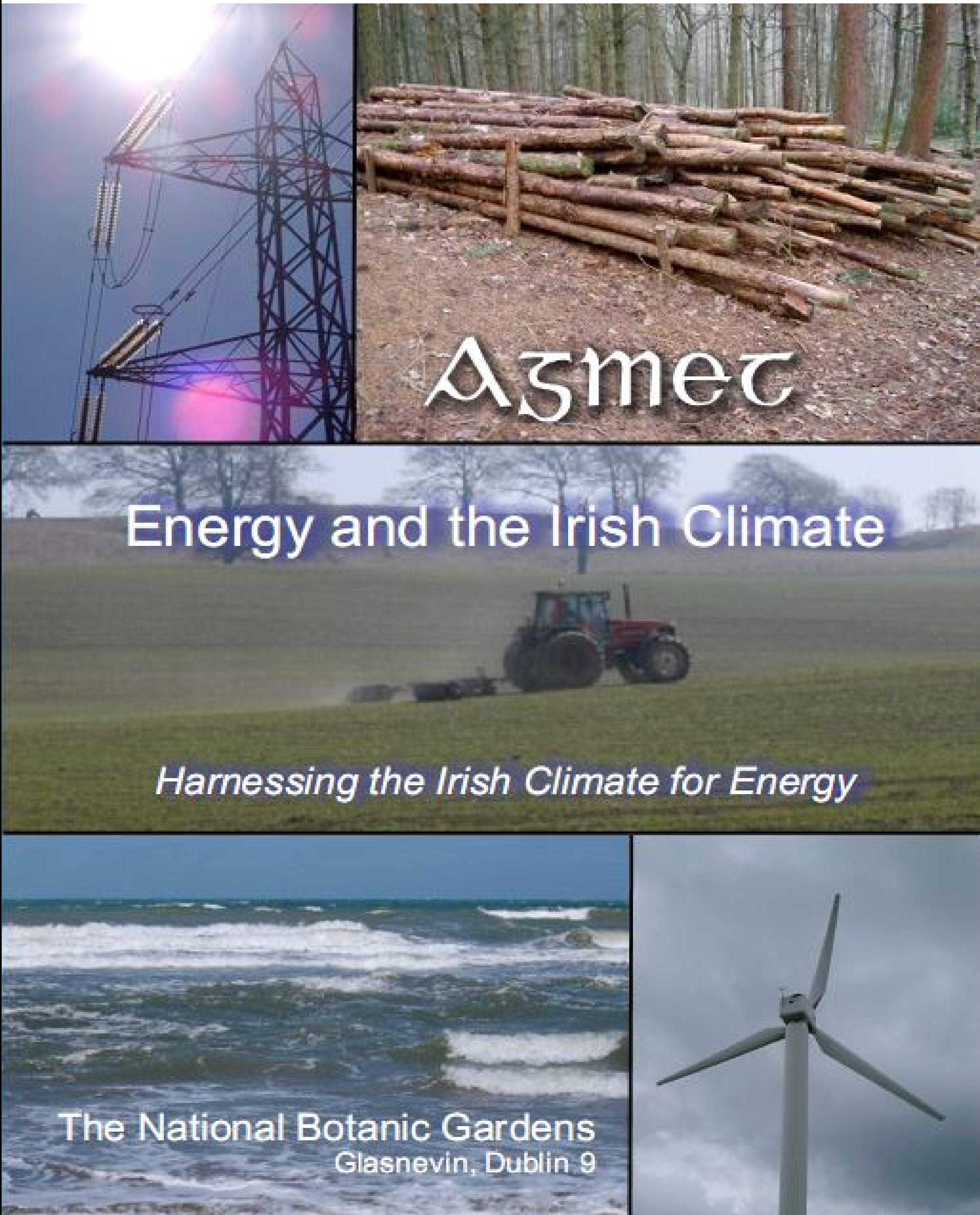
Agmet
Energy and the Irish Climate
Harnessing the Irish Climate for Energy
The National Botanic Gardens
Glasnevin, Dublin 9
29th February 2008

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15:30 Close

About Agmet

AGMET was founded in 1984 and has the full title of "Joint Working Group on Applied Agricultural Meteorology." Membership is open to anyone with an interest in the subject. Currently members are drawn from Met Éireann, Teagasc, Geological Survey of Ireland, Environmental Protection Agency, Office of Public Works, Universities, other third-level Colleges, Department of Agriculture Fisheries and Food and Department of Agriculture and Rural Development, Northern Ireland.

