



17 May 2005

Mr Bob Hanna
Chief Technical Advisor
Department of Communications, Marine and Natural Resources
Adelaide Road
Dublin 2

Dear Mr Hanna

Re: Energy Research, Development and Demonstration

Further to the request for views on the above paper please find enclosed a submission from Dublin Institute of Technology. The description of capacity for R, D&D on page 7 of the report does not include the substantial and growing activities within DIT, our submission therefore includes an appendix that provides a description of these.

We note that the Department is to hold a public seminar to discuss the background and material in the review paper. DIT would be keen to be represented at that seminar. As I have a considerable interest and extensive personal expertise in this area (I attach a short CV for information) I would be grateful for the opportunity to personally participate in the seminar.

With kind regards,

Yours sincerely

PROFESSOR BRIAN NORTON



Professor Brian Norton

BSc (Hons) MSc PhD DSc ILTM FEI FIEI HonFCIBSE FIAE CEng

Professor Brian Norton became the second President of Dublin Institute of Technology in September 2003. Prior to his appointment he had been Dean of Engineering and Built Environment at University of Ulster.

His research underpins the development of solar collectors, low heat loss glazings and photovoltaics. His work is cited extensively internationally. He is the recipient of grants totalling over €10 million. Author or co-author of six books (including a sole-authored major advanced text) and over 300 papers including 130 in learned journals. He has supervised thirty doctorates and serves as Associate Editor of “Solar Energy” - the premier international journal in the field and on three other editorial boards.

Until recently Professor Norton chaired of the World Renewable Energy Network and the BSI Technical Committee on Solar Heating and represented the UK university sector on the Board of the Foundation for the Built Environment, which owns the UK Building Research Establishment He was a ministerial appointee to the Construction Industry Training Board and chaired its Audit Committee. Professor Norton chaired the Northern Ireland Business Education Partnership and the chairs the Eco-Energy Trust. He was a member of the Built Environment Panel for the U.K. national 2001 Research Assessment Exercise. In 2001/02 he acted as Specialist Advisor to the Committee for Enterprise, Trade and Investment of the N.I. Assembly. He is currently a member of the NI government Energy Policy Steering Group and Chair of the Board of Management of Action Renewables, which is responsible for developing renewable energies in Northern Ireland. He also serves on a joint committee of the UK research councils and on the Council of the Irish Academy of Engineering.

He has a BSc (Hons) in Physics from University of Nottingham and MSc and PhD degrees, in Engineering Experimentation and Applied Energy respectively, from Cranfield University and DSc from the University of Nottingham. He is a Fellow of the Irish Academy of Engineering, the Energy Institute and the Institution of Engineers of Ireland. He is a Chartered Engineer (both in the UK and Ireland) and Member, Higher Education Academy. Among his awards are the Gold Medal of the Amir of Bahrain for "outstanding research achievement in solar thermal applications.", the Napier Shaw Medal of the Chartered Institute of Building Services Engineers, the Roscoe Award of the Energy Institute and the Honorary Fellowship of the Chartered Institute of Building Services Engineers, the highest honour for his professional discipline. From 1989 he was Professor of Built Environmental Engineering at University of Ulster and in 2003 he was made an Honorary Professor of the University of Ulster.



Submission for
Energy Research, Development Demonstration Consultation Paper
of
Department of Communications, Marine and Natural Resources

Dublin Institute of Technology

Aungier Street
Dublin 2
Email: president@dit.ie



Introduction

DIT hosts dedicated Energy Research teams, strengthened by the arrival of its new President Professor Brian Norton, internationally recognised in the Energy field. Currently DIT has a range of Energy Research projects and courses across the Faculties of Science, Engineering and Built Environment, which are detailed in Appendices I and II respectively. This diversity of Energy Research illustrates the range of expertise and capability available at DIT which is brought together in this submission.

DIT has formulated responses to:

3.0 Institutional and Governance Options

The Department has expressed a preference for the option below but is interested in the views of stakeholders

‘Establish an energy research coordination council, served by a small secretariat, which would meet on a quarterly basis to identify needs and priorities in energy research, set a balance between short-term or responsive research and long term opportunities and which would arrange the coordination of projects on a domestic level as well as ensuring that Irelands position is represented on an EU and international basis’

(Option 3.3 (2))

DIT would like to support the option to

‘Establish an energy research agency or institute with the ability to disburse funding and co-ordinate R, D & D in the energy sector. The establishment of such an agency would require further considerations of a policy remit, taking particular account of the existing remit of Sustainable Energy Ireland (SEI). In all likelihood primary legislation would be required to give such a body a sound statutory foundation.’

(Option 3.3 (3))

However it is recognised that this would require a longer time period due to policy changes and therefore would look to Option 3.3 (2) to move forward.

4.0 All Island Perspective

The Department is particularly interested in the views of stakeholders in NI on the strategic goal of cooperation on energy R, D & D on an all-island basis and how the goal could be addressed most effectively.

