

**DEPARTMENT OF COMMUNICATIONS, MARINE AND NATURAL RESOURCES
ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION CONSULTATION PAPER**

TRINITY COLLEGE DUBLIN RESPONSE

Those in Trinity College involved in various aspects of energy management and research would like to respond to the consultation paper from the Energy Research, Development and Demonstration Consultation Paper through the following comments and observations. There is a strong consensus that whatever strategy is adopted for research and development in energy that it should be holistic and coordinated. As the pervasive mechanism underlying national progress and development, energy and its management encompasses many inter-related strands and thus any strategy should be inter-disciplinary in nature. In this context we would also endorse the idea of an all-Ireland Seminar to discuss the issues and indeed would be willing to collaborate in running such a forum.

We have addressed the key issues in the Consultation paper in the following sections and there is an appended list of existing projects to indicate current activities in the area for reference.

Section 3 Institutional and Governance Options

We would endorse the favoured option for the establishment of an energy research coordination council (Option 2) as a mechanism for identifying and promoting a strategy for energy research. Our preferred means of servicing such a body, to drive the research and capacity building, would be through appropriate existing state agencies having a large compass, such as Science Foundation Ireland (SFI) in preference to SEI. However, it is recognized that other bodies such as the HEA (through PRTL funding for example) or the EPA (who have built up significant relevant research funding experience over the past few years) should be considered, particularly for the capacity building aspects. Whatever the funding mechanism(s) that are used, they should be based upon the accepted principle of competitive tendering. Nevertheless, the approach should allow for two way initiation of relevant research, that is, from the bottom-up as well as by direct initiation through the proposed coordination council.

Section 4 All-Island Perspective

Given the nature of energy management and our geopolitical position as a nation, it is essential that the strategic objectives of energy research be on an all-island basis. Research links are already well-established in this context such as between TCD and both Queens University and the University of Ulster, going back over many years and these will continue. There have also been many projects under the EU Inter-Reg programme which have cross-border links. In short, the need to foster cross border collaboration can easily be accommodated within any funding framework.

Section 5 EU Perspective

There is no doubt that any proposed strategy for energy research would draw on available expertise and programmes arising through the EU. A key principle in both the current Framework Programme and the next (FP7) is that of ‘sustainability’ and this has particular implications for a small island nation such as Ireland with characteristic geological, environmental and economic conditions. Thus the Lisbon agenda presents particular problems in the context of sustainability for such an island economy. Research needs to centre on how the suggested free market for services would affect these characteristic conditions, for example, the role of a carbon tax, the sustainability of peat as an energy source and how Kyoto protocols are to be assessed and met. Significant research has already been completed or is underway on these topics but the particular aspects related to a policy for energy management should come under the remit of a strategy to be produced by the proposed energy research council. The EU context is the framework within which a policy is necessarily derived but it is also the source of much of the expertise and funding to support an energy research programme.

The benefit from the EU FP7 programme can be maximised by collaboration with industry, both Irish and European, and networking with other European universities. Targeted actions by Ireland may be required in order to penetrate, more strategically, established European research networks on energy topics so that gains are made from the much needed added value of involvement in EU R&D. TCD is already delivering on a number of these projects but substantial capability development is needed to harness even further the benefits from more intense involvement.

Section 6 Links with the Environment

The sustainability and management of energy production in Ireland over the coming decades has to be strategically assessed with regards to both the economic impacts as well as environmental impacts – that is, the integrated, holistic approach is essential. This balance is particularly relevant now, under the implications of national obligations arising from the Kyoto protocol with respect to greenhouse gases - energy production and consumption being a core anthropogenic influence on such emissions. Hence, a strategic approach to future energy management needs to be developed on the basis of sound research which particularly considers the contribution of renewable energy to Ireland’s increasing energy demands. These need to be related to its characteristic climatic conditions and its geographical position. Such considerations will be wide-ranging as such factors as land use policy will be involved.

Thus, while policies such as the employment of carbon taxes as an instrument of control may not be currently favoured by government, there is an increasingly critical requirement for informed management of energy resources, particularly with respect to energy related emissions. The key issue remains, that the externalities of energy consumption and production are not yet fully internalized.