The main activities of Agmet are:

- the provision of support of agro-meteorology for professionals working in Ireland
- the publication of books about agriculture and the weather
- holding conferences on agro-meteorology,
- the development of agro-meteorology education in Ireland
- interaction with other organisations
- awarding the Austin Burke Silver and Bronze medals

The publications and conferences of Agmet are designed to bring the existing knowledge of agricultural meteorology to a wider audience. Every leap-year Agmet organises a topical conference.

Previous Conferences

Making Science Work on the Farm, 2007, held at Teagasc Johnstown Caslte

Climate Change and Irish Agriculture, 2004, held at The Royal Irish Academy

Weather and Agro-environmental Management, 2000, at The Geological Survey of Ireland

The Balance of Water, 1994, held at Trinity College Dublin

The Future of Irish Agriculture–Role of Climate, 1992, held at University College Dublin

Weather and Agriculture, 1988, held at University College Dublin

Agmet Publications

Climate, Weather and Irish Agriculture (2nd Edition), edited by T. Keane and J. F. Collins, 2004

Agro-Meteorological Modelling – Principles, Data and Applications, edited by N. M. Holden, 2001

Agroclimatic Atlas of Ireland, edited by J. F. Collins and T. Cummins, 1996

Irish Farming, Weather and Environment, edited by T. Keane, 1992

Weather, Soils and Pollution form Agriculture, compiled by M. Sherwood, 1992

Climate, Weather and Irish Agriculture, edited by T. Keane, 1986

The Austin Burke Silver Medal

The 'Austin Bourke Medals' were launched by the AGMET Group in 2004 to help promote excellence in agricultural meteorology. The Medals are associated with the late Dr. Austin Bourke, who was, and remains, an inspirational figure in the field of agricultural meteorology in Ireland. The Silver Medal is awarded for long-term outstanding contributions to agrometeorology while the Bronze Medal is awarded for a specific outstanding contribution. Presentation of the 2nd Silver Medal will take place during the conference.

The Austin Bourke Medal Selection committee has recommended that Dr Anthony Brereton be awarded the Austin Bourke Silver Medal 2008 in recognition of his outstanding contribution to agrometeorology.

In their deliberations the committee cited Dr Brereton's sustained and enthusiastic input to agrometeorology and the vast output of his work on modeling grassland systems and climate. Like Austin Bourke's blight model, Dr Brereton's grass model is simple, practical and used extensively. Dr Brereton was a founding member of the AGMET Group and contributed internationally to the work of the WMO Commission for Agricultural Meteorology, European Grassland Federation and EU contract studies on agro-climate related issues. Recently Dr Brereton has made valuable contributions to climate change modeling and environmental studies.

Summaries for Keynote Presentations

Wind Energy in Ireland

Rick Watson

UCD School Of Electrical, Electronic & Mechanical Engineering

In this presentation the challenging targets adopted by the Government and the EU over the last number of years for the proportion of electricity demand to be met from renewable sources are reviewed. The development of wind energy in Ireland and the parallel developments in wind turbine technology over the last 16 years are then traced from the first wind farm of 6.45 MW at Bellacorick installed in 1992 to the situation at the end of 2007 with over 800 MW of wind capacity installed countrywide. The contribution of wind to the present day electricity demand is then examined. The planned future developments to meet the Government and EU targets are outlined and some of the potential bottlenecks to this development are identified and solutions proposed.

Future energy potential of *Miscanthus* in Europe

A Hastings, J Clifton-Brown, M Wattenbach, C P Mitchell, P Stampfl and P Smith

University of Aberdeen, Scotland.