DIT supports an all-Island energy research agenda

Commissioning of a small number of All Island sectoral studies, e.g. building stock; decentralised energy supply; etc., would kick-start collaboration between R,D & D stakeholders North and South. This would engage stakeholders in debate and could result in identification of All Island issues. Whilst limited amounts of funding for North-South collaboration are already available these are not targeted for some specific energy areas. A public invitation for a small number of specific funded studies would drive active engagement between energy R,D & D groups North and South and focus thinking on All Island issues.



5.0 EU Perspective

Due to the timeframe for Framework Programme 7, the Department is interested in views on this topic in advance of general responses to the other points raised in this paper.

DIT supports maximising Ireland's involvement in Framework Programme 7 and recognises that building partnerships and research teams within an EU context is important to furthering knowledge and building capacity in an Irish context.

DIT would like to suggest promoting and providing focussed advice and awareness raising activities on available funding for potential participants of the Energy sector in Framework Programme 7 through nationwide workshops and seminars. Also through the provision of funding for group coordination

Previous 'lack of effectiveness' was partially due to a combination of lack of capability and capacity in energy R,D & D. Whilst this was unavoidable due to the rapid changes taking place in all sectors in Ireland opportunities now exist to harness current necessary activities, in a number of energy/environment related areas, related to implementation of EU Directives to both capture and retain knowledge and expertise in Ireland. DIT's experience in this area suggests that centralised funding support either for development of groups active in activities under current and upcoming Directive implementation programmes or for creation of a national centre of excellence specialising in the application dimensions of these areas is now of critical importance in capturing and building national capacity and capability to not only meet future needs but also influence policy development at a European level. One specific option would be the creation of a public-privately supported Built Environment Research Institute or National Construction Innovation Centre similar to BBRI (Belgium); CSTB (France) or BRE (UK).

6.0 Links with Environment

The Department welcomes any views on the energy/environment interface from an R, D & D perspective.

DIT supports a broader more holistic and sustainable approach to coordinating Energy Research in Ireland and would suggest widening the remit further to include the social impacts of energy.

Broadening the scope of R, D & D to address the multiple dimensions of the energy/environment interface would provide an opportunity to actively incorporate environmental externalities. Greater understanding and integration of these externalities can provide greater leverage in shifting energy related markets to more sustainable patterns and development directions, ultimately resulting in competitive advantage. Considering the roles externalities play in changing patterns of consumption DIT would support further broadening of energy R,D & D scope to explicitly cover and target development of knowledge and skills in the cross-over or inter-disciplinary areas forming between the conventional inter-related pillars of



sustainability, namely economic; societal and environmental areas. This could be achieved through creation of a number of coordinated inter-Departmental funding programmes or opportunities, i.e. jointly developed and funded by different government Departments, addressing areas where there are significant synergies.

7.0 Long-term vs. short-term goals

The Department invites views on the short term/long term balance and the role which R, D & D might play in positioning the energy sector to meet future challenges

DIT supports a balance of short and long term funding, recognising the need for both, in a coordinated nationwide strategy for Energy Research.

The need for R, D & D groups to have the ability to respond to short-term goals is acknowledged. However, this ability can only be built on a foundation of longer-term work and projects, allowing for the required expertise and capacity to be built up. The new ‘body’ with responsibility for R, D & D should promote the development of collaborative groups of Universities, Institutes and other Research bodies to provide greater flexibility and expertise in meeting both short and long-term goals.

Foresight issues are important for positioning the energy sector and would enable R, D & D funding to be placed more effectively.

Current funding for postgraduate and postdoctoral studies are not sufficiently focussed on energy/environment areas. Whilst long-term funding is important effectiveness of this relies heavily on opportunities for involvement in advanced work once studies have been completed. The R,D & D sector currently is not able to provide many opportunities at this level due to the relatively small scale of many of the stakeholders and imbalance between commercial and public opportunities to support their development. The proposed creation of dedicated national centre(s) outlined in Section 5 would alleviate much of the pressures on many of the stakeholders thereby enabling rapid growth in the short-term to meet demand for highly skilled jobs associated with an increase in the potential number of advanced graduates that long-term funding in the energy/environment sector would produce. Whilst a greater number of advanced graduates would be beneficial there is also significant value in balancing this with increasing the number of high skill job opportunities to attract candidates with high potential who could make use of existing postgraduate/postdoctoral funding opportunities.

8.0 Funding

The Department welcomes views from stakeholders on the measures that could influence better coordination between public and private funding of energy R, D & D.

It should be recognised that the Energy sector is no different from other sectors and that the State should fund longer term fundamental research and industry would come in at an applied stage or towards commercialisation.



Often in the Energy sector there are much longer payback periods, which industry may not be willing to fund, it is in this regard that monitoring and coordination by the proposed 'body' of private and public funds would be necessary.

