The Irish Energy Tetralemma

Enterprise Opportunities by Primary Fuel

August 2010

Forfás

Table of Contents

Executive Summary

This report supplements the eleven fuel reports and explores the potential enterprise opportunities by primary fuel choice. The enterprise opportunity is incorporated into the Tetralemma Index as an indicator under the competitiveness pillar. Detailed below are the summary messages for enterprise opportunities for each fuel type and the associated scores for each scenario can be found in Appendix A. The enterprise indicator comprises of qualitative and quantative analysis and looks at enterprise opportunities in the domestic market, the export potential and the potential employment, across the three scenarios and three timeframes (2010, 2020 and 2030). The reader should note that the scoring given to each fuel type is relative to the other fuels.

Brown coal

Brown coal is highly unattractive as a contributor to GDP in Ireland under all scenarios to 2030. This is primarily due to the fact that Ireland has no brown coal reserves of its own coupled with the economics of brown coal whereby importing it for power generation is rather uneconomic and significantly inferior to using black coal. This weak position is further reinforced by the negative environmental and climate impact of brown coal.

Black coal

In 2010, black coal provides domestic economic value and employment due to the existing coal-fired capacity at Moneypoint and its supporting supply chain. Due to the lack of indigenous reserves, and as a consequence a lack of necessary skills and technology however, Ireland can capitalise little on the demand for coal in the international market but can exploit some opportunities in construction and plant management. Scores are assumed to be identical under all scenarios in 2010 because there is insufficient time for pathways to diverge (as is the case for all other fuels).

For 2020, the enterprise value is high for all scenarios. This is mainly due to opportunities arising from the advent of carbon capture and storage (CCS) and Ireland's potential to build cleaner coal-fired power plants with CCS in the country, from which indigenous firms can benefit. Furthermore, through domestic CCS demonstration, Irish firms can also gain expertise and develop technology which can be exported. Under the low scenario, it is assumed that Moneypoint power station will be replaced with a similar power plant at the end of its lifetime and there is potential for further coal-fired capacity to be installed. While this will continue to generate turnover and employment from black coal, export opportunities will be limited as conventional coal expertise has already been highly developed elsewhere.

In 2030, for the medium and high scenarios, the opportunities available in CCS will be mature especially in the export market where 2030 is thought to see a number of large-scale projects. Even in the low scenario, black coal scores high on enterprise value in relation to other fuels as Moneypoint's replacement(s) and supply chain will still be used.

Conventional oil

In 2010, conventional oil, as the main and ubiquitous transport fuel has a high enterprise value in all scenarios through the domestic market in terms of both turnover and employment. Export opportunities, however, are fairly limited due to a lack of indigenous supplies and respectively competitive exportable skills.

All three scenarios continue to show the same high scores for enterprise in 2020 because the transport system is still likely to rely heavily on petroleum products. This position is firm in the low scenario, however in the medium and high scenarios, oil's position will be on a par with some renewables. Nevertheless, some marginal value will be lost through the replacement of oil-fired generation with other technology, either renewables (high scenario) or more efficient gas plant (low scenario) or both.

In 2030, economic value will have been reduced for the high and medium scenarios, though only moderately, due to the peaking of conventional oil production and the fact that by this date it is expected that other fuels or energy vectors will be increasingly used for transport - biofuels, electricity and hydrogen. Under the low scenario, however, there will be limited alternatives to oil for transport so it will generate greater enterprise value than most other fuels.

Unconventional oil

Unconventional oil will not be widely available on the international market in 2010, which coupled with the fact that Ireland has no indigenous reserves means that Ireland is not well placed to capitalise on this energy source in the short-term.

This position is set to continue in 2020 for all scenarios.

The scenarios diverge for 2030, with opportunities disappearing under the high scenario, due to stringent policy on carbon emissions. In contrast, for the low scenario, less stringent environmental policy enables firms to capitalise on the opportunities with this fuel, especially using it to replace conventional oil for transport as production of the latter peaks. The medium scenario is positioned between these two extremes.

Natural gas

The development of the Corrib gas field potentially provides high economic value to Ireland in 2010 under all the scenarios assuming it comes on-stream. Export opportunities in combined cycle gas turbine (CCGT) technology are also available for Ireland.

These export opportunities will continue to be present, in all scenarios in 2020. However, in 2020 the Corrib gas field will be nearing depletion so it will be less able to provide turnover and employment. Ireland will continue to import gas from abroad and there will be some infrastructure which can create value for Irish firms for this, e.g. natural gas storage.

By 2030, gas CCS should prove to be increasingly viable as costs of the technology are reduced, meaning that under the high and medium scenarios, economic value could be generated for Ireland. Compared to coal CCS, however, the potential is small. In the low scenario, value is gained for Ireland through the continued use of gas in power generation.

LNG

In 2010, the enterprise value of LNG to Ireland is negligible since Ireland gets the majority of its LNG from the UK, and does not currently have its own infrastructure.

If an LNG terminal is built in Ireland at Shannon, as is assumed under all scenarios, then in 2020 the value of LNG in terms of employment and contribution to the domestic market will be considerably higher.

By 2030, in all scenarios, domestic market and employment opportunities will be high since LNG will be used to make up for the reduced availability of indigenous natural gas. There will still be a high demand for gas as a commodity, especially for transport, under all scenarios, though less so for the high scenario since alternative fuels will increasingly be used, such as electricity or biofuels. Export opportunities, however, will not be large for Ireland, without a resource of its own.

Peat

In 2010, the Irish peat extraction and processing industry provides value from the employment opportunities and turnover to Irish firms. Peat also contributes to value in the power sector as there are currently three peat-fired power stations in Ireland. There are no export opportunities in peat as an energy source since Ireland uses all the peat that is extracted.

It is envisaged that this value is set to decrease dramatically in 2020 under the high scenario as it is thought that the peat fired power stations will have closed (their licenses are due to expire before 2020) and they will not be able to operate due to stringent environmental regulation. Some employment in the peat industry will still exist: approximately 300 small, normally two-man extraction operations are likely to continue supplying households for domestic heating. Under the medium scenario, it is envisaged that at least one of the peat-fired power plants is given an extended license, potentially as a co-fired plant to lessen emissions. The low scenario assumes that either the lifetime of the power stations will be extended or that they will be replaced so that Ireland's peat resource will continue to contribute to the economy. A higher score is given to the export market since Ireland could export technology such as co-firing technology to other peat using countries such as Finland or Estonia.

By 2030, the peat resource in Ireland will have been depleted to such an extent that its enterprise value will be minimal under all scenarios.

Woody biomass

Due to Ireland's relatively high existing uptake of woody biomass in the domestic market, as well as high woody resource, in 2010 it achieves a medium score on all criteria relative to all other fuels. The export market for woody biomass is relatively mature and there is some potential to tap into this, but not in the short-term.

In 2020, woody biomass is expected to have largely penetrated the domestic market in all scenarios, but the indigenous resource is limited, thus offering medium enterprise value compared to all other fuels.

Employment however is expected to be high for woody biomass.

In 2030, the situation largely remains the same, with employment opportunities still high and supply chain issues surrounding the provision of wood for energy have been resolved and a greater level of certainty can be attributed to its supply. However, overall woody biomass scores 'medium' against the other fuels considered.

Woody biomass appears as one of the most stable fuels among those examined as it performs relatively well against all criteria, in all three timescales and in all scenarios.

Non-woody biomass

Non-woody biomass is explored in its application mostly as renewable transport fuels, in 2010 the biofuel market features a relatively high degree of development with EU mandates spurring on government adoption of national targets. This gives non-woody biomass a good enterprise position, but the market size is still rather small and therefore the score is average compared to other fuels.

However, in 2020 for both the high and medium scenarios, biofuels uptake is set to increase substantially both domestically and in the international market. This is prompted not only by the adoption of national mandates in more countries, but also of a high carbon price (making the fossil fuels alternatives more expensive). As a result, in both these scenarios all criteria achieve high scores, bearing in mind that the domestic and international markets will be bringing high enterprise value for Ireland. The low scenario is an exception, whereby the uptake of biofuels is not supported to the same degree and scores remain at their average level.

In 2030, all scenarios see top scores for non-woody biomass, as both the market will have matured by then and either environmental regulation will support the wide update or ever scarcer fossil fuels will make biofuels an attractive option. Ireland has the potential to capitalise on that both in the domestic market and internationally.

This makes non-woody biomass the highest rated form of biomass and one that in reality should have a large market as it has a significant level of policy support which in reality should remain consistent into the future.

Bio-residues

Bio-residues are already used for energy to a large extent in Ireland and internationally. They offer a relatively good enterprise value in the domestic market as volumes are predictable and fairly constant. Due to the relatively small-scale of the resource, however, index scores are average, as other fuels offer greater value in the same context.

Bio-residues achieves scores moderately across all criteria, scenarios and timescales. This is because the uptake of bio-residues can to a large extent be considered independent of commodity prices, support for renewables, and the carbon price as it is a technically mature technology which also has the added advantage of being a suitable solution for waste disposal.

Bio-gas

Bio-gas, which is produced from landfill and sewage gas, is an already established fuel and technology, including in Ireland. This gives it good scores in 2010, but overall scale is limited. Export opportunities are technically rather limited (scoring 'low') as it is a technology that tends to be adopted locally at present.

In 2020, for all three scenarios bio-gas maintains its medium position as its use is not considered to grow or diminish substantially. This is despite the possible decrease in landfill gas (as the size of landfills decrease under new regulation), as sewage gas will still continue to grow at a modest rate and make up for this. The export market will probably pick up as more countries start to adopt bio-gas technologies and there is potential for Ireland to tap into this market and export technical knowledge - which gives rise to the scores against this criterion.

In 2030, the situation is largely unchanged and biogas enjoys a relative good standing although it is not a particularly strong option, mainly because the domestic market is small and international opportunities tend to be captured by established market leaders.

On-shore wind

The onshore wind market in Ireland is performing well at present and is a high value source of energy. Hence in 2010 its scores are high on the domestic dimension. The export opportunities for Ireland, however, are limited with other nations dominating the international market (Denmark, Germany, USA, etc.), leading to average scores. As employment is also at a moderate level, the total score for on-shore wind is overall average. In 2020, uptake is set to increase substantially in Ireland and scores high on both the domestic and employment dimension in the high and medium scenarios. Whilst this is driven by a strong domestic demand, the export market will be fairy constrained, unless Ireland invests is some manufacturing capacity to capitalise on the international demand. In the low scenario, where the uptake of renewables is not supported, onshore wind maintains an average rating overall and the export market score decreases to low.

In 2030, all scores are maintained as for 2020 in all three scenarios, whereby on-shore wind is either a top option compared to other fuels (in the high and medium scenarios) or an average performer in the low scenario.

Off-shore wind

Off-shore wind is still trying to earn a mainstream technology status with only a handful of operational farms (1 in Ireland). Therefore in 2010 this energy source performs poorly against all 3 criteria as it does not generate any substantial enterprise opportunities at present.

However, the situation changes dramatically in 2020 in the high scenario, where due to strong support for renewables offshore wind is seen as a big opportunity for Ireland. Even so, access to international markets will remain moderate for Ireland. In the medium scenario, the assessment is more sober and less favourable as offshore wind will have to compete with both ubiquitous fossil fuels and more established renewables (such as onshore wind). The low scenario for 2020 shows no change against the current rating of offshore wind, which is rather low in enterprise terms.

The trends continue to 2030 where offshore wind is among the strongest options for enterprise in the high scenario, a moderate choice for the medium scenario and fairly unattractive in the low scenario for the same reasons outlined above for 2020.

Off-shore wind has a great deal of potential in Ireland, and unlike other proven renewable technologies, the major barrier to entry is mainly technological. If this is overcome with the right type of incentives, Ireland has every opportunity to become a major world player in this market.

Solar thermal

The solar thermal market in Ireland has had a very low uptake and achieves low index scores. As a result, Ireland is not is a good position to sell to international markets at present (2010) either, and employment is low.

The technology however is mature and relatively cost effective and in 2020 its enterprise rating improves in absolute terms and in relation to other fuels. The domestic market is expected to be strong in the high and medium scenarios and there are good, although moderate, opportunities for Ireland to serve the large international demand (due to strong competition from competitors such as China and southern European countries). Even in the low scenario, solar thermal performs well, with medium scores, against many of the other fuels explored.

In 2030, all scenario trends continue with no change as the same drivers and arguments will still be at play.

Solar PV

Solar PV is a well developed but still excessively expensive technology with some additional supply chain bottlenecks (e.g. silicon). The uptake has therefore been fairly low, except in Germany and China where the costs are subsidised to a large extent. As a result, in 2010, enterprise opportunities for Ireland are low for all criteria in all three scenarios.

In 2020 and 2030 under the low scenario, the rating remains low as the circumstances necessary to encourage the use of solar PV do not occur. However, in the medium and high scenarios, the overall rating increases to medium, as the market grows enough to allow Ireland to leverage its high end manufacturing capabilities in order to enter this part of the supply chain. However, in order for solar PV to be adopted widely in Ireland the costs will still have to be defrayed with strong financial incentives which might not be viable.

In the high scenario there will be a large export market for Solar PV and as a result Ireland scores high on this particular criterion in 2020 and 2030 (although this does not increase the overall score for the fuel). Export scores are high also because it is believed that not only will the potential market be large but that Ireland will be able to capitalise on this significant opportunity.

Wave

Wave (and tidal) energy are both commercially unproven and expensive technology which is why at present it scores low against enterprise opportunities (2010). However, it has to be acknowledged that Ireland has a significant ocean energy resource and is substantially backing efforts to harness this resource currently.

Assuming that this support continues into the future and that the technological advances follow those of wind, then in a world which is conducive to renewables and supports its growth (i.e. the high scenario), wave will perform exceptionally well and grow to form a significant part of the domestic market in Ireland. Furthermore, as the world market for this technology has yet to form, there are minimal barriers to entry and Ireland should be able to become a major exporter. These two factors combined will induce a high level of employment in this sector. As a result, in the high scenario, wave scores 'high' on all three criteria for both 2020 and 2030.

In the medium scenario where conditions do not allow for a mass adoption of this technology, there will be some penetration but not at the same rate as in the high scenario. In this scenario for both 2020 and 2030, wave achieved medium scores overall. Nevertheless, as there is strong national support for developing domestic schemes, the scores against this criterion is high.

In the low scenario for 2020 and 2030, where there is limited support for renewables at home and internationally, it is assumed that wave technology does not have the support systems needed to develop it to a mature stage. As a result, on all dimensions scores are low.

Tidal

As per WAVE (above).

Geothermal

There is some scope for geothermal energy in Ireland but this is unlikely to come online in 2010 which is why it scores low against all criteria. This trend will continue in 2020 and 2030 where support for geothermal will remain limited and therefore the low rating is maintained.

In 2020 and 2030, however, with support for geothermal increasing domestically and internationally, and a potentially significant growth in the US market there will be room for expansion of this sector in Ireland and to serve overseas demand. Therefore, in both the high and medium scenarios geothermal achieves medium scores. In the low scenario, geothermal as most other renewables are not expected to offer any significant enterprise opportunities and the scores are low.

Hydro

With the large-scale hydro schemes already developed and much of the small-scale potential also taped in Ireland, the value of this energy source for the national economy is fairly limited. International markets are also relatively negligible and will not carry much weight now, or in the future. However, availability is managed and increased by way of reservoirs and pumped storage schemes[1]. As a result, hydro achieves low scores on all criteria, scenarios and timescales.

Nuclear fission

The dominant characteristics of the high scenario appear to be consistent with and relatively favourable for nuclear deployment in Ireland. The high carbon price contributes to better comparative economics. The low carbon characteristics of nuclear fit well with other clean fuels. Nuclear also scores well in terms of security of supply, another key characteristic of the high Scenario. From an enterprise perspective, these conditions favour nuclear over fossil fuels but they are also the conditions that favour renewables. The implications include deployment on an earlier rather than later timescale, and the opportunity for later export of goods and services in niche areas to third countries may be possible to a limited extent (fuel element component manufacture for example).

The medium scenario does not appear to have strong enough drivers, such as persistently high carbon prices, to precipitate decisive conditions for nuclear deployment and the enterprise benefits which follow. If nuclear were to deliver benefits in this scenario, it seems more likely to be later rather than earlier and to an extent that is more limited.

The low scenario implies weak carbon prices and poor nuclear economics relative to fossil fuels. It is highly unlikely that nuclear would develop strongly and therefore enterprise prospects would be poor. Under these conditions, the enterprise potential of nuclear would be considerably worse that for fossil fuels and not as good as renewables, which do not require decisions of the same level of national significance to proceed as would be required for nuclear.

1 See www.spiritofireland.org

12.1: Enterprise Opportunities for Fossil Fuels

Coal

12.1.1 Brown coal

Brown coal is highly unattractive as a contributor to GDP in Ireland. As 97 per cent of coal imports are comprised of bituminous or black coal, and Ireland has no brown coal reserves, current enterprise value is minimal. This is unlikely to change in the future through to 2030 as brown coal is only economic when the fuel can be extracted near the power plant.

The lack of prospects for generating value from brown coal will be especially pronounced under the medium and high scenarios since its high sulphur content, along with other chemicals, will prohibit brown coal's use if more stringent environmental policy and regulation is introduced. Furthermore, carbon capture and storage (CCS) is not likely to be economic with brown coal compared to its potential using black coal, as shall be seen below.

12.1.2 Black coal

Value of the domestic market

Ireland imports all of its coal and a result does not generate enterprise value from extraction or processing. However, the combustion of coal at Moneypoint, currently the only coal-fired power station in Ireland, provides Ireland with turnover and employment.

Under the low scenario, where fossil fuels are not highly constrained by policy, it has been assumed that Moneypoint will continue to operate until around 2020, when the plant will be 35 years old, and then replaced with a similar coal-fired power plant, as in the business-as-usual scenario developed by SEI[2]. Under the medium and high scenarios, where this situation would not fit with policy and regulatory requirements, it has been assumed that coal electricity generation will be deployed with CCS.

Opportunities in carbon capture and storage

Under the medium and high scenarios, Moneypoint is replaced with a new, more efficient plant with CCS, as the International Energy Agency (IEA) advises Ireland in its "Ireland 2007 Review"[3]. Given Moneypoint's age, it would not be economic to retrofit it with CCS (The Irish Academy of Engineering, 2009). The new CCS-ready plant would be developed in two stages starting with a smaller demonstration plant, with the main power plant coming on-line once demonstration has proved successful and the emissions trading scheme has covered the full cost of coal, around 2020. The replacement to Moneypoint would be in place until beyond 2030 with a predicted lifespan of 25 years [4]. By 2030, there may be more than one coal CCS power plant as coal will be preferable to gas CCS due to cost and concerns over security of supply.

---

2 SEI, 2009, *Ireland's Low-Carbon Opportunity: An analysis of the costs and benefits of reducing greenhouse gas emissions*

3 International Energy Agency, 2007, *Energy Policies of IEA Countries: Ireland 2007 Review*

4 SEI and Environmental Protection Agency, 2008, *Assessment of the Potential for Geological Storage of Carbon Dioxide for the Island of Ireland*

The replacement would most probably use the Kinsale gas field as a CO_2 storage site (there is a 70 per cent probability that Kinsale is suitable, subject to further geological testing). It has been estimated by SEI that were the Kinsale project to go ahead, costs would be around €2.9 billion for power generation at Moneypoint, CO_2 capture and compression, long distance pipelining and injection and storage at Kinsale.

Other estimates of economic value have been suggested for a range of sites including Moneypoint and Cork. A new 900 MW pulverised coal (PC) plant would have capital costs in the range of €2.5 billion to €2.7 billon and an annual operating cost of €208 million to €399 million[5], which could be captured by Irish firms. For an integrated gasification combined cycle (IGCC) plant using coal gasification, which seems to be preferred option for Ireland in SEI's 2006 CCS study, ranges are slightly lower, with capital costs capital costs of €2.5 billion to €2.7 billion and operating costs €306-€309 million[6].

IEA have also estimated the typical costs per CCS project, which are shown in Table 12.1.

Table 12.1: Required investment in CCS per project under IEA's BLUE map scenario

CCS stage	Investment (USD)
Plant investment	1.4 billion
Transport and storage infrastructure and operating investment	70 million per year

Source: SQW Energy adapted from IEA (2009)

The speedy demonstration of CCS is necessary to ensure first mover advantage, and gain the required learning, expertise and training within Irish firms so that they can compete for the contracts to build a full scale plant and capture as much of the possible economic value. This ability may be limited, however, by shortages that have been identified in Ireland of engineers, for example design and development engineers.

Without demonstration, it may be that other non-Irish firms are better placed to gain contracts if they have gained expertise through the demonstration projects taking place across Europe. An indication that this could happen is signalled by the fact that there are no clear plans for demonstration in Ireland (beyond a government led working group on CCS), whereas demonstration plants are already set to be built in the UK, Germany, the Netherlands, Poland, Spain and Italy, with the help of EU funding. Yet even without an Irish CCS demonstration plant, Irish businesses can capture some of the economic value of a CCS plant in Ireland due to their location.

Export opportunities

Global opportunities in coal production and from electricity production from coal are set to grow significantly in the period to 2030. IEA's World Energy Outlook 2008, for example,

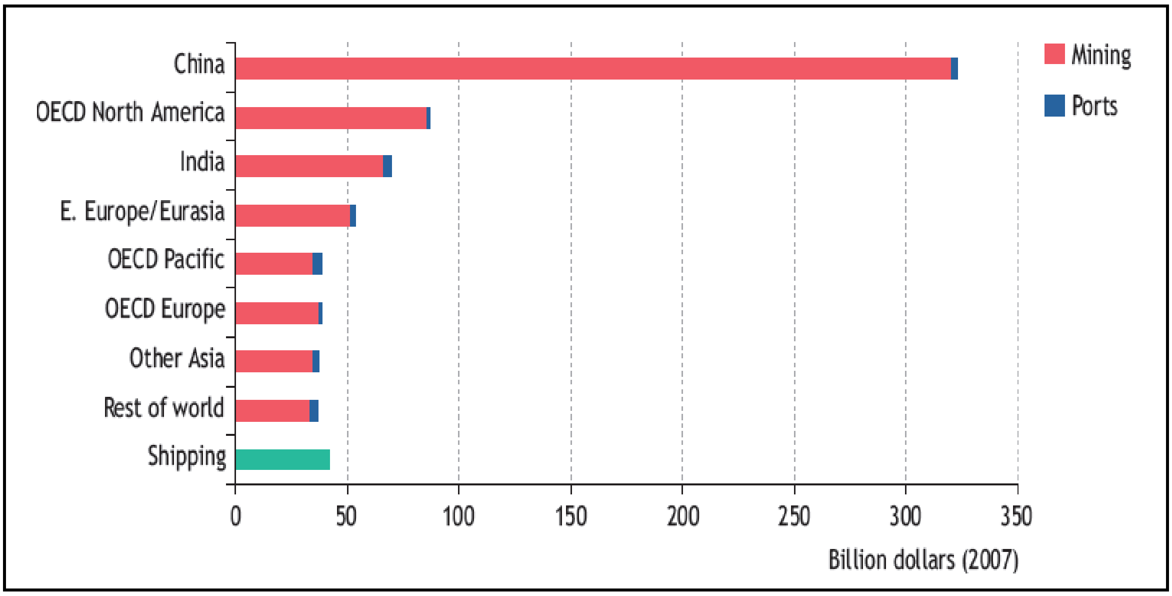
---

5 SEI and Environmental Protection Agency, 2008, *Assessment of the Potential for Geological Storage of Carbon Dioxide for the Island of Ireland*

6 SEI and Environmental Protection Agency, 2008, *Assessment of the Potential for Geological Storage of Carbon Dioxide for the Island of Ireland*

estimates that global demand for coal will increase by 2 per cent each year in that time period. The same report also estimates the required investment in coal infrastructure up to 2030 to be US$728 billion, with a major part to be spent on mining in China[7], as shown in Figure 12.1.