European field experiments demonstrate *Miscanthus* to have the highest energy yield per hectare of all potential energy crops. In addition, previous modeling studies have calculated the potential energy yield for the EU25 for current conditions and future climate scenarios. Here we use MiscanFor, a newly developed Miscanthus crop growth model that can be parameterized for different genotypic traits, to further investigate the potential of Europe to produce this bioenergy crop. Under current conditions we show that 10% of arable land can produce 1,225 PJ y^{-1} and mitigate 126 Pg of Carbon CO_2 equivalent per year. We show that climate change will reduce this to 261 PJ and mitigate 26 Pg of Carbon CO_2 equivalent for *Muscanthus x giganteus* but could increase to 1,646 PJ and mitigate 175 Pg of Carbon CO_2 equivalent by selective breeding of new drought / frost tolerant cultivars. The greatest proportion of EU25 primary energy that could be achieved by *Miscanthus* is 10% (2.4 EJ) if using 35% of current cropland, and using drought / frost tolerant cultivars. Using current cultivars 7.5 % could be met under current climate dropping to 0.5 to 2.5 % under future climate scenarios. Our results suggest that *Miscanthus* could make a contribution to Europe's future energy and climate mitigation needs, but if it is to do so, plant breeding programs need to focus on making the cultivars more robust under future climates.

Ocean Energy Exploitation and Ireland's wave energy resource

Eoin Sweeney, James Ryan and Glenn Nolan

Marine Institute

Ocean Energy as a source of renewable energy has been the subject of ongoing research and development in Ireland over the past few decades. With the continuing rise in the price of energy and increasing pressures on finding cleaner energies, the commercial prospects for Renewable Ocean Energy Technology are recognised. International developments are accelerating and Ireland's offshore renewable energy resources are considered as being among the best in the world. In recent years, prototype devices have been developed by a number of ocean energy companies in Ireland and internationally.

The Marine Institute and Sustainable Energy Ireland published the National Strategy for Ocean Energy in partnership with Department of Communications, Marine and Natural Resources, in 2005 (DCMNR, 2005). This phased strategy aims to introduce ocean energy into the renewables portfolio in Ireland and to develop the ocean energy sector. It aims to support national developers of wave energy devices through concept validation, model design optimisation and scale model testing.

Phase 1, an offshore test site for ¼ scale prototypes was developed in Galway Bay, research capability has been enhanced. and funding has been provided to researchers and developers.

Phase 2 provides for the demonstration of Pre-Commercial Single Devices, This phase provides a mechanism to bring successful designs from the prototype stage to the construction of a fully operational pre-commercial wave energy converter which will supply power directly to the electricity network. The results of this phase will be used to assess the commercial viability of the technology and the resulting industrial opportunities available to Ireland.

Phase 3 will involve pre-commercial small array testing and evaluation over a sustained period (2011-2015).

Phase 4 involves development of strategies for commercial deployment of wave power technologies (2016 onwards).

The opportunities provided by wave energy arise at two levels:
(1) The potential for integrating carbon free ocean energy into the Irish suite of renewables at an acceptable cost and
(2) The potential for home based manufacture/service industry associated with ocean energy development.

Key to all of this is quantifying the available wave resource. Some studies have been conducted to date to assess the Irish wave resource and the Irish Wave Atlas will be presented.. More recently oceanographic models of waves around our coast have been used to estimate the potential wave resource. These models have also been used to provide real-time forecast information to the wave energy device developers to assess conditions at a particular site over a forecast period of several days.

In this talk, we will review the ocean energy strategy and related developments to date and assess the extent to which ocean models and measurements are beneficial to the development of the Irish wave resource as an energy source. Arising from both electricity generation and the export market for Ocean Energy Technology, the OE Strategy postulates that significant values will accrue to the Irish domestic economy.

Solar Energy and the Irish Climate

Brian Norton

President of Dublin Institute of Technology

The intensity and spatial, skyward and spectral distribution of solar energy depends on the prevailing climate and changes with the time of day and year, solar geometry (latitude, incident plane inclination and orientation, shading and local weather (cloud cover, precipitation, airborne dust/pollution).

The Irish climate is characterised by variable but significant cloud cover leading to large diffuse components of solar radiation. The same prevailing winds from the equatorial Atlantic that bring the clouds also give rise to higher annual diurnal ambient temperatures than would generally ensure for most locations at this latitude. These factors combine to have important implications for the selection of appropriate solar energy collector technologies: for example, even solar energy concentrating collectors with non-imaging reflector geometries specifically intended to harness diffuse solar radiation can only collector a fraction – and that fraction decreases with the level of concentration – of the available diffuse solar radiation. The climate therefore favours the use of non-concentrating, low concentration ratio or non-optical solar energy concentrating devices. However, in a solar thermal collector, minimising heat losses is as important as maximising solar gain, so the relatively high annual ambient temperatures that prevail in Ireland mean there is a smaller annual potential to loose heat. The latter improves thermal solar energy collection device efficiency.