With the ever increasing demand for energy R,D & D to meet implementation requirements of a number of EU Directives immediate opportunities are available to 'establish and maintain appropriate capacity'. DIT's experience with the competitive processes adopted related to commissioning such work is very effective in increasing capability, however most stakeholders in Ireland have similar levels of capability and capacity and therefore rely heavily on sub-contracting to external partners. This scenario does not greatly support building appropriate national capacity. An innovation in the competitive process could be a requirement to explicitly outline and measure how knowledge established through such projects is retained and used to build capacity. The use of State funding for similar related work would greatly enhance ability for Irish stakeholders to take a stronger role in such projects.

Whilst it is traditionally easier to engage the private sector in R,D & D of tangible technologies, development of knowledge related to techniques is also valuable in meeting national objectives. Due to the relatively small scale of private sector actors it is very difficult for them to commit to R,D & D of techniques, this aspect would benefit greatly from State funding and could be met by appropriate National Centres of Excellence.

9.0 Capacity building

The Department invites views on what steps can be taken to improve and expand the critical mass of the R, D & D community building capacity to meet future needs and any other issues which arise about necessary skills in the energy sector

Long term funding is required to support Third Level research to allow training and therefore expertise to exist providing a workforce to fill future needs within the sector. Recognising that knowledge transfer is essential in building capacity and crucial to the future of Energy Research is the retention of this knowledge base within Ireland. One suggestion where Energy Research is carried out by EU research groups is that a Researcher in Residence scheme be employed, where the researcher is involved in the project with the aim of gaining the relevant project expertise.

Building capacity could be greatly enhanced in the energy in buildings sector through the creation of a national centre of excellence building critical mass by attracting and concentrating input and engagement from all energy sector R,D & D actors in Ireland.



Appendix I

Energy Research Activity in DIT

DIT currently has a range of diverse research projects in the Energy sector across a number of Faculties including Science, Engineering and Built Environment. This diversity of ongoing research illustrates the range of expertise and capability. Also DIT is in the process of planning a new city centre campus at Grangegorman, which will be characterised by the application of the principles of sustainable development in all aspects. This will offer a unique environment to trial and test many of the technologies under development.

A. Energy & Buildings Research Activity in DIT

Investigation and Development of Numerical Methods for Building Energy Simulation

A large fraction of total energy use is associated with moderation of environmental conditions within buildings. The cost of this energy and the associated CO₂ emissions make energy conscious design, operation and refurbishment of buildings imperative. To this end building energy simulation tools are increasingly used to determine peak heating and cooling loads, size thermal plant, anticipate annual energy consumption and analyze thermal comfort.

A building energy model comprises a large set of differential equations originating in sub-models, which describe heat transfer modes at building elements. Implicit numerical solution methods are suggested by the stiffness of the problem and the better-known simulation packages utilise them. However, the more commonly used methods are drawn from a limited, 'traditional' set and are often just marginally A-stable. Stronger stability properties are desirable to prevent persistent, unrealistic oscillations in the solution, and more efficient solution methods would offer improved accuracy which could, if desired, be traded for greater speed of execution.

Test programs, which include efficient error estimation and automatic time-step adjustment, are written for established and recently developed numerical methods. A test methodology new to this application is applied and a number of A-stable and L-stable methods are identified or developed which offer superior stability and/or greater computational efficiency when compared with those currently in use. For example, a proposed development of the solver within the European reference model, ESP-r, is shown to produce about 30% less error than the currently used method. It is worth noting that improvements in the numerical solver used in conjunction with a building energy model have a global impact on performance whereas enhancement of one of the constituent models probably has a more limited effect.

DIT Researchers: Mr M Crowley

Collaboration: Prof M S J Hashmi, Dublin City University



Enhanced evaporative cooling of buildings in temperate climates – experimental investigation and design optimisation

Concern with energy consumption has focused attention on conventional building cooling systems, based on refrigerant vapour compression. Interest in evaporative cooling, as an effective alternative cooling technique, has been traditionally focused on hot dry climates. Meteorological enthalpy analysis, however, suggests that the technique has considerable unrealised potential with contemporary building cooling systems (chilled ceilings, fan coil systems, displacement ventilation) in temperate and maritime climates. A study of the field however, exposes key areas in which the knowledge is deficient; including feasible and viable approach conditions, availability analysis and energy and thermal performance. These issues have been addressed using a combination of experimental measurement and analytical methods. The key results include: (i) A feasible limit of 3K on the secondary approach temperature (SAT), with a primary approach of the order 1 K have been found. Availability is strongly dependent on SAT achieved but the approach is not constant - reducing with wet bulb temperature (WBT); (ii) Very high levels of availability are possible in north European climates. In Dublin availability levels of over 80% are possible with 15°C cooling water in chilled ceilings; levels of 97% are possible with 18°C - both at 3K SAT; (iii) The dynamic energy performance of the process is encouraging with annualised COPs in the range 6-12 readily achieved; (iv) Thermal efficiency levels up to 0.76 have been found with cooling tower air flow rate and secondary water flow rate having a relatively strong impact. Primary water flow rate has a relatively weak impact but considerable impact on the COP achieved - indicating scope for optimisation of the process.

Generally the technique has considerable potential to reduce electrical power consumption, particularly in deep plan buildings, characterised by steady internal loads and longer cooling seasons. Considerable energy benefits accrue at off design conditions.

Construction value 120, 000 euros

DIT Researchers: B Costelloe

Collaboration: Dr. D. Finn, University College Dublin

Hollow mirror light pipes with light emission from base and walls through controllable apertures.

Research is underway using a full scale vertical 1m diameter 6m long light pipe with three test rooms built around it to provide monitoring of the light pipe base and along the light pipe to its top inlet. The research aims to establish: (i) The feasibility of using light pipes in Irish climates for daylight provision to deep plan buildings; (ii) Daylight efficiency of the light pipe and reduction in electrical energy consumption when using a light pipe for artificial light transmission; (iii) Daylight spectrum transmission efficiency relative to the UV band width (iv) Improved efficiency potential from using light concentrating systems.

DIT Researchers: Mr A Farrell, Dr D Kennedy and Prof B. Norton



Sustainability Research Development Group (SRDG)

The Sustainability Research Development Group was established in DIT in 2004. SRDG is a newly formed applied research grouping working in the areas of sustainable development related to buildings. The groups creation was a reaction to current national objectives related to the establishment of a knowledge based society; evolution of the demands on buildings driven by initiatives such as EPBD and ongoing amendments to Building Regulations; ongoing pressures related to energy security; climate change; and the ever increasing depth of understanding of the various impacts of buildings.

SRDG provides a structure that maintains two-way dialogue with the various disciplines that input to the sustainable development of the built environment, feeding back research output and perspectives to education and professional training programmes. We aim to establish interdisciplinary research topics focused on the cross-over areas between disciplines to address contemporary sustainability issues. Core strengths include building energy performance (assessment and prediction), low-energy architecture (design process and artefact), detailed design analysis, low-energy technologies and techniques and building stock studies. SRDG provides support for the development of professional, post-graduate and post-doctoral research. Realising a sustainable solution requires knowledge of the inter-dependencies of design and construction issues.

Current research development topics:

- Hygro-thermal performance of closed-panel timber construction
- Life Cycle Analysis in Irish construction
- Integrated Design Process
- Impact of climate change on Irish building stock
- Barriers to Sustainable Building Design and Construction
- Urban Block Development Performance Impacts
- Building stock benchmarking

SRDG Research Projects (2004)

Energy Performance Survey of Irish Housing

CODEMA – DIT Partnership

Value: Appx. € 221,000

Duration: 6 months

A detailed survey of Irish housing stock to determine both a) levels of compliance with existing regulations governing energy conservation and b) actual vs. theoretical energy performance. The survey will also serve as a pilot demonstration of potential Home Energy Rating methods in the context of SEI's Home Energy Rating programme. The objectives were (i) to determine the actual vs. calculated energy performance of a sample of Irish dwellings (ii) to determine levels of compliance with current and previous Irish regulations governing the energy performance of Irish dwellings from 1997 onwards; (iii) to demonstrate an economical method of conducting Home Energy Rating surveys in the context of SEI's Home Energy Rating programme.



DIT Researchers: Dr K Shanks, Mr A MacPhaidin

Feasibility of Large Scale Solar Water Heating for Hotel in Killarney

Sustainability Research Development Group

Value: € 3,000

Duration: 3 months

The study evaluated the feasibility of retrofit large scale solar water heating in a hotel complex in Killarney. This included evaluation of technical and non-technical issues and sensitivities to externalities.

DIT Researchers: Dr K Shanks, Mr A MacPhaidin

B. Electrical Power Engineering Research Group

The DIT Electrical Power Engineering Research Group (DITEPER) has been established within the School of Control Systems and Electrical Engineering in the Faculty of Engineering. The Group members are Eugene Coyle, Michael Farrell, Joseph Kearney, Michael Conlon, Kevin Gaughan and Malabika Basu.

The emphasis of the Research Group is in the following areas:

- Renewable energy
- Quality of electrical supply
- Reliability and adequacy assessment
- Power systems analysis and control
- Development and control of power electronics converters
- Development and application of fuel cells

Current specific projects in the Electrical Power area are as follows:

- Development of a Unified Power Quality Conditioner (DITUPQC)
- Fuel Cell Engineering
- Integration of Wind Energy in Electric Power Networks
- Adequacy Assessment of the Irish Electricity Supply System
- Unique Phase Balancer
- Power Quality and Its Effect on Appliance Reliability
- Energy Monitoring and Targeting System Utilising Building Simulation Software

Development of a Unified Power Quality Conditioner (DITUPQC)

The Electrical Power Engineering Research Group recently won funding of €332,000 over a period of three years from Enterprise Ireland under the Commercialisation fund. The project objectives are to develop and facilitate the commercialisation of a Unified Power Quality Conditioner (UPQC). The UPQC involves the optimal control of a power electronics-based conditioner which comprises both shunt and series elements. The UPQC will find application in dealing with problems of power quality in power networks, including power factor correction, voltage sags and swells, voltage flicker,



phase unbalance and harmonic filtering. Michael Conlon and Kevin Gaughan are the Joint Principal Investigators and Malabika Basu is the Senior Researcher for this project.

