Title	A Green Agenda for the Irish Renewable Energy Sector
Author(s)	Das, Satyasiba; Best, Michael H.; Ryan, Paul
Publication Date	2010-06
Publication Information	Das, S., Best, M. and Ryan, P. (2010) "A Green Agenda for the Irish Renewable Energy Sector", CISC Working Paper No. 38.
Publisher	CISC
Item record	http://hdl.handle.net/10379/2458

Centre for Innovation and Structural Change Working Paper Series

A Green Agenda for the Irish Renewable Energy Sector

CISC Working Paper No. 38
June 2010

Dr Satyasiba Das
Centre for Innovation and Structural Change
National University of Ireland, Galway
satyasiba.das@nuigalway.ie

Professor Michael H. Best
Centre for Industrial Competitiveness
UMass at Lowell
Michael_Best@uml.edu

Dr Paul Ryan
Centre for Innovation and Structural Change
National University of Ireland, Galway
Paul.a.ryan@nuigalway.ie

'Multidisciplinary insights into innovative change'

The Centre for Innovation and Structural Change (CISC) is a national inter-disciplinary research institute, based at National University of Ireland, Galway, focused on building an internationally-recognised programme of research and education on innovation processes and policies that are fundamental to the development of a knowledge-based economy. CISC is one of the four major research institutes within NUI, Galway and it is aligned to the Applied Social Science and Public Policy thematic research priority. Established in 2002, CISC was initially awarded competitive funding under the third Irish Government's Programme for Research in Third Level Institutions (PRTLI 3). Since then CISC has been awarded significant additional competitive funding both nationally and internationally and has developed a distinguished record in scholarship and research innovation and structural change.

The core focus of CISC is providing multidisciplinary insights into innovative change. CISC is an umbrella research institute, offering a common ground where researchers from different disciplines and backgrounds can meet and debate, where they can consider processes and issues from different perspectives. Innovation happens at cross-over points whereby CISC provides a forum for the formal and informal interactions necessary to enable an interdisciplinary community of researchers to flourish. The exchange of ideas and the challenging of knowledge generate an intellectual energy and a spirit of enquiry. This collaborative environment fosters new approaches and the synergy generated aligns best practice in innovation research with current policy, business and management practice thinking. These new approaches and insights are disseminated and shared with a wide variety of national and international stakeholders.

Research at CISC can be divided into five key research areas, with some research initiatives spanning more than one area. The core research areas are:

- **Innovation Systems**
- **Industry Clustering**
- **Internationally traded services**
- **Inter-organisational systems**
- **High Performance Work Systems**

For further information on CISC please see our website: www.nuigalway.ie/cisc

Contact:

Angela Sice
Development Office
Tel: +353 91 492817
Email: **angela.sice@nuigalway.ie**

Dr. James Cunningham
Director
Tel: +353 91 493472
Email: **james.cunningham@nuigalway.ie**

Ireland's EU Structural Funds Programmes 2007 - 2013
Co-funded by the Irish Government and the European Union

HEA
Higher Education Authority
An tÚdarás um Ard-Oideachas

NUI Galway
OÉ Gaillimh

A Green Agenda for the Irish Renewable Energy Sector

1. Introduction: The Challenge and Opportunity

For reasons of energy security, climate change obligations, and cost, pressure is building for Ireland to establish a renewable energy (RE) industry with the capacity to address security, climate change, and competitiveness goals. The Government has set goals of 15% of electricity from renewable by 2010 and 33% by 2020[1]. The barrier to the achievement of RE goals is not the lack of natural resources. While Ireland does not have appreciable fossil fuels, it has vast wind, wave, and tidal energy resources. Presently, wind energy is Ireland's lowest cost source of electricity with low environmental externalities. Besides wind power, the west coast of Ireland is the site of Europe's most abundant source of accessible wave power with at least as much potential as off-shore wind energy (SEI 2004 p. xvi; Staudt, 2007 p. 7)[2].

Ireland therefore is in the enviable position that it has the natural resources which, combined with proven wind turbine technology, can supply its total electricity energy needs with renewables. Sustainable Energy Ireland's Brian Mother way states that "Ireland has 13% of Europe's coastline. In terms of wave and wind energy that is the equivalent of a natural gas oilfield". Similarly, Harvey Appelbe of Tonn Energy comments that "Because the country has such a vast natural energy resource, and as the technology becomes proven, and the government policy and supports take effect, Ireland can really be the 'Texas of Europe' exporting large quantities of green electricity" (Knowledge Ireland, Winter 2009).