Figure 12.1: Cumulative investment in coal-supply infrastructure by region in IEA's Reference Scenario [8], 2007-2030



Source: IEA, World Energy Outlook, 2008

In terms of coal-fired power plants, additional global opportunities can be found in the new technology which is developing to increase coal's efficiency. It is suggested that supercritical technology will become the norm by 2030 and that there will be a significant increase in the installation of both ultrasupercritical and IGCC technology after 2020[9]. In total, around US$6.8 trillion is projected to be invested in power generation, of which a significant part will comprise of investment in coal. This is due to the forecast that coal will increase its share of power generation from 41 per cent to 44 per cent in 2030[10].

In spite of this immense spend on coal as an energy source, Ireland has a limited chance to claim a sizeable proportion of this opportunity outside of construction and plant and operations management. It will be unable to build on any expertise in mining with no coal resources of its own and, equally, in the power sector, only has experience of Moneypoint which was constructed over 20 years ago. Moneypoint has recently undergone an environmental retrofit and the work was contracted to LURGI, a German chemical and

7 International Energy Agency, 2008b, *World Energy Outlook*

8 IEA's reference scenario takes into account government policies and measures which were enacted or adopted up to mid-2008

9 International Energy Agency, 2008, *World Energy Outlook*

10 International Energy Agency, 2008, *World Energy Outlook*

construction firm, who has expertise in flue gas desulphurisation (FGD) technology, reflecting the fact that indigenous expertise is unlikely to be extensive.

IEA also predicts huge opportunities for global CCS as high as US$125 billion annual investment average from 2010 to 2050[11]. Table 12.2 provides IEA estimates of the cumulative investment required for CCS under their most ambitious scenario where carbon reductions are high.

Table 12.2: Additional investment in for CCS from 2010-2020 under IEA's BLUE map scenario[12]

CCS stage	OEDC Europe (US$ billion)	Total investment (US$ billion)
Capture (power generation only, not upstream capture)	4.8	26.1
Transportation	1.8	14.9
Storage	0.1-0.8	0.8-5.6
Total	6.7-7.4	39.8-44.6

Source: SQW Energy adapted from IEA (2009)

As with making the most for Irish firms of the CCS opportunity within Ireland, to capture a proportion of the considerable international market for CCS, Ireland will have to have demonstrable expertise in CCS, and to close the skills gap which has emerged, for example, in the engineering sector.

Export opportunities may also be restricted by the extent to which the market has developed by 2030, with the IEA claiming that CCS deployment on a large scale will be challenging within that timescale[13].

Employment

General global estimates of employment suggest 0.1 person years per MW for operation and maintenance of coal-fired power plants[14]. Applied to Moneypoint, with a rated capacity of 915 MW, employment equals 91.5 person years. This does not include other employment from transportation, for example.

11 International Energy Agency, 2009, *Technology Roadmap: Carbon Capture and Storage*

12 IEA's BLUE map scenario is their most ambitious scenario, bringing emissions at 50per cent of the 2005 level by 2050, with high rate of technology and policy development, similar conditions to those of the Tetralemma high scenario.

13 International Energy Agency, 2008a, *Energy Technology Perspectives: Scenarios and Strategies to 2050*

14 Institute for Sustainable Futures (no date) *Energy sector jobs to 2030: a global analysis*

12.1.3 Summary of Enterprise Value of Coal

Detailed below is a summary of the enterprise values of coal used in the Tetralemma Index. A red score signifies low potential, yellow medium potential and green for high potential.

Table 12.3: Enterprise results for coal

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				2020				2030			
High scenario												
Brown coal	1	1	1	1	1	1	1	1	1	1	1	1
Black coal	10	1	10	10	10	5	10	10	10	10	10	10
Medium scenario												
Brown coal	1	1	1	1	1	1	1	1	1	1	1	1
Black coal	10	1	10	10	10	5	10	10	10	10	10	10
Low scenario												
Brown coal	1	1	1	1	1	1	1	1	1	1	1	1
Black coal	10	1	10	10	10	1	10	10	10	1	10	10

Source: SQW Energy

Oil

12.1.4 Conventional Oil

Value of the domestic market

Ireland has no indigenous oil production or interconnecting pipeline infrastructure and therefore can expect limited enterprise value in the upstream supply chain. In general, the oil importation and distribution sector in Ireland is relatively small [15].

Ireland does have one refinery, however, at Whitegate, where 40 per cent of Ireland's oil is processed, with the remainder of oil products being refined in the UK. The owners, Tosco Corp. a subsidiary of Phillips, have guaranteed that Whitegate will stay open to at least 2016 (hydrocarbons-technology, 2009). Under all scenarios for Ireland, it is envisaged that another

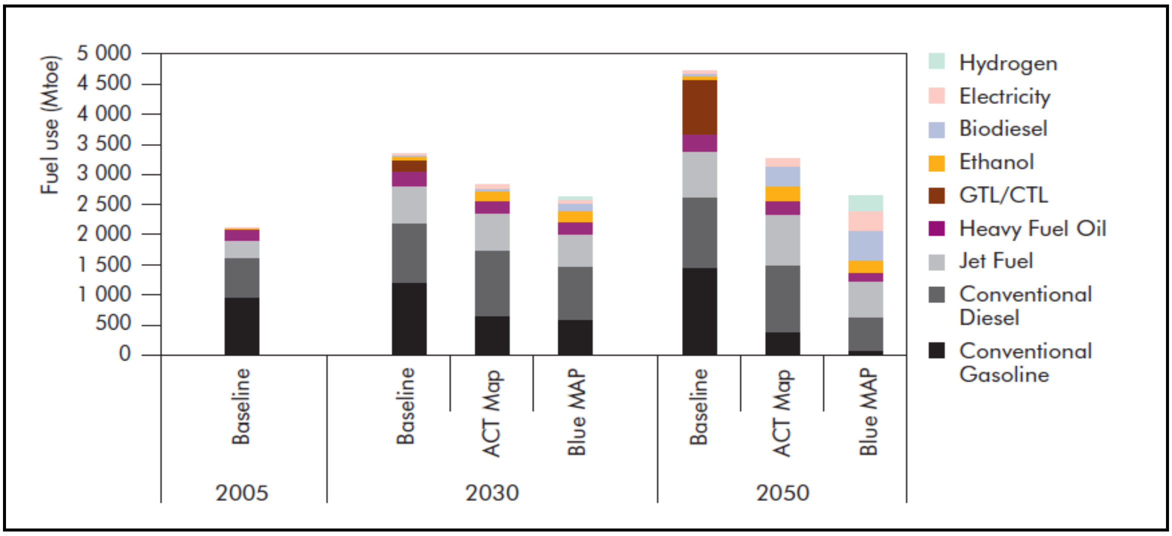
15 Amárach Consulting & Hirsch, R., 2006, *Ireland's Oil Dependence: Trends, Prospects and Options*

refinery will be built to replace Whitegate, and under the low scenario, the new refinery will be constructed to process the oil currently refined in the UK.

In the electricity sector, Ireland currently relies on two oil-fired power plants and two oil and gas fired ones, totalling 2146 MW[16]. Even in SEI's business-as-usual scenario (2009), which corresponds roughly with the low Tetralemma scenario, these will be replaced by combined cycle gas turbines (CCGT) due to concerns over security of supply and peak oil. In SEI's abatement scenario (2009), oil generation is replaced with renewable generation. This is also due in part to projections in oil prices. Oil will average US$100 per barrel (in real 2007 US$) over the period 2008 to 2015, rising to over US$120 in 2030 (US$200 a barrel in nominal terms) according to IEA[17] which will deter investment in oil as a fuel for electricity generation. There is evidence that this is already happening, as even power plants that can continue to run on oil are being converted, for example, Tarbert oil-fired power plant is being converted to gas in 2012. It has also been announced that some oil-fired plants are due to close[18] by 2010.

While demand for oil in the electricity sector will reduce, IEA's global projections show that although other energy sources, such as biofuels, electricity and hydrogen, will increase their share in transport, conventional oil will still be used to fuel the majority of transport up to 2030, even in their high scenario, as shown in Figure 12.2. Ireland can thus continue to generate value from this fuel through transportation of oil and refining for this purpose.

Figure 12.2: IEA's projections of energy use by year and scenario



Source: IEA, World Energy Outlook (2008)

16 Amárach Consulting & Hirsch, R., 2006, *Ireland's Oil Dependence: Trends, Prospects and Options*

17 International Energy Agency, 2008, *World Energy Outlook*

18 Finfacts Ireland, 2007, *ESB to close three power plants*. Available at: http://www.finfacts.com/irelandbusinessnews/publish/article_1010398.shtml

Export opportunities

There are very limited export opportunities for Ireland in conventional oil, as there is no indigenous resource, and the range skills and expertise that could be exported are not being developed in Ireland, compared to countries that have their own reserves.

Employment

Employment opportunities relating to oil as an energy source are already disappearing in Ireland, especially in the power sector.

12.1.5 Unconventional Oil

The limited opportunities for conventional oil contributing to economic value in Ireland also apply to unconventional oil. As with conventional oil, Ireland is not well placed to capitalise on this energy source since it does not have the necessary resource and expertise compared to other countries in order to compete. In the low scenario, to 2030, there will be some opportunities in the transportation, refinement and distribution of unconventional oil, as conventional oil becomes prohibitively expensive for some uses [19]. However, in the high scenario, the use of unconventional oil would be seriously constricted due to the carbon intensive processes involved in its extraction from tar sands and oil shale amongst other sources. This would not fit with the stringent environmental policy assumed in the high scenario and associated economic costs (through a high carbon price).

19 International Energy Agency, 2008b, *World Energy Outlook*

12.1.6 Summary of Enterprise Value of Oil

Outlined below is a summary of the enterprise values for oil used in the Tetralemma index.

Table 12.4: Enterprise results for oil

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				**2020**				**2030**			
High scenario												
Conventional oil	10	1	10	10	10	1	10	10	5	1	5	5
Unconventional oil	5	1	5	5	5	1	5	5	1	1	1	1
Medium scenario												
Conventional oil	10	1	10	10	10	1	10	10	5	1	5	5
Unconventional oil	5	1	5	5	5	1	5	5	5	1	5	5
Low scenario												
Conventional oil	10	1	10	10	10	5	10	10	10	1	10	10
Unconventional oil	5	1	5	5	5	1	5	5	10	1	10	10

Source: SQW Energy

Gas

12.1.7 Natural Gas (pipeline gas)

Value of domestic market

Ireland has become increasingly reliant on gas for electricity production. The country's indigenous reserves, however, are insufficient to support future increase[20], and any increase in imports will generate limited economic value to Ireland.

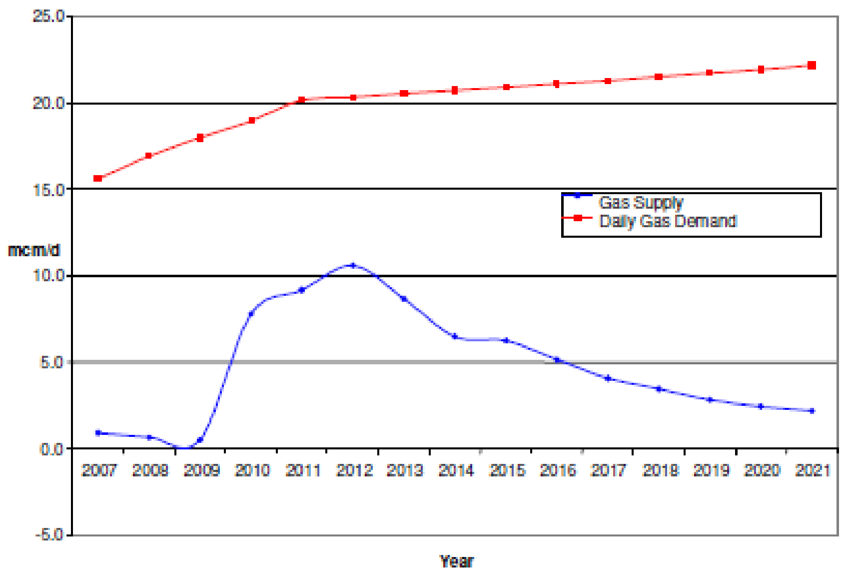
The development of Corrib gas field, could temporarily halt this trend. According to an economic assessment of the site, the Corrib field could create 131 permanent jobs and contribute €3 billion to Irish GDP over its lifecycle of 15-20 years, due to the replacement of

20 International Energy Agency, 2007, *Energy Policies of IEA Countries: Ireland 2007 Review*

imports with local gas production [21]. Around half of Ireland's gas demand for 2010-2020 would then be supplied from indigenous fuel [22].

Other sources are more conservative with the effect of Corrib on economic value. It is thought that three years of high gas production rates (at 10 mcm per day, compared to 1 mcm per day prior to production at Corrib) will be followed by a swift fall in production rates. In general, Corrib's 'contribution to gas demand will be relatively small and short lived'[23] according to a report by DCENR/ DETI.

Figure 12.3: Irish annual gas demand and indigenous supply balance to 2021



Source: DCENR/DETI (2008)

Enhanced gas recovery (EGR) may also be possible in the future [24], although its enterprise value is highly uncertain because no cost estimates are available for offshore EGR [25]. In any case, EGR may take decades or more to mature as a commercial technology.

Gas storage reserves (other than liquefied natural gas)

In addition to liquefied natural gas (LNG), which is discussed in detail further below, construction of other storage facilities has been recommended for Ireland by DCENR/DETI (2008). This has the potential to create further additional economic value for Ireland.

21 Goodbody Economic Consultants, 2007, *Economic Assessment of the Corrib Gas Project*

22 International Energy Agency, 2007, *Energy Policies of IEA Countries: Ireland 2007 Review*

23 DCENR/DETI, 2008, *Study on Common Approach to Natural Gas Storage and Liquefied Natural Gas on an All Island Basis*

24 SEI, 2006, *Carbon Dioxide Capture and Storage in Ireland: Costs, Benefits and Future Potential*

25 SEI, 2006, *Carbon Dioxide Capture and Storage in Ireland: Costs, Benefits and Future Potential*

Carbon capture and storage with gas

Gas-fired power plants equipped with CCS could comprise some of the opportunities outlined in the previous section relating to coal CCS. The capital costs of retrofitting the existing four gas power plants at Cork and connecting these to infrastructure for transportation and storage at Moneypoint are €3.7 billion, with annual operating costs of €399 million, from which indigenous firms can benefit. The higher capital costs compared to coal CCS reflect the fact that there are four different power plants to convert to CCS, and this will translate to greater employment opportunities. However, higher operating costs, which are a result of higher gas commodity prices compared to coal, may prevent Ireland from reaping additional economic benefits if more of the gas demand is met through imports in 2020 and 2030[26].

Export opportunities

Ireland has the opportunity to be an international expert in advanced gas generation technology (new plants and retro-fitting older facilities). Ireland is well placed to export CCGT, given that Irish firms have a long history with this technology. Ireland's Electricity Supply Board (ESB), for example, has formed a consortium with Polish state-owned company, Energa SA, to build a 800 MW gas-fired power plant in Poland by 2015[27], showing that export opportunities currently exist.

Employment

It is estimated that, on average, the gas sector provides 16 person years of employment per MW for construction, installation and manufacture; for operation and maintenance, the figure is 0.05 person years per MW, half the number per MW required for coal[28]. Applied to the current and near future set of power plants using gas, this equates to around 84.5 person years in operations and maintenance[29]. The Whitegate CCGT plant (445 MW), which is due to finish construction in May 2010, would require 7,120 person years for its construction, installation and manufacture in total, using the above benchmarks, though not all will be captured by Ireland's firms. Given that in all scenarios gas is set to increase in the power sector (including replacing oil), in the medium and high scenarios with CCS deployment the employment opportunities are set to increase.

12.1.8 Liquefied Natural Gas (LNG)

Value of the domestic market

Currently, Ireland relies on Great Britain for its LNG with the UK investing circa €15 billion up to 2010 to develop its terminals and associated infrastructure. Ireland could get an all-island LNG terminal itself, if Shannon LNG, a wholly Irish-owned subsidiary of Hess LNG, owned by two US firms, receives the go-ahead to build a €400 million LNG receiving terminal on the

---

26 SEI and Environmental Protection Agency, 2008, *Assessment of the Potential for Geological Storage of Carbon Dioxide for the Island of Ireland*

27 Nasdaq, (29 October 2009), Energa, *Ireland's ESB Plan 800-MW Gas-fired Pwr Plant*. Available at: http://www.nasdaq.com/aspx/stock-market-news-story.aspx?storyid=200910280624dowjonesdjonline000466&title=update-energa-irelands-esb-plan-800-mw-gas-fired-pwr-plant

28 Institute for Sustainable Futures (no date) *Energy sector jobs to 2030: a global analysis*

29 This is assuming 1690MW of gas capacity: Aghada (430MW), Marina (85MW), North Wall (270MW), Poolpeg (460MW) and Whitegate (445MW)

Shannon estuary. When built, this terminal could supply a maximum of 40 per cent of the Irish gas market[30].

According to an economic assessment of the proposed terminal, construction costs would amount to €500 million (in 2007 prices)[31]. This includes €200 million in foreign direct investment, and €300 million on indigenous materials, services and labour. Total impact on Ireland's GDP per annum during the construction phase is estimated at €129 million[32]. The timing of this spend is in doubt, however, since, although construction was due to occur from 2009 to 2013, it had still not commenced, at the time of writing.

The assumed lifespan of the LNG terminal is 30 years or longer (2030 and beyond), with €30 million per annum operation costs and an estimated yearly contribution to GDP including indirect effects of €33 million[33].

Export opportunities

Minimal export opportunities for Ireland are seen to come from LNG, on the basis that exports to Northern Ireland are part of the single All-island market that the Shannon terminal is intended to serve, unless a significant trans-shipment facility was developed.

Employment

An estimate of the indigenous labour spend during the construction of the terminal is €60 million[34].

12.1.9 Summary of Enterprise Value of Gas

Outlined below is a summary of the enterprise value for gas in the Tetralemma Index.

30 DCENR/DETI, 2008, *Study on Common Approach to Natural Gas Storage and Liquefied Natural Gas on an All Island Basis*

31 DKM, 2008, *Shannon LNG – Economic Benefits to the Irish Economy*

32 DKM, 2008, *Shannon LNG – Economic Benefits to the Irish Economy*

33 DKM, 2008, *Shannon LNG – Economic Benefits to the Irish Economy*

34 DKM, 2008, *Shannon LNG – Economic Benefits to the Irish Economy*

Table 12.5: Enterprise results for gas

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				**2020**				**2030**			
High scenario												
Natural Gas	10	5	10	10	5	5	5	5	5	5	5	5
LNG	1	1	1	1	5	1	5	5	10	1	10	10
Medium scenario												
Natural Gas	10	5	10	10	10	5	5	5	10	5	5	5
LNG	1	1	1	1	10	1	5	5	10	1	10	10
Low scenario												
Natural Gas	10	5	10	10	10	5	10	10	10	5	10	10
LNG	1	1	1	1	10	1	5	5	10	1	10	10

Source: SQW Energy

Peat

12.1.10 Peat

Value of domestic market

The latest study to give a value to the peat industry to Europe in general and to Ireland, estimated that the total value of peat sales within the European Union was in the range of €390 million, with Ireland's share as €153 million, the second largest share after Finland[35]. A summary of the enterprise value of peat according to Paappanen et al (2006) is shown in Table 12.6.

35 Paappanen, T., Leinonen, A. and Hillebrand, K., 2006, *Study on the impacts of peat used for energy purposes in the European Union*

Table 12.6: Value of enterprise related to peat as an energy source to Ireland

Year	Value of domestic trade	Export value	Employment
2005[36]	€153 million	0	2,300 man-years

Source: Paappanen et al (2006)

Apart from the peat extraction and processing industry, value is derived from two main sectors:

- Large-scale electricity generation – around 74 per cent of peat use as a fuel
- Residential heating – which comprises the remaining 26 per cent of the market[37]

Ireland has three power plants which primarily use peat as a fuel, with a total capacity of 370 MWe. As Ireland's ability to exploit other indigenous fossil fuels is limited by a lack of resource, peat currently provides substantial value to Ireland, producing 8.5 per cent of the electricity. The licenses for these power stations are due to expire in the next decade, thus the value of peat as an energy source in 2020 and 2030 depends on decisions as to what happens after they expire.[38] There are three main options for future scenarios: firstly, to continue to operate these power plants, to replace them with more efficient peat power plants, and finally, to discontinue with electricity production using peat. The latter case, for example, has been suggested as a likely scenario by Sustainable Energy Ireland[39] in their abatement scenario, in order to respond to curbs in carbon emissions. In contrast, for the business-as-usual scenario, it is assumed that the three power plants will continue to be run, and thus will continue to generate value for Ireland.

An additional option is for co-firing of peat with biomass, which could take off in the medium scenario. For example, the state-owned firm, Bord na Móna, which specialises in peat, has experimented extensively with co-firing using different types and proportions of biomass[40].

In terms of residential demand for heating from peat, research suggests that this is a relatively static market with no major changes predicted at least to 2020[41].