DIT Researchers: Dr Michael Conlon, Mr Kevin Gaughan, Dr Malabika Basu, Dr Eugene Coyle, Mr Michael Farrell, Mrs Jayanti Navilgone Ganesh, Mr Iurie Axente

Fuel Cell Engineering

Under the DIT-funded TERS Research Support Scheme, a €50,000 research grant was awarded to the Electrical Power Engineering Research Group towards the development and application of fuel cell technology. A fuel cell research team was developed, including Eugene Coyle, Michael Conlon, Kevin Gaughan (electrical engineering) and Gavin Duffy (chemical engineering) and David Kennedy and Jim Brunton (mechanical engineering). Two students, Steffen Schutz and Gerhard Sauer from the Fachhochschule Darmstadt in Germany have enrolled as MPhil students at DIT under the supervision of Eugene Coyle and David Kennedy. Mr James Brunton (a staff member) is also registered for an MPhil degree. This initiative has resulted from contacts over a number of years with Dr Heinz Schmidwalter of the Fachhochschule Darmstadt, Germany. An additional link has been established with Dr James Hamilton of Department of Chemistry and Engineering Physics, University of Wisconsin, Platteville, USA.

DIT Researchers: Dr Eugene Coyle, Mr Michael Farrell, Dr David Kennedy, Mr James Brunton, Mr Kevin Gaughan, Dr Michael Conlon, Mr Gavin Duffy

External Researchers: Dr Heinz Schmidwalter (Fachhochschule Darmstadt, Germany), Dr James Hamilton (University of Wisconsin, Platteville, USA)

Integration of Wind Energy in Electric Power Networks

The impact of deregulation on the electricity supply network and the drive to install significant capacity of renewable (in particular, wind) energy to the system presents significant technical challenges on a number of fronts to design engineers. Staff members Joseph Kearney and Michael Conlon are studying the impact of medium and large-scale renewable energy generation capacity to the Irish electricity network. In particular, the impact on power quality issues on the operation of wind generation is being investigated. This work has led to collaboration with the wind energy generation company Airtricity, focusing on a number of power quality issues at the Corneen wind farm in County Cavan.

DIT Researchers: Dr Michael Conlon, Mr Joseph Kearney, Dr Eugene Coyle

Generation Adequacy in the Irish Electrical Supply System

A research grant of €34,000 was awarded to Michael Conlon under the DIT Scholarship Scheme to investigate the assessment of generation adequacy in the Irish electricity supply system. Generation adequacy assessment relates to determining whether there is sufficient generation capacity installed to meet the present and future demand for electricity. This issue is particularly



relevant in Ireland at present as a result of the increased levels of wind energy generation which is in the process of being installed in the system. William Carr is enrolled as an MPhil student and is undertaking this project under the supervision of Michael Conlon.

DIT Researchers: Dr Michael Conlon, Mr William Carr

Unique Phase Balancer

Mr Hugh O’Kelly, of Premium Power, has recently completed a part-time MPhil degree in design of a phase balancing system which has been installed at the Waterford Crystal plant. A significant risk of power failure is introduced into large electrical fine glass furnaces due to their requirement of two-phase power. Such a power failure could lead to catastrophic solidification of the furnace contents. The question of reducing this risk has occupied the minds of numerous engineers in the glass industry, and solutions have hinged on the issue of balancing a two-phase load over three phases. The system design is based on a capacitor/inductor method by which a two-phase load may be converted to three-phase by connection of the reactive elements between the loaded phases and the unloaded one. This project was supervised by Eugene Coyle and Michael Farrell.

DIT Researchers: Mr Hugh O’Kelly, Dr Eugene Coyle, Mr Michael Farrell

Power Quality and Its Effect on Appliance Reliability

The Electricity Supply Board sponsored a scholarship which enabled the School of Control Systems and Electrical Engineering to recruit postgraduate student Steven McGovern. Steven has recently completed this work and was awarded the degree of MPhil. The research was aimed at identifying the effects of supply variation, caused by network switching and other transient phenomena, upon customer appliances. In particular the study focused on how such transients affect the power supplies of household appliances such as personal computers and televisions. As part of this work, a test circuit was used to inject impulse transients onto a power supplies and to access the potential impact on appliances. A simulation study was made on a typical distribution network to determine under what conditions maloperation will occur.