It is unlikely the contours of a future industry have ever been as predictable as that of renewable energy. Only the timing and trajectory are in doubt. While technological breakthroughs will alter the composition of energy sources and the fate of individual companies, the broad industrial outlines of the post-carbon technology age are coming into focus. As Eoin O'Driscoll of Forfas stated "We understand the underlying science principles involved in solar, tidal, bio-fuels, wind. What we don't know is how to harness the sun, wind, waves and crops to produce energy in a cost-efficient manner. ..Its more of the engineering challenges and the deployment challenges and the cost-conversion challenges than it is around

[1] The Government's *Energy White Paper* published March 12, 2007.
[2] This section of the Lucerna report on renewable energy will therefore focus principally on wind and wave energy potential and challenges.

basic science". The timing and trajectory, however, are important. Regions and nations that lead the way in the transition will enjoy the economic advantages of leadership in that industry.

Ireland has engineered the development of new industries in the past but none as complex as this RE sector. In the case of the Information and Communication Technology (Computer & Communication hardware and Software & Communication services) and Medical technology (Medical Devices, Equipments, and Services) the Irish Development Agency (IDA) attracted affiliates of foreign headquartered companies with a range of government supports. This included fostering close industry and education partnerships in the creation of a curriculum to educate a labour force that matched both the technical skills and the size to rapidly ramp up production. The end result was the development of a competitive advantage in complementary capabilities to foreign headquartered technology-leaders. These capabilities evolved from the rapid establishment to scale of world class manufacturing plants with an educated, low cost labour force to the remote management of a range of other routine business processes.

Because of changes in both Ireland and the rest of the world, this model will not drive the creation of a renewable energy industry. Its success created imitators abroad and increased costs at home. Inviting large numbers of rapidly growing foreign firms to establish Irish affiliates to deliver world class manufacturing capabilities is no longer sufficient to drive the creation of a new industrial sector in Ireland. To establish a new and rapidly growing RE industry in Ireland, the Government needs to do more than offer services and facilities that keep costs low. The challenge is multi-faceted.

Growing an indigenous RE industry will depend upon mutual interactions amongst growing enterprises across a set of technologically inter-dependent and inter-related sub sectors as well as with civic bodies. That demands a structural change in the existing Irish innovation system to a scale that the entire country will act as a full scale laboratory for these sectors (as Denmark[3] did for wind industry). An entirely different business model will be required and needs to be supported.

[3] Denmark particularly began the transition to a RE industry in the 1970s when a rapid rise in oil prices brought the issue of energy security to the attention of the public and government for the first time. While no country has completed the transition to a post-carbon age industrial system, they have made important advances.

In recent years considerable attention has been paid to the lack of and potential for development of the renewable energy industry. In addressing these challenges a plethora of reports have been produced on the sector and its opportunities and challenges[4]. However missing from these governmental and advocate reports and elsewhere within Ireland is a rigorous discussion of the population of enterprises that currently or potentially constitute the RE industry within Ireland, both indigenous and foreign headquartered, their strategies, and how the existing business organisation capabilities and projects compare to an endpoint of an established RE industry. While no simple mapping can be done from RE clusters elsewhere such as in Massachusetts or Denmark, we can identify a number of inter related sub-sectors that will constitute such an industry. Within each sub-sector potential industry drivers can be identified and emerging technological capabilities can be characterised. The research methodology is, in part, to characterise emerging distinctive national competitive advantages by interrogating the product concepts and emerging technology capabilities of rapidly growing companies, of companies that have successfully attracted finance and forged technology development alliances with global leaders. Such an exercise of technology capability characterisation is subject to ongoing reassessment as real-world events unfold. At the same time it offers a starting point for developing a strategy for business organisation development and the interdependent roles of government, foreign headquartered companies, indigenous ventures, business alliances, university programs and research centres.