The productivity of solar water heaters depends on the desired temperature of hot water withdrawal. One way of representing this is to consider the number of days that a solar water heater can solely meet a given hot water demand. For a specific but typical solar water heater specification, the tank temperature reaches or exceeds 37°C from between 120 days to 160 days across Ireland. The latter being similar to that achieved for example in the Benelux countries and the Czech Republic. For tank temperatures over 43°C, only 40 days can be achieved[1]. A solar water heater in Ireland can satisfy around 40% of a typical annual domestic hot water demand.

Climatic conditions in Ireland are for significant periods of the year, not generally too far from those required to maintain human comfort. Thus employing appropriate glazing, selecting the optimal building orientation, high thermal insulation and sufficient thermal mass for diurnal heat storage are able to provide a building that would have minimal auxiliary heating requirements. Some examples of the applications of such technologies will be presented and current advances discussed.

[1] Y.G. Yohanis, O. Popel, S. Frid and B. Norton, Geographic variation of solar water heater performance in Europe, IMechE Journal of Power and Energy, 220, Part A, 395-407, 2005

Solar energy can be converted to electricity using photovoltaic devices. These have found cost–effective use in stand-alone applications in Ireland (e.g. powering parking meters, portable signage and bus-shelter lighting) where the cost of providing and managing grid-connected provision is disproportionate to the scale of the energy used by the application.

The effect of photovoltaic (PV) surface orientation and inclination on grid-connected photovoltaic system performance in the Irish climate has been investigated using validated simulations. Insolation, PV output, PV efficiency, inverter efficiency, system efficiency, performance ratio (PR) and PV savings have been estimated annually, seasonally and on monthly bases for various surface inclinations and orientations. Incident insolation and PV output have been found to be maximum for a surface with inclination 30° facing due south and minimum for a vertical surface with orientation 90° east or west from south. The monthly optimum collection angle maximising incident insolation varies between 10° to 70°. For the particular location and system studied, the maximum annual PV efficiency, the inverter efficiency, the PR and the system efficiency were for a south-facing surface with an inclination of 20°. The latter is again is consequence of the large diffuse component of insolation. For a horizontal surface, the monthly variation of system parameters can be significant over a year. The economics (and potential economic viability) of a PV installation that is supplying a load that is also connected to an electricity grid, depends strongly on the electricity price. This can vary with time in a fixed manner to reflect demand. Such variable prices are referred to as a tariff. For time-dependent tariff rates, the annual PV savings are higher for a system oriented (with same inclination) more towards the west than east while for constants tariff rates, the PV savings was the same for east or west orientation[2].

Aspects of current research that should lead to more economically viable applications of solar energy in Ireland will be presented.

[2] J. D. Mondol, Y. G. Yohanis, B. Norton, The impact of array inclination and orientation on the performance of a grid-connected photovoltaic system, Renewable Energy, 32, 118-140, 2007

Abstracts for Research Presentations

Simulating Climate Change And Its Effects On The Wind Energy Resource Of Ireland

P Nolan, P Lynch, S Dunne, J Hanafin, R McGrath, T Semmler and S Wang

Meteorology and Climate Centre, University College Dublin and
Community Climate Change Consortium for Ireland (C4I), Met Éireann, Dublin

Greenhouse gas emissions are having a significant effect on the Earth's climate. Climate models predict that global temperatures could rise by a further 1°C - 5°C over the next 100 years, depending on the amounts of greenhouse gases emitted and the sensitivity of the climate system. There is evidence that increasing temperatures will lead to changes in the wind climatology of Ireland. The impact of greenhouse gases on climate change can be simulated using Global Climate Models (GCMs). However, long climate simulations using coupled atmosphere-ocean general circulation models are currently feasible only with horizontal resolutions of 50 km or greater. Since the wind energy resource of Ireland exhibits a high degree of spatial heterogeneity this is inadequate for the simulation of the detail and pattern of climate change and its effects on the wind resource. In the C4I Project, we are using a Regional Climate Model (RCM), the Rossby Centre Regional Atmospheric Model, to simulate the wind climatology of Ireland at high spatial resolution. The RCM has been validated by performing a 40-year simulation of the Irish climate (1961-2000), driven at the lateral boundaries by ECMWF ERA-40 global re-analysis data, and comparing the output to Irish weather station data and ERA-40 data. Results confirm that the model is able to simulate wind patterns over Ireland with a high level of accuracy. Projections for the future Irish climate were generated by downscaling the Max Planck Institute's ECHAM GCM data using the RCM. Simulations were run for a reference period 1961-2000 and future period 2021-2060. The future climate was simulated using a number of greenhouse gas emission scenarios (A1B, A2, B1 & B2) developed under the auspices of the IPCC. Results for the downscaled simulations show an overall increase in the energy content of the wind for the future winter months and a decrease during the summer months. To address the issue of model uncertainty it is planned to use the climate version of the COSMO model to simulate climate change and its effects on the wind climatology of Ireland. The COSMO model is developed by Deutscher Wetterdienst (DWD). To assess the skill of the COSMO model in simulating the wind climatology of Ireland, a preliminary experiment was carried out consisting of a 2-year series of 24 hour forecasts (2005-2006). Results confirm that the model simulates the wind patterns over Ireland with a high level of accuracy.

