An associate of WOW – Paul Monaghan, wishes to share his thesis for his MSc on renewable energy.

Paul writes: 4th September 2007

Hi Derek,

I trust you are keeping well.

I have completed my MSc in Environmental Protection entitled 'Integrated renewable energy options for Irish Industry.'

Attached is the introduction, abstract, some discussion, conclusions and recommendations.

As previously discussed and if you think it worthy you might put up some or part of this on the website.

Thank you Paul

Abstract

The scope of the renewable energy technologies under review in this paper are: 1) Biomass boilers (heat or steam production); 2) Geothermal heat pump systems (simultaneous space heating & cooling); 3) Solar thermal system (hot water and space heating) & Wind power (electricity generation). This research paper tries to understand the barriers to renewable energy deployment in the industrial sector through reviewing publicly available data on industry and case study information. By analysing specific case study data in other sectors of the economy the reader and potential decision maker in industry will be able to use the information collated to make a more informed decision about the potential integration of renewable energy options in their respective facilities. There are no technical barriers in utilising these technologies, which are well established in other 'advanced renewable economies' such as Austria, Denmark & Sweden. The ETS discriminates against renewable energy implementation in industry. Therefore the scheme should be revised to auction the majority of credits and/or introduce a carbon tax that positively discriminates in favour of the most efficient renewables systems e.g. through a rebate scheme. The market is sufficiently mature in the area of biomass projects for suppliers to offer long-term heat or steam contracts taking the CAPEX and fuel supply risk away from the end-user. There has been a significant increase in the use of renewable energy in Irish industry (158.73% between 1990-2005). However this has been isolated to a small number of sectors that have a readily available alternative energy supply on their doorstep. The sectors that have seen a significant increase in utilising renewable energy sources between 1990-2005 are primarily the food & beverage (2,600%) and wood (78.69%) processing industries, the former using the animal by-product tallow in boilers, as an alternative to oil and the latter using various wood residues in combustion processes. The overwhelming evidence from surveys conducted point to embedded management strategies to deal with the efficient use of energy and its conservation, especially in ''large'' energy users, but not renewable energy. The main reasons for this are high capital costs & availability, longer payback periods and security of supply (large enough & continuous resource). It is telling that no companies surveyed have set renewable energy target and objectives, unlike energy efficiency and conservation measures.

The range of payback periods, without publicly funded subsidies is 5.7-14 years. The shortest payback period was for the biomass boiler, with the longest for the solar thermal system. The range of payback periods, with public subsidies was 3.6-10 years; the wind turbine had the shortest payback period, but had a disproportionate level of public funding (43.3%) and the solar thermal system the longest. Wind power had the highest cost per MW installed at €1.1 million, with the biomass boiler the least expensive at approx. €0.317 million. A large decrease in carbon emissions is possible using renewable energy systems and/or carbon neutral fuels, when compared to the conventional fossil fuel technologies. The best performing renewable technology for CO_2 savings is the wind turbine (1.35kg CO_2/kW system output). The renewable technology that yielded the lowest savings was the solar thermal system at 0.23kg CO_2/kW system output. This figure was 0.49kg CO_2/kg steam produced for the biomass boiler. Evidence from case studies demonstrates that significant energy savings can be realised through the use of renewable energy, although initial capital intensity is high. The range of annual energy savings as a % of CAPEX was 7.14-15.62%. The highest return on investment was the wind turbine, with the solar thermal system yielding the lowest return. Other benefits of renewable energy may also accrue such as enhanced security of supply, fuel diversification, potentially lower operation & maintenance costs, especially solar & geothermal, supporting local employment and fuel suppliers and creating a resource of goodwill among employees, corporate and the wider public, which can be drawn upon to implement other beneficial energy related projects, within industry.

Against the backdrop of increasing & fluctuating fossil fuel prices, intensification of the EU-ETS and impending peak oil, the following actions needs to take place to assist a renewable energy breakthrough in industry: A) The full range of benefits must be actively disseminated to industry by organisations such as the SEI e.g. through the large industrial energy networks (LIEN) and also champion specific high visibility ‘best practise’ renewable energy projects in industry similar to other projects supported in the commercial sector; B) There is considerable potential for the integration of renewable energy, especially solar thermal in low temperature industrial processes however the groundwork research needs to be done between the state agencies and industry e.g. RE RD & D programme-SEI C) If energy management and decision makers factor in energy price inflation (> 7.5% per annum between 2000-2005) then payback periods for renewables, even without subsidies would be further reduced and therefore more attractive to industry. This would bring the payback period for the biomass steam boiler project to less than 5 years-assuming energy inflation of 7.5%; D) As the energy consumed by equipment over its lifetime far exceeds its original cost this can be balanced against the annual energy savings achievable with renewable energy systems therefore a broader more strategic outlook, by energy managers towards renewable energy, would see a change in attitudes and acceptance of the capital invested recouped over the equipment’s lifecycle.