2. The emerging structure of the Irish RE sector

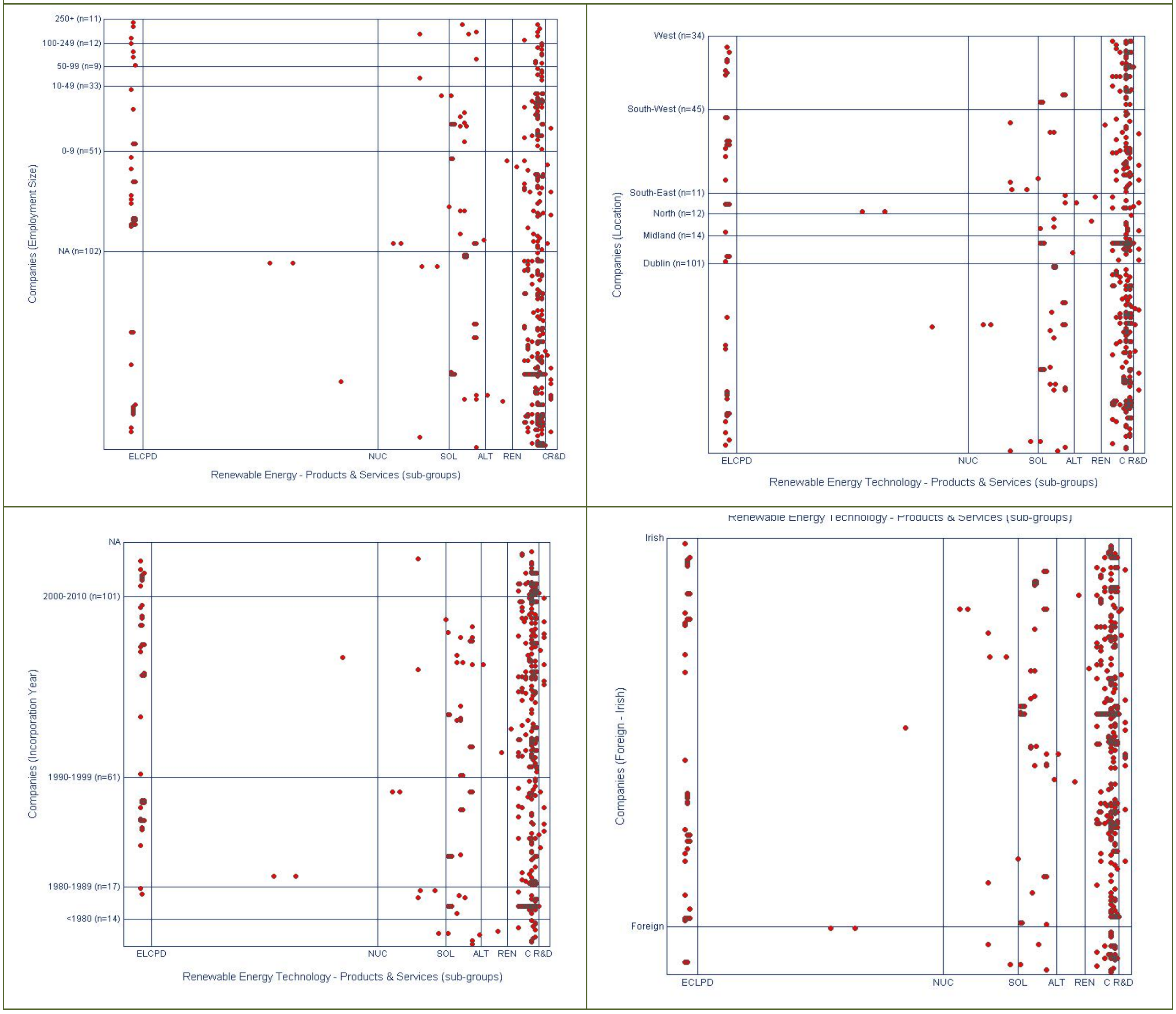
A sample of RE industry companies is drawn from the Lucerna database. A product pool was constructed of the product groups (5 digit correspondence at Kompass classification) and products at 7-digit level at Kompass, for the RE Technology Based Cluster (TBC). There are 227 engineering products and service catagories that are defined by using Kompass 7-digit product classification. Scatter plots (see figure 1) were created by Lucerna researchers in which the companies that provide services or products are represented on the Y-axis and the actual products are represented on the X-axis. In the resulting figures, 208 RE firms which were sorted in terms of employment size, origin, incorporation year, and by region are

[4] See especially the excellent work of Sustainable Energy Ireland and its extensive range of RE reports at www.seai.ie/publications.

represented on the Y-axis. Each of the 236 red marks on the figures indicates products that are produced by corresponding companies on the X-axis. By taking products as a proxy for firm capability, the red marks in the figures indicate certain clusters of activity. This exercise allows us to better understand the industry segments in which Irish production capability lies.