The nearing of peat reserves to depletion may impact on Ireland's ability to increase, let alone maintain, the value of the peat industry, for example, to expand the number of peat-fired power stations, even if environmental considerations are left aside. Peat reserves in

---

36 These are values from 2005, but are still applicable because the Irish peat industry is a static industry (Paapanen *et al*, 2006)

37 Paappanen, T., Leinonen, A. and Hillebrand, K., 2006, *Study on the impacts of peat used for energy purposes in the European Union*

38 West Offaly and Lough Ree both commenced operation in 2005 and have a 15 year life span (ESB Power Generation, no date); Edenderry, which has been operating since 2000, has a license which expires in 2015 (Edenderry Power, 2009)

39 SEI, 2009b, *Ireland's Low-Carbon Opportunity: An analysis of the costs and benefits of reducing greenhouse gas emissions*

40 Bord na Móna, 2009, Bord na Móna – Energy [Website] Available at: http://www.billionm.ie/energy/

41 Paappanen, T., Leinonen, A. and Hillebrand, K., 2006, *Study on the impacts of peat used for energy purposes in the European Union*

Ireland are subject to large measurement variations. While some commentators believe that Ireland's peat resource will continue to be available past 2030, if current extraction rates are maintained, IEA[42] suggests that Irish reserves are expected to last another 15 to 20 years at current production rates, so may not be available in 2030. In any case, as the remaining resource may still have been depleted in under 50 years (45 years according to Paappanen et al (2006) and 30-40 years for Bord na Móna's reserves according to SQW Energy (2009), an expansion in use would reduce longevity further.

Table 12.7 below summarises the level of peat longevity in Ireland expressed as the reserves-to-production ratio.

Table 12.7: Projected peat longevity in 2010, 2020 and 2030 in years remaining

	2010	2020	2030
Peat	20	10	0

Source: IEA and Bord na Móna

In general, given the limited lifespan of peat bogs in Ireland at current extraction rates, it is not envisaged that the domestic market can expand considerably. If there is any change, it would seem more likely to contract as the resource is depleted, with a corresponding impact on employment.

Export opportunities

In 2005, the EU export market was valued at €17.9 million. Ireland's export market, however, is currently minimal. According to SEI[43], Ireland exported just 8 kilotonnes of oil equivalent (ktoe) of peat, in 2007. This equates to approximately 1.4 per cent of total Irish peat production. Paappanen et al (2006) estimate that value of international peat trade to Ireland is zero. The same reasons as to why the domestic peat market would be unlikely to expand apply equally to the export market, namely, this would shorten the lifespan of the peat resource in Ireland.

There may however, be other opportunities remaining, in terms of expertise and advanced technologies to be exported. For example, there are opportunities in increasing efficiencies in extraction, process and for power plants. Ireland could capture the market for more efficient peat power plants if they decide to build new ones once the licenses have expired, and then export the technology. Finland, for example, has 55 peat power plants, and Estonia 40, and these are likely to need replacing, especially in for the low scenario where climate change considerations are not so pressing.

The most likely expertise in extraction and processing of peat to be exported would come from Bord na Móna. This is because Bord na Móna has the advantage of size: with a turnover of €401.6 million in 2008/09, the company supplies 80 per cent of the peat in Ireland for all uses, (they also work in other energy markets apart from peat). Their size means that they have sufficient resources to undertake R,D&D. As mentioned above, Bord na Móna is currently

42 International Energy Agency, 2007, *Energy Policies of IEA Countries: Ireland 2007 Review*

43 SEI and Environmental Protection Agency, 2008, *Assessment of the Potential for Geological Storage of Carbon Dioxide for the Island of Ireland*

experimenting with the co-fuelling of peat with different types of biomass at its peat-fired power plant in Edenderry.

In contrast, the majority of peat producers in Ireland are two-man operations, since this is the manpower required in order to use a hopper to extract the resource. These small contractors would be unlikely to have the capacity for major breakthroughs in extraction and processing technology.

Apart from the potential opportunities from exporting Bord na Móna's expertise, Ireland may not be best placed to capitalise on any advances in technology relating to peat. This is because other countries may be better placed to develop both peat extraction machines and boilers and peat power plants. Finland, for example, had 22 peat machine and boiler manufacturers when a count was last taken, while Ireland had one. Moreover, Finland also has 55 peat-fired power plants, so is likely to already have the necessary in-house expertise for both replacement equipment and new plants. In addition, Finland also has large nation-wide peat producers, from which innovations could potentially come.

Employment

From a total employment in the EU from the peat industry of 12,000-15,000 man-years, Ireland's employment is 2,300 man-years. Out of this, only around 127 people are employed on the electricity production side[44]. Thus most of the value in terms of employment comes from extraction, processing and transportation.

44 Paappanen, T. and Leinonen, A., 2005, *Fuel peat industry in EU, country reports – Finland, Ireland, Sweden, Estonia, Latvia, Lithuania*

12.1.11 Summary of Enterprise Value of Peat

Table 12.8 below summerises the enterprise value for Peat in Tetralemma Index.

Table 12.8: Enterprise results for peat

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				**2020**				**2030**			
High scenario												
Peat	10	1	10	10	1	1	5	1	1	1	1	1
Medium scenario												
Peat	10	1	10	10	5	1	5	5	1	1	1	1
Low scenario												
Peat	10	1	10	10	10	5	10	10	1	1	1	1

Source: SQW Energy

12.2 Enterprise Opportunities for Renewables

12.2.1 Introduction – GVA of renewables in the EU

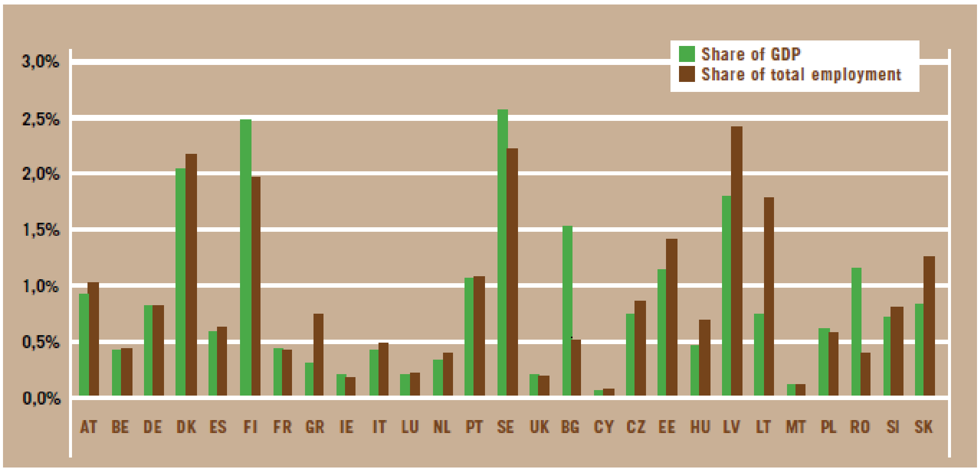
Since 1990 the renewable energy industry has seen substantial growth, mainly due to public promotion policies. The fivefold increase in investment expenditures for new renewable plants to almost €30 billion in 2005 was the main driver for this expansion. In parallel, operational and maintenance expenditures also increased continuously, due to the growing number of plants in operation. Furthermore, European suppliers gained considerable global market shares in booming renewable energy technology fields such as wind and solar PV. Total value added generated by renewables deployment has roughly doubled since 1990. Due to increasing labour productivity, total employment has grown by approximately 40 per cent.

Achieving the 2020 Renewable Energy targets for the EU leads to total gross value added in the renewables sector of about 1.1 per cent of GDP, with €129 billion added to the economy. If no renewable policies are implemented then only 0.19 per cent of total GDP will be added to the economy. In terms of jobs, achieving the 2020 targets will mean an additional 410,000 jobs added net to the EU economy.

This development has led to the establishment of a strong cross-sectoral renewables industry in Europe. It comprises all the activities needed for planning, manufacturing and installing facilities that use renewables, for operating and maintaining them and for supplying them with renewable fuels (where required, such as biomass) – direct economic impact. It is furthermore connected with several industries that form its upstream supply chain - indirect economic impact.

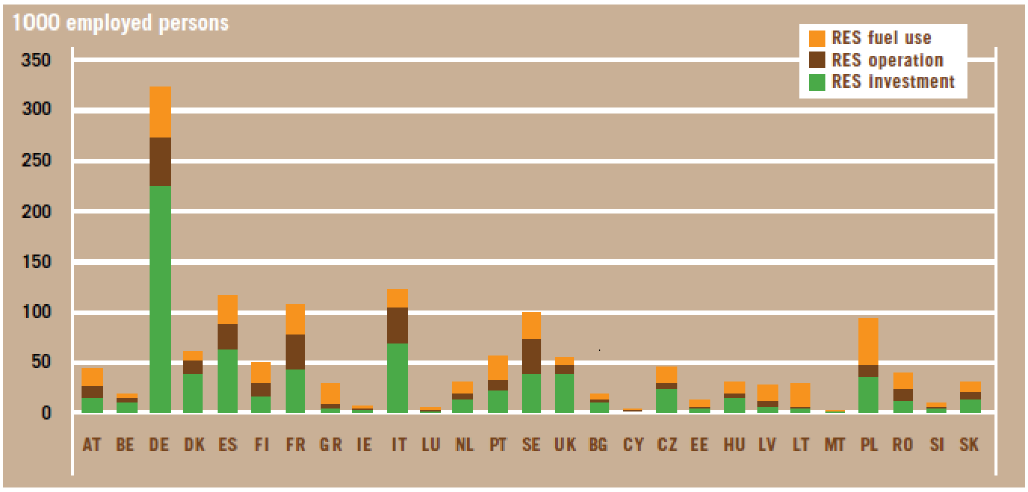
The economic relevance of the renewables industry varies strongly among countries as shown in Figure 12.4 below and mainly reflects the differences regarding deployment level, technology structure and differences in market shares of the renewable energy industries. Shares in GDP and total employment vary from country to country. Ireland has few employees in the renewable energy sector (Figure 12.4), and as such the share of the sector in terms of national GDP is low when compared with other countries.

Figure 12.4: Renewable energy related gross economic and employment impacts in EU member states in 2005



Source: EC Renewables Economic Growth and Employment 2006

Figure 12.5: Gross employment impact of renewable deployment in 2005 by EU member state and renewable expenditure category



Source: Source: EC Renewables Economic Growth and Employment 2006

Biomass

12.2.2 Woody biomass

Value of the domestic market

Table 12.9 shows the potential Irish bioenergy development to 2020. Woody residues is estimated to produce 65 MW of electricity and 603 MWth of heating by 2010. This is expected to grow to 85 MW and 1,440 MWth by 2020.

Table 12.9: Scenario for Bioenergy Development to 2020, Installed Capacity

	Bioenergy Option	Unit	2003	2010	2020
Electricity & CHP	Anaerobic digestion for CHP	MWe	*	15	35
	Dry agricultural residues for CHP	MWe	0	20	50
	Energy crops for CHP	MWe	0	5	75
	Landfill gas	MWe	15	30	40
	Wood residues for CHP	MWe	*	65	85
	Total Electricity & CHP	MWe	15	135	285
Heat	Wood heating	MWth	603	897	1,440
Transport	Liquid biofuels	Million litres per year	0.01	78	107

Source: SEI, 2005

In 2003 Ireland's total annual energy potential of all pulpwood, sawmill residues and harvestable forest residues produced in Ireland was 20.3 PJ, which was estimated at that point to rise to 26 PJ by 2015. In reality the minimum quantities available in 2003 was 3.6 PJ and this was predicted to rise to 9.4 PJ by 2015. The quantity of pulpwood and sawmill residues that would be available for energy production will depend on the price that the energy market can afford to pay[45].

If it's assumed that there is a 50 per cent growth rate per year of wood energy for biomass available then in 8.5 PJ will be available in 2010, 29 PJ in 2020, and 98 PJ in 2030. At a global value rate of US$4/GJ this means that the value of the Irish woody biomass market could reach US$ 393m in 2030.

Export opportunities

Rapidly developing international bio-energy trade may eventually evolve over time into a "commodity market" which can secure supply and demand in a sustainable way. It is clear that on a global scale and over the longer term, large potential biomass production capacity can be found in developing countries and regions such as Latin America, Sub-Saharan Africa and Eastern Europe. If the global bio-energy market is to develop to a size of 400 EJ over this century (which is quite possible given the findings of recent global potential assessments) the value of that market at US$4/GJ (considering pre-treated biomass such as pellets) amounts

45 COFORD, 2003, *Maximising the Potential of Wood Use for Energy Generation in Ireland*

some US$1.6 trillion per year. This is likely to occur over the next century and it is estimated that about a tenth of this value is created every decade. Assuming that half of this can be attributed to the biofuels (non-woody biomass) market, it would mean that about US$80 billion can be attributed to the bioenergy (woody biomass, bio-residue and biogas) market in general by 2020. Furthermore, it is assumed that half of this can be attributed to woody biomass with the rest split between bio-residue and biogas.

The woody biomass market will be a key part of the greater bioenergy market in the future as it not only is a renewable fuel but also has the additional advantage of bolstering rural communities, providing additional income to forest landowners and diversifying local economies.

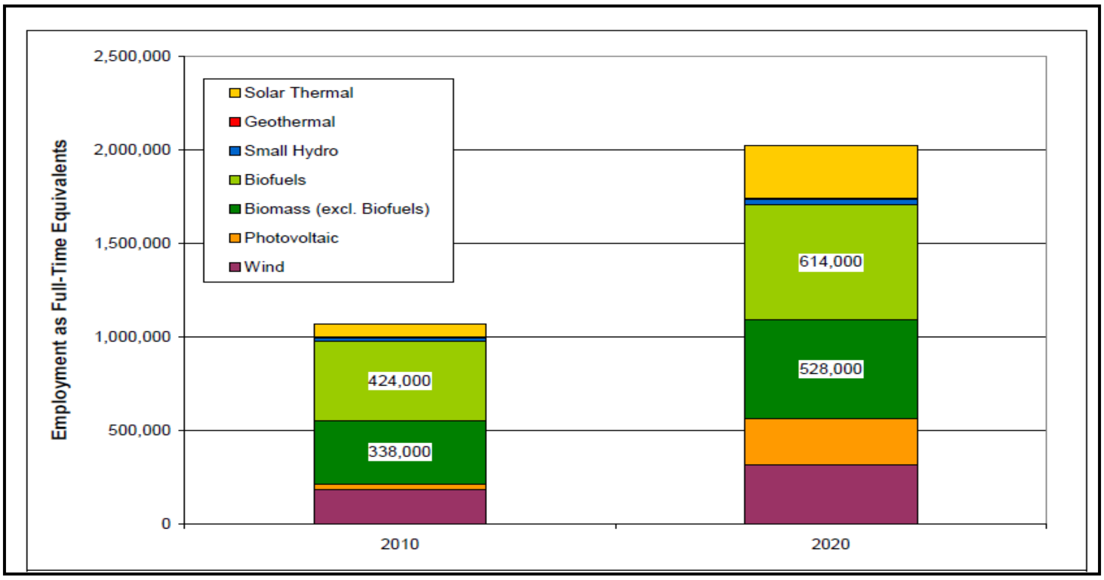
Global trade of woody biomass was just over 11 million tonnes in 2007, up from 5.6 million tonnes in 2003 (included in this category is wood for energy and a smaller share of sawmill bi-products used for the manufacturing of wood panels). The major trade flows have been within the European continent and between Canada and Western European countries. Trade of wood pellets, which account for a large share of biomass trade, reached a record of over 3 million tonnes in 2007[46].

The rapid expansion in global trade of biomass is likely to continue over the next 3-5 years as more countries are favouring renewable energy and local, relatively-inexpensive supplies of biomass are reaching their limits.

Employment

According to an SEI 2005 study, the total number of biomass jobs created in 2010 for the EU 15 will be 338,000 and 528,000 in 2020. No estimate of Ireland's share of this has been provided. Figure 12.6 shows the employment in bioenergy in relation with other renewable energy systems in the EU 15.

Figure 12.6: Projected employment in renewable energy in the former EU 15



Source: SEI, 2005 (figure produced by European Renewable Energy Council 2003)

46 Wood Resource Quarterly, 2007, Press Release available at: http://www.prlog.org/10078176-global-trade-of-woody-biomass-has-almost-doubled-in-five-years.html

The SEI study uses the terms “direct”, “indirect” and “induced” when deducing employment by energy type. In the context of this report, direct employment relates to those working in bioenergy projects (including fuel supply), indirect employment relates to sectors serving the bioenergy projects, and induced employment relates to jobs created by the stimulation of general economic activity. The focus of this report is direct employment.

Total jobs are assumed to increase between 2010 and 2030. Construction and installation (C&I) jobs in the wood heating sector are estimated to be 120 FTE by 2010 but gradually reducing to 75 FTE by 2020 and 25 FTE by 2030. This is in line with the main biomass capacity scenarios for 2020 and the potential saturation of the biomass C&I market beyond 2030. C&I employment is driven by the amount of capital investment in a particular technology in a particular year. It was assumed that new capital investment was distributed evenly over the years to 2010, in order to achieve the 2010 capacity scenario, and was again distributed evenly over the years from 2011 to 2020 to achieve the 2020 capacity scenario. This means that there is a jump to be made from the present situation to the scenario where substantial capital investments are being made every year to 2020. In reality, there will be a more gradual take-off to capital investment, and more peaks and troughs over the timescale to 2020 as individual large projects are built. However, the “smoothed” capital investment assumption made in this study is considered adequate to gain an insight into the possible employment potential of bioenergy. The employment production functions were then applied to the capital investment estimates.

The Operations and maintenance (O&M) employment is driven by the amount of energy produced by a particular technology in a particular year. Linear interpolation was applied to the scenario for bioenergy development to estimate the energy output for each technology to 2020. The production functions were then applied to those energy output estimates.

12.2.3 Non-woody biomass (biofuels)

Value of the domestic market

In 2010, 5.75 per cent of the transport fuels on the Irish market should be of biogenic origin, according to the EU biofuel directive. This ambitious target can be met by a combination of indigenous production of biofuels (first and second generation) and imports [47].

The higher production costs of biofuels compared to diesel and petrol mean that government action is necessary to realise the development of the former. Under the “Pilot Excise Relief Programme” in 2005 the Irish government granted full excise relief to 8 projects producing a total of 8 million litres of biofuels per year over a two year period. The pilot programme has served the purpose of initiating activity on biofuels in Irish transport fuel supply. It has also demonstrated the level of latent interest in biofuels development with many Irish developers wanting to expand into this area.

Based on the experience of the Pilot programme, the Department of Communication, Energy & Natural Resources (DCENR) and the Department of Finance agreed upon an expanded excise relief which was announced in the 2006 Budget. It aimed to deliver 163 million litres of biofuels per year onto the Irish market by 2008 and result in a 2 per cent biofuels penetration. The current production of biofuels is about 8 million litres per year.

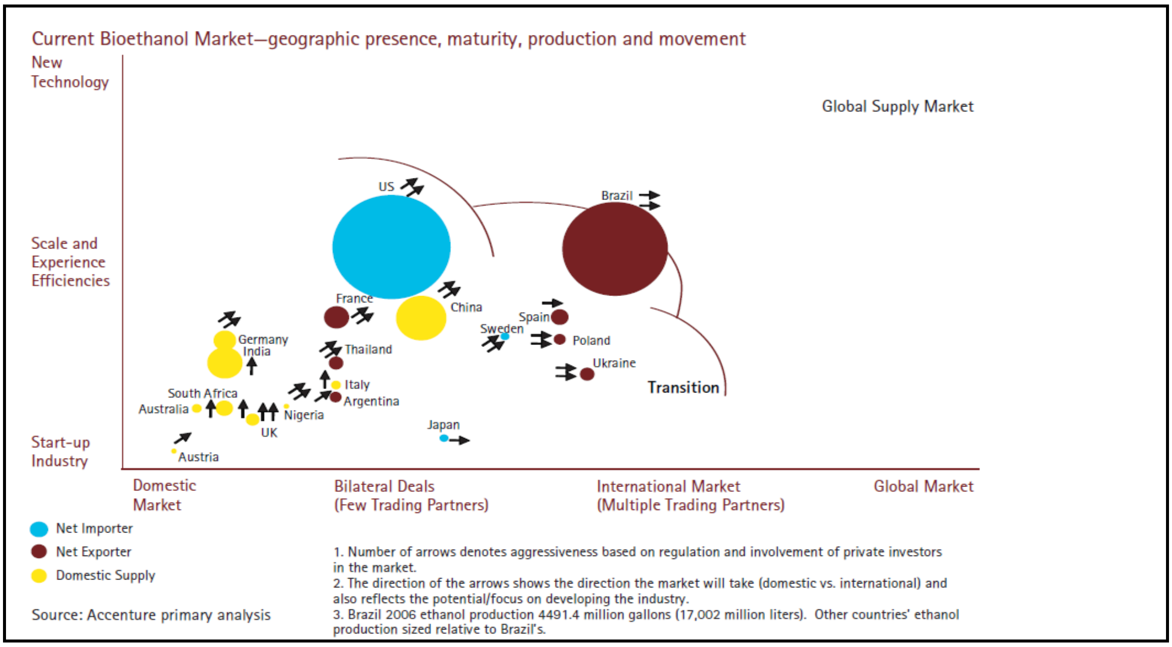
---

47 SEI, 2005, *Policy Incentive Options for Liquid Biofuels Development in Ireland*

Export opportunities

Biofuels (primarily made up of bioethanol and biodiesel) is a fast growing industry. There is already a significant amount of international trade in bioethanol. Brazil exports significant volumes of bioethanol to a number of countries including the US, Japan and the EU. France is exporting bioethanol to Japan and Thailand has targeted countries in Asia for the excess bioethanol capacity it is planning to have. In addition, a number of other countries (including Spain, Poland, Ukraine, Nigeria and Argentina) are producing (or will produce by 2007–2008) bioethanol for export. Figure 12.7 shows this in detail.

Figure 12.7: Current Bioethanol Market



Source: Accenture, 2007

While the bioethanol market is yet to reach a truly global market, the pull toward such a state is being supported by:

- Brazil's exporting of its expertise to help other countries develop their bioethanol industries for domestic consumption as well as export. For example, Brazil is actively assisting Nigeria, Venezuela and Argentina. Some countries, such as Brazil, are also looking at options around strategic storage for ethanol that will enable the country to supply ethanol on a longer-term basis, which would be less subject to price volatility.
- The size of future US demand relative to its current production. If the US does stick to the announced 35 billion gallon target, then it will become a significant net importer. Although the US is investing more on energy technology research than ever before, imports will continue to be used to plug demand/supply gaps. Domestic first-generation and cellulosic ethanol may make up a significant proportion of this bioethanol, but in 10 years, it is unlikely that this kind of scale can be achieved without significant imports.
- China's aggressive bioethanol targets. The country has targets of up to 50 per cent of gasoline consumption in some of its provinces and it is investing significantly in

research to improve the economics. Although it is currently able to meet domestic demand, it is expected to be an importer of bioethanol.

- Although Japan is a big gasoline market (and therefore a big target market for bioethanol), it is unclear whether Japan will invest in the biofuels route in a significant way or invest further in hybrids and fuel cells. Japan's automotive manufacturers are the leaders in hybrid cars and have not invested significantly in flex-fuel models. Today, virtually all the ethanol imports from Brazil and more recently from France are for use in its alcohol and beverage industry.[48]

Biodiesel is currently predominant only in the European fuel market. Unlike bioethanol, biodiesel can be produced from waste cooking oil and by-products of meat rendering, including animal fats and tallow. It is expected that these sources will become more commonplace at the local level because municipalities, businesses and individuals are attracted by the environmental aspects of recycling these by-products and are reaping the dual economic benefits of avoiding disposal costs and displacing standard diesel.

The EU accounts for 90 per cent of global biodiesel generation and more than half of this is produced by Germany, France, Italy, and Austria. Growth in 2007 itself for the market was 25 per cent.

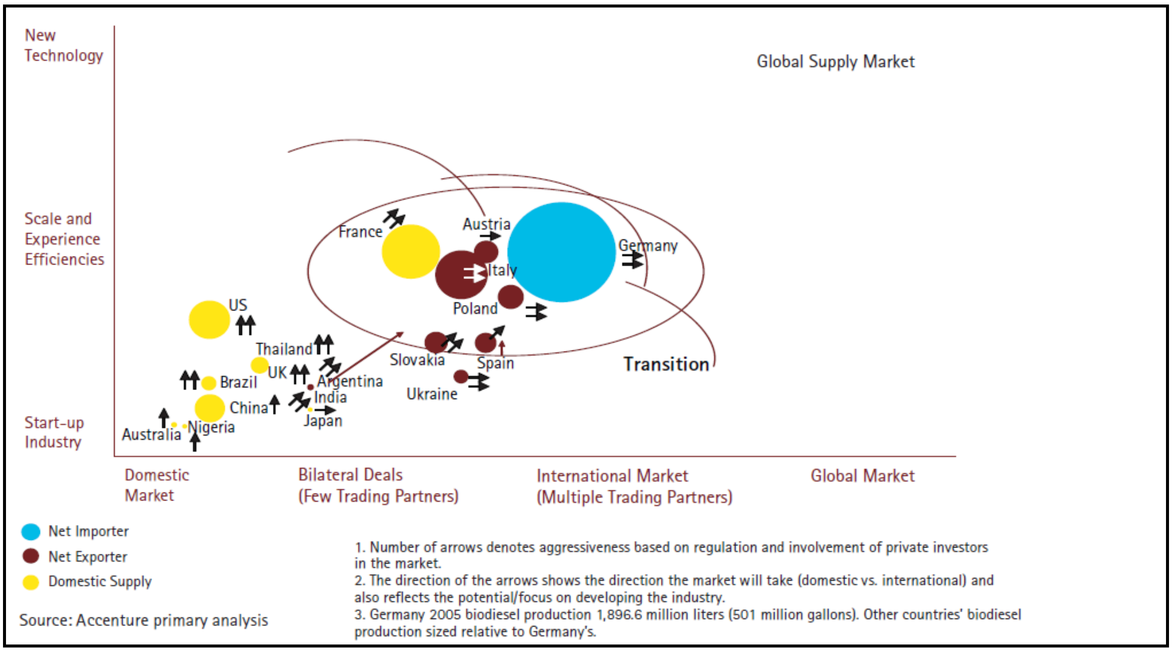
The EU is already establishing a standard for biodiesel based on soy's characteristics in the same way that the EU has developed biodiesel standards based on the characteristics of rapeseed, making it easier to produce, export and import. Soy's costs and energy balance are comparable to rapeseed, and the global soy market is substantial and mature—soy bean constitutes 68 per cent of all major traded oilseed products. Hence, trading soy-based biodiesel might be a way to establish a market quickly.

In "The EU Strategy for Biofuels," there is a clear intent to encourage development of biofuels production in the new member states. Some countries, such as Poland and Spain, which are currently exporting most of their volume, may need to reduce exports as domestic consumption ramps up. Therefore, the EU will continue to pull biodiesel volumes from countries such as Canada (not on chart), Ukraine and, in the future, Argentina.

The current biodiesel market is shown in Figure 12.8.

48 Accenture, 2007, *Irrational Exuberance: An assessment of how the burgeoning biofuels market can enable high performance*

Figure 12.8: Current biodiesel market - geographic presence, maturity, production and movement



Source: Accenture, 2007

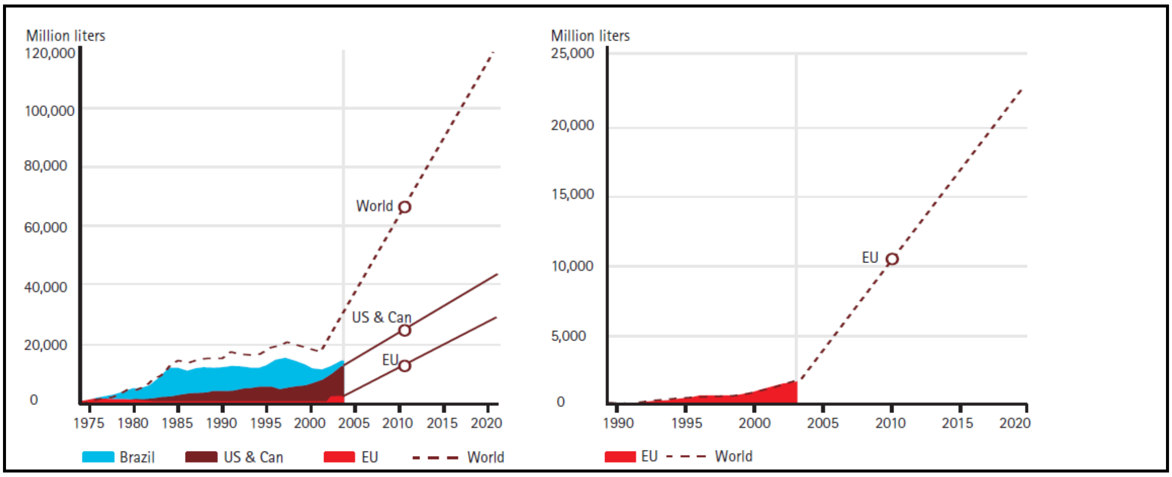
Currently, the market for biofuels is not a true global supply market. Such a market would include the following characteristics:

- Price transparency—that is, product flows to the market where it adds the most value.
- Producers that have a cost advantage in producing biofuels are net exporters.
- Importing countries that may also produce biofuels acknowledge that some proportion of their demand needs to be met with imports.
- Markets exist where many buyers and many sellers spanning multiple geographies can connect and transact. Regardless of the prominence of domestic agendas, there are factors pulling the countries toward a global supply market:
  - Feedstock economics;
  - Ability to import/export;and
  - Advances in technology.
- Impact and affordability of incentives in encouraging the presence of ambitious players (new and international) and in creating a more efficient and competitive market.

Current and Future Growth in the Biofuels Market

As Figure 12.9 shows, the International Energy Association (IEA) is forecasting growth in both ethanol and biodiesel production in the range of three to four times current production.

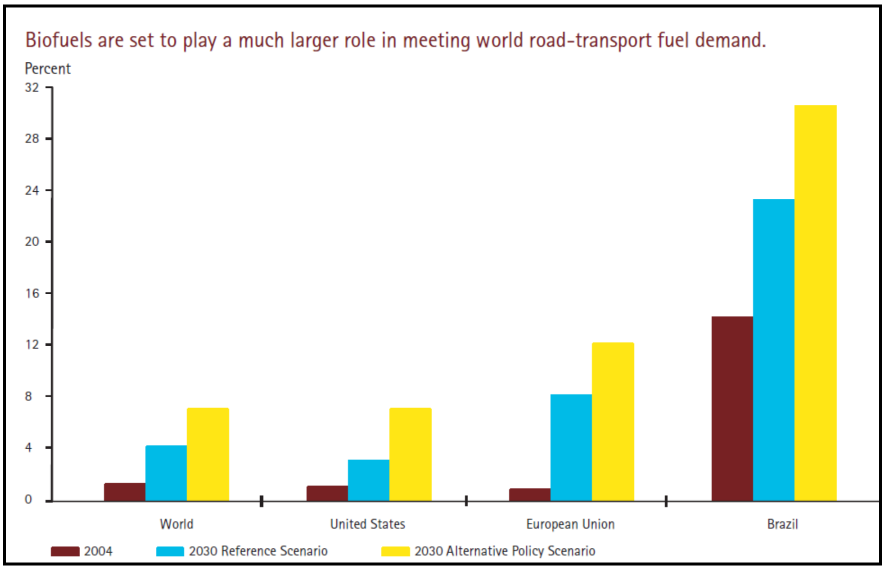
Figure 12.9: Ethanol (left) and biodiesel (right) production projections to 2020



Source: Accenuture, 2007

Today, biofuels make up just over one per cent of road fuel demand worldwide. Even in the most optimistic scenario, it is unlikely that biofuels will make up more than eight per cent of that demand (see Figure 12.10). The upper limit of biofuels' (bioethanol plus biodiesel) share of road-transport fuel consumption, even in the US and the EU, is likely to be between 10 per cent and 15 per cent. But this is still significant growth. In bioethanol terms alone this would require the industry to grow by approximately five times to satisfy 20 per cent of global fuel demand, based on current production levels by 2020.

Figure 12.10: Share of biofuels in road transport fuel consumption



Source: Accenuture, 2007

In 2006, global production of biofuels reached US$25.4 billion and is projected to grow to US$81.1 billion by 2017. A 2008 market study estimated that the total biofuel market was €33 billion with bioethanol accounting for 85 per cent of the global market and biodiesel the rest[49]. As a result of biofuel consumption mandates a market study by Pike estimates that the value of the biofuel market could surpass US$280 billion by[50]. The path to this could be hampered by stock availability, production capacity and infrastructure compatibility.

The first generation bioethanol was made from food crops. However, long-term and sustainable answers to fuel production cannot come from diverting food crops. Again, biotechnology - the 21st century technological breakthrough - is bringing innovative and effective solutions for the development of second generation biofuels. Research is underway to commercialise "second-generation" production techniques that can make biofuels from woody material, grasses, agricultural and some additional types of non food plant waste.

Growing conditions in Ireland are particularly suited to the production of Miscanthus and Willow for 2nd generation biofuels with market entry expected between 2015 and 2020. The synthesis of 3rd generation biofuels from algae is attracting significant investment and could prove a revolutionary technology.

Table 12.10: The Bio fuel Market for Ireland

	Biofuels	Bioethanol (global)	Biodiesel (global)
2010	US$30 billion (interpretation of Forfás,2009) €33 billion Euros (CBDM, 2008)	€28.05 billion (CBDM, 2008)	€4.95 billion (CBDM, 2008)
2020	US$81 billion (Forfas, 2009) US$280 billion (Pike Research, 2008)	(not available)	(not available)
2030	US$270 billion (50 per cent increase on 2020 average above)	(not available)	(not available)

Source: SQW analysis

12.2.4 Bio-residues

Value of the domestic market

According to the SEI, anaerobic digestion and dry agricultural residues for CHP will have a combined installation of 35 MW in 2010 and 85 MW in 2020. As the construction and installation costs/MW is estimated to be €4000,000/MW in 2010 and € 3,333,000/MW in 2020 the value of the industry in Ireland could reach €283 million in 2020. The results are summarised in Table 12.11. The value is assumed to nearly double in line with world market value estimates.

49 CBDM, 2008, *The Market and Business Intelligence Company Reviews*

50 Pike Research, 2008, http://www.pikeresearch.com/research/biofuels-markets-and-technologies

Table 12.11: Scenario for Bioenergy Development to 2020, Installed Capacity

	Bioenergy Option	**Unit**	**2003**	**2010**	**2020**
Electricity & CHP	Anaerobic digestion for CHP	MWe	*	15	35
	Dry agricultural residues for CHP	MWe	0	20	50
	Energy crops for CHP	MWe	0	5	75
	Landfill gas	MWe	15	30	40
	Wood residues for CHP	MWe	*	65	85
	Total Electricity & CHP	MWe	15	135	285
Heat	Wood heating	MWth	603	897	1,440
Transport	Liquid biofuels	Million litres per year	0.01	78	107

Source: SEI, 2005

Value of the export market

The bio-residue export market is expected to be a part of the total bio-energy export market and is assumed to form a quarter of the total market after bio fuels are accounted for reaching US$60 billion by 2030.

Employment

Employment for bio-residue in 2010 in construction and installation is estimated to be 80 FTE and 47 in 2020. The operations and maintenance employment is likely to be 10 FTE for each year.

12.2.5 Bio-gas

Value of the domestic market

A study by SEI assumes that in a Business As Usual scenario for landfill gas approximate 30MW will be installed by 2010 and 40 MW by 2020. However, in a scenario where there is accelerated development with more open and flexible support then 40 MW of landfill gas energy will come online by 2010 and 50 MW by 2020.

According to SEI (2005) the capital costs in 2010 for landfill gas will by €925,000/MW and € 771,000/MW by 2020. The value of the domestic market based on these figures are shown in Table 12.12. This trend is expected to carry on till 2030.

Value of the export market

The bio-gas export market is expected to be a part of the total bio-energy export market and is assumed to form a quarter of the total market after bio fuels are accounted for. Table 12.12 summarises the export potential.

Employment

Employment for landfill gas in 2010 in construction and installation is estimated to be 18 FTE and 3 in 2020. The operations and maintenance employment is likely to be 10 FTE for each year.

Table 12.12: The Bio-gas Market for Ireland

	Bio-gas (Export Opportunity)	Bio-gas Market in Ireland
2010	US$ 20 billion	€28 million (BAU) €37 million (BAU)
2020	US$ 40 billion	€31 million(BAU) €39 million (BAU)
2030	US$ 60 billion	€34 million (BAU) €42 million (BAU)

Source: SQW analysis

12.2.6 Summary of Enterprise Value of Biomass

Outlined below in Table 12.13 are the results used for enterprise opportunities in the Tetralemma index for biomass.

Table 12.13: Enterprise results for biomass

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				2020				2030			
High scenario												
woody biomass	5	5	5	5	5	5	10	5	5	5	10	5
non-woody biomass	5	5	5	5	10	10	10	10	10	10	10	10
bio-residues	5	5	5	5	5	5	5	5	5	5	5	5
bio-gas	5	1	5	5	5	5	5	5	5	5	5	5
Medium scenario												
woody biomass	5	5	5	5	5	5	10	5	5	5	10	5
non-woody biomass	5	5	5	5	10	10	10	10	10	10	10	10
bio-residues	5	5	5	5	5	5	5	5	5	5	5	5
bio-gas	5	1	5	5	5	5	5	5	5	5	5	5
Low scenario												
woody biomass	5	5	5	5	5	5	10	5	5	5	10	5
non-woody biomass	5	5	5	5	5	5	5	5	10	10	10	10
bio-residues	5	5	5	5	5	5	5	5	5	5	5	5
bio-gas	5	1	5	5	5	5	5	5	5	5	5	5

Source: SQW Energy analysis

Wind – onshore and offshore

12.2.7 Onshore Wind

Value of the domestic market

In Ireland wind is set to contribute the majority of the 40 per cent renewables target and could hold as much as a 34 per cent share of total electricity generation into the future. Ireland is well positioned to capitalise on wind energy as it has some of the best wind resources in the world and has an existing expertise base in operating wind farms.

Currently Ireland's total installed capacity is 1,570.1 MW, generated from 124 wind farms in 23 counties[51]. Obstacles for wind in Ireland include:

- At present, a failure to align planning regulations with grid connection timelines is having a significant adverse effect on development. Currently, the standard planning permission granted to a wind farm development typically expires after 5 years. However it can take up to 6 years to process a grid connection application. As a result, many projects are delayed to such an extent that their original planning permission expires. Extensions are generally only awarded to developers who have completed substantial works on their site; however there is no tight legal definition of what "substantial works" means. Developers are unable to commence works until they receive a connection offer and authorisation to construct from the CER.[52]
- Another issue is the delivery of infrastructure. A national plan for the expansion and upgrading of the electricity grid infrastructure is needed if Ireland is to significantly increase the number of wind farms in operation, and take advantage of many wind rich areas which are currently inaccessible in terms of proximity to the grid.
- With regard to support systems, the current renewable energy feed-in-tariff scheme is capped at 1,500 MW, most of which will be taken up by projects which have already received connection offers. Of the 3,000 MW currently being processed for connection offers, it is likely that only a very small percentage will benefit from the scheme unless the cap is removed. Developers in the application process who do not know what support system might be available at the end of the process face considerable uncertainty. For this reason, initial work on a follow-on support scheme for future developments should commence.

Global market

Wind is possibly the most lucrative renewables market for Ireland. A total of 23,851 MW of new power capacity was constructed in the EU in 2008. Out of this, 8,484 MW (36 per cent) was wind power; 6,932 MW (29 per cent) gas; 4,200 MW (18 per cent) PV; 2,495 MW (10 per cent) oil; 762 (3 per cent) MW coal; 473 (2 per cent) MW hydro and 60 MW (0.3 per cent) nuclear power capacity. In other words, wind energy is the leading technology in Europe and the renewable share of new power installations was 57 per cent in 2008. A total of 64,935 MW of installed wind energy capacity was operating in the EU by end 2008, 15 per cent higher than in 2007[53].

---

51 IWEA, 2010, *Wind map of Ireland*, http://www.iwea.com/index.cfm/page/windmap

52 Irish Wind Energy Association, 2009

53 EWEA, 2009

The current market for wind turbines is dominated by Germany, Spain and Denmark. German manufacturers and suppliers hold a leading position in the global competition. According to data from the German Wind Energy Institute (GWEI), in 2007 their share of turbines and components at €6.1 billion amounted to just under 28 per cent of global value creation. In the same year, the export quota of German manufacturers was 83 per cent. For 2008 the industry forecasts value creation in Germany of €7 to €8 billion. This co-responds to at least 25 per cent of global value creation. The German wind industry can also achieve this proportion this year and in the coming years.

For both onshore and offshore, ongoing opportunities will exist in the financing, procurement, project management, delivery and servicing of wind farms in Ireland. While manufacturing of turbines might not be possible in Ireland given the established industrial base, there is scope for business model innovation, supported by project management skills.

Airtricity, SWS and others have shown that it is not necessary to control all elements of the value chain such as the manufacture wind turbines to be internationally successful in wind energy. The innovation in the business model is to provide the service while stripping costs out of the delivery process. While current equipment supply constraints will result in a premium to manufacturers, capacity is increasing and costs will come down. So long as the technology can be bought on the open market, then well financed companies specialising in project management and supply chain logistics with the engineering capacity to deploy turbines will continue to do well.

Export opportunities

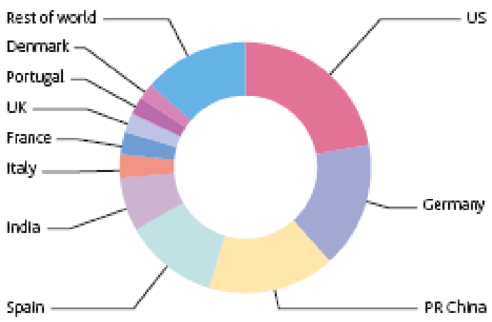
The world market size for wind energy is estimated at €25 billion per annum growing at a rate of 20 per cent per annum. However, as noted this is dominated substantially by the German wind industry.

The wind industry is growing rapidly all around the world. According to data from the GWEI the turnover of the sector in 2007 was at €22.1 billion around 40 per cent above the turnover for the previous year. Industry estimates for 2008 anticipate a turnover of €30 billion. Representing a growth of 37 per cent with an increase in the number of newly installed turbines, particularly in the USA and China. The turnover in new turbine business in America and Asia is now almost at the same level as in Europe.

Figure 12.11 shows total installed capacity and new capacity in 2009.

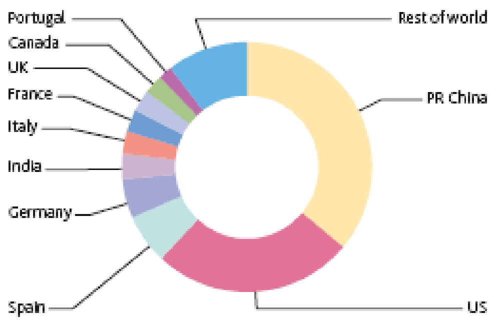
Figure 12.11: Top 10 Total Installed and New Capacity in 2009

TOP 10 CUMULATIVE INSTALLED CAPACITY 2009



	MW	%
US	35,064	22.1
PR China	25,805	16.3
Germany	25,777	16.3
Spain	19,149	12.1
India	10,926	6.9
Italy	4,850	3.1
France	4,492	2.8
UK	4,051	2.6
Portugal	3,535	2.2
Denmark	3,465	2.2
Rest of world	21,391	13.5
Total top 10	137,114	86.5
World total	158,505	100.0

TOP 10 NEW INSTALLED CAPACITY 2009

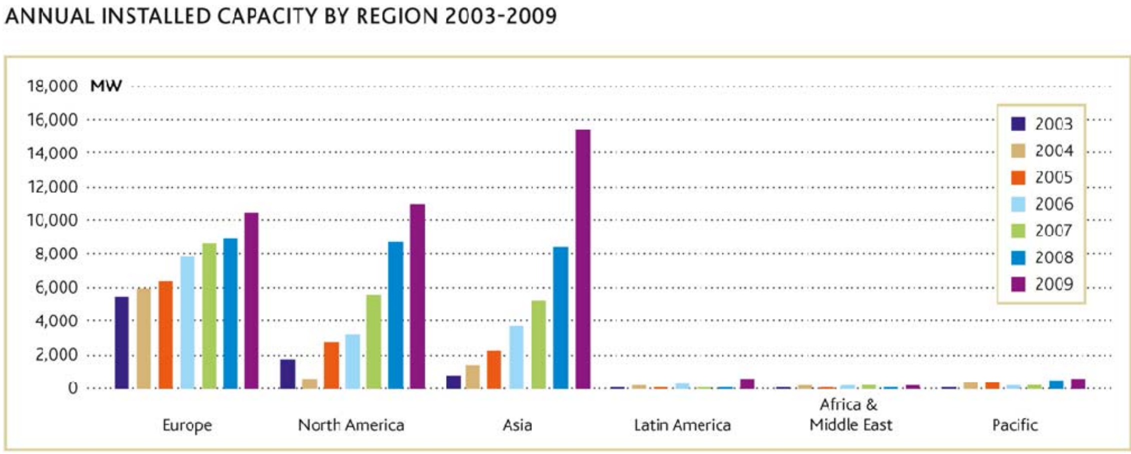


	MW	%
PR China	13,803	36.0
US	9,996	26.1
Spain	2,459	6.4
Germany	1,917	5.0
India	1,271	3.3
Italy	1,114	2.9
France	1,088	2.8
UK	1,077	2.8
Canada	950	2.5
Portugal	673	1.8
Rest of world	3,994	10.4
Total top 10	34,349	89.6
World total	38,343	100.0

Source: Global Wind Energy Council, 2009

According to the forecast of the Global Wind Energy Council (GWEC), Europe will maintain its lead in installed capacity beyond 2012. However, the Council expects the largest market growth in China and the USA: by 2012 the wind power capacity should rise to 61,300 MW in North America and 66,000 MW in Asia – more than triple in less than five years. Wind turbines will then be generating a total of 102,000 MW in Europe and 240,000 MW worldwide. According to current forecasts of the German Wind Energy Institute, by 2012 the market for new turbines will double to over 50,000 MW or around €60 billion. Figure 12.12 below shows total installed capacity by region.