DIT Researchers: Mr Stephen McGovern, Dr Eugene Coyle, Mr Michael Farrell, Dr Michael Conlon

Energy Monitoring and Targeting System Utilising Building Simulation Software

Achieving energy efficiency in buildings has become a major challenge. Building energy management systems (BEMS) are installed to provide monitoring and control of the building systems and service plant. Part-time research student Brendan Swords is engaged under the supervision of Eugene Coyle in design of an automatic energy monitoring and targeting system, utilising building simulation software to maximise efficiency and environmental comfort. Approximately one third of our primary energy



supply is consumed in buildings. The scope of the research encompasses the following:

- study of energy monitoring and targeting systems and energy performance analysis systems;
- study of building simulation programs;
- design of energy monitoring and targeting software, and of integration and data acquisition, and
- installation and implementation of energy monitoring and targeting system on a selected site.

DIT Researchers: Mr Brendan Swords, Dr Eugene Coyle

Grid Integration of Photovoltaic Energy Sources

The integration of renewable energy sources into electricity supply grids present certain challenges from a network management point of view. The objective of maximum energy tracking is usually significant in the development of these resources. However, because of the variable nature of some renewable resources (in the case of wind and solar, for example) the impact on the grid needs also to be considered. This research area was recently initiated and is currently looking at the design and construction of grid inverters for PV panels which can maximise the available solar resource whilst providing benefits in terms of power quality enhancement

DIT Researchers: Mr Kevin Gaughan, Dr Malabika Basu, Dr Michael Conlon, Dr Eugene Coyle, Mr Kevin O Farrell, Mr Keith Sunderland

C. Photovoltaic research activity at DIT

DIT currently has a range of diverse research projects within the Photovoltaics area across a number of Faculties namely Science, Engineering and Built Environment. Activities include the (i) investigation of ZnO based transparent conducting oxide (TCO) for silicon based solar cells (ii) development of luminescent solar concentrators using novel Quantum Dot technology for increased photovoltaic efficiency (iii) evaluation of autonomous PV powered lighting systems and (iv) development of an Integrated Photovoltaic Solar Thermal water/air heater for temperate climates.

ZnO based transparent conducting oxide (TCO) for silicon based solar cells

ZnO has been identified as an alternative for conventional transparent conducting oxide (TCO) materials in Si based solar cells due to their superior electro-optical properties. Highly textured surface is essential to achieve gradient refractive index and facilitate sufficient light trapping. Sol gel processing offers a method, which has the potential for making such textured thin films as well as low temperature crystallization and the possibility of low cost fabrication. Zhao *et al* fabricated *a*-Si:H solar cells on ZnO:Al films using a combustion chemical vapour deposition process (CCVD). An efficiency of 9.4% has been demonstrated. Electro-optical and morphological characteristics could be improved using a sol gel approach. Even a small improvement in the efficiency of current solar cell is beneficial to the scientific development of non conventional energy sources. The objective of



the programme is to fabricate doped sol gel nano layered ZnO materials to achieve better device performance in Si based solar cells

*DIT Researchers: Dr. SC. Pillai, Dr. D McCormack and Dr. J Colreavy
Collaboration- IMT, Neuchatel, Switzerland*

Quantum Dot Solar Concentrator

The Quantum Dot Solar Concentrator (QDSC) is a novel luminescent approach to solar energy concentration, which replaces dyes in a fluorescent solar concentrator, with quantum dots (QDs). By adopting quantum dot technology to concentrate both direct and diffuse solar radiation onto a photovoltaic cell (i) smaller photovoltaic areas are required per unit electrical output, (ii) higher efficiency conversion of solar energy to electricity ensues and (iii) electricity generation is significant in cloudy and winter conditions as diffuse insolation is concentrated. As a QDSC consists of nanoscale quantum dots seeded in acrylic or glass its projected cost is likely to be much less than that of the displaced photovoltaic cells. The overall cost of a smaller photovoltaic cell and quantum dot solar concentrator combination will therefore be less than current conventional photovoltaic cells for the same electrical output. A critical analysis is also being undertaken comparing commercially available quantum dots with laser dyes.

This work funded by Sustainable Energy Ireland is part of a European consortium FULLSPECTRUM involving 17 academic and industrial partners, whose aim is to make more efficient use of the solar spectrum for energy generation.

*DIT Researchers: Dr S Gallagher, Ms B Rowan, Mr S Botta
Dr J Doran, Prof B Norton and Dr H Byrne*

Autonomous PV powered lighting systems

A generic model for combined daylight and PV powered lighting systems is being developed and validated which will be employed to undertake technical and economic optimisation. New components will be added to TRNSYS (a Transient Energy System Simulation Tool) in order to extend its capacity to electric lighting and interconnection of PV building integrated distributed generation systems. The major focus of this study is PV powered artificial sources. There is a minor interest in daylight and non-PV powered artificial sources, primarily for reference/benchmarking purposes.