There are a number of key messages that can be discerned from the scatter plot figure 1. First, this is obviously a relatively new sector as indicated by the recent incorporation years of the member firms. The employment structure shows most are small firms. This is due to the newness of the sector and the fact that most firms are in the consultants (C) band. There is a further concentration of small firms in the R&D band. Electrical production and distribution ELCPD) has most large firms. There is a wide distribution of firms in alternative (Alt) and renewable (REN) energy bands. Most of the firms in all bands are indigenous. Future rounds of Kompass data will facilitate us to track the growth and evolution of sectors and firms across bands.

Figure 1: Scatter plots of Energy TBC



3. Recommendation for a Renewable Business Model

3.1 Inter-Organizational Relationships and Cluster Formation

Our initial interrogation of Lucerna found a small population of innovative enterprises in an industry in which Ireland has a natural competitive advantage (2007 Kompass data)[5]. To date, the gap between the actual and the potential realisation of the natural advantage in RE is wide. What would it take to create a dynamic RE cluster capable of turning the country's natural advantage into a competitive advantage? Put simply, it requires the emergence and rapid growth of not a few but a large number of business enterprises. And while the understanding of cluster formation is not a hard science, history does reveal a few key relationships.

> First, we find firms do not grow alone, but as members of groups of enterprises, mutually adjusting one to the other. For this reason, amongst others, the open-systems business model is a building block.
>
> Second, we find inter-sector feedback loops: the PC and semiconductor industries; furniture making and woodworking machines; the combustion engine and the car body industry.
>
> Third, we find interactions between emerging industries and government funded physical infrastructure: the car and the highway system; ICT and the fiber-optic Internet backbone, electrical appliances and the national grid.
>
> Fourth, we find interplay between technology driven enterprises and university conducted basic research. In fact, from an innovation perspective we can see technology management as cutting across universities and enterprises to link basic, technological, developmental, and applied research with new product development.
>
> Fifth, we find government funding of a basic research and a science and technology infrastructure centered in research-intensive universities. While this is most

[5] Currently being updated with recently available Kompass data. This will show areas where evolution and growth is occurring.

pronounced in high tech sectors, the interplay of specialist technology education and product-led business strategies is universal.

In all of these cases we are not simply looking at the existence of a list of activities in the industrial, governmental and educational spheres. We are looking for interactive, cross-institutional processes by which the activities in each institutional sphere mutually adjust to one another to establish an innovative system.

3.2 Tapping the technological capabilities of affiliates of technology leaders headquartered in Ireland

MNEs currently located in Ireland may amend their business models to employ their capabilities in the RE arena. There is great scope to utilise capabilities of MNEs in materials, machining, engineering, hardware and software, electronics and S&T knowhow in the RE arenas.

Several major IT companies with a major presence in Ireland are entering into the smart grid space with investments and acquisitions elsewhere. Gary O'Callaghan, of Siemens Ireland, makes the point: "Renewable energy would form the bedrock of a smart grid in Ireland...If the government is going to invest heavily in the national infrastructure to achieve its target of 33 percent of renewable energy, it would get additional savings by deploying smart grid technologies (Siliconrepublic.com)."

Elsewhere, projects are being developed. IBM is working with a Danish research group to build a smart grid that will support electric cars. "Electric vehicles are one of the technologies we can use to incorporate renewable energy into transportation," said Danish Minister of Climate and Energy, Connie Hedegaard. To achieve this on a large scale, electric vehicles require smart technologies to control charging and billing, to minimise carbon emissions, and to ensure the stability of the overall energy system. At present the consortium is implementing a demonstration project on the Danish Island of Bornholm (Siliconrepublic.com, 26th February 2009).

Analog Devices Inc., a Massachusetts-based IT company with a long presence in Ireland has seized the smart-grid opportunity by acquiring power-line communications technology from Domosys Corporation, a privately held Canadian company. The technology is effective for advanced metering infrastructure systems that utilities need for smart-grid applications (Suzanne Deffree, Managing Editor, News -- Electronic News, 25th February 2009).

While the details need to be worked out, we do know this: achieving climate change and energy independence goals is about reinventing the grid to take full advantage of both the IT revolution and renewable energy technology advances. Only then will the RE industry come of age in a self- reinforcing and self-organising set of inter-industry dynamics to become the foundation of a post- carbon age, knowledge-intensive industrial economy.

