. This may partly explain why so little consideration has been given to this element to date. A single Fixed Price scheme on the other had would match perfectly the risk profile on the revenues to the capital intensity of the project without the need for discounting any portion of the revenues.

Matching the Desire to Reduce Portfolio Price Volatility of the Consumer: There are large bodies of research that suggest it is more beneficial for electricity systems to achieve their longer run cost of electricity in a way that minimises the volatility of the energy costs from year to year (Doherty et al., 2008). This point may well be self evident but it is particularly pertinent for a small, open and competitive economy like Ireland's. A traditional argument on the inclusion of wind energy in national electricity portfolios is that it is an effective hedge for part of the portfolio against high fuel or electricity market prices. The literature points at the dampening effect wind has on the long term portfolios costs of electricity (Doherty et al., 2008). However, the current REFIT scheme, i.e. allowing REFIT contracted supply businesses to keep the unvalued upside in the market, effectively means that the customer will not benefit from the dampening effect that wind generation can have in a portfolio. In effect, the current REFIT scheme hands over, at the worst possible times from a portfolio risk perspective (i.e. during high price years), market upside revenue to the supply business which may go completely unvalued and may make no contribution to the incentivisation of wind generation.

Alternatively, the single Fixed Price scheme would match perfectly the consumers desire to provide incentives to wind generation and reduce it long-run portfolio price volatility. Just as REFIT payments are made to the wind generation from the Public Service Obligation (PSO) mechanism during times of low prices, revenues would flow to the consumers through the PSO from the wind generation at time of high prices. If a single Fixed Price scheme was to be adopted, consideration would have to be given to the market structure in executing such an instrument, but a CfD type instrument similar to that being discussed in the UK may be appropriate (Pöyry, 2010a). If a renewable project where to receive variable and uncertain prices from a wholesale market structure, the CfD may prove a useful instrument in combination with the wholesale market prices in delivering the financial equivalent of a Fixed Price scheme.

6. Conclusions

This paper has quantified for the first time in the public domain the costs and expected value of the Irish REFIT support scheme for wind generation. While the cost of the REFIT scheme to the electricity consumer appears to be lower than the cost of wind energy support schemes in other countries, significant inefficiencies have been identified in the scheme. All the evidence suggests that the optionality inherent in the scheme is being undervalued in the market, possibly due to the incompatibility of the uncertain and sporadic cash flows with the wind farm and supplier business models. It would seem that the uncertain nature of this part of the support scheme has caused the market to heavily discount the revenues, effectively rendering this part of the support scheme a waste of money. The analysis has shown that a simple Fixed Price support scheme could incentivise a similar amount of wind generation capacity onto the system for approximately half the cost to the end consumer, or alternatively incentivise an increased volume of wind generation capacity onto the system for the same cost as the existing REFIT. Furthermore, the single Fixed Price scheme would provide a simpler more certain support scheme which, if implemented correctly, would lend itself to hedging consumers' inter-year electricity price volatility.

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