1.0 Introduction

Irelands is a signatory to the 1997 Kyoto Protocol, with a commitment to a legally binding target of a 13% reduction of greenhouse gas emissions, during the target period 2008-2012, based on 1990 emission levels. Ireland has been effectively allocated an emissions quota of 63 mtCO_2e per annum over the target period. Emissions in 2004 were 68.46 mtCO_2e or 23.1% above 1990 levels. EPA figures indicate emissions levels in excess of 70 mtCO_2e for 2006. Ireland will not meet its obligations under Kyoto, without the use of flexible mechanisms.

Industry has a role to play in helping Ireland Inc. meeting its international commitments. The mechanism employed by Government to regulate greenhouse gas emissions in industry is the emissions trading scheme (ETS). Over 100 of the largest CO_2 emitters in industry (inc. the energy generation sector) have been issued permits by the EPA, with carbon credits allocated based on historical and verifiable emissions from each operation. The first national allocation plan of carbon credits came into effect in 2005 (NAP I, 2005-2007). NAP II is due to into effect in 2008 and will cover the period up to 2012.

Ireland has seen an unprecedented growth in industrial output; 25% increase between 2000-2004.The overall share of GHG emissions from industry increased from 7.9% to 8.2% between 1990-2004, although this is significantly less than other sectors that have seen double-digit emission increases, such as transport over the same time period. The industrial sector accounted for 18.3% of total final energy consumption in 2004 or 2.16 million tons oil equivalent and the consumption of oil & gas has increased by 53.57% and 19.55%, respectively between 1990-2005. Decoupling between energy consumption and production was evident in the late 1990's, with 'absolute' decoupling in 2000. The main reasons for this trend were 1) Accelerating energy costs; 2) licensing of larger industries (& energy users) by the EPA and 3) the management of energy more efficiently. The conundrum for industry is that despite this decoupling fossil fuel prices continue to rise significantly, effecting industries bottom line. However if industrial output increases, so to will primary energy consumption mainly in the form of oil, gas and indirectly through electricity use.

Increased energy consumption means an increased in energy costs, although still low when compared to other overheads such as raw materials and labour. However this increase can still negatively impact on the industries competitiveness, which is effectively been eroded by increased fossil fuel prices putting pressure on existing jobs and potentially diverting new investment away from Irish industry.

Oil dependence in industry is running at 33%, followed by electricity then natural gas. All of the oil and the majority of gas are imported and the generation of electricity is based mainly on fossil fuels, with an increasing percentage utilising natural gas from the U.K., which has its own security of supply difficulties. In addition the EPA has pointed to the low penetration of combined heat & power (CHP) facilities, which usually run on natural gas for clean & efficient electric generation (when compared to other fossil fuels). This pattern of consumption is clearly unsustainable in the long-term. In addition the vista of peak oil is upon the horizon. Recent energy price increases and fluctuations have seen the price of a barrel of oil (Brent crude) seesaw between $30-$70 per barrel. It is therefore safe to assume as peak oil approaches these increases and fluctuations will become much more pronounced inevitable penalising the largest consumers and polluters, including industry. Harry J. Longwell, Executive Vice President of Exxon Mobil (2003) has already indicated peak oil occurred in the 1960's followed shortly thereafter by gas. More conservative estimates put peak oil at sometime between 2025-2050, but this timetable is highly dependant on the short-term and widespread roll out of low carbon technologies and energy efficient measures (IEA).

The benefits of renewable energy to industry are clear. The main benefits are substantial annual energy savings, significant reductions in emissions and enhanced security of supply position by reducing industries dependence on costly, climate changing and non-renewable energy sources. There are many others, which are detailed in this research document. The main focus of this research paper is on selective renewable energy technologies and their potential applications & transfer to

an industrial setting, while highlighting the barriers to renewable energy deployment within industry and outlining some possible solutions primarily through specific case study analysis and policy measures. However this author favours a dual approach by industry i.e. continuation of the widespread implementation of energy efficient & conservation measures, including energy management systems through voluntary organisations (LIEN) in partnership with state agencies (SEI), with regulatory oversight (EPA). This is a top down approach addressing the issues of energy demand thereby reducing or stabilising consumption. Renewable energy is a bottom up approach displacing fossil fuel consumption, releasing capital for other projects, reducing the sectors burden on the environment, while improving its security of supply and assisting industry achieving regulatory compliance.