3.3 Building an Industry-embedded Science and Technology Infrastructure

Companies need to do more than make products; they need to have new product development and technology management capabilities if they are to contribute to the growth of an indigenous, innovative RE industry. Important as these enterprise capabilities are, the creation of a RE industry will require the industrial innovation capabilities that are rooted in interactions amongst a critical mass of flexibly specialised enterprises.

Building a dynamic renewable energy industry exposes many of the shortcomings of the Irish high-tech economy as presently constituted. While Ireland's economy grew rapidly over a two decade period, it was not based on the development of an indigenous S&T infrastructure and technology development within Ireland. Strikingly, there was under-investment by the Irish government in science, technology, and innovation in the period 1994-1999. It did fund education and ramped up the output of science and engineering graduates in sync with the needs of the affiliates of foreign-based high tech companies. This did not leave Ireland with an independent direction to technology and future industrial development. It was passive in technology priorities. It worked until costs rose. But the seeds for RE and clean technology and transportation were not planted in the education and research system and the transition will accordingly be that much harder.

Despite improvements in public investment in S&T since 1995, Ireland is not well prepared for technology-led transitions at least in terms of R&D capability. A report by the Irish

Energy Research Council stated the following: “A review of the current status of energy research in Ireland reflects the historically low levels of investment [c. Euro 6 million in 2005] with fragmented research effort on a wide range of topics” (IERC, 2008 p. 18). For 2005, Ireland spent 0.07% of GDP on energy R&D and this is in contrast to Denmark (0.30% of GDP); Netherlands (0.27%); Norway (0.30%); and Switzerland (0.40%). (IERC,2008 p. 13; European Commission, 2007).

Government leadership will be required to oversee the establishment of both the smart grid and a science and technology (S&T) infrastructure in which ‘third-mission’ R&D capabilities of university labs foster the growth of a critical mass of firms which both benefit from and contribute to advancing and shaping Ireland’s S&T infrastructure.

The troika model of interplay amongst industry, government, and university was not lost on economic policymakers elsewhere. The Nordic countries, more so than anywhere else, have institutionalised just such a complex to foster the emergence and growth of high tech sectors. In Denmark, Sweden, Finland and Norway, the government has funded basic research, fostered industry and university research partnerships, and sought to leverage emerging ‘indicators’ of competitive advantage and turn them into clusters with a critical mass of companies. They have thought and acted long term.

We might call the troika a framework for government technology management (TM) policymaking. As for the Nordic countries, TM is not a government add-on to policymaking; it is about effectively administering the interplay of business organisation, production capabilities and skill formation, the capability triad.

Ireland simply does not have the critical mass of resources to compete with a Route 128’s 3000 plus high tech companies, or Silicon Valley’s 6000 plus high tech companies. But both of these regional innovation systems began with industry and university partnership capabilities and government funding of basic research. Long term partnerships can be an organisational means to link basic research, technological research, developmental research, applied research and new product development into a single system. This is a common feature of the most successful high tech industrial districts.

In this regard, the Shannon Energy Valley project was initiated by partners from NUI, Galway, University of Limerick, Shannon Development and the Irish Technology Leadership Group (which is based in silicon Valley). The aim is to harness the resources of the Western

Irish seaboard region as well as the research and development expertise at the two universities. Professor Terry Smith of NUI, Galway stated that "the Shannon Energy Valley concept seeks to provide a big-picture coherent ecosystem relating to energy" (Irish Examiner, March 16, 2010)

4. Renewable Energy Sub-sectors and Companies: A Strategic Audit

Wind energy is the most advanced of the renewable electricity generating technologies. Ireland is currently one of the world's leading countries in the use of wind energy for electricity generation (Irish Times, 27 May, 2010). A recent SEAI report reveals the share of electricity generated from renewable resources in 2009 was 14.4%, two-thirds of which was wind. Perhaps not surprisingly however, given the lack of renewable energy R&D, Ireland has no wind energy technology making companies. History, too, has a role. Turbine technology development goes back at least to the early days of water-powered textile mills. Many generations later, military funded jet engine companies invested heavily in R&D in turbine technology. Wind turbine development began in earnest in the 1980s in northern Europe and more recently advances have been made in the U.S. as well. Innovations in advanced materials are continuously upgrading turbine efficiencies. Consequently, given the head start, regions with wind energy clusters such as Denmark have a well established competitive advantage.