Experimental Characterisation Of Both Air And Ground Source Heat Pumps Operating Under The Irish Maritime Climate

N Burke, M Greene, J Lohan, L Dimache, R Clarke and F Fitzgerald

Sustainable Energy Research Group, Centre for Sustainable Resource Development, Galway-Mayo, Institute of Technology, Dublin Road, Galway, Ireland.

Geologically, Ireland is situated on a thick part of the Eurasian plate which offers relatively few true geothermal sources of thermal energy. As a result, Ireland's supply of thermal energy is mainly solar based as embodied within both the air and ground. Climate therefore plays a significant role in dictating the performance of ground and air source heat pumps as it controls the supply of thermal energy. Fortunately, the moderate Irish maritime climate offers very favourable conditions for the successful performance of heat pumps as it provides relatively warm air temperatures and warm, moist ground conditions. This presentation describes an experimental test facility that has been put in place at the Galway-Mayo Institute of Technology's Dublin Road campus to investigate the performance of both air and ground source heat pumps in the Irish climate. The test facility described employs one 10kW Air Source Heat Pump (ASHP) and two 15kW Ground Source Heat Pumps (GSHPs), one GSHP uses a horizontal collector to extract energy from the upper ground layer and the second GSHP uses a vertical collector consisting of three, 100m deep boreholes. The test facility monitors the local weather conditions including ground temperatures and moisture conditions, borehole temperatures and heat pump efficiencies. Continuous monitoring for this study was initiated in December 2006 and this presentation outlines the sensitivities of the three heat pump to fluctuations in the climate and seeks to demonstrate the variations in the sensitivity of performance of individual heat pumps with climate, along with differences in performance between heat pumps. Such information will provide a valuable input when selecting both the type and size of heat pumps for Irish installations.

Development Of An Automated Test Facility To Characterise The Performance Of Solar Thermal Collectors To International Standards In Ireland

J Lohan, P J McAllen, F Fitzgerald, R Clarke, N Burke, M Greene and L Dimache

Sustainable Energy Research Group, Centre for Sustainable Resource Development, Galway-Mayo, Institute of Technology, Dublin Road, Galway, Ireland.

Reflecting the recent surge in the uptake of solar thermal conditions in Ireland, great interest
is expressed in unbiased information that describes the performance of these systems under Irish climatic conditions or the sensitivity of performance to collector type or installed configuration. This project sought to address these issues by developing an automated test facility at GMIT's Dublin Road Campus that is capable of continually accessing the thermal performance of solar thermal collectors under Irish conditions. This presentation will deliver the key facets of the ISO 9806-1 standard to which the GMIT facility has been designed, an overview of the facility that has been put in place, along with initial test results that have been recorded from a 2m² flat plate solar collector for January and February 2008. Such a facility will be available to test a range of solar panels from those based on flat plate, evacuated tube or heat pipe collectors. This data can be used to provide more accurate guidelines for the design and installation of solar thermal collectors in Ireland.

Comparison of physical properties of wood pellets available to Irish consumers with the possibility of miscanthus as a raw material

A Nolan, K McDonnell and JP Carroll

UCD Biosystems Engineering, University College Dublin, Earlsfort Terrace, Dublin 2, Ireland and Teagasc Research Centre, Oak Park, Carlow, Ireland.

Pelletising is a method of increasing the bulk density of biomass materials into densified pellets, such as wood pellets, for efficient transport and storage. The quality of wood pellets available on the market can vary considerably depending on the biