

## ECONOMICS OF WIND

### Introduction

This paper sets out a modern economic approach to analysing and evaluating Ireland's electricity market. Its findings are drawn from published economic papers and journals and in particular the work of Shimon Awerbuch one of the World's leading economic advisors on the energy sector. The data is now a little dated (2003) but all the findings still hold.

### Key Economic Impacts on the Irish Electricity Market

Renewables in general and wind in particular have 3 major economic impacts on Ireland's competitive position. These are:

- (1) The importance of wind's competitive position in the generation mix when appropriate discount factors are used in the evaluation
- (2) The value of renewables in terms of a mixed generation portfolio and the impact on security of supply and fuel diversity.

#### **(1) The correct estimation of generating costs for renewables and fossil fuels**

Investment in generating plant, whether it be a CCGT facility or a wind turbine will impact on the resulting prices for the lifetime of those assets; which is at least 25 years. In determining the optimum generation mix it is therefore essential for policy makers to understand the various long term costs per kWh of each generation type.

The methodology used to date to arrive at these costs has been to project annual fuel and operating costs for 25-30 years and then discount them back at some arbitrary rate, often the individual investment company's cost of capital. The use of such arbitrary rates makes comparatives of energy costs from competing generation meaningless. To properly compare electricity costs from each generation type we need to look at each ones individual cost streams. Fundamentally the traditional economic approach fails on two counts: (1) to separately evaluate the various cost streams and (2) to apply the relevant market risk to each stream. It is obvious that an upfront capital cost financed with a fixed rate loan has significantly less risk than a 25 year forward contract for a volatile fossil fuel. Yet traditionally economic analysts in the electricity sector have lumped all cost streams together e.g. fossil fuels and operating costs and discounted them at arbitrary discount factors without regard to the relevant risks. A company's cost of capital has no bearing or relationship with a projected stream of future fuel costs. The need to apply relevant risks to particular income or cost streams was recognised 40 years ago by William Sharpe and John Lintner who developed the Capital Asset Pricing Model (CAPM) and has been used in financial markets to evaluate different investment proposals ever since. While it is an established and tested theory it was not utilised by the electricity sector until recently in evaluating alternative generation projects.

Segmenting cost streams and applying the relevant discount factors to establish a present value allows analysts to compare cost streams with different time shapes. In the electricity sector it allows us to compare the cost of electricity from a wind turbine (which has a large upfront capital cost with relatively small annual maintenance outlays) with gas fired generation (which has a smaller upfront outlay combined with higher annual fuel and maintenance costs). The more accurately the discount rate