Section 7 Long-term vs short-term goals

We fully recognise that future research needs to be aimed at both long-term and short-term goals: the balance can be struck by the new Advisory Council. Pre-commercial and demonstration funding is by its nature more likely to be in response to short to medium term needs and opportunities. Nevertheless, it is also felt that the opportunity for bottom-up research should exist and that a *basic* research fund in the energy sector to cover both technical and policy developments should form part of the strategy being formulated by the Department. Ideally this fund would not be prescriptive in the research conducted. For example, an approach similar to the EU Framework Programmes might be adopted, where a broad, strategic work programme forms part of the call for proposals.

While the 'branch-plant' philosophy may affect energy management in many practical and commercial ways, there remains a strong need for long term goals in national energy management which will be peculiar to this island's situation.

Section 8 Funding

Links with industry such as those that exist should be pursued, although it is recognised that many indigenous Irish companies are not of sufficient scale to be able to part-fund research projects. However, in the past, multi-national companies such as oil and power distribution companies have been involved in funding energy related research as have companies such as Bord na Mona. These connections should be encouraged as a matter of policy in any research strategy.

Moreover, it is also felt that Ireland is often viewed as an ideal demonstration country for some of the renewable energy technologies, particularly in terms of wind and wave power, and so collaborations with such companies (eg Vestas) should also be targeted. A mechanism should be developed which would support effective research from industry. For example, SEI and EI both have models for exploitation of innovation and involvement of private funding which could be utilized.

Section 9 Capacity Building

TCD, as a long established university, regards capacity building as an essential part of any strategic development in the energy field. This capacity building is of vital importance across a wide range of disciplines which all have a stake in the energy field such as Civil Engineering (Transport and Environmental), Mechanical Engineering, Electrical Engineering, Computer Science Environmental Sciences, Law and Economics. The key objective for such capacity building should be the development of a cohort of interdisciplinary expertise over the next few years. This may be achieved in conventional fashion by the funding of postdoctoral posts and PhD researchers via scholarship programmes (such as the IRCSET scheme) which can be effective in directing resources to talented graduates. Nevertheless, such a scheme cannot operate in isolation and the graduates would need to be part of a larger, integrated research effort supported by some sort of base funding mechanism. While the restructuring of universities, currently underway, might help in the promotion of interdisciplinary research, a specific structure aimed at integration specifically related to energy is a strong possibility.

Any funding schemes aimed at capacity building should primarily be focused on recurrent rather than capital investment which promotes short lead-in times. This would mean that the majority of the financial resource is targeted at the development of expertise in the form of graduate students. It is also now assumed that any funding mechanism aimed at the third level sector has to include the real overhead costs of such research activity. The funding mechanism should promote the interdisciplinary nature of energy research and also encourage expertise from abroad to come to Ireland, either in the long term or in a mentoring capacity.

Finally, it is suggested that an immediate means of building the requisite capacity in energy management can be achieved through the establishment of an interdisciplinary taught MSc course, specifically designed. Such courses are currently favoured by EU policy in educational development and are an integral part of the strategy under the Bologna Declaration. In addition, modules in energy should be incorporated as part of a four year structured PhD study.

It is our contention that the management of the carbon cycle in Ireland has its own characteristic conditions which warrant a specifically tailored research programme to support the development of a national policy.

In summary, we suggest that a programme of research in energy production and management represents an opportunity in the national context that should be grasped and used to effect. It is an opportunity to develop a truly integrated programme relevant to the peculiar needs of energy management in a small island economy which nevertheless has to relate to the global context. Nationally, we need an energy policy to reflect that situation and it is only a fully integrated holistic research programme which will support that objective. Such research as exists is fragmented and it needs an interdisciplinary framework to pull it together and develop it in an effective manner for the national benefit as well as making an international contribution to what is already a global issue. An all-island workshop-conference would be an excellent means of debating these issues and would help in formulating the right research objectives. We would be pleased to assist in designing a suitable framework for such a conference and would help in running it.

STRATEGIC DEVELOPMENT OF RENEWABLE ENERGY IN IRELAND

Implications of the bio-geochemical carbon cycle on the management of energy resources
in Ireland

INTRODUCTION

It is generally acknowledged that, nationally, diversification of energy sources is to be preferred, both from the security of meeting energy requirements as well as addressing the need for sustainability. Clearly the use of renewable energy sources is a major factor in meeting the needs of sustainability of supply, notwithstanding the economic aspects. On the other hand, most fuels used in energy production have environmental emissions associated with their use. The sustainability of energy sources also has to take account of these emissions, particularly in the context of emissions of greenhouse gases to air. Energy and carbon balances need to be evaluated.