Figure 12.12: Annual Installed Capacity by region 2003-2009



Source: Global Wind Energy Council, 2009

In another study GWEC [54] estimates that the wind industry could be worth €80 billion annually with approximately 1,250 GW of wind power installed. This is an optimistic forecast and is based on the assumption that current planning restrictions do not occur. They base this assumption on this particular renewable resource providing 12 per cent of the world's electricity needs.

A later study by GWEC in 2008 estimates that this figure could be revised up to €90 billion (in a moderate scenario) and could be worth up to €150 billion in an advanced scenario, despite some pressure in the supply chain[55]. Supply chain pressures in the past have included in particular a shortage of gearboxes and the range of bearings used in turbines. The cost of wind turbine generators has fallen significantly overall, and the industry is recognised as having entered the "commercialisation phase", as understood in learning curve theory.

Capital costs per kilowatt of installed capacity are taken as an average of €1,300 in 2007, rising to €1,450 in 2009. They are then assumed to fall steadily from 2010 onwards to about €1,150. From 2020 the scenario assumes a levelling out of costs at around €1,050. All figures are given at 2007 prices in Table 12.14 and Table 12.15 below where these trends are outlined.

---

54 GWEC, 2005, *Wind Force 12*

55 The Reference scenario, which is derived from the International Energy Agency's World Energy Outlook 2007, starts off with an assumed growth rate of 27 per cent for 2008, decreases to 10 per cent by 2010, and then falls to 4 per cent by 2030. By 2035, the growth rate stabilises at 1 per cent.

Under the Moderate wind energy scenario growth rates are expected to be substantially higher than under the Reference version. The assumed cumulative annual growth rate starts at 27 per cent for 2008, decreases to 19 per cent by 2010, continues to fall gradually to 11per cent by 2020 until it reaches 3per cent in 2030 and 1 per cent after 2040.

Under the Advanced wind energy scenario, an even more rapid expansion of the global wind power market is envisaged. The assumed growth rate starts at 27 per cent in 2008, falls to 22 per cent by 2010, then to 12 per cent by 2020 and 5 per cent by 2030. Thereafter, the growth rate will level out at around a 1 per cent annual increase.

Table 12.14: Summary of Global Wind Energy Outlook Scenarios for 2020

Global Scenario	Cumulative wind power capacity (GW)	Electricity output (TWh)	Percentage of world electricity (Energy Efficiency)	Annual installed capacity (GW)	Annual investment (€billion)	Jobs (million)	Annual CO_2 saving (million tonnes)
Reference	352	864	4.1%	24	32.14	0.54	518
Moderate	709	1,740	8.2%	82	89.39	1.30	1,044
Advanced	**1,081**	**2,651**	**12.6%**	**143**	**149.35**	**2.21**	**1,591**

Source: GWEC, 2008

In the Reference scenario the annual value of global investment in wind power equipment increases from €25.8 billion in 2007 to €26.5 billion in 2010, then to €39 billion by 2030 and peaks at €47 billion in 2050 [all figures at €2007 values]. In the Moderate scenario the annual value of global investment in the wind power industry reaches €40.2 billion in 2010, increases to €89.4 billion by 2030 and peaks at €104.4 billion in 2050. In the Advanced scenario the annual value of global investment reaches €50.3 billion in 2010, increases to €149.4 billion by 2020 and peaks at €169.3 billion in 2030. All these figures take into account the value of repowering older turbines.

Table 12.15: Global investment and employment in Energy, 2007-2030

	2007	2008	2009	2010	2015	2020	2030
Reference							
Annual Installation (MW)	19,865	18,016	18,034	18,307	20,887	24,180	30,013
Cost €/KW	1,300	1,350	1,450	1,438	1,376	1,329	1,301
Investment €billion/ year	25,824,500	25,873,673	25,910,012	26,545,447	28,736,673	32,135,267	35,058,575
Employment job-year	329,232	387,368	418,625	424,648	479,888	535,074	634,114
Moderate							
Annual Installation (MW)	19,865	23,871	25,641	28,904	54,023	81,546	84,465

Cost €/KW	1,300	1,350	1,450	1,392	1,170	1,096	1,050
Investment €billion/ year	25,824,500	32,225716	37,179,828	40,220,810	63,182,874	89,390,391	88,658,740
Employment job-year	329,232	397,269	432,363	462,023	882,520	1,296,306	1,486,589
Advanced							
Annual Installation (MW)	19,865	25,509	30,005	36,468	84,160	142,674	165,000
Cost €/KW	1,300	1,350	1,450	1,379	1,112	1,047	1,026
Investment €billion/ year	25,824,500	34,437,535	43,506,723	50,304,975	93,546,253	149,352,592	169,297,423
Employment job-year	329,232	422,545	499,967	572,596	1,340,016	2,214,699	2,810,395

Source: GWEC, 2008

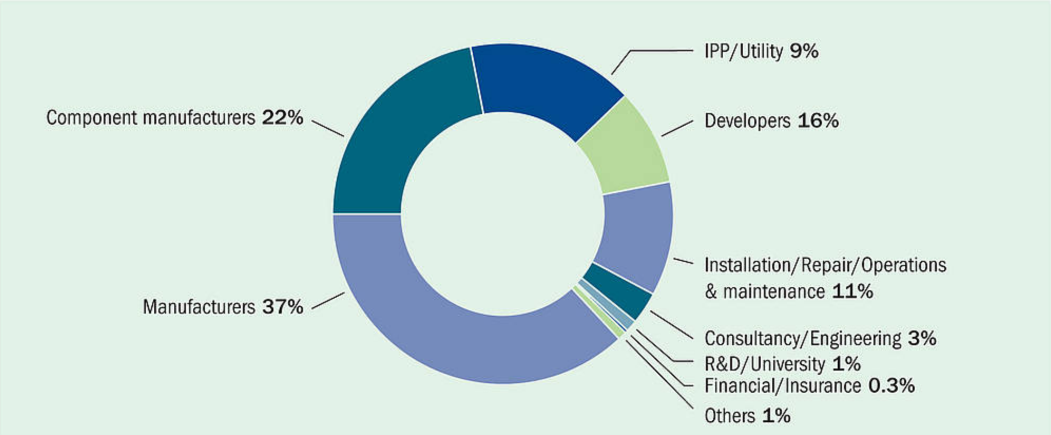
Approximately 75 per cent of the total cost of energy for a wind turbine is related to upfront costs such as the cost of the turbine, foundation and electrical equipment grid-connection. Thus a wind turbine is capital-intensive compared to conventional fossil fuel fired technologies such as a natural gas power plant, where as much as 40-70 per cent of costs are related to fuel and O&M.

Ireland, as noted previously, does not have the capability to manufacture wind turbines which means that the real value added to the economy will come from spend in operations and maintenance which accounts for approximately 25 per cent of lifetime costs. Furthermore, the market in manufacture and installation of turbines has to a large extent been captured by front runners Germany and Spain and in the future will also be competitive with China, India and the US increasing production and as manufacturing costs decrease.

Employment

Most of the jobs generated by wind are in wind turbine and component manufacturers as illustrated by Figure 12.13 below.

Figure 12.13: Wind Sector Employment, 2007



Source: EWEA, Wind Employment, 2007

Table 12.16 below shows the number of direct jobs in the wind industry by country in 2007. In 2009 Ireland had 1,500 jobs. Statistics show that 15.1 jobs are created in the EU for every MW installed and 0.4 jobs are created per MW of cumulative capacity in operations and maintenance and other activities.

Table 12.16: Number of direct jobs in the wind industry (2007)

Country	No. of direct jobs
Austria	700
Belgium	2,000
Bulgaria	100
Czech Republic	100
Denmark	23,500
Finland	800
France	7,000
Germany	38,000
Greece	1,800
Hungary	100
Ireland	1,500[56]

56 Irelands 2009 Wind Energy employment

Italy	2,500
Netherlands	2,000
Poland	800
Portugal	800
Spain	20,500
Sweden	2,000
United Kingdom	4,000
Rest of EU	400
Total	**108,600**

Source: EWEA, 2008

Table 12.17 outlines the total global and local potential market of wind and then estimates that the operations and maintenance value of this and could be a market that Ireland could tap into if they developed significant expertise in this particular area. In order to calculate the local value of the wind industry, it is assumed that by 2010 there will be 1,500 MW of installed wind industry (a minor increase on the current level), and then a doubling every decade. This means that by 2020 there will be 3,000 MW and by 2030 there will be 6,000 MW.

It is assumed that the value creation for Ireland, per MW will be equivalent as at a global level. In order to calculate the value per MW for each time period, the installation and global values in Figure 12.14 are applied.

Table 12.17: The Onshore Wind Market value for Ireland

	Global Wind (value)	**Global Wind (O &M - 75%)**	**Irish O & M**	**Irish Employment**
2010	€30 billion (Forfás, 2009 growth rate of 20%) €43.2 billion (GWEC, 2005 growth rate of 25%) €27 billion (GWEC, 2008, Reference Scenario) €40 billion (GWEC, 2008, Moderate Scenario) €50 billion (GWEC, 2008, Advanced Scenario)	€7.5 billion (Forfas,2009) 10.8 billion Euros (GWEC, 2005)	€1.7 billion (SQW analysis based on GWEC forecasts)	2,000 (EWEA, 2008)

2020	€80 billion (GWEC, 2005) €32 billion (GWEC, 2008, Reference Scenario) €90 billion (GWEC, 2008, Moderate Scenario) 150 billion (GWEC, 2008, Advanced Scenario)	€20 billion (GWEC, 2005)	€2.4 billion (SQW analysis based on GWEC forecasts)	(not available)
2030	€40 billion (GWEC, 2008, Reference Scenario) €29 billion (GWEC, 2008, Moderate Scenario) €170 billion (GWEC, 2008, Advanced Scenario)	(not available)	5.9 billion (SQW analysis based on GWEC forecasts)	(not available)

Source: SQW analysis

12.2.8 Offshore Wind

Offshore Industry in Ireland

The first offshore wind farm (Arklow, co-developed by Airtricity and GE Energy) opened in 2004 with a rated output of 25 MW. Arklow is currently operated by GE Energy as a demonstration platform for their 3.6 MW offshore turbines[57]. However, according to the Airtricity website, Phase II of the project is on hold due to changes in the Irish electricity market; with the expansion of the REFIT scheme they are deciding how best to take the project forward[58].

At present there are 5 companies actively involved in developing offshore wind energy projects in Ireland; these are Airtricity, Oriel Windfarm, Eco Wind, Saorgus and Fuinneamh Sceirde Teoranta. Eco Wind have full consent for a project at Codling Bank, the other companies have projects at various stages in the permitting process. It is estimated that the total capacity of these sites will eventually supply up to 2,000 MW of additional energy into the national grid[59].

It is the view of the IEA that the current focus of market interest in Ireland is for onshore wind generation. The government has decided that onshore wind requires priority attention since it provides a lower cost solution than offshore wind development[60].

57 General Electric, 2004

58 Airtricity, 2008

59 National Offshore Wind Association of Ireland, 2008

60 International Energy Agency, 2007, *Energy Policies of IEA Countries: Ireland 2007 Review*

Export Potential for Offshore Wind

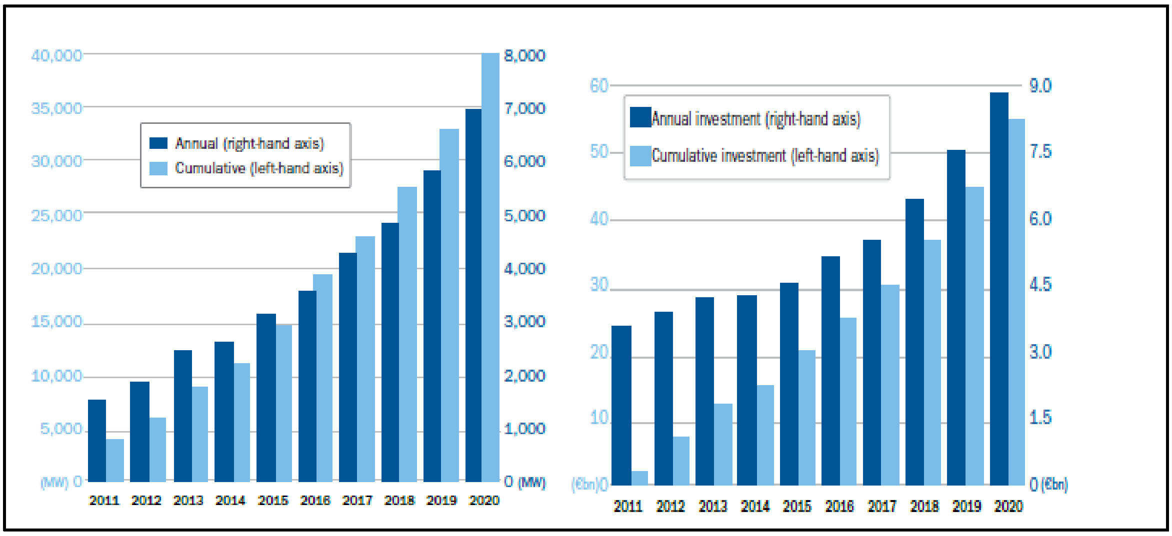
Compared to onshore wind energy, the offshore sector is still in its infancy. In 2009 the first wind farms of the new 5 megawatt class will be built in Germany. Besides the turbines of the 2-4 megawatt class, in future turbines of 5-6 megawatt will also be deployed in the leading offshore market of Great Britain and other markets.

The latest study by the EWEA in 2009 examining the state of offshore now and in the future states that offshore wind power's economically competitive potential in 2020 is 2,600 TWh, equal to between 60 per cent and 70 per cent of projected electricity demand, rising to 3,400 TWh in 2030, equal to 80 per cent of the projected EU electricity demand. The EWEA estimates the technical potential of offshore wind in 2020 at 25,000 TWh, between six and seven times greater than projected electricity demand, rising to 30,000 TWh in 2030, seven times greater than projected electricity demand.

Between 2011 and 2020, EWEA expects the annual offshore market for wind turbines to grow steadily from 1.5 GW in 2011 to reach 6.9 GW in 2020 (See Figure 12.14). Throughout this period, the market for onshore wind turbines will exceed the offshore market in the EU.

Annual investments in offshore wind power are expected to increase from €3.3 billion in 2011 to €8.81 billion in 2020.

Figure 12.14: (left) Offshore wind energy annual and cumulative installations 2011-2020 (MW); (right) Annual and cumulative investments in offshore wind power 2011-2020 (€billion 2005)

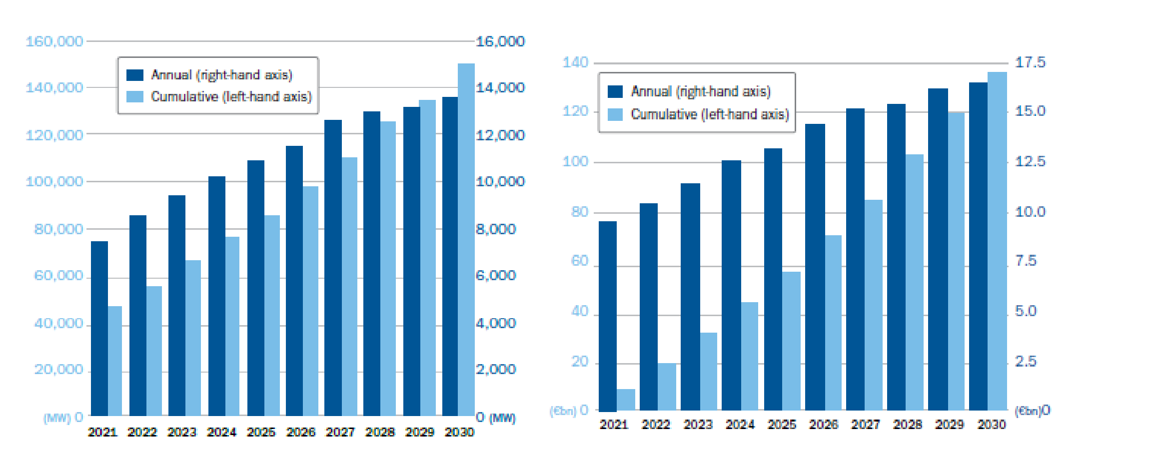


Source: EWEA, 2009

Between 2021 and 2030, the annual offshore market for wind turbines will grow steadily from 7.7 GW in 2021 to reach 13.6 GW in 2030. In 2027, the market for offshore wind turbines for the first time is expected to exceed the onshore market in the EU.

Annual investments in offshore wind power are expected to increase from €9.8 billion in 2021 to €16.5 billion in 2030.

Figure 12.15: (left) Offshore wind energy annual and cumulative installations 2011-2030 (MW); (right) Annual and cumulative investments in offshore wind power 2011-2030 (€billion 2005)



Source: EWEA, 2009

Table 12.18 summarises the results for onshore wind market potential.

Table 12.18: Offshore Market Potential

	European Market (Annual Investments)
2010	3.3 billion Euros (EWEA, 2009)
2020	8.81 billion Euros (EWEA, 2009)
2030	16.5 billion Euros (EWEA, 2009)

Source: SQW analysis

12.2.9 Summary of Enterprise Value of Wind

Outlined below in Table 12.19 are the results used for enterprise opportunities in the Tetralemma index for wind.

Table 12.19: Enterprise results for biomass

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				**2020**				**2030**			
High scenario												
On-shore wind	10	5	5	5	10	5	10	10	10	5	5	5
Off-shore wind	1	1	1	1	10	5	10	10	10	5	10	10
Medium scenario												
On-shore wind	10	5	10	10	10	5	5	5	10	5	5	5
Off-shore wind	1	1	1	1	5	5	5	5	5	5	5	5
Low scenario												
On-shore wind	10	5	5	5	5	1	5	5	5	1	5	5
Off-shore wind	1	1	1		1	1	1	1	1	1	1	1

Source: SQW Energy analysis

Solar

12.2.10 Solar thermal

Value of Domestic Market in Ireland

In 2008 Ireland had 52,080 kWth of operating solar thermal capacity and according to European Solar Thermal Industry Federation (ESTIF)[61] had grown by 191 per cent on the previous year. We will assume that in the high scenario this will grow by another 200 per cent a year by 2020, and then by another 200 per cent a year by 2030 which will give mean that there will be 1,040,000 kWth in 2020 and 20,800,000 kWth in 2030. Based on the assumption that the costs per kWth are €320/KWth the resulting Irish market values for the three time periods are given in Table 12.20.

61 ESTIF, 2008, *Solar Thermal Markets in Europe*

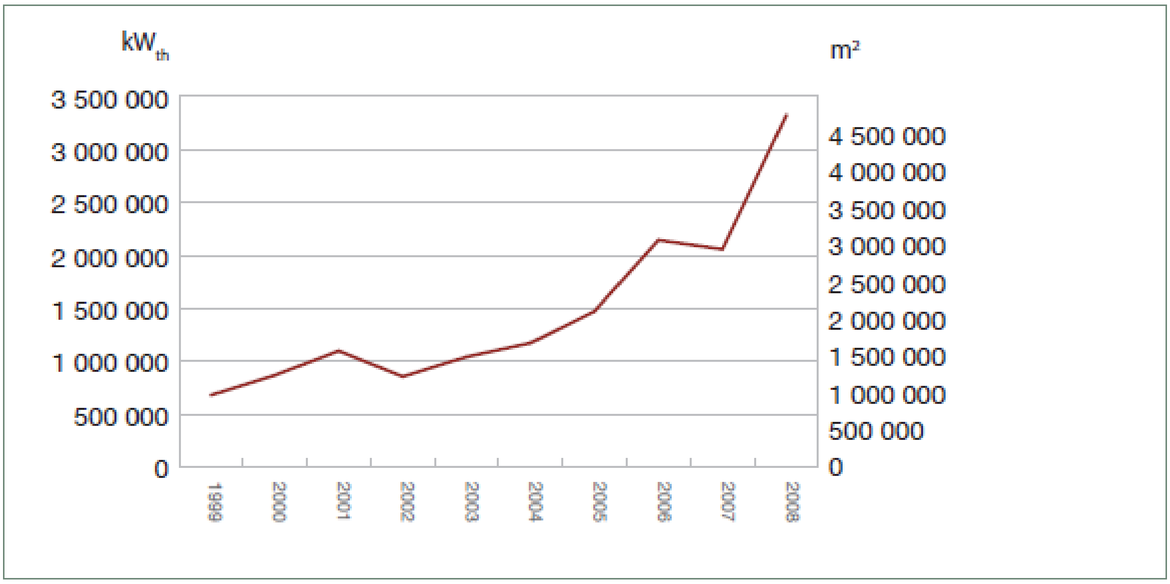
Export Potential

The solar thermal market in the EU and Switzerland showed a strong performance in 2008: It grew by 60 per cent to 3.3 GWth of new capacity (4.75 million m^2 of collector area), see Figure 12.16. While the biggest push clearly came from the German market which more than doubled, demand for solar thermal technology grew strongly also in smaller markets.