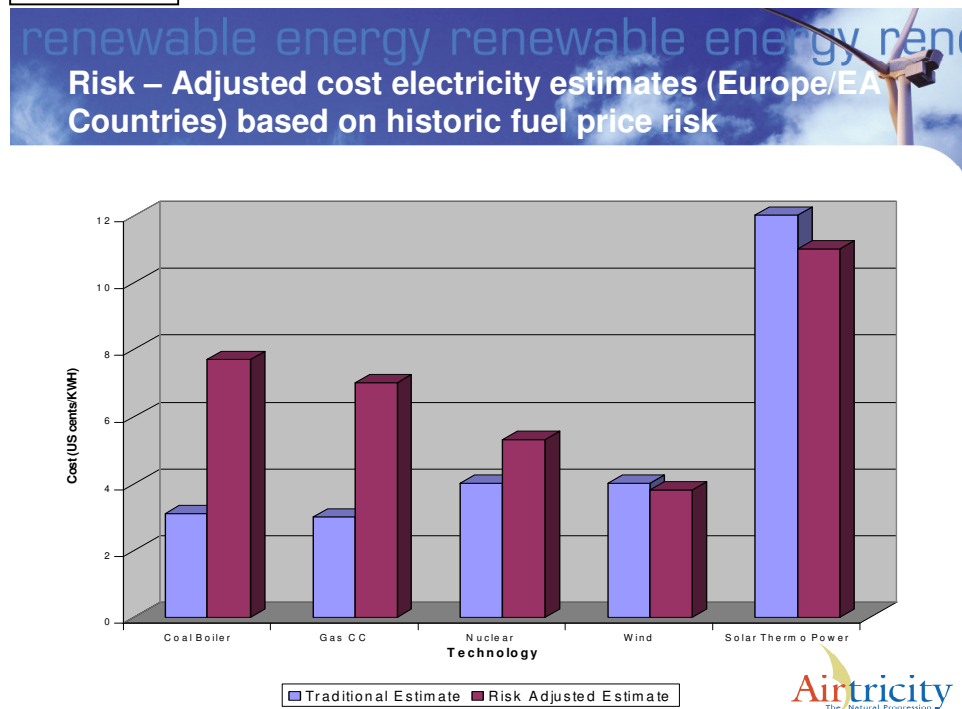
## Appendix 1

reflects the real risk of the relevant cost streams the more accurate is the comparison.

### What is the correct discount rate for future cost streams?

The key issue is that known costs streams have higher discount rates than speculative ones. This principle has to-date been widely ignored by electricity analysts who have traditionally used discount rates of between 5-10% for risky fossil fuel generation. Utilising the CAPM the nominal empirically derived discount rate for fossil fuel costs are in the order of 2-3% (Ref Power Economics May 2003 'The true cost of fossil-fired electricity' Dr Shimon Awerbuch). As a consequence over a 25-30 year life, fossil fuel generation is considerably more costly than had previously been believed. Figure 1. below compares the traditional view of electricity costs by generation type with costs determined by the application of proper discount rates to relevant cost flows i.e. the risk adjusted rate.

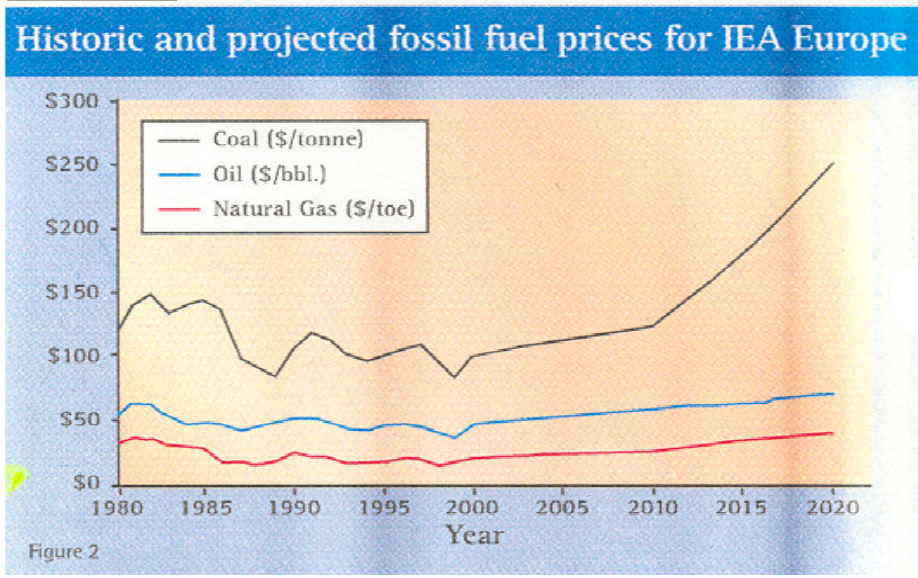
Figure 1.



Using a traditional discount rate of between 5-10% say 7% and using typical projected conversion efficiencies in the range of 55% with an annual capacity of 85% energy planners estimate a levelised generation cost (including maintenance) of €3 per kWh.

Utilising a CAPM and assuming future average fuel prices are as projected in Figure 2 below the cost estimates of CCGT generation would be between €5&7cents. If fuel price volatility over the last 5 years is a good indicator for the next 30 years the best estimates would be closer to a levelised cost of €7cents per kWh.

Appen Figure 2.

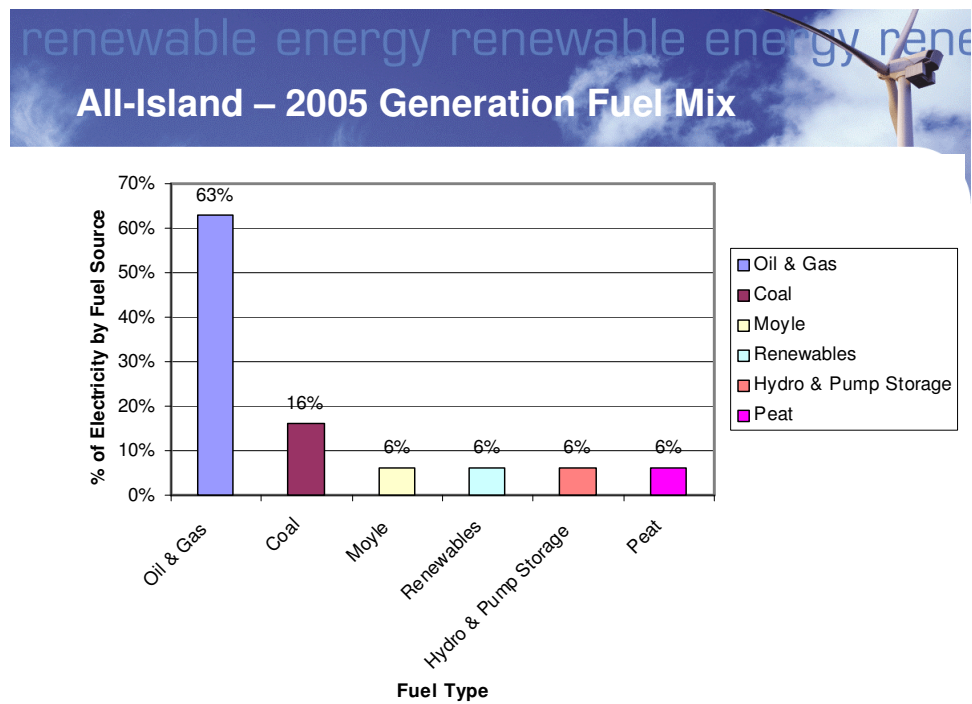


It can be clearly seen that the correct application of risk results in renewables having a much lower levelised cost than the more volatile fossil fuel options including CCGT. This has fundamental implications for policy makers, when considering what their generation mix should look like in 2025.

**(2) The value of Renewables in a mixed generation portfolio.**

The IEA in its 2003 country review recommended Ireland to “develop a clear policy on security of fuel supplies for electricity generation, including diversity of fuels, generation technologies and dual-fuelling, to avoid over dependence on imported gas in the long term.” From Figure 3 below it can be seen that Ireland is moving in the wrong direction.

Figure 3.



## Appendix 1

In 2005 on an all island basis 63% of Ireland's generation capacity is from gas and oil versus an EU average of 24% and Ireland will import 90% of its fuel for energy generation versus an EU average of 50%. The move to gas is continuing despite the IEA warning, the impact on Ireland of oil price volatility and the strong economic logic supporting security of supply reasons to reduce this dependency.

Given that Ireland has chosen not to go down the nuclear route and that large hydro schemes are not possible then it is important for Ireland to significantly increase the percentage of renewables in the generation portfolio as quickly as possible. Investment in renewables displaces additional gas and oil fired generation which reduces their market price and the impact of their volatility.

While recent oil and gas price hikes have brought onshore wind generation costs in line with fossil fuel costs, many people still believe renewable based electricity costs more. They therefore believe increasing wind in the generation mix will cost more. They conclude that when wind at 5cents/kWh is added to a 3-4cent/kWh fossil fuel generating mix overall costs must rise. This view ignores the financial risks created primarily by fuel price volatility. Adding wind to a fossil fuel portfolio may well raise the overall weighted-average cost. However it also produces a second equally important effect: it reduces risk. The two effects will combine to reduce expected generation costs (as illustrated in Figure 4 below). This is the basis of portfolio management.

Figure 4.

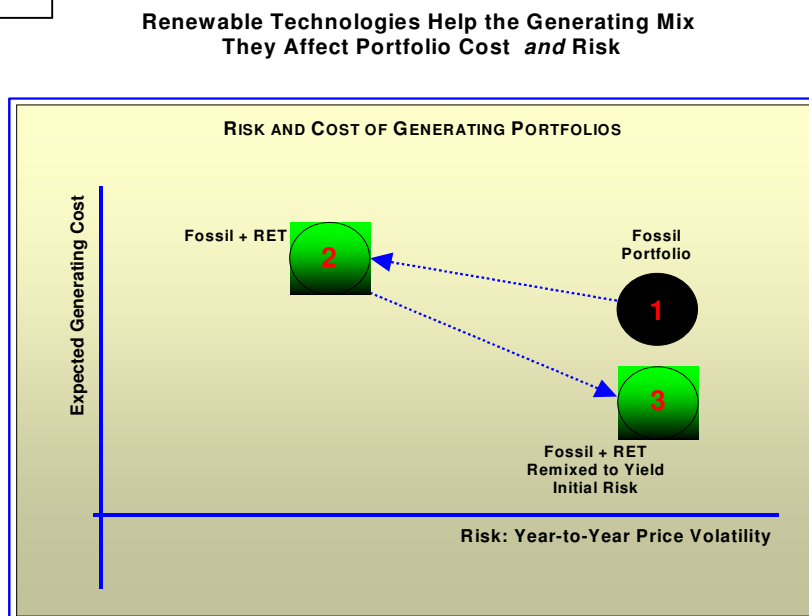


Figure 1: Absent a Risk Dimension: Generating Cost Means Little

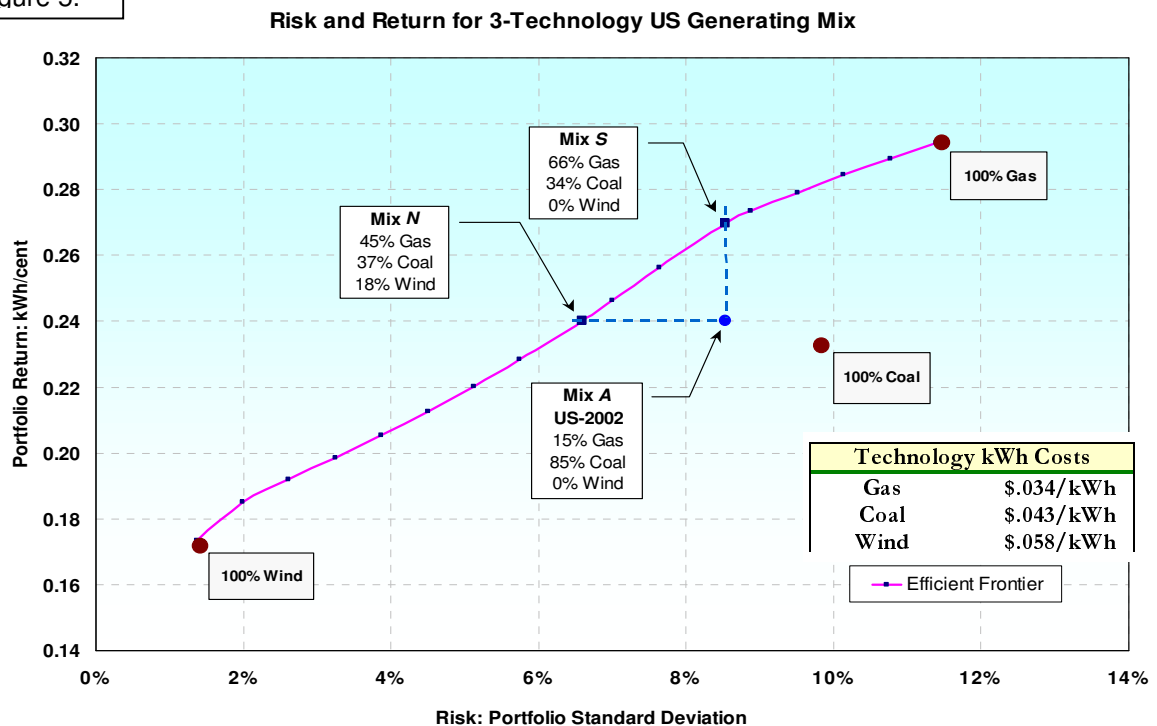
**Greater renewables presence in the generating mix provides an effective hedge against fossil fuel price volatility thereby enhancing energy security while at the same time reducing cost.**

We can clearly illustrate this utilizing a simple model based on the US generating mix in 2002.

## Appendix 1

Figure 5 shows the risk-return for the 2002 US generating mix (Mix A), expressed in terms of coal and gas only (i.e. ignoring nuclear and oil-fired sources).<sup>1</sup> Generating costs, the inverse of *portfolio return*, are given in the box. For example, a 100% wind portfolio has a return of approximately .17 which yields a kWh cost of  $1/.17 = \$0.58$ .

Figure 5.



Source: Awerbuch, Stirling, Jansen and Beurskens, 2004

The US-2002 Mix A lies below the Efficient Frontier (EF), which implies that its cost and risk can be improved over time. For example Mix-N offers the same expected cost as the current US-2002 Mix but with lower risk so that it is more desirable. Mix-N contains 18% wind thus again contradicting widely held notions that adding wind to the US mix increases cost. Mix N demonstrates the key portfolio idea: although wind costs 70% more than gas, it can displace other technologies in the existing US mix in such a manner as to reduce risk without increasing overall generating cost. This “free-lunch,” widely ignored in public and corporate policymaking, is created by the portfolio effect.

**This is a strong economic rationale for policy makers to develop a mix of generation type with a large portion of renewables within the generation portfolio.**

In addition to creating wealth transfers from oil/gas importing to exporting economies, oil/gas price changes effect macroeconomic activity in a number of ways. Oil price increases reduce production output and wages. They induce inflationary tendencies and raise interest rates, thereby reducing aggregate demand. Moreover, it is becoming increasingly clear that in addition to oil price levels, oil price volatility creates uncertainty that reduces wealth and stifles investment. Oil prices changes do not affect all industries uniformly. Given capital and labour inflexibility, oil price changes alter the relative cost of goods and services, which shifts demand and raises unemployment in those sectors most affected.

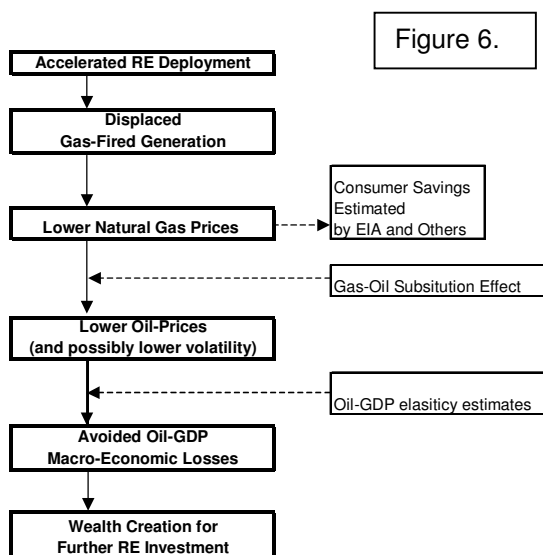
<sup>1</sup> Results of this section are summarized from Awerbuch, Stirling, Jansen and Beurskens, [2004].

## Appendix 1

Monetary policy responses influence the macroeconomic impact of oil prices shocks, and sometimes even worsen them.

A number of studies carried out in the US (Hamilton 1983, Darby 1982, Bruno and Sachs 1982, Tatom 1993) indicate that a 10% increase in oil prices results in a 0.5% decline in GDP. The macroeconomic impacts are global including oil exporting countries such as the UK (Monk, et.al.1994). Recent price movements in oil and their macroeconomic impact have been widely reported in the media and debated among prominent economists like Alan Greenspan (CNN 2004). Government economists now need to re-examine this impact and look at the policy implications for renewable investment.