ENVIRONMENTAL SUSTAINABILITY

Thus, the sustainability and management of energy production in Ireland over the next twenty years has to be strategically assessed with regards to both the economic impacts as well as environmental impacts. This balance is particularly relevant now, under the implications of national obligations arising from the Kyoto protocol with respect to greenhouse gases - energy production being a core anthropogenic influence on such emissions. In conjunction with the Kyoto obligation, sustainable development is now a key aspect of national governmental policy, in line with European Union strategic policy. For example, the current EU research programme, Framework 6, has sustainability as its main theme. Nevertheless, we are in the situation where indigenous energy resources on the supply side are inadequate while at the same time trying to take account of the long term issues of sustainability including life cycle analysis – this is the essence of the problem in Ireland.

RENEWABLE ENERGY AND THE CARBON CYCLE

Hence, a strategic approach to energy management for the next twenty years (and beyond) needs to be developed on the basis of sound research which particularly considers the contribution of renewable energy to Ireland's future energy demands based on its characteristic climatic conditions and its geographical position. While the employment of *carbon taxes* as an instrument of control has currently been ruled out by the government, there is an increasingly critical requirement for informed management of energy resources, particularly with respect to energy related emissions.

Thus management of energy resources depends in a fundamental way on the corresponding management of the carbon cycle which, in turn, relates to Ireland's hydrogeology and geography. There are several geographical facets to Ireland which makes it unique with regards to energy resources and its carbon cycle compared to other countries in Europe. The country faces into the Atlantic seaboard ensuring certain

climatic conditions which happen to favour the harnessing of both wind and wave energy. The same climate favours the growing of certain biomass crops for renewable energy use. Also, approximately 20% of the country is covered in wetlands (peat) which up to now have been extensively used (and denuded) as an energy resource with possible implications for these wetlands as carbon sinks.

Other carbon sources and sinks also have to be factored into the management of the energy cycle. For example, the country has a strong agricultural sector, which has implications in terms of carbon emissions with respect to land use practices (crops grown and animal stocking densities etc).

The current principle anthropogenic emissions of greenhouse gases are from power stations (such as the burning of imported coal at the Moneypoint power station), emissions from transport and certain types of industry (eg cement manufacture) as well as from agriculture. Carbon sinks occur in the extensive wetlands, natural vegetation and forestry. Renewable energy policy has to be set in this context and to determine whether particular energy sources in this sector are truly carbon neutral or otherwise.

In addition, the current development policy (SEI) for the use of biofuels in transport is acknowledged but needs to be set in context with overall energy management and emissions. In the case of energy crops, similar studies have been carried out by TCD in developing countries in Africa.

TECHNOLOGIES FOR ENERGY GENERATION AT DIFFERENT SCALES

Research should also include the role of emerging technologies in the context of energy management, both at a national level and also at a local level for on-site houses. Such technologies may be new or evaluation of existing technologies. The role of energy management and conservation within buildings should be included in policy development for renewable energy.

At a national level, an energy strategy needs also to consider the increasing role of other undeveloped renewable energy sources, encompassing wave/tidal power and the potential for large scale hydro power. A review (economic and environmental) of the existing non-renewable resources available is also an essential first step in the overall assessment: peat, oil, natural gas resources (for example, the development of the Porcupine Basin /Corrib gas field).

On the medium scale the use of sustainable biomass or so-called energy crops (such as short-rotation forestry) may be considered. Anaerobic digestion for the production of biogas to feed efficient combined heat and power (CHP) units is an option. The potential of photovoltaic cells, fuel cells, or synthetic photosynthesis, or any other promising technology would be included in terms of feasibility in an Irish context, drawing on available information and data.

At the small scale, for rural housing, issues arising from the use of geothermal heat, solar energy or micro-hydro would be included.

Wetlands (peatlands) have a special significance in Ireland especially with regard to carbon emissions coupled with the fact that they have been intensively used as an energy source. It is not clear whether existing natural wetlands act as a carbon source or sink. Hence, a rigorous carbon-balance needs to be evaluated in such environments to determine the net production / assimilation of carbon gases for such an ecosystem.