With 2.1 million m^2 of newly installed capacity, the German domestic market increased its share of the European market (EU27 + Switzerland) to 44 per cent in 2008. Spain, Italy and France overtook Greece, which was in second position in 2007. Together, these six countries currently account for 84 per cent of Europe's solar thermal market (for comparison – these countries account for only 54 per cent of Europe's population and 61 per cent of its GDP).

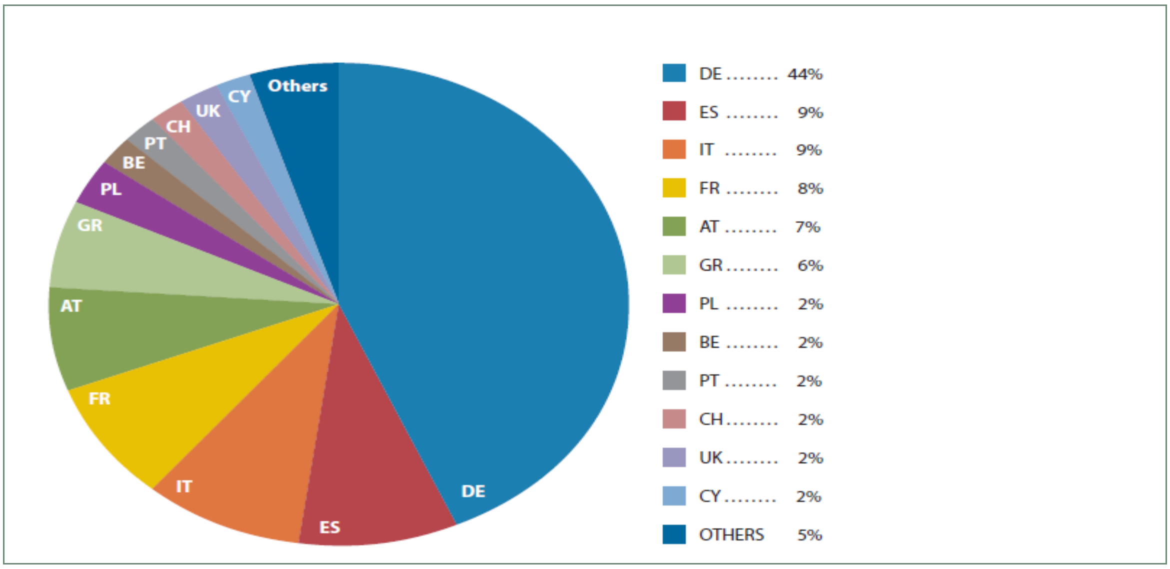
The enormous growth in Germany together with its very dominant position hides the fact that some of the smaller markets have developed extremely positively as well. With 130,000m^2 newly installed collector area in 2008 (+90 per cent), Poland has confirmed its position as the 7th largest market in Europe. Sales in Belgium increased to 91,000 m^2 bringing it into 8th position.

Figure 12.16: Solar Thermal Market in EU-27 + Switzerland (Glazed Collectors)



Source: ESTIF, 2008

Figure 12.17: Share of European Solar Thermal Energy



Source: ESTIF, 2008

A study by Frost & Sullivan of the European Solar Thermal Heating Systems Market, finds that the market earned revenues of over €958.9 million in 2008 and estimates this to reach €2.2 billion in 2014.

A joint study by Greenpeace and the European Solar Thermal Industry Association have made predictions based on advances in solar thermal technology, coupled with the growing number of countries which are supporting CSP projects in order to achieve both climate change and power demand objectives.

Over the period of the scenario, solar thermal technology will have emerged from a relatively marginal position in the hierarchy of renewable energy sources to achieve a substantial status alongside the current market leaders such as hydro and wind power. From a current level of just 355 MW, the total installation by 2015 will have passed 6400 MW – 18 times more than today. By 2025, the annual installation rate will be 4,600 MW/a. At the end of the scenario period, the total installed capacity around the world will have reached the impressive figure of 36,850 MW.

In terms of capital investment, it is assumed in the scenario that during the initial years, solar field investment costs – including all system costs – are at a level of US$ 6,000/kW installed. These specific investment costs then fall gradually over the timescale of the scenario, and are cut by almost half in 2025. This means that the investment volume in solar thermal power plants will rise from US$60 million in 2006 to US$16.4 billion in 2025.

Finally, a further projection is made for the potential expansion of the solar thermal power market over another two decades up to 2040. This shows that by 2030 the worldwide capacity will have reached 100,000 MW, and by 2040 a level of almost 600,000 MW. Increased availability of plant resulting from the greater use of efficient storage technology will also increase the amount of electricity generated from a given installed capacity.

Table 12.20: Key results for Greenpeace ESTIA Scenario 2002-2025

Capacity of solor thermal power in 2025	36,850 MW
Electricity production in 2025	95.8 TWh/year
Employment generated	54,000
Investment Value	16.4 billion $ per year
Carbon emissions avoided	362 million tonnes CO_2
Annual carbon emissions avoided in 2025	57.5 million tonnes CO_2
Projection 2025 to 2040	
Capacity of solar thermal power in 2040	600,000 MW
Electricity production	16,000 TWh
Percentage of global demand	5 per cent

Source: Greenpeace/ESTIA Scenario, 2005

Employment

In 2005 solar thermal already provided up to 40,000 full-time jobs in Europe (approximately 1 full-time job per 80 kWth of newly installed capacity)[62]. This ratio has been used to estimate the number of jobs that Ireland could generate in this industry.

Table 12.21: The Solar Thermal Market

	Irish Market Value	Global Market Value	Employment Potential
2010	€16,640,000 (High scenario)	€958.9 million (Frost and Sullivan,2009) (European Market Value)	650
2020	€332,800,000 (High scenario)	€11.48 billion (Greenpeace, 2005)	13,000
2030	€6,565,000,000 (High scenario)	€15 billion (Greenpeace, 2005)	26,000

Source: SQW Analysis, Conversion US$1 to €0.7

62 ESTIA/Greenpeace, 2005

12.2.11 Solar PV

Value of the domestic market

While there is little opportunity for Ireland in large scale solar electricity generation due to their geography, potential does exists in technology development of PV and thin film technologies. Ireland has some of the leading semiconductor and electronics companies, well established in Ireland, as well as highly qualified surface chemists and engineers accompanied by top-class semiconductor and materials research.

The solar energy market in Ireland is at a very early stage of development. The latest provisional figures for 2007 (SEI, 2009b[63]) show that solar energy accounts for about 1 ktoe from total final energy consumption of 13,336 ktoe, or less than 0.01 per cent.

The EC[64] forecasts that the solar energy in Ireland will grow to account for 67 ktoe out of a final energy demand of 15,714 ktoe, which is still under 0.5 per cent of total final energy demand. Solar PV is forecast to increase from under 10 MW today to about 100 MW by 2030 – less than 1 per cent of total forecast generating capacity.

However, while solar energy in Ireland is supported by renewable energy policy initiatives and grants, and there are targets for renewable heat and electricity[65], there are no specific targets or forecasts associated with solar energy.

Current International Markets for Solar

Solar power has an estimated global market of €10 billion per annum growing at a rate of 25 per cent per annum. In 2007 the solar sub-sector was second only behind wind for total investment and attracted the largest share of private equity/ venture capital funding.

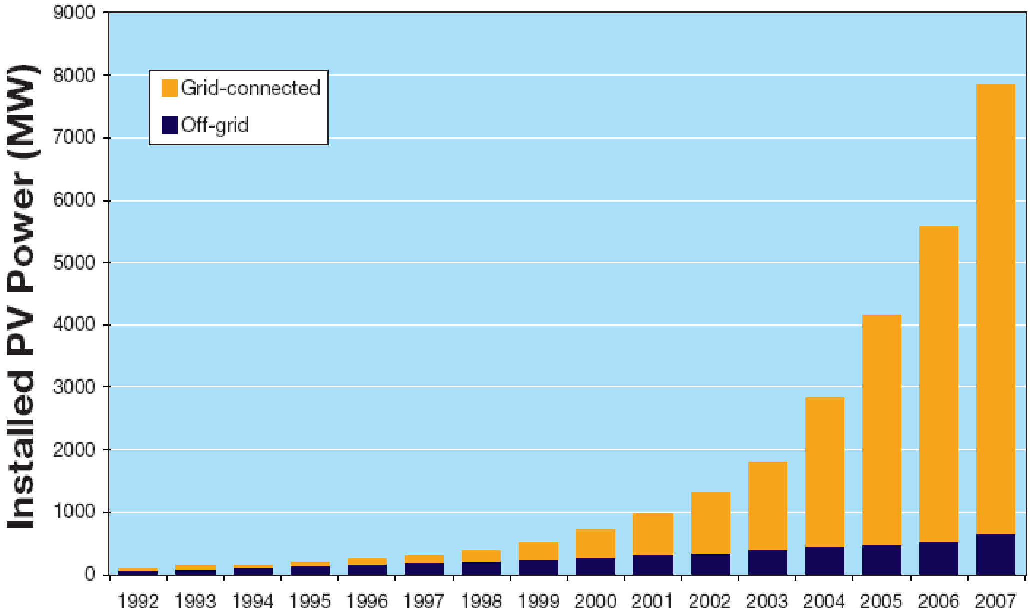
PV is experiencing exponential growth rates– especially in India and China. As shown by Figure 12.18 below cumulative installed capacity of PV has grown exponentially.

63 SEI, 2009b, *Ireland's Low-Carbon Opportunity: An analysis of the costs and benefits of reducing greenhouse gas emissions*

64 EU-27 Energy baseline scenario to 2030, 2007 update. Consistent with this finding, the Green-X model predicts available solar PV resource in the region of 26 ktoe/year by 2020 (Green-X, 2004)

65 12 per cent and 13 per cent of heat and electricity to come from renewable sources by 2020, respectively

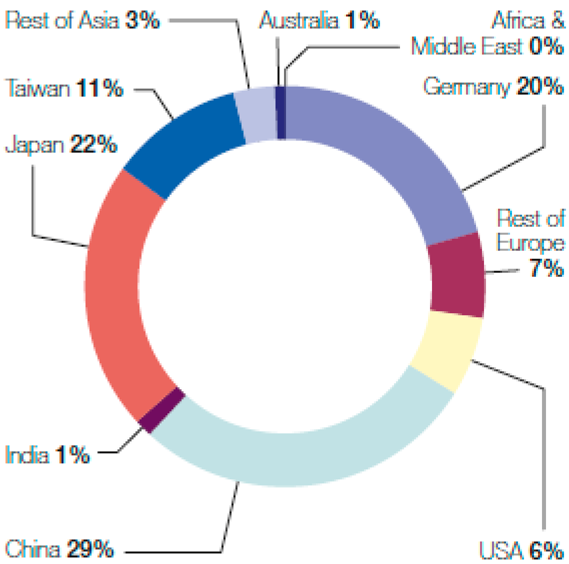
Figure 12.18: Cumulative grid and off-grid PV power in IEA - PVPS reporting countries



Source: IEA, 2008

Germany, Japan and the US account for 70 per cent of global cumulative capacity. These countries also account for 63 per cent of global PV production. However, China, India, Australia, Korea and Spain are all expected to become important global players in terms of installed capacity and manufacturing. China has already become a major global PV manufacturer reaching a 15 per cent share of global PV cell production by 2006. Figure 12.19 shows the regional and national shares of PV production in 2007.

Figure 12.19: Regional and national shares of global PV cell production in 2007



Source: EPIA, 2008

Grid connected, building integrated systems are the most dynamic sector. These are mostly in industrialised countries but may do well in emerging countries. Off grid PV systems for water pumping and rural electrification constitute 10 per cent of the total PV market. Such appliances remain important in remote areas and are likely be so in developing countries [66]. Currently the solar electricity industry is worth more than an annual €13 billion.

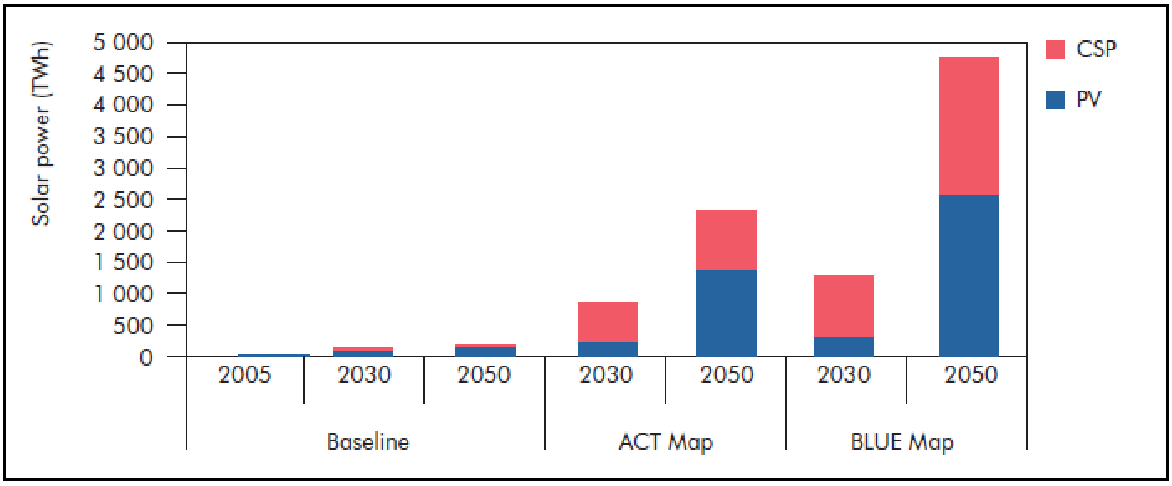
Future Markets for Solar Energy

Solar electricity is projected to grow a thousand fold from today's level by 2050 to 2,319 TWh/yr (1,383 TWh for PV) in the IEA ACT scenario and 4,754 TWh/yr (2,584 TWh/yr for PV) in the IEA Blue Map scenario[67] . Both scenarios assume that there are sustained and effective incentive schemes in the next 5-10 years and will allow for costs to decrease. The baseline doesn't allow for this so makes a negligible impact. Figure 12.20 illustrates the possible variations in solar generation in the future under different scenarios.

66 International Energy Agency , 2008a, *Energy Technology Perspectives: Scenarios and Strategies to 2050*

67 The ACT and Blue Map scenarios used by the IEA are optimistic visions for the world in the future and simply reflects on what needs to be done to meet their ambitious targets. There is nothing about the likelihood of these things happening or the policy instruments that would be needed for them to come to the forefront. The ACT scenario envisages bringing back global emissions in 2050 to 2005 levels, while the Blue Map scenario considers the impact of halving those emissions. The Baseline scenario is the most realistic and risk adverse scenario and assumes that only policies that have been implemented to date will continue to be implemented.

Figure 12.20: Solar Generation under three different IEA scenarios



Source: IEA, 2008

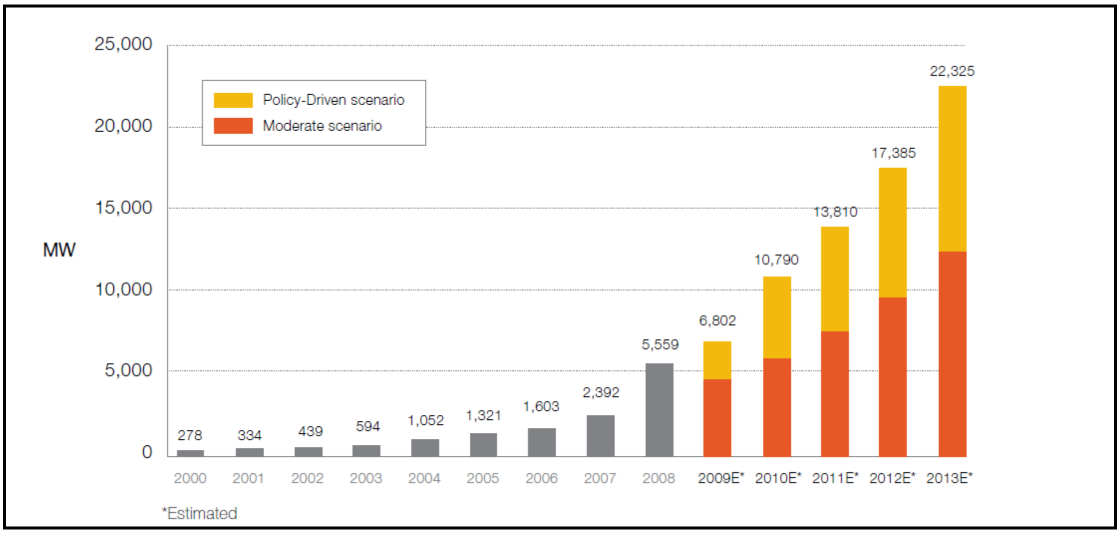
Concentrated solar power is expected to be deployed widely in those regions and also Latin America and Africa. A market of 6 GW/yr in 2010 is assumed in the ACT scenario and 10GW/yr in the Blue MAP scenario. However, the industry forecasts production of PV cell/modules at 23 GW/yr by 2011.

In its Policy-Driven[68] forecast for Europe, EPIA[69] expects Germany to remain as the major PV market in Europe with increasing roles from France and Italy. If the cap is removed in Spain, EPIA expects these 4 countries to represent more than 75 per cent of the European market by 2013.

68 The EPIA in 2008 devised two scenarios for thinking about the future solar market. The Moderate scenario is based on the assumption of a 'business as usual' scenario which does not assume any major enforcement of existing support mechanisms. The Policy-Driven scenario is based on the assumption of the follow-up and introduction of support mechanisms, namely FiT, in a large number of countries.

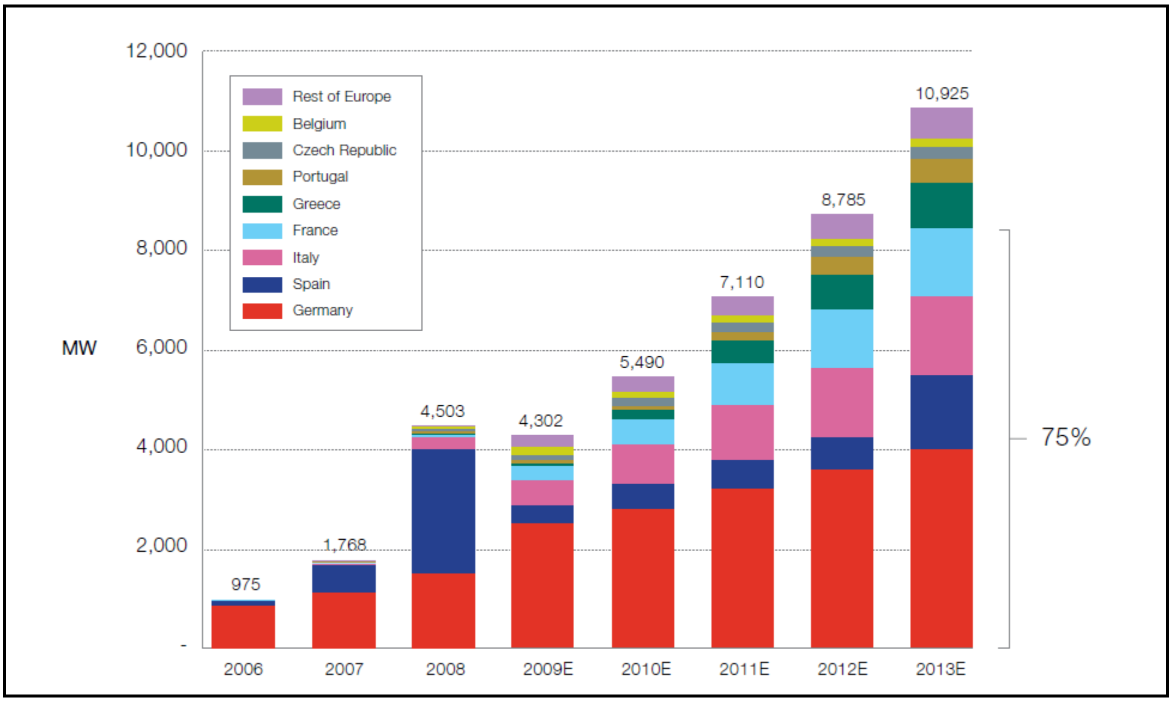
69 European Photovoltaic Industry Association (EPIA), 2008, *Global Market Outlook Until 2013*

Figure 12.21: Global annual PV market till 2013



Source: EPIA, 2008

Figure 12.22: European PV output until 2013 (Under the Policy Driven Scenario)



Source: EPIA, 2008

Due to a strong continuous growth of the global PV market and a slower process to establish new silicon production facilities than for downstream processes in the supply chain, polysilicon supply has represented the main bottleneck of the PV industry since 2005. Over the last 3 years, established polysilicon producers have more than doubled their total production capacity and many new players have entered the polysilicon business. Due to this impressive increase in polysilicon production, EPIA expects the silicon shortage to end most probably by the end of 2009 or beginning of 2010[70].

In 2008, the EPIA released another publication with Greenpeace titled "Solar Generation V", outlining how the solar generation could develop into the long run.

Table 12.22 calculates the projected market value of PV systems up to 2030 under respectively the advanced and moderate scenarios[71]. This shows that by the end of the scenario period, the annual value of the PV market would have reached €454 billion worldwide under the advanced scenario and €170 billion under the moderate scenario.

Table 12.22: Solar Generation results for global PV market up to 2030

	Current situation	Scenarios		
	2007	**2010**	**2020**	**2030**
Advanced Scenario				
Annual Installation in GW	2.4	6.9	56	281
Accumulated Capacity in GW	9.2	25.4	278	1,864
Electricity Production in TWh	10	29	362	2,646
PV Contribution to electricity consumption-reference scenario (IEA)	0.07 per cent	0.16 per cent	2.05 per cent	8.90 per cent
PV Contribution to electricity consumption-alternative scenario	0.07 per cent	0.20 per cent	2.18 per cent	13.79 per cent
Grid connected people/households/people living in PV in Million	5.5	18	198	1,280
Off grid connected people in Milan	14	32	757	3,216
Employment in thousand people	119	333	2,343	9,967
Market value in Billion €	13	30	139	454
Annual CO_2 savings in Mt	6	17	217	1,588
Cumulative carbon savings in Mt	27	65	976	8,953

70 European Photovoltaic Industry Association (EPIA), 2008, *Global Market Outlook Until 2013*

71 The Advanced Scenario is based on the assumption that continuing and additional market support mechanisms will lead to a dynamic expansion of worldwide PV installed capacity. Market support programmes create economies of scale and PV prices will fall faster as a result, leading to a further market push. Under the Moderate Scenario envisages the development of PV against the background of a lower level of political commitment.