DIT Researchers: Mr K O'Farrell, Dr K Beattie and Prof B. Norton

Integrated PV/ Solar Thermal water/air heater

An integrated semi-translucent photovoltaic panel coupled to a solar air and water-heating unit sets the boundaries of the investigation. The panel design is derived from a preliminary parametric analysis of the governing factors associated with panel efficiency through energy balances relating to the solar insolation, electrical energy generated, thermal energy generated (air temperature, water temperature) and water and air mass flow rates for the panel. The design incorporates an air duct, which can change in depth and is attached to the top of a conventional solar water panel. The Glazing is replaced with a semi-translucent photovoltaic panel, which allows for thermal



energy generation (into water and air), light transmission, and electrical energy generation. Preliminary theoretical and experimental characterisation of the PV-T is presented: theoretical investigation into the operating point for the thermal air component, and an experimental characterisation into the thermal water cooling component, for the temperate climate of Ireland.

DIT Researchers: Mr A Farrell, Dr D Kennedy and Prof B. Norton



Appendix II

Education and Training in DIT for the Energy sector.

Building Services Engineering

DIT has the only honours degree in Building Services Engineering in the State for 21 years now. Both the ordinary level and the honours level are heavily concerned with energy use. The honours programme is modularised with modules on Refrigeration, Air Conditioning and Ventilation, Energy Management, Facilities Engineering and Heat Transfer in Buildings. All these modules are existing and can make a major contribution to the issue of Energy Efficiency. There are also extensive and unique Laboratory Facilities in the field, with 5 lecturers in the Department active in area of energy research

Energy Management

This subject is designed to inform the student of global and building services related energy issues. The aim of the course is to give the student an understanding of the fundamentals of energy management from design to operation of buildings.

The subject aims to develop an awareness of the role of the building services engineer in the energy efficient design and operation of buildings. Having completed the course, the student will be able to: (i) Explain the need for careful management of energy; (ii) Identify appropriate technologies used for the efficient use of energy and generation of renewable energy; (iii) Analyse the use of energy in new and existing buildings and make comparisons with existing benchmarks.

Heat and Mass Transfer

This is an undergraduate level programme in the fundamentals of heat transfer and thermal. The aim of the programme is to provide an introduction to heat and mass transfer and to enable students to apply the basic principles to common engineering problems. A primary concern is that a student leaves the programme being reasonably competent at solving basic heat transfer problems. Having successfully completed this programme the student will be able to: (i) Identify and compute the rate of thermal energy (conduction, convection and radiation) and/or mass transfer between systems or system and its surroundings (ii) Perform engineering computations for problems involving heat and/or mass transfer and know when, and of what nature, simplifying approximations may be made (iii) Select and apply appropriate analytical/numerical solution techniques and/or correlations to heat and/or mass transfer problems; (iv) Perform the kinds of calculations, which lead to a rational design, and/or an improved understanding of the performance of thermal and mass exchange systems; (v) Implement theory and analysis in carefully designed mechanical engineering laboratory experiments.



Building Heat Transfer

The aim of the module is to achieve an appropriate knowledge and understanding of the principles of the subject matter and reach a level of appropriate academic competence in descriptive, analytical and computational elements and apply this knowledge to conserving energy in this field. Skills: An ability to analyse the thermal performance of a building in order to optimise its thermal design and make recommendations to the architect; To be competent at thermal load assessment, by manual prediction techniques or use of computer software programmes, for plant sizing purposes; To understand the influence of thermophysical properties of the space's fabric surfaces and thermal comfort

Air Conditioning and Ventilation Engineering

The aim of the module is to achieve an appropriate knowledge and understanding of the principles of the subject matter and reach a level of appropriate academic competence in descriptive, analytical and computational elements and apply this knowledge in the optimisation of engineering solutions. Having completed the course, the student will be able to: (i) Appropriately comprehend the principles involved; (ii) Apply the principles in a logical and appropriate manner; (iii) Where appropriate, measure and evaluate empirically the major issues; (iv) Analyse and compute some of commonly encountered models in a manner which leads towards a resolution of the situation presented (v) Evaluate the often competing potential solutions so as to formulate an optimum and appropriate solution.

Refrigeration

This subject treats vapour compression and vapour absorption refrigeration systems and the allied areas of cooling distribution, free cooling, dehumidification and ice thermal storage. Aims: (i) To bring the student to a suitable level of knowledge and understanding of the principles of the subject matter; (ii) To develop in the student an appropriate level of competence in the descriptive, analytical and computational elements of the subject.; (iii) To enable the student to apply the subject material in the design and optimisation of engineering solutions. Having completed the course, the student will be able to; (i) Explain the performance characteristics of refrigeration system components and complete appropriate design calculations for each; (ii) Design/select energy conscious and applicable cooling, refrigeration and allied systems; (iii) Describe whole (refrigeration) system performance; (iv) Demonstrate knowledge of industrial and other applications of refrigeration: (v) Integrate, in an energy conscious way, refrigeration systems and other energy conversion systems.