Finally, within the context of renewable energy management, the issue of climate change needs to be addressed. For example, increasingly extreme weather patterns may favour wind energy generation, but may also affect the sustainability of the peatlands. On the other hand, warmer temperatures may promote enhanced growth of biomass resources.

There are other pressing engineering requirements in a policy for energy management such as the integration and management of power transmission and storage facilities, particularly in the context of intermittent power generation from wind.

There is considerable research capacity at TCD able to meet the multidisciplinary aspects of this problem (shown schematically in the attached figure), arising from the Departments of Botany and Zoology (greenhouse gas emissions and biomass production from energy crops, the carbon cycle in peat and other wetlands), Civil and Environmental Engineering (economic evaluation of pyrolysis and gasification of agricultural wastes as energy sources, economic evaluation of the impacts on the economy of carbon taxes and other policies, valuation of the external costs of transport including air pollution and noise, gaseous emissions from transport, wetland hydrology, solar energy, stability of wind generators, traffic demand management measures to reduce energy requirements), Mechanical Engineering (large scale power generation systems, combustion, heat pipe technology and energy efficiency in manufacturing) and the Department of Computer Science (automated energy monitoring and management).

A summary of the existing research capacity within TCD under each of the main energy themes is set out below.

ENERGY RESOURCES

Departments of Botany and Zoology

- Greenhouse gas emissions and biomass production from energy crops,
- The carbon cycle in peat and other wetlands.

Department of Civil, Structural and Environmental Engineering

- Wind and wave forecasting for renewable energy predictions.
- Waste to energy (for example, pyrolysis and gasification of agricultural wastes).
- Geothermal energy and resources

ENERGY PRODUCTION

Department of Mechanical Engineering

- Fundamental research for **large scale power generation systems** is being carried out into the enhancement of heat transfer in heat exchangers / boiling heat transfer / two phase flow and heat transfer / flow induced vibrations in power plant heat exchangers, including nuclear power plants / and the cooling of gas turbine blades.
- Fundamental research is also directed towards improving **combustion** efficiency and reducing emissions, for both industrial scale and domestic systems.
- The development of **heat pipe based heat exchangers** for waste heat recovery in climate change mitigation technology and services.

Department of Civil, Structural and Environmental Engineering

- Active research group on wind turbine systems.
- Wave power generation and erosion mitigation / finite element dynamic analysis of spine connector for wave energy device.
- Design and implementation of geothermal energy technology from individual house level to regional scale.
- Anaerobic digestion of organic wastes for the production of biogas.

ENERGY MANAGEMENT

Department of Computer Science

- *Energy Efficiency* - The Department provided technical expertise for an EU wide SAVE pilot action for procurement of energy efficient desktop PCs within TCD.
- *Energy Monitoring* – using wireless sensor networks to monitor building energy consumption and usage in detail.
- *Energy Management* – Context-aware computing makes use of sensor data (e.g., user presence, temperature, light, noise etc...) to enable highly efficient power management of building components.

Department of Civil, Structural and Environmental Engineering

- The following areas of research in the field of Transportation relate to energy management from a local to a national scale. Traffic demand management including design of all public transport options / congestion charging including

electronic methods / carbon taxation charging level estimation / external cost evaluation techniques using environmental economics models / valuation methods for costs to the environment of air pollution and noise, traffic management / landuse and transport planning / transport-energy-environment interface modelling / evaluation of transport policies.

- Energy efficient building design.

Department of Mechanical Engineering

- **Energy Efficiency in Manufacturing**

Investigation of new cooling systems for manufacturing processes such as grinding, with a view to improved product quality, reduced energy requirements and reduced usage of environmentally unfriendly coolants

Departments of Botany and Zoology

- Implications of land-use practices (agriculture, forestry, peatlands etc) with respect to carbon cycling.

SUMMARY

In terms of the perceived needs for research in energy in the Department of the Marine, Communications and the Natural Environment, the need is for the development of a model for the sustainable development of renewable energy which takes into account the economics of the development of indigenous energy sources at the same time as the environmental emissions. The implication is for management of the carbon cycle which acknowledges the characteristic nature of Irish conditions, hydrological and climatic.

Many of the component issues have been carried out at Trinity College under a variety of contracted research projects over many years from such agencies as the EPA, government departments and the EU but the integration of these and other research results into a coherent study is seen as a vital need in the development of an overall national energy policy.