	Current situation	Scenarios		
	2007	**2010**	**2020**	**2030**
Moderate Scenario				
Annual Installation in GW	2.4	5.3	35	105
Accumulated Capacity in GW	9.2	21.6	211	912
Electricity Production in TWh	10	24	283	1,291
PV Contribution to electricity consumption-reference scenario (IEA)	0.07 per cent	0.14 per cent	1.20 per cent	4.34 per cent
PV Contribution to electricity consumption-alternative scenario	0.07 per cent	0.17 per cent	1.70 per cent	6.73 per cent
Grid connected people/households/people living in PV in Million	5.5	14	136	564
Off grid connected people in Milan	14	59	837	2,023
Employment in thousand people	119	252	1,462	3,718
Market value in Billion €	13	24	94	204
Annual CO_2 savings in Mt	6	15	170	775
Cumulative carbon savings in Mt	27	61	839	5,333

Source: EPIA/Greenpeace, 2008

The Solar Generation Advanced Scenario shows that by 2030, PV systems could be generating approximately 2,646 terawatt hours of electricity around the world. Under this scenario, the global installed capacity of solar power systems would reach 1,864 GW by 2030. About 74 per cent of this would be in the grid- connected market, mainly in industrialised countries.

Employment

Much of the employment creation is at the point of installation (installers, retailers and service engineers), giving a boost to local economies. According to Solar V, 10 jobs are created per MW during production and about 33 jobs per MW during the process of installation. Wholesaling of the systems and indirect supply (for example in the production process) each create 3-4 jobs per MW. Research adds another 1-2 jobs per MW. Over the coming decades, it can be assumed that these numbers will decrease as the use of automated machines will increase. This will be especially the case for jobs involved in the production process.

In 2007, the German PV industry alone employed 42,000 people. By 2030, following the Solar Generation Advanced Scenario, it is estimated that 10 million full-time jobs would have been created by the development of solar power around the world. Over half of those would be in the installation and marketing of systems.

Table 12.23: Worldwide employment for Solar under solar generation scenarios defined by EPIA

Year	Installation	Production	Wholesaler	Research	Supply	Total
Advanced Scenario						
2007	77,688	22,968	6,890	2,986	8,613	119,145
2010	220,162	62,546	18,764	8,131	23,455	333,058
2015	559,282	147,373	44,212	19,159	55,265	825,292
2020	1,632,586	393,530	118,059	51,159	147,574	2,342,907
2025	3,877,742	839,338	251,801	109,114	314,752	5,392,747
2030	7,428,118	1,406,841	422,052	182,889	527,565	9,967,466

Year	Installation	Production	Wholesaler	Research	Supply	Total
Moderate Scenario						
2007	77,688	22,968	6,890	2,986	8,613	119,145
2010	166,518	47,306	14,192	6,150	17,740	251,906
2015	486,219	128,121	38,436	16,656	48,045	717,478
2020	1,018,552	245,519	73,656	31,917	92,070	1,461,713
2025	1,806,321	390,978	117,294	50,827	146,617	2,512,037
2030	2,770,569	524,729	157,419	68,215	196,773	3,717,705

Source: EPIA, 2008

Table 12.24 summarises the EPIA/Greenpeace results for the total global value of solar PV. In order to calculate the Irish share of this global market it is assumed that in 2010 that they have not tapped into this market, but that by 2020 they could potentially share about 1 per cent of the global value under the Moderate Scenario. This is probably the maximum value that can be extracted by Ireland as they will unlikely have a large domestic market for solar energy (without very high subsidies like in Germany), they are only likely to contribute to a small part of the value chain for PV (primarily in manufacturing components) and the market to a large degree has been cornered by Germany and Spain and will likely be dominated by China and India in the future.

The Irish share of the market includes both local and export potential. The local market is expected to be negligible.

Table 12.24: The solar market potential for Ireland

	Total Global Value (Global value)	**Employment (Global Value)**	**Irish Share (1 per cent of moderate scneario)**
2010	€30 billion Advanced Scenario (AS) € 24 billion Moderate Scenario (MS)	333,000 (AS) 251,000 (MS)	n/a
2020	€ 139 billion (AS) € 94 billion (MS)	2.3 Million (AS) 1.5 Million (MS)	€ 1 billion 150,000 in employment
2030	€ 454 billion (AS) € 204 billion (MS)	1 billion (AS) 3.7 million (MS)	€ 2 billion 400, 000 in employment

Source: SQW Analysis, EPIA/Greenpeace (2008)

12.2.12 Summary of Enterprise Value of Solar Thermal and Solar PV

Outlined below in Table 12.25 are the results used for enterprise opportunities in the Tetralemma index for solar thermal and solar PV.

Table 12.25: Enterprise results for solar thermal and solar PV

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				**2020**				**2030**			
High scenario												
Solar thermal	1	1	1	1	10	5	5	5	10	5	5	5
Solar PV	1	1	1	1	5	10	5	5	5	10	5	5
Medium scenario												
Solar thermal	1	1	1	1	5	5	5	5	5	5	5	5
Solar PV	1	1	1	1	5	5	5	5	5	5	5	5
Low scenario												
Solar thermal	1	1	1	1	5	5	5	5	5	5	5	5
Solar PV	1	1	1		1	1	1	1	1	1	1	1

Source: SQW Energy analysis

Marine

12.2.13 Marine – wave and tidal

The Carbon Trust estimates that the world wide revenue from ocean energy electricity sales could be between £60 and £190 billion per year. Europe's accessible wave power resource is calculated to be of the order of 320,000 MW with the highest resource available near the West of Ireland. Wave energy may be regarded as stored wind energy; it is therefore possible that the potential wave energy market is at least as large as that for offshore wind energy (estimated to be 70,000 MW by 2020), according to the Ocean Strategy for Ireland report [72].

There is already a promising sector emerging in Ireland with companies such as Wavebob, Ocean energy Ltd., SeaGen and OpenHydro. Scotland is strongly pursuing ocean technology on the back of lower sterling costs and the Marine Energy Centre in Orkney, the only grid connected wave and tidal research centre in the world. In December 2008 the Scottish Government announced the £10 million Saltire prize for demonstration in Scottish waters of a commercially viable wave or tidal energy technology that achieves a minimum electrical output of 100GWh over a continuous 2 year period using only the power of the sea and is

72 SEI, 2005a, *Ocean Energy Strategy in Ireland*

judged to be the best overall technology after consideration of cost, environmental sustainability and safety.

The Future of Marine Energy in Ireland

Recent studies have indicated that the available European wave energy resource is capable of delivering 320,000 MW of electrical power. A 2001 paper on the European resource estimated that in the UK, Ireland, Greece, France and Italy, 106 promising locations could supply 48TWh/yr to the European electrical grid network using present day technology. This would require approximately 13,700 MW of marine current generation capacity.

While the scale of the ocean energy resource is appreciable, there are no commercially viable ocean energy systems available at present and the market for this technology is presently at a development stage. A developed ocean energy market could similarly accommodate a number of ocean energy device manufacturing companies.

The opportunity, therefore, exists at present to develop technical solutions that will allow the economic exploitation of this valuable energy resource. In calculating the economic benefit of the proposed Ocean Energy strategy, it is assumed that national developers will be able to produce fully developed commercially viable large-scale arrays of ocean energy converters suitable for the electricity market by 2016. Following this date it is assumed that the sector will develop at a rate similar to that of the wind industry during the 1990s. It is also assumed that all equipment is designed and manufactured in Ireland. The rate of job creation is based on figures determined for the Danish wind industry.

The key benefits are summarised in Table 12.26. In summary, the Ocean Energy sector, excluding exports, in 2020 is estimated to be €176 million leading to the creation of 313 jobs in the research, manufacturing, installation and maintenance sectors. Following a period of sustained growth, the industry could reach a cumulative value of €784 million by 2025 supplying 911 jobs to the Irish economy.

Table 12.26: Value to the Economy of Domestic Market for Ocean Energy

	2020	2025
Annual MW installed	24 MW	85 MW
Cumulative MW installed	84 MW	485 MW
Annual Electricity Produced	259 GWh	1,488 GWh
Annual CO_2 avoided	89,534 tonnes	514,860 tonnes
Annual Value of Market (Manufacture + Installation)	€49 million	€180 million
Cumulative value of Market	€176 million	€784 million
Annual cost of CO_2 avoided assuming €20/tonne	€2 million	€10 million
Cumulative cost of CO_2 avoided	€5 million	€34 million
Cumulative Benefits (Markets + CO_2)	€181 million	€818 million
Number of jobs created	313	911

Source: Ocean Energy in Ireland, DCENR, 2005

Export opportunities

The UK low development rate scenario for wave energy assumes a market penetration of wave energy of 900 MW by 2020 with the market beginning in 2012. In considering the export market potential for ocean energy in Ireland, it is assumed that the UK market represents 50 per cent of the penetration of wave energy in Europe by 2020. It also assumes that a successful wave energy industry in Ireland would secure 20 per cent of this market. It is likely that some amount of industrial development funding will be required to ensure Ireland develops a manufacturing and exporting industry[73]. The estimation of such funding requirements is not a subject for this document.

In assessing the export potential for Ireland, the above assumptions are applied in order to estimate the total size of the export market for Europe only, with the additional assumption that Ireland secures 20 per cent of this market. Additionally it is assumed that the ocean energy market begins to grow from 2012 onwards using the same growth rate profile as the European wind sector.

---

73 SEI, 2005, *Economic Benefits of Developing Ocean Energy in Ireland*

Summary results are presented in Table 12.27 indicating cumulative export sales of 360 MW of ocean energy systems by 2020 and 587 MW by 2025. This could provide, in addition to the national market described earlier, a value of €360 million and an additional 574 jobs to the Irish economy in 2020. In 2025, these figures may then rise to €1,587 million and 1,329 jobs respectively. The gross benefits to the Irish economy are therefore a market valued at €536 million with 887 jobs in 2020 increasing in value to €2,371 million with 2,240 jobs created by 2025[74].

Table 12.27: Value to the Economy of the Export Market for Ocean Energy

	2020	2025
Annual MW Exported	95 MW	298 MW
Cumulative MW Exported	360 MW	1,587 MW
Annual Value of Export Market (Manufacture only)	€95 million	€298 million
Cumulative Value of Market	€360 million	€1,587 million
Number of Jobs Created	574	1,329

Source: SEI, 2005b

Table 12.28: Cumulative Value of Domestic + Export Market for Ocean Energy

	2020	2025
Annual MW Supplied	119 MW	383 MW
Cumulative MW Supplied	444 MW	2,072 MW
Annual Value of Market	€144 million	€478 million
Cumulative Value of Market	€536 million	€2,371 million
Number of Jobs Created	887	2,240

Source: SEI, 2005b

74 SEI, 2005, *Economic Benefits of Developing Ocean Energy in Ireland*

12.2.14 Summary of Enterprise Value of Marine

Outlined below in Table 12.29 are the results used for enterprise opportunities in the Tetralemma index for marine.

Table 12.29: Enterprise results for marine

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				**2020**				**2030**			
High scenario												
Wave	1	1	1	1	10	10	10	10	10	10	10	10
Tidal	1	1	1	1	10	10	10	10	10	10	10	10
Medium scenario												
Wave	1	1	1	1	10	5	5	5	10	5	5	5
Tidal	1	1	1	1	10	5	5	5	10	5	5	5
Low scenario												
Wave	1	1	1	1	1	1	1	1	1	1	1	1
Tidal	1	1	1		1	1	1	1	1	1	1	1

Source: SQW Energy analysis

Geothermal

12.2.15 Geothermal

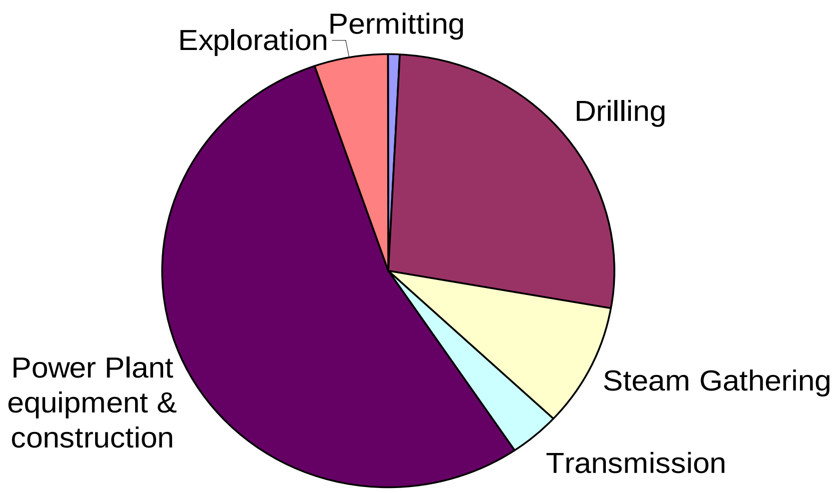
Cost Structure of Geothermal Energy

Geothermal plants incur high initial fixed costs but lower operations and maintenance costs over their lifetime as there are no associated fuel costs. Capital costs are high (relative to traditional fossil fuel plants) as they involve the additional costs of drilling and exploring for steam as well as the costs associated with the physical plant. In fact, drilling costs can account for as much as one-third to one-half of the total cost of a geothermal project (International Energy Agency 2008a[75]). However, as there are no fuel costs the geothermal

75 International Energy Agency, 2008a, *Energy Technology Perspectives: Scenarios and Strategies to 2050*

plants are capital intensive investments that have short pay back periods. The typical cost structure for a geothermal plant is shown in Figure 12.23.

Figure 12.23: Sample break up of costs for a typical Geothermal Plant



Source: Geothermal Energy Association, 2009

The capital costs of a geothermal plant can range quite significantly depending on resource temperature, chemistry and technology employed and plants typically have lifetimes between 30-45 years. According to REPP capital costs are approximately between US$1,150 and US$3,000. As these are 1999 figures it is estimated that the lower value for 2010 is more correct as technology advances would have driven costs down and initial studies have shown Ireland to has a significant geothermal resources which means that both exploratory and actual construction costs will be even lower. This figure is further substantiated by the IEA.

Economic Benefits to Ireland

Geothermal power tends to keep economic benefits local as construction and then subsequent costs tend to be incurred locally. Table 12.30 below summarises some of the economic benefits produced by an average, 50 MW facility over 30 years of operation on federal lands in the United States according to a study by the Geothermal Energy Association. The figure shows that the total economic output of such a plant is in the region of US$750 million.

Table 12.30: Sample Economic Benefit of a 50 MW Geothermal Power Plant

Employment (direct, indirect and induced)		**212 fulltime jobs/** **800 person-years (p-*y)**[6]
Economic Output (over 30 years, nominal)		$749 million
Royalties	Contribution to the Federal Government	$5.46 million
	Contribution to the State	$10.9 million
	Contribution to the County	$5.46 million

Source: Geothermal Energy Association, 2009

Table 12.31 shows the contribution of Western States in the US's Geothermal Plant economic contributions and economic output. According to this study by the Geothermal Energy Association approximately US$85 billion is contributed to the economy for 5,635 MW which means that a megawatt of geothermal energy on average contributes US$15 million to the economy.

Table 12.31: Summary of US Western States' Near-Term Geothermal Potential and Resulting Employment and Economic Contribution

	New Power Capacity MWs	Direct and Indirect and Induced Employment (Power Plant Jobs/ Construction & Manufacturing Employment)**	30 Year Economic Output (nominal)
California	2,400	10,200 ft jobs/ 38,400 person * yrs	$36 billion
Nevada	1,500	6,375 ft jobs/ 24,000 person * yrs	
Oregon	380	1,615 ft jobs/ 6,080 person * yrs	
Washington	50	212 ft jobs/ 800 person * yrs	
Alaska	25	106 ft jobs/ 400 person * yrs	
Arizona	20	85 ft jobs/ 320 person * yrs	
Colorado	20	85 ft jobs/ 320 person * yrs	
Hawaii	70	298 ft jobs/ 1,120 person * yrs	
Idaho	860	3,655 ft jobs/ 13,760 person * yrs	
New Mexico	80	340 ft jobs/ 1,280 person * yrs	
Utah	230	978 ft jobs/ 3,680 person * yrs	
Wyoming, Montana, Texas, Kansas, Nebraska, South Dakota, North Dakota	Potential Exists; Resources not studied in WGA Report	Not studied	Not studied
Total Western States (additional to current)	**5,635 MW**	**23,949 fulltime jobs/ 90,160 person*years of construction and manufacturing employment**	**84,410,046,000.00** **Almost 85 billion dollars to the U.S. economy over 30 years**

Source: Geothermal Energy Association, 2009

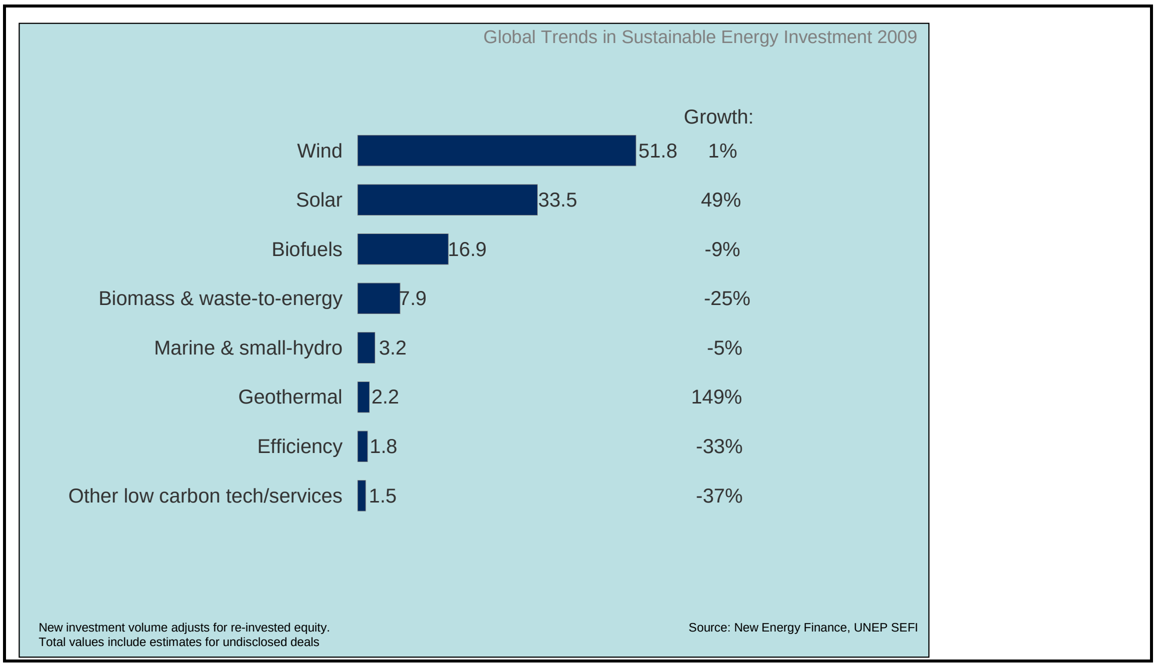
Furthermore, the Geothermal Energy Association estimates that approximately for every dollar invested in geothermal energy, the resulting growth of output to the economy is US$2.50. This means that the investment required for a 50 MW power plant would result in a growth of output of US$350 million to the US economy. This means that on average each megawatt averages a contribution of US$7 million to the economy.

Based on these calculations it is estimated that an average megawatt of geothermal energy will contribute US$11 million to a local economy[76]. If we assume that there is substantial support for renewable energy (i.e. the high scenario) we can assume that two new 50 MW geothermal plants are built over the next decade and in the decade following, we can estimate the potential contribution to the Irish economy. It is assumed that in the low scenario only one 50 MW plant is built each decade.

Export opportunities

In 2008 close to US$155 billion was invested in renewable energy worldwide not including large hydro. Of the US$155 billion, US$105 billion was spent directly developing 40 GW of power generating capacity from geothermal, wind, solar, small-hydro and biomass sources. It means that renewables currently account for the majority of investment and over 40 per cent of actual power generation capacity additions last year[77]. Geothermal investment saw an additional growth of USUS$2.2 billion (equal to a 149 per cent increase) between 2007 and 2008, see Figure 12.24.

Figure 12.24: Financial New Investment, by Technology, 2008 and growth on 2007, USUS$ billions



Source: UNEP, 2009

76 This estimate might need to decrease over time if EGS technology comes online and makes it cheaper to build geothermal energy

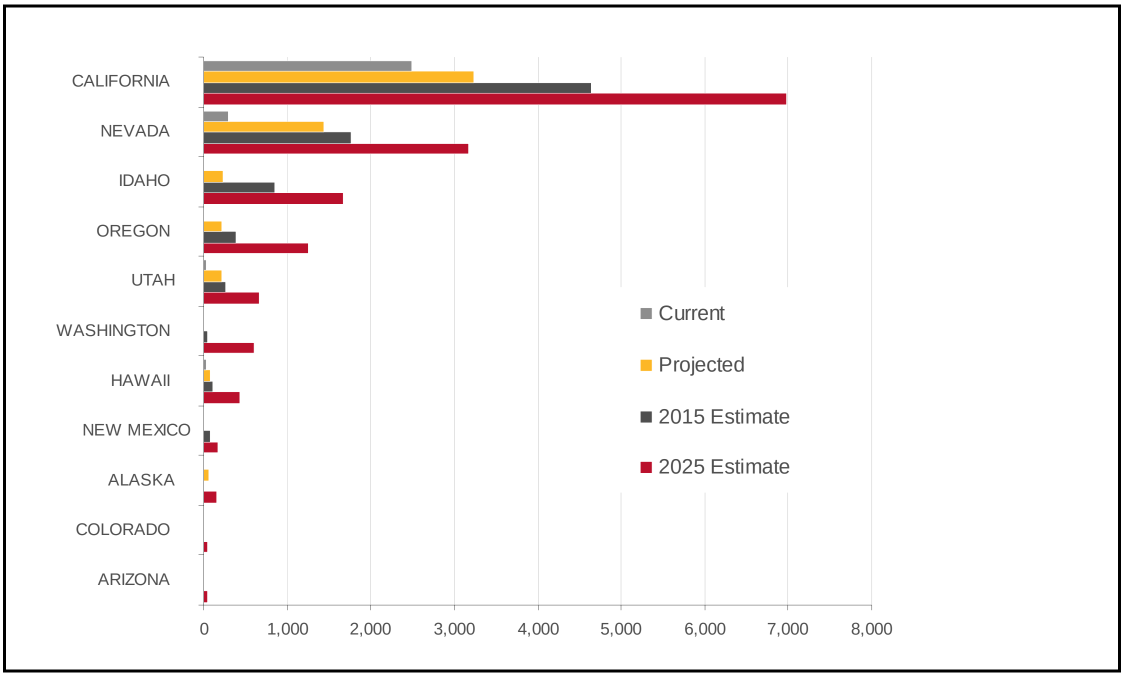
77 United Nations Environment Program (UNEP), 2009, *Global Trends in Sustainable Energy Investment*

There is significant geothermal activity with about 10 GW of total world capacity in 2007 and several countries are planning to ramp up production including Indonesia, Mexico, New Zealand, Nicaragua and the United States. In Australia, as at September 2009, there now 48 companies pursuing geothermal energy in Australia, including 19 listed companies, with 391 geothermal tenements covering 362,000 km^2. The Industry has invested US$325m between 2000 and 2008 and is forecast to invest US$1,528m Australia-wide by 2012[78].