5.0 Discussion of Results

Introduction

In line with the aims & objectives of this research project the case study information and analysis is to provide the decision maker with a range of Renewable Energy options that meet some or all of a modern industries energy requirements, be it heating, cooling, hot water, steam or electricity. A Renewable Energy system can stand alone or can be integrated with other renewables and/or conventional fossil fuel energy technologies to provide industry with an overall efficient, (partially) renewable, cost effective, secure and low carbon solution to its energy needs. We see this in the context of industries sustained efforts since the early to mid 1990's to reduce energy consumption and emissions (business as usual scenario). However energy prices continue to increase and despite decoupling between production output and energy consumption in the industrial sector the demand for primary energy and/or electricity will accelerate albeit at a slower pace. Only with Renewable Energy playing a significant role in industry can it achieve the win-win scenario of continuing to grow and expand, while at the same time reducing its environmental burden and protecting its competitiveness. However the application of Renewable Energy in Industry should not be done in isolation only with the integration of a sound energy management system incorporating efficiency and conservation techniques will the full benefits of Renewables be realised. The implementation of an energy management system will see energy demand reduced. In addition any building or structure should incorporate high levels of insulation and air tightness in line with the Energy Performance Directive (EPBD) and soon to be revised building regulations, as envisaged under the new National Climate Change Strategy (NCCS). It is preferable these features would included at the design stage. Lastly improvements in process efficiencies not just in terms of yields but reductions in energy demand and/or integrating solar thermal systems all will contribute to making industry more amenable to the application of Renewable Energy based Technologies. Cost-benefit analysis have been carried in the literature review and results sections, this includes payback periods with and without any available Government subsidies. Even where the paybacks are greater than 5 years the case studies clearly demonstrate significant annual energy savings, emission reductions, improved cash flow situation, a reduced dependence on fossil fuels (security of supply) and very low maintenance levels, especially for heat pump and solar thermal systems. Outside of the food & beverage and wood industries, which utilise renewable by-products there is little or no Renewable Energy integrated within Irish Industry, although information in the public domain (EPA & LIEN) indicate a genuine interest in renewables, with discussions at management level, cost-benefit analysis and even feasibility studies being carried out. It appears though from response to the questionnaire that the focus of energy management is weighted towards energy efficiency and conservation projects, which are less capital intensive, have shorter payback periods and are

better understood. There seems to be a pervading attitude in industry that these types of projects pose less of a risk and you get 'more bang for your buck,' when compared to Renewable Energy. Some of the barriers, perceived or otherwise to the rollout of Renewables in Industry outlined in the LIEN newsletter, 2004 are still in place such as complex grid entry arrangements. This currently only applies to the largest energy consumers, who may wish to become auto producers of on-site power, but still require a grid connection. This situation should improve under the National Development Plan, 2007-2013. Other barriers have been removed with deregulation, which has improved competition in the market e.g. in the electricity and gas utilities. Security of supply issues are being addressed with more and more suppliers offering short-term or long-term equipment and fuel supply contracts (ESCO's) and other improvements in the supply chain, as envisaged under the Bioenergy Action Plan. With the inevitable and substantial year-on-year increases in fossil fuel prices decision makers within industry must factor this into their payback calculations and take a more strategic outlook towards Renewable Energy Technologies bringing them into the mainstream of power supply instead of waiting for the worst effects of peak oil (& gas) and the 'fossilised' technologies that depend on conventional fuel sources. Companies such as Novartis in their public corporate governance literature have already expressed a much broader view of recovering the capital expenditure of renewable systems over their lifecycle. One could argue that senior decision makers within any organisation have a responsibility to themselves, their employees and shareholders, who can all be one and the same to move their energy supply and associated technologies to a more sustainable path sooner rather than later given the disproportionate effect any potential interruption in the flow of primary energy or electricity may have on high value production lines and the impact on various customer bases. Finally in appendix IV a Road map is provided which should provide energy professionals etc with a useful tool in the implementation of a Renewable Energy project (s) building a comprehensive and accurate picture as to its potential feasibility in partnership with selected vendors, while addressing any barriers throughout the process in a systematic way.