Nonetheless, Ireland has a number of companies, most notably Airtricity and SWS Energy, that operate large wind farm systems. The ability to store wind energy is the key to success for wind energy. Gaelectric is a pioneer in wind energy storage using a compressed air technology and the firm is planning to invest more than €2 billion in America over the next six years (Irish Examiner, 29 March, 2010). Another complementary technological capability is the software solution developed by Servusnet which provides a real-time picture of how wind installations are performing. This software capability can be extended to wave and solar power installations. Consultant services further pad out the RE sector. AirEn Services, for example, provides site assessment, wind measurement and grid application services for wind energy to both domestic and commercial clients.

Wave and tidal technologies, however, are not dominated by established companies elsewhere. Ocean wave energy technology lags some way behind wind energy technology. Ireland has at least 3 companies that are engaged in ocean energy technology development and production with the potential, in the long run, to play important roles in the development of the industry globally.

OPENHYDRO group was formed in 2004 following a "technology trawl" by two Irish businessmen that identified the open center turbines designed by Irish-American Herbert Williams who had been working on the technology since 1995. The three became controlling owners in the new company and have since raised over Euro 50 million for development, including Euro 15 million from Imera. In 2008, after 18 months of testing, it became the first tidal energy company to connect a tidal turbine to the U.K. national grid from a testing site at the European Marine Energy Centre off Orkney, Scotland, which illustrates how Ireland currently lags behind Scotland in marine energy. OpenHydro designs, produces, and manufactures both 250kW Open-Centre turbines and is beginning the production of a new generation 1MW Open-Centre Turbine. Although early days in tidal wave technology, the potential for scale is considerable. Presently, OpenHydro turbines are being installed for utilities at tidal sites in Nova Scotia and the Channel Islands.

WAVEBOB is a first generation wave energy technology developer and operates an open system business development model. Wavebob has entered into a joint venture with the Swedish company Vattenfall, the fourth largest energy producer in Europe to develop a 250MW wave farm off the west coast of Ireland. Chevron's Technology Ventures subsidiary is also an investor in Wavebob. Wavebob has established a US location near Annapolis, Maryland and the largest wave tank in the world at the US Navy Academy.

Another emerging wave power company OCEAN ENERGY is trialling its 'OE Buoy' at the Marine Institute/SEI test centre in Galway Bay. The west coast of Ireland is an attractive test site because it offers testing in one of the most vigorous wave regimes in the world. Furthermore, the demonstration test centre allows wave energy developers an advantage over developers in the US which are forced to negotiate inter-departmental jurisdictions before getting permission for ocean testing.

Both OpenHydro ($2.36 million) and Ocean Energy ($1.16 million) received marine energy funding from the Scottish government in 2007 for testing their devices near Orkney where it plans to build the world's largest commercial wave energy farm. In 2008, Ireland announced an investment of €2 million for a grid-connected test site for full scale prototypes to be located in northwest Ireland. This will complement a sub-scale test facility in the Bay of Galway. Nevertheless, it appears that there are less than five wave energy converters worldwide that have moved beyond the concept phase to demonstrate a capacity to generate electricity in a real-life, sea environment.

5. Two Barriers to a Renewal Energy Industry

What has kept RE from becoming a major industry in Ireland given the country's unique natural advantage? The reasons are partly general but also specific to Ireland. Two stand out.

First, the renewable energy industry everywhere has been held back, perhaps strangled at birth by national grids designed, constructed, and laid out geographically to electrify economies around centralised fossil fuel and nuclear technologies. This is not to underestimate the positive effects on industrial growth of the creation of the grid in its time. The electrification of the economy was driven by a hugely successful electric power industry which ushered in a new phase of industrial development that impacted everything including product and process design, plant layout, and the geographical location of industries and cities.

At the same time, the structural links between the grid and fossil fuels unintentionally erected a barrier to the emergence and growth of a dynamic RE industry. This is illustrated by Ireland. Ireland's RE natural resources are most pronounced along the west coast which is not connected to the grid except for 'light end' household usage. The existing grid is like a one-way highway system from a place, in this case 24 large fossil fuel power stations, to companies and households. It is not organised to flow from the west, where RE sources are abundant, to population centres and it is not organised for two-way flow of electricity and information. Consequently, if an RE industry had begun to emerge as even a minor source of national energy supply, the grid would have choked it.