There is also a great deal of activity taking place in the US where existing the existing skill base appears to be overstretched[79] and this problem could significantly be exacerbated as the US DOE recently announced a US$350 million investment in EGS. Included in this budget, is funding for complementary activities such as a web-based, public geothermal database for resource, power plant, and institutional data; international collaborative activities; investigation of low temperature geothermal opportunities; and support for geothermal workforce development to meet the needs of a rapidly growing energy sector. The US Association of Energy Engineers predicts that with this stimulus package expected to create more than 100,000 green jobs, finding staff with the right skills will be tougher. Ireland can potentially tap into this gap by developing highly skilled employees in this sector.

A market study by Glitnir estimates the investment requirement to service currently planned projects to be USUS$9.5 billion based on GEA's May 2007 Update on US Geothermal Power Production and Development. A total Investment of US$16.9 billion will be required to develop available resources through 2015 and a further US$22.5 billion during the following 10 years. The US Geothermal current and potential projects are shown in Figure 12.25.

Figure 12.25: US Geothermal (MW) installed capacity



Source: Glitner, 2009

78 Geodynamics, 2009, *Australia Geothermal Energy*

79 NZ Geothermal Association, 2009

Employment and job creation

The number of jobs created by geothermal plants can be divided into both direct and indirect jobs. In the case of geothermal plants, the number of indirect jobs can be quite significant as there is typically a high level of infrastructure (for example roads) required for geothermal plants that tend to be situated in remote areas. For instance, according to REPP[80] in 1996 the geothermal industry employed directly 1,300 people and an additional 27,700 in an indirect capacity.

According to Figure 12.25 above for 5,635 MW approximately 24,000 full time jobs were created. Induced and indirect jobs are not included in this calculation as these will vary considerably from plant to plant and the figure cannot be applied with any confidence. This means that if we assume two 50 MW plants being built between 2010 -2020 and 2020-2030 then 250 jobs will be created for each plant if only direct jobs are considered. The results are summarised in Table 12.32 below.

Table 12.32: The Geothermal Market

	Economic add	Export potential	Employment potential for Ireland
2010	n/a	USUS$9.5 billion (Glitner,2007) (€ 6.65 billion)	n/a
2020	USUS$ 550 million (€350 million) (High Scenario) USUS$ 225 million (€125 million) (Low Scenario)	USUS$16.9 billion (Glitner,2007) (€ 11.83 billion)	500 jobs
2030	US$ 550 million (€350 million) US$ 225 million (€125 million) (Low Scenario)	US$22.5 billion (Glitner, 2007) (€ 15.75 billion)	500 jobs

Source: SQW analysis, US$ = € 0.7

12.2.16 Summary of Enterprise Value of Geothermal

Outlined below in Table 12.33 are the results used for enterprise opportunities in the Tetralemma index for geothermal.

80 REPP, 2009, *Economics of Geothermal Energy*, available at: http://www.repp.org/geothermal/geothermal_brief_economics.html

Table 12.33: Enterprise results for geothermal

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				**2020**				**2030**			
High scenario												
Geothermal	1	1	1	1	5	5	5	5	5	5	5	5
Medium scenario												
Geothermal	1	1	1	1	5	5	5	5	5	5	5	5
Low scenario												
Geothermal	1	1	1	1	1	1	1	1	1	1	1	1

Source: SQW Energy analysis

Hydro

12.2.17 Hydro

Ireland has exploited almost its entire hydro capacity. There is scope for some small scale hydro developments but this is limited and available primarily in mountainous areas. The cost for installing a hydro system varies substantially and depends on the location and how much electricity the system can generate. A typical 5 kW scheme suitable for an average home might cost £20,000 - £25,000 including installation[81]. If Ireland could potentially tap into 32-76 MW[82] of small scale hydro that could add approximately between 6,400 and 15,200 MW to the Irish electricity system. With an average cost of £22,500 that is an additional £14 million to £342 million to the Irish economy or an average of £178 million. The outcome of the assessment of wind and hydro stprage options was not available at time of publication.

There could potentially be a substantial export capacity in terms of developing countries for small scale hydro under the Clean Development Mechanism but there are currently no surveys of the total value of this industry. Moreover, the export industry, even if valued to be large, will tend to be fragmented and difficult for Irish enterprise to enter as small hydro tends to favour local enterprise. As a result, the export value for this industry will be very low.

The small scale hydro industry will create low value jobs that are relatively low in number and as a result employment potential is not regarded very highly.

81 Energy Savings Trust, 2009, *Hydroelectricity* (available at: http://www.energysavingtrust.org.uk/Generate-your-own-energy/Hydroelectricity)

82 Cork County Council, 2005

12.2.18 Summary of Enterprise Value of Hydro

Outlined below in Table 12.34 are the results used for enterprise opportunities in the Tetralemma index for geothermal.

Table 12.34: Enterprise results for hydro

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				2020				2030			
High scenario												
Hydro	1	1	1	1	1	1	1	1	1	1	1	1
Medium scenario												
Hydro	1	1	1	1	1	1	1	1	1	1	1	1
Low scenario												
Hydro	1	1	1	1	1	1	1	1	1	1	1	1

Source: SQW Energy analysis

12.3 Enterprise Opportunities for Nuclear

12.3.1 Value of the Domestic Market

In any scenario for nuclear compared with other forms of generation:

- There is extremely unlikely to be any significant impact of nuclear on "Enterprise" on a 2010 timescale, and as such no estimates are provided for this time period.
- Domestic markets are more likely to be developed before export markets in relation to nuclear.
- If nuclear is deployed, there is likely to be a significant minimum level of employment necessary up to and beyond 2030 to meet the construction, operational, regulatory, decommissioning and supply chain requirements for a nuclear unit compared with other forms of energy supply.
- Given the very scale of nuclear power that could be deployed in Ireland, it is unlikely that significant local nuclear supply chain infrastructure such as uranium enrichment and reprocessing facilities would be feasible. Fuel element manufacturing and assembly may be possible and desirable and although export potential is likely to be limited, local employment prospects would be strong.

In light of this, nuclear energy, if it will ever be developed in Ireland, will only occur in the high scenario where its development may be supported. In the medium scenario, nuclear is only likely to be present from 2030 onwards (i.e. assuming support takes longer to occur).

In order to determine the potential value of nuclear power to the Irish economy, the capital cost of the plant should be considered. For nuclear power plants any cost figures normally include spent fuel management, plant decommissioning and final waste disposal. These costs, while usually external for other technologies, are internal for nuclear power (i.e. they have to be paid or set aside securely by the utility generating the power, and the cost passed on to the customer in the actual tariff).

Decommissioning costs are about 9-15 per cent of the initial capital cost of a nuclear power plant[83]. However, when these are discounted, they contribute only a few per cent to the investment cost and even less to the generation cost. In the USA, they account for 0.1-0.2 per cent/kWh[84], which is no more than 5 per cent of the cost of the electricity produced.

The back-end of the fuel cycle, including used fuel storage or disposal in a waste repository, contributes up to another 10 per cent to the overall costs per kWh, - less if there is direct disposal of used fuel rather than reprocessing.

There is a large amount of literature on the costs of construction and they are not necessarily comparable. A summary of plant costs are given in Table 12.35. From this table we calculate that on average a plant will cost approximate US$6 billion and this will be the minimum value to the economy if such a plant is built in Ireland in 2020 or 2030.

83 World Nuclear Association, 2009, *The Economics of Nuclear Power*. Available at: http://www.world-nuclear.org/info/inf02.html

84 World Nuclear Association, 2009, *The Economics of Nuclear Power*. Available at: http://www.world-nuclear.org/info/inf02.html

Table 12.35: Nuclear plant costs worldwide

Name	Cost	Cost/KW
KHNP Shin Kori 3&4 1350 MWe APR-1400	US$ 5 billion	US$1,850/kW
Bruce Power Alberta	US$ 6.2 billion	US$2,800/kW
2x1100 MWe ACR	US$6.6 billion	US$1,530/kW
AEO Novovronezh 6&7 2136 MWe net	US$5 billion	US$2,340/kW
NRG South Texas 2 x 1350 MWe ABWR	US$ 8 billion	US$2,900/kW
CPI Haiyang 2 x 1100 MWe	US$3.25 billion	US$1,477/kW
CGNPC Ningde 4 x 1000 MWe CPR-1000	US$7.145 billion	US$1,786/kW
CGNPC Bailong/Fangchengang 2 x 1000 MWe CPR-1000	US$3.1 billion	US$1,550/kW
CNNC Tianwan 3&4, 2 x 1060 MWe AES-91	US$3.8 billion	US$1,790/kW

Source: World Nuclear Association, 2009

Value of the Export Market

The US is the global leader in nuclear energy technology manufacturing, having a total market value of nearly US$45.2 billion in 2002 and growing to an estimated US$50.8 billion by year-end 2009. By 2013, SBI[85] estimated that the U.S. market value would reach US$61.1 billion, growing at an eleven-year compounded annual growth rate (CAGR) of 2.8 per cent.

The US, France, and Japan comprise more than half of the global value of nuclear energy technology manufacturing. SBI estimates that France's market value will grow from US$28.9 billion in 2009 to US$34.8 billion in 2013 (3.4 per cent CAGR) and Japan will grow from US$19.6 billion to US$23.7 billion (3.4 per cent) in 2013. On a share basis, through 2013, the top three manufacturing nations will maintain their leadership positions, although they will lose share to other nations such as China and South Korea, which will accelerate their manufacturing efforts.

However, there is very little opportunity for Ireland to tap into this global chain as conversion and enrichment only occur in these countries at present and there is a natural monopoly on

85 SBI, 2009, *Nuclear Energy Technologies Worldwide: Components and Technologies*. Available at: http://www.marketresearch.com/product/display.asp?productid=1926673

this. Furthermore, as noted previously, Ireland will have to become strongly competitive locally before they will be able to enter the international market in any form. This is unlikely to happen by 2030.

Employment Opportunities

In 2007, there were 574 nuclear energy establishments in the United States accounting for a total of 80,242 jobs, including jobs in power generation, plant and equipment production, public administration and nuclear consulting[86].

According to Nuclear Energy Institute (NEI)[87], an average nuclear power plant employs 1,400 to 1,800 people during construction (with peak employment as high as 2,400) and then subsequently employs 400 to 700 people long-term, at salaries typically substantially higher than the average salaries in the local area. On average we can assume then that a typical nuclear power plant in Ireland if developed could generate about 2,000 jobs.

12.3.2 Summary of Enterprise Value of Nuclear

Outlined below in Table 12.36 are the results used for enterprise opportunities in the Tetralemma index for nuclear power.

Table 12.36: Enterprise results for nuclear

	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total	Domestic market	Export market	Employment	Total
	2010				**2020**				**2030**			
High scenario												
Nuclear fission	1	1	1	1	5	1	5	5	5	1	5	5
Medium scenario												
Nuclear fission	1	1	1	1	1	1	1	1	5	1	5	5
Low scenario												
Nuclear fission	1	1	1	1	1	1	1	1	1	1	1	1

Source: SQW Energy analysis

86 PEW, 2009, *The Clean Energy Economy*

87 NEI, 2009, *Economic Benefits of New Plant*

Appendix A: Bibliography

Accenture, 2007, *Irrational Exuberance: An assessment of how the burgeoning biofuels market can enable high performance*

Amárach Consulting & Hirsch, R., 2006, *Ireland's Oil Dependence: Trends, Prospects and Options*

André P.C. Faaij and Julije Doma, 2006, *Emerging international bio-energy markets and opportunities for socio-economic development*

Bord na Móna, 2009, Bord na Móna – Energy [Website] Available at: http://www.billionm.ie/energy/

COFORD, 2003, *Maximising the Potential of Wood Use for Energy Generation in Ireland*

DCENR/DETI, 2008, *Study on Common Approach to Natural Gas Storage and Liquefied Natural Gas on an All Island Basis*

DKM, 2008, *Shannon LNG – Economic Benefits to the Irish Economy*

Edenderry Power Station, 2009, [Website] Available at: http://www.edenderrypower.ie/inside.asp?id=13

ESB Power Generation (no date) West Offaly Power Station. Available at: http://www.esb.ie/downloads/about_esb/west_offaly.pdf

ESB Power Generation (no date) Lough Ree Power Station. Available at: http://www.esb.ie/downloads/about_esb/lough_ree.pdf

Energy Savings Trust, 2009, *Hydroelectricity* (available at: http://www.energysavingtrust.org.uk/Generate-your-own-energy/Hydroelectricity)

European Photovoltaic Industry Association (EPIA), 2008, *Global Market Outlook Until 2013*

EPIA/Greenpeace, 2008, *Solar Generation V*

European Commission, 2009, *Renewables Economic Growth Employment Summary*

European Commission, 2006, *Wind Statistics*

European Wind Energy Association (EWEA), 2009a, *Economics of Wind Energy*

EWEA, 2009b, *Offshore: Oceans of Opportunity*

EWEA, 2007, *Wind Energy and the Job Market*

EWEA, 2004, *Wind Energy Study*

ESTIF, 2008, *Solar Thermal Markets in Europe*

Finfacts Ireland, 2007, *ESB to close three power plants*. Available at: http://www.finfacts.com/irelandbusinessnews/publish/article_1010398.shtml

Forfás, 2009, *A Statement of Opportunities in the Energy-related Goods and Services Sector*

Frost & Sullivan, 2009, *Solar Thermal Systems Market in Europe will Double the Revenue*. Available at: http://blog.taragana.com/pr/frost-sullivan-the-solar-thermal-systems-market-in-europe-will-double-the-revenues-4364/

Geodynamics, 2009, *Australia Geothermal Energy*

Geothermal Energy Association, 2009, *Socioeconomics and Geothermal Energy*

Glitnir, 2007, *Debt Financing for Geothermal*

Global Wind Energy Council (GWEC), 2008a, *Global Wind 2008 Report*

Global Wind Energy Council (GWEC), 2009, *Global Wind 2009 Report*

GWEC, 2008b, *Global Wind Energy Outlook*

GWEC, 2005, *Wind Force 12*

Goodbody Economic Consultants, 2007, *Economic Assessment of the Corrib Gas Project*

Greenpeace & ESTIA, 2005, *Concentrated Solar Thermal Power – Now!*

Hydrocarbons-technology, 2009, *Whitegate Oil Refinery, Republic of Ireland*. [Website] Available at: http://www.hydrocarbons-technology.com/projects/whitegate/

Institute for Sustainable Futures (no date) *Energy sector jobs to 2030: a global analysis*

International Energy Agency, 2009, *Technology Roadmap: Carbon Capture and Storage*

International Energy Agency, 2008a, *Energy Technology Perspectives: Scenarios and Strategies to 2050*

International Energy Agency, 2008b, *World Energy Outlook*

International Energy Agency, 2007, *Energy Policies of IEA Countries: Ireland 2007 Review*

InterTradeIreland and Forfás, 2008, *Environmental Goods and Services Sector on the Island of Ireland: Enterprise Opportunities and Policy Implications*

Nasdaq, (29 October 2009), *Energa, Ireland's ESB Plan 800-MW Gas-fired Pwr Plant*. Available at: http://www.nasdaq.com/aspx/stock-market-news-story.aspx?storyid=200910280624dowjonesdjonline000466&title=update-energa-irelands-esb-plan-800-mw-gas-fired-pwr-plant

NEI, 2009, *Economic Benefits of New Plant*

Paappanen, T., Leinonen, A. and Hillebrand, K., 2006, *Study on the impacts of peat used for energy purposes in the European Union*

Paappanen, T. and Leinonen, A., 2005, *Fuel peat industry in EU, country reports – Finland, Ireland, Sweden, Estonia, Latvia, Lithuania*

PEW, 2009, *The Clean Energy Economy*

Pike Research, 2008, http://www.pikeresearch.com/research/biofuels-markets-and-technologies

REPP, 2009, *Economics of Geothermal Energy*, available at: http://www.repp.org/geothermal/geothermal_brief_economics.html

SBI, 2009, *Nuclear Energy Technologies Worldwide: Components and Technologies*. Available at: http://www.marketresearch.com/product/display.asp?productid=1926673

Sustainable Energy Ireland (SEI), 2009a, Energy Statistics Databank

SEI, 2009b, *Ireland's Low-Carbon Opportunity: An analysis of the costs and benefits of reducing greenhouse gas emissions*

SEI, 2006, *Carbon Dioxide Capture and Storage in Ireland: Costs, Benefits and Future Potential*

SEI, 2005a, *Ocean Energy Strategy in Ireland*

SEI, 2005b, *Economic Benefits of Developing Ocean Energy in Ireland*

SEI, 2005c, *Bioenergy Training and Education Needs*

SEI, 2005d, *Policy Incentive Options for Liquid Biofuels Development in Ireland*

SEI, 2003, *A Resource Study on Recovered Vegetable Oil and Animal Fat*

SEI, (no date), *Landfill Gas Resource 2010/2020 Potential and Scenario Development*

SEI and Environmental Protection Agency, 2008, *Assessment of the Potential for Geological Storage of Carbon Dioxide for the Island of Ireland*

SQW Energy, 2009, *The Irish Energy Tetralemma Index,* Fuel Reports 1-4

The Irish Academy of Engineering, 2009, *Review of Ireland's Energy Policy in the Context of the Changing Economy*

United Nations Environment Program (UNEP), 2009, *Global Trends in Sustainable Energy Investment*

Wood Resource Quarterly, 2007, Press Release available at: http://www.prlog.org/10078176-global-trade-of-woody-biomass-has-almost-doubled-in-five-years.html

World Nuclear Association, 2009, *The Economics of Nuclear Power*. Available at: http://www.world-nuclear.org/info/inf02.html

Forfás Board Members

Eoin O'Driscoll, Chairman	Managing Director, Aderra
Martin Shanahan	Chief Executive, Forfás
Simon Barry	ROI Chief Economist, Ulster Bank Capital Markets
Bob Brannock	President, International Europe and Lifestyle Protection, Genworth Financial
Timothy Dullea	Formerly Chief Executive Officer, Tipperary Co-op
Prof. Frank Gannon	Director General, Science Foundation Ireland
Sean Gorman	Secretary General, Department of Enterprise, Trade and Innovation
Miriam Magner Flynn	Managing Director, Career Decisions
William O'Brien	Managing Director, William O'Brien Plant Hire Ltd
Barry O'Leary	Chief Executive, IDA Ireland
Paul O'Toole	Director General, FÁS
Frank Ryan	Chief Executive Officer, Enterprise Ireland
Dr Don Thornhill	Chairman, National Competitiveness Council
Michael O'Leary	Secretary to the Board, Forfás

Forfás Publications

The Role of State Owned Enterprises: Providing Infrastructure and Supporting Economic Recovery Forfás	July 2010
Annual Competitiveness Report 2010 Volume 1: Benchmarking Ireland's Performance National Competitiveness Council	July 2010
Costs of Doing Business in Ireland 2010 National Competitiveness Council	July 2010
Monitoring Ireland's Skills Supply: Trends in Education and Training Outputs 2010 EGFSN, FAS	July 2010
National Skills Bulletin 2010 EGFSN, FAS	July 2010
Forfás Annual Report 2009 Forfás	June 2010
Future Skills Needs of the Wholesale and Retail Sector EGFSN, Forfás	May 2010
Review of supports for exploitation of Intellectual Property from Higher Education Research Forfás, Department of Enterprise Trade and Innovation	May 2010
The Expert Group on Future Skills Needs - Statement of Activity 2009 EGFSN	April 2010
Single Window: Assessment of the Costs of Trade-Related Regulatory Requirements in Ireland Forfás	March 2010
Annual Employment Survey 2009 Forfás	March 2010
Evaluation of Framework Programme 6 in Ireland Forfás	March 2010
Maximising the Environment for Company Research and Development Advisory Science Council	March 2010
Review of Labour Market Programmes Department of Enterprise Trade and Employment	March 2010
Profile of Employment and Unemployment Forfás	March 2010
Management Development in Ireland Management Development Council	March 2010

Forfás Evaluation of Irish Membership of the European Molecular Biology Laboratory Forfás	March 2010
Ireland's Broadband Performance and Policy Actions Forfás	January 2010
Regional Competitiveness Agendas Forfás	January 2010
Annual Business Survey Of Economic Impact 2008 Forfás	January 2010
Annual Competitiveness Report 2009, Volume Two: Ireland's Competitiveness Challenge National Competitiveness Council	January 2010
The Role of PhDs in the Smart Economy Advisory Science Council	December 2009
Research strengths in Ireland: A bibliometric study of the public research base Forfás/HEA	December2009
Driving Export Growth: Statement on Sectoral Competitiveness National Competitiveness Council	December 2009
Sustaining Investment in Research and Development Advisory Science Council	December 2009
Developing the Green Economy in Ireland Department of Enterprise Trade and Employment	December 2009
Future Skills Requirements of the Food and Beverage Sector EGFSN	November 2009
Health Life Sciences in Ireland - An Enterprise Outlook Forfás	November 2009
Skills in Creativity, Design and Innovation EGFSN	November 2009
Monitoring Ireland's Skills Supply - Trends in Education and Training Outputs 2009 EGFSN, FÁS	November 2009
National Strategy for Higher Education - Forfás Submission Forfás	October 2009
Statement on Energy National Competitiveness Council	October 2009

The publications of Forfás and the advisory groups to which it provides research support are available at www.forfas.ie

To sign up for our email alerts contact us at info@forfas.ie or through the website.
August 2010

Forfás
Wilton Park House
Wilton Place
Dublin 2

Tel: +353 1 607 3000
Fax: +353 1 607 3030

www.forfas.ie