It is the view of this author than partnerships and synergies need to be formed between the major stakeholders in planning and implementing a 100% Renewable Energy based industry and Industrial Park/Estate, the latter incorporated elements of district heating (feed in industrial waste heat) and biomass CHP, which would underpin other renewables and energy management control systems. Organisations that may form such partnerships would include, but is not limited to SEI, EPA, IDA and directly from Industry the LIEN or Responsible Care etc. The knowledge gained and disseminated from such an endeavour would be invaluable to industry and would act as a template to integrate some or all of the Renewable Energy systems demonstrated into other enterprises.

6.0 Conclusions

A) Tackling energy related & emissions concerns is a pro-growth strategy (Stern).

B) The most important single policy is probably the right tax system, to encourage alternative energy and discourage oil consumption.

C) Technology is not a barrier to renewable energy deployment in industry and is well established in other countries such as Austria, Demark and Sweden, especially biomass combustion (Austrian & Sweden), wind turbines (Denmark) and heat pumps (Austria).

D) Renewable technologies that run on biomass and wind are already competitive with their fossil fuel counterparts.

E) One of the criteria for renewable energy projects & financial assistance should be based (proportionally) on the technology/system with the highest efficiencies & yields, especially for solar thermal installations. This will maximise system output and give the public the best value for money.

F) Autoproducers of energy (electricity) from renewables that require a grid connection such as wind turbines or biomass CHP need to be aware of the main difficulties bringing this part of a project to fruition i.e. 1) Access to the grid, which can be a lengthy process; 2) Grid related technical problems that can potentially lead to energy plant downtime, especially in the case of wind turbines and 3) Planning-can be a lengthy & onerous exercise.

G) Significant 'strengthening' and reinforcement of the grid is required to reduce the risk of transmission quality problems and overcome stability issues. Significant funding under the NDP has been allocated to address these issues.

H) The quality and range of renewable energy case study information on the SEI website, at the beginning of my research (Autumn 2006) on a scale potentially useful for industries was disappointing. The majority of available case study information concentrated on energy efficiency and energy conservation projects. This situation did improve in 2007 with additional biomass, heat pump & solar fact sheets becoming available, with good technical, financial & environmental performance data.

I) Wood pellets are ideal for industrial use in terms of density, handling, transport, moisture content and calorific value, but are more likely to follow fossil fuel price increases (as oppose to wood chip), as they are more energy intensive to produce.

J) Biomass market is sufficiently mature for a range of suppliers to offer a long-term or short-term contract to the end-user, where the supplier takes all of the equipment CAPEX and fuel supply risk i.e. the client is effectively buying the steam and/or electricity, usually over a 10-15 year period, which is energy or consumer price indexed. They are referred to as ESCO's (Energy Service Companies).

K) Heat pump and solar thermal systems boast exceptionally low maintenance costs.

L) The heat pump system offers the user the highest efficiency levels, with the case studies under this review yielding a coefficient of performance of ≥ 3.75

M) Solar thermal systems are ideal for low temperature applications (20-100°C range), such as hot water and space heating but also feed water applications for example in boilers & bottle wash operations.

N) There is significant potential for solar thermal systems and low temperature applications in industrial processes including but not limited to cleaning, biochemical reactions, defrosting, dehydration and laminating (Schnitzer, Brunner & Gwehenberger).

O) The site with annual mean wind speed of 20km/h with a hub height of 30m and a power density of 150W/m² is an economically viable annual wind speed for power generation (G.M. Joselin Herbert, S. Iniyan, E. Sreevalsan, S. Rajapandian).

P) The overwhelming preoccupation of industries surveyed, when it comes to energy is its efficient use and conservation. There were no targets & objectives set by any of the companies from the EPA public files reviewed. None of the projects under the EPA sponsored CGPP had a renewable energy element or theme and only a minority (2.86%) of LIEN organisations surveyed were currently utilising renewable energy or had any future plans to do so (7.14%). If you remove industries that are utilising renewable by-products such as tallow and wood residues renewables are very much relegated to the margins of energy generation.

Q) Renewable energy technologies tend to have a high initial CAPEX, when compared to with conventional systems e.g. €240,000 for a 150kW heat pump system versus €80,000 for a conventional boiler and air conditioning unit (Ratio 3:1).

R) Payback periods of renewable technologies w/o subsidies: 5.7-14.0 yrs.

S) Payback periods of renewable technologies, with subsidies: 3.6-10.0 years.

T) The best performing renewable technology for carbon emission reductions was the wind turbine at 1.35kg CO_2 savings/kW output. The least favourable performer was the solar thermal system at 0.23kg CO_2 savings/kW output. The biomass boiler yielded a saving of 0.49kg CO_2/kg steam output (assuming a running time of 3,000 hrs.).