The intermittent nature of renewable energies has been a second major obstacle to the growth of renewable energy. This has changed. Innovations in long distance transmission technology and convergence of IT and energy technology in the form of the "smart grid" have greatly reduced the intermittency barrier. We turn next to two "game changing" technological and organisational changes in the electric power industry infrastructure both of which attenuate the intermittency challenge of renewable energies.

Globally, technological advances in the transmission and distribution of electric power are moving fast. Innovations in transmission technology have greatly reduced the loss energy in long distance power transmission. High voltage, direct current transmission (HVDC) lines enable efficient transfer of power over hundreds of miles. This technology is critically important to the economics of wind energy. It involves converting AC current from renewable sources to DC current for long distance shipment before reconversion at the point of application. Denmark exports up to half its wind energy during peak periods and uses the same transmission lines for imports as required. At present projects in India and China to transmit power over much greater distances are underway. Investments in nanotechnology and superconductivity technology in the U.S. are being undertaken to tap market opportunities and enhance the economics of sending wind and solar generated industry from mid-west and south-west regions to the east coast (Pernick and Wilder 2007).

These technological advances are not lost on Irish entrepreneurs. Imera Power, headquartered in Dublin, is using advanced HVDC long distance technology to link Ireland’s grid to mainland UK and later to the North Sea.20 Once completed, Imera’s three cable lines linking Ireland with mainland UK have the capacity to transmit nearly 15% of Ireland’s energy generating capacity.21 The project is part of a bigger drive to create a pan-European offshore electricity network, the EuropaGrid. The project includes schemes to integrate the offshore wind farms in the North Sea region with the existing main power grid. Offshore wind energy potential in the region is estimated to be 68,000 megawatts (Irish Examiner).

As important as advances in long-distance electricity transmission is to fostering the growth the REs, the idea of the “smart grid” has complementary and even greater long term effects. In fact, the “smart grid” has been likened to the interstate highway and the internet highway in terms of its revolutionary impact on business and industrial structure. A smart grid is 'an electricity network that can intelligently integrate the actions of all connected to it - consumers, suppliers and those who do both (Eamon McKeogh of UCC).' The ‘smart grid’ approach involves a two-way flow of power and information. It enables a combination of central power stations and small and widely distributed power suppliers. A smart grid can attenuate the natural fluctuations of wind, wave, tides, and sun with real time analysis of, and response to, supply from sources scattered throughout the country and off-shore, and demand both locally and nationally.

The convergence of IT and energy tech is not new. But the smart grid, an Internet-enabled two-way conversation between the source and use of electricity, is creating new market opportunities involving an emerging network of devices connected by switches, routers, and software. It will require sensors to anticipate disruptions, circuits to redirect spiking currents, automated meter readers, and intelligent control systems that will automatically power down non-critical appliances such as daytime lighting during periods of peak demand. P&W 181. In the words of CleanEdge (2009) "these devices, from commercial refrigeration units to residential washing machines, will have a unique identifier—an Internet Protocol, or IP address—that will allow the integration of buildings, vehicles, cell phones" (p. 8).

A smart grid which connects disparate sources of renewable energy sources will act as a standardising force by open-system interface protocols. Intel's public interface rules sparked the rapid growth of the PC industry by diffusing experiments and design activities across thousands of specialist firms linked by the public interface rules. Network economies were established by numerous specialist, niche producers that set the standard for their link in the value chain.

Like the two previous "highways" the "smart grid" will rely on government funding and industry standards to flourish. But the potential is huge. Consequently, many IT leaders are entering into the smart-grid space: Cisco, GE, Google, HP, IBM, Analogy Devices. First generation smart-grids are being developed by IT and utility partnerships. For example, the Pecan Street Project in Austin, Texas, includes Cisco, Dell, GE, IBM, Intel, Microsoft, and Oracle to create a showcase next generation grid.

6. Discussion and conclusions

Three lessons can be drawn from this initial audit of RE companies in Ireland with respect to the goals of carbon emissions reduction, energy independence, and economic growth.

First, the RE sector as currently constituted is small. Even stretching to include very small wind farm developers and consultancies the total is closer to 50 than to 100 firms. Airtricity aside, there are no large employers. In contrast to emerging RE clusters, such as Denmark's wind energy cluster with over 200 firms, many of which are technology-driven and some of which are large employers, RE in Ireland is far short of a critical mass of enterprises to suggest the realisation of the climate change and energy independence goals.