Facilities Engineering

This subject introduces the student to the facilities engineering environment. It includes design, construction and maintenance of common facilities services systems. This subject is designed to give the student an introduction to the facilities systems and processes found in electronics, healthcare and pharmaceutical companies. The aim of the course is to give the student an



understanding of the fundamentals of facilities engineering from design to installation. *Having completed the course, the student will be able to:* (i) Describe some of the different facilities systems found within the electronics, healthcare and pharmaceutical industries; (ii) Outline some of the fundamental principles of the various systems; (iii) Apply evaluation techniques to achieve optimum design and cost effectiveness; (iv) Calculate basic system capacities (v) Demonstrate competency in selection, design and analysis of the various systems; (vi) Work in conjunction with manufacturing engineers to research a manufacturing problem and present a solution.

Mechanical Engineering Modules

Thermodynamics

This is an undergraduate module in thermodynamics theory and practice. This course is designed to give students a foundation in classical thermodynamics. The module builds upon the knowledge and understanding of basic thermodynamics and heat transfer developed in the 1st year physics and chemistry modules. The structure of the module follows a standard degree format in thermodynamics and covers an appropriate quantity of the recommended class texts plus supplementary information, which is complimentary to the texts. The aim of the module is present a comprehensive treatment of classical thermodynamics and to introduce the student to the fundamental concepts of thermodynamic components and properties, and to the development and use of laws of thermodynamics.

Applied Thermodynamics

This is an undergraduate module in applied thermodynamics theory and practice. The module builds upon the knowledge and understanding of classical thermodynamics developed in the introductory module in the second of the mechanical engineering programme. The module structure follows a standard degree format in thermodynamics and covers an appropriate quantity of the required class texts. The aim of this module is to develop and enhance the students' knowledge and understanding of applied thermodynamics to present material related to thermodynamic cycles, mixtures & psychometrics, chemical reactions, and fuel cells and to develop an ability to use thermodynamics in applications typically found in engineering practice.

Fluid Dynamics

This is an undergraduate module in fluid mechanics theory and practice. The module builds upon the knowledge and understanding of fluid mechanics developed in introductory modules and in the third year of the mechanical engineering degree programme. The module structure follows a standard degree format in fluid mechanics and covers an appropriate quantity of the required class texts.

The aim of the module is to develop and enhance the students' knowledge and understanding of relevant fluid mechanics theory, and to develop their ability to confidently solve complex engineering problems involving fluid flow systems.



Fluid Mechanics

This is an undergraduate module in fluid mechanics theory and practice. The module builds upon the knowledge and understanding of basic fluid mechanics developed in introductory modules. The structure of the module follows a standard degree format in fluid mechanics and covers an appropriate quantity of the recommended class texts.

The aim of the module is to develop and enhance the students' knowledge and understanding of relevant fluid mechanics theory, and to develop their ability to confidently solve complex engineering problems involving fluid flow systems.

Heat and Mass Transfer

This is an introductory course in heat (conduction, convection & radiation) and mass transfer with engineering applications taken from various disciplines. The module structure follows a standard degree format in heat and mass transfer and will cover large portions of the required class text. It will also cover material, which is complimentary to the text.

The aim of this module is to introduce students to heat (conduction, convection & radiation) and mass transfer and to enable students to apply the basic principles to common engineering problems. A primary concern is that students leave the course being reasonably competent solving heat and mass transfer problems. Employers expect this and the professional engineering bodies require that students have a minimum level of competency.

School of Control Systems and Electrical Engineering

The School of Control Systems and Electrical Engineering offers a number of modules directly related to the Energy Sector across its Undergraduate and Postgraduate programs.

Within the Bachelor of Engineering Technology Degree (DT009), one of the two streams offered is a specialisation in Electrical Energy Systems. This Degree includes the following Modules:

Electrical Energy Systems (Module 1)
Electrical Energy Systems (Module 2)

One of the four options in the Honours Degree in Electrical and Electronic Engineering (DT021) is Power Systems Engineering and this which comprises the School's main involvement in the Energy Sector. The current energy-related Modules offered in DT021 are:

POWR 2051 Electrical Machines and Power Systems
POWR 3051 Power Systems
POWR 4051 Power Systems Engineering
WIND 4051 Wind Energy for Electricity Supply (Elective)



Within the Part-Time Electrical Engineering Degree (Part 2) (K235), the School offers the following subjects:

Electrical Power Systems (Modules 1 and 2)
Electrical Building Services (Modules 1 and 2)

Within the Masters of Advanced Engineering (FT220), a Power Electronics module is offered. The School has also developed three modules as part of the proposed MSc in Energy Management:

Embedded Generation
Sustainable Energy Supply – Policies and Markets
Wind Energy for Electricity Supply