Price volatility in addition to price increases also impacts economies (Ferderer 1996). Volatility increases uncertainty about future oil prices which leads companies to postpone investments, and disrupts labour markets. Given that investment in renewables can mitigate the economic losses produced by the Oil-GDP effect then it can be argued that investment in renewables could be funded by the economic wealth arising from avoided Oil-GDP losses. This funding model is set out in Figure 6 below:



First, increased Renewables penetration reduces demand for gas, which reduces natural gas prices. A number of studies have recently estimated that this will have a significant impact in the US as part of the American Debate over a national renewable portfolio standard (RPS). Lower gas prices inturn put pressure on oil prices, to the extent that gas and residual oil are substitutes in heating and co firing etc. The downward pressure on oil prices helps avoid GDP losses by mitigating the consequences of the Oil-GDP effect.

Figure 7 shows the impact on GDP on a range of countries due to the doubling of oil prices.

Figure 7.

Table 2: Recently Estimated Oil Price-Shock Effects	
Oil Importers	Oil Exporters

## Appendix 1

Country	GDP Elasticity <sup>a/</sup>	Country	GDP Elasticity <sup>a/</sup>
Taiwan	-8.4%	Indonesia	-4.3%
Hong Kong	-6.5%	Malaysia	-5.6%
Japan	-5.8%	Norway	5.1%
South Korea	-8.7%		
Philippines	-3.6% <sup>b/</sup>		
Singapore	-4.2%		
Thailand	-8.4%		
France	-9.8%		
Germany	-8.1%		
Greece	-2.4%		
U.K.	-3.8%		
<b>Average</b>	<b>-6.3%</b>	<b>Average</b>	<b>-1.6%</b>
a. GDP change for Oil-Price Doubling			
b. Statistically Insignificant			
Source: P. Leiby, Impacts of Oil Supply Disruption in the US; IEA/ASEAN Workshop: Cambodia, April 6, 2004			

Investment in a MW of non-fossil energy technology creates a GDP externality by helping society avoid macroeconomic losses. Investors cannot recoup the full measure of this effect which accrues to all members of society. As a consequence they may under invest in renewables and other non-fossil technologies, a situation that could be remedied with a certificate trading programme, but this would need government direction.

**It is important that policy makers take on board the macroeconomic consequences of fossil price movements on national economies. Empirical evidence on the Oil-GDP effect has been developing over the last 25 years, in some two or three dozen or more studies, conducted in both western and eastern countries by academic and other research organisations, NGOs, as well as multi-lateral entities. This evidence convincingly suggests that rising oil prices and their volatility produce negative macroeconomic consequences including reduced output and employment, increased inflation, and a loss to financial and other assets. The negative Oil-GDP relationship is by now widely accepted. It should now also be recognised that this exposure can be significantly reduced through investment in renewables.**

## Conclusion

**Future fossil fuel price streams are systematically risky. Traditional estimates of fossil fuels ignore this. As a consequence traditional electricity generating cost estimates significantly understate the true economic cost of fossil-based generation. Finance-oriented, risk-adjusted estimates suggest that the cost of gas-fired generation is at least 50% higher than widely believed. Further, the negative beta estimates imply that fossil fuel price spikes have a double whammy effect for consumers. They not only drive up the cost of everything from driving to switching the lights, but they also produce measurable declines in consumers' wealth – higher energy prices eventually lower their incomes and the value of their homes and other assets. Finally, the negative Oil-GDP relationship implies the need for new energy security concepts that stress the design of optimal generating portfolios that avoid needless exposure to fossil price risk.**

## Appendix 1

**Addressing these fundamental issues will not easily happen at the company level. It is only clear government policy based on sound and tested financial theory that will enable Ireland to move to a position of relative competitive advantage in a European context. Given that any infrastructure investment locks a country in for the next 25 years we need a clear energy policy statement sooner rather than later.**