Second, a number of indigenous RE technology development companies have attracted foreign partnerships and funding in ocean energy technologies. This reflects both the success that Ireland has achieved in wind farm projects and the promise of wind, waves and tides as sources of energy generation in Ireland. In fact, it confirms meteorological findings that Ireland has a natural advantage in a resource that can potentially not only supply all of Ireland's electricity needs but be an export earner.

Third, most if not all of the energy technology companies in Ireland are organised in terms of an open-systems business model. Here we find a similarity with the business model at the centre of the emergence and success of both high-tech sectors and design-led sectors elsewhere in the world. In both variants, the open-systems business model has fostered industrial innovation.

New business models tend to be introduced to a region or nation in the same process as the introduction or creation of new industrial sectors. The success of the new business model is not lost on new companies in pre-existing sectors and they become diffusion vehicles. The leading business model in Ireland today is that of an affiliate of a foreign headquartered company. The local units are networked, as noted before, but along global production chains. The open-system business model is a vehicle for a different form of networking in which companies specialise on core capabilities and partner for complementary capabilities. This alters the prevailing model of innovation within the economy and creates growth potential from cluster dynamic processes (Best 2001).

Of particular importance to Ireland, the technical challenges to the transition to a RE industry are largely resolved in the case of wind energy but ocean power technologies are still in the developmental stages. The technological challenges posed by the intermittency of RE are being addressed by R&D projects elsewhere and rapid advances are underway. Perhaps most relevant, the concept of the ‘smart grid’ is integrating IT and energy tech in ways that promise step-change improvements in energy efficiency and the application of diffused energy storage capacity.

Globally, the confluence of IT and energy technology is creating a huge opportunity in the form of the reinvention of the electric utility grid. The smart grid has the opportunity to incorporate many of the leading innovations of high tech in the production and delivery of energy. Many argue that the smart grid will be to the electric power industry what the Interstate Highway program was to the transportation industry in America and fiber optics and packet switching to the Internet-driven communications industry.

Could renewable energy play a role in driving growth in the Irish economy like the IT or medical devices industry in the 1980s and 1990s? Not on its own. The emergence and growth of a dynamic RE industry will require government leadership in establishing three inter-related infrastructures. First, designing and building a smart grid takes advantage of the latest developments in digital information technology to better manage and deliver a range of centralised and distributed energy sources. But it has pervasive public good characteristics and will not be built without government funding.

Second, as is the case in all high-tech industries, establishing a science and technology infrastructure involves close partnering between technology-driven enterprises and scientific and technological research in independent, university departments and laboratories. The IDA’s challenge was to attract affiliates of fast growing companies headquartered elsewhere in which the technology was crystallised to create an industry where one had not existed. It did not require the development of an indigenous S&T infrastructure, the basic research was conducted elsewhere. A certain S&T infrastructure has been created in IT and medical devices over the past decade.

Third, the emergence of a critical mass of rapidly growing, technology-driven companies will depend upon a business organisation development infrastructure. In the past Ireland has relied upon the attraction of affiliates of rapidly growing foreign headquartered enterprises to establish a foothold in a new industry. Establishing, for the first time, cluster dynamic processes will require financial institutions regulated to foster long-term commitment to company development as well as liquidity requirements. Both the leading technology development states in the U.S. and the Nordic countries offer models for support systems and institutions that encourage and enable the transition of technology development companies from basic research to proof of concept to early stage technology development to product development to production and marketing.

The consequences of fostering the emergence and growth of an innovative renewable energy industry in Ireland extend beyond the benefits of the industry itself. They would include the transition to a model of industrial development that would establish a national technology management capability that could enhance performance in all sectors.

But there is some cause for optimism. Brial Motherway of SEAI reports that “the level of entrepreneurial activity is staggering, the amount of people with ideas is staggering and established companies such as Kingspan and Glen Dimplex have reoriented themselves to capitalise on this opportunity” (Knowledge Ireland, Winter 2009). The history of industrial evolution based on capabilities tells us that from these seeds of entrepreneurial activity and existing firms’ reorientation grow the most successful of modern industries. The necessary capabilities and skills will be a blend of the old, such as those in electrical and engineering, and newer, such as marine energy and green software development.