U) The renewable technology under review with the best annual return on investment, as a percentage of CAPEX (w/o subsidies) was the wind turbine at 15.62% (assuming a commercial tariff of €0.101c/kWh). The least favourable return was the solar thermal system at 7.14%.

V) The solar thermal system ranked the least favourably in terms of payback period (both with and w/o subsidies), efficiency and emissions reduction.

W) The cost per megawatt installed was highest for the wind turbine project at €1.1 million (average of €1.21 million over the three turbines) and lowest for the biomass steam boiler at €0.317 million.

X) The main advantages of Renewable Energy expressed in the questionnaire were 1) Cost savings; 2) Emission reductions and 3) Security of supply.

Y) The main barriers or obstacles to renewable energy (questionnaire) are given as: 1) Security of supply (large enough & continuous resource); 2) Capital cost; 3) Technology issues; 4) Planning & Regulatory approval; 5) Site availability and 6) Payback periods.

Z) The main advantages of energy efficiency/conservation over renewable energy were given as 1) Less capital intensive; 2) Better understood & 3) Shorter payback periods.

7.0 Recommendations

A) The ETS discriminates against renewables in industry. Therefore the majority of carbon credits should be auctioned to achieve a breakthrough for renewable energy in industry, by making these technologies economically more attractive to industry.

B) It is recommended to shift to a more sustainable path, by using instruments such as carbon trading and utilising low carbon technologies, including renewables (Stern).

C) With the acceleration of biomass installations the EPA should commission a report into the potential environmental impacts of biomass residue & disposal from the combustion processes. The ash from wood pellets or chips is mineral rich and can be used as a fertilizer. The question needs to be answered; landfill or land spreading (or both)?.

D) SEI needs a more focused and comprehensive approach in advocating renewable energy projects in industry. Partnerships should be formed (similar to participation in the first round of IS 393 implementation) to realise Ireland's first 100% Renewable Energy powered Industry and/or Industrial Park. This could act as a catalyst and example for others to follow.

E) The main benefits of Renewable Energy are well documented i.e. energy cost savings, reduced carbon emissions and an enhanced security of supply position. However it is imperative other advantages are put to the fore, such as 1) potentially reduced levels of maintenance, especially for solar and heat pump system; 2) supporting local employment in the areas of equipment, fuel supply and consultants; 3) Improved safety e.g. wood pellets are a more stable fuel than gas; 4) Shorter supply chains (significantly reduced carbon footprint) and 5) Potential ability to harness the goodwill generated both inside and outside the company for the implementation of other energy related projects.

F) The financial benefits that may accrue due to lower maintenance activity, especially solar and heat pump systems should be researched, costed and disseminated, which will allow for their inclusion in any payback calculations.

G) In terms of payback periods more realistic annual fuel price increases need to be factored into the equation; moving forward say use 7.5-10% (Staudt). This would certainly bring technologies like wind turbines and biomass boilers within the 5 year payback criteria even without subsidies.

H) Planning exemptions to certain renewable projects, especially if they compliment existing supports e.g. Reheat programme, as outlined under the NCCS, 2007-2013 need to be fast-tracked to encouraging renewable energy uptake in the industrial sector.

I) SEI need to construct a comprehensive renewable energy technology database for all potential users to raise awareness of their benefits, which would provide a blueprint for their application in Irish industry. It could also include international case study information from renewable projects

successful implemented, including industry from other countries, as well as Ireland.

J) Energy managers, professionals and decision makers need to take a much more broader and strategic outlook of renewable energy projects than just simple payback periods, as many other benefits can accrue to industry.

K) Equipped with the knowledge of continuing fossil fuel price increases and fluctuations, Intensification of the EU-ETS and impending peak oil industry should positively discriminate in favour of Renewable Energy Technologies, especially when considering investing substantial amounts of capital in new or replacement conventional fossil fuel technologies such as boilers or CHP installations, with lifecycles covering the next 20 plus years.

L) Although only in its infancy and requiring a higher level of planning, design and integration Solar Thermal technology should be incorporated into industrial processes. The system design engineer should focus on the process operating at the lowest possible temperature in order to increase collector efficiency and reduce storage losses.

COMMENTS FROM

WOW Alternative Energy Solutions Ltd.

This is just the level of dedication and exploration we need to establish the facts and strive to improve in order to find the ultimate solutions.

Thank you for sharing this information with us Paul. In my view, this is a very thorough and valuable area of work.

I wish you every success for the future.

Kindest regards

Derek Tyrrell
Director
WOW Alternative Energy and Environmental Solutions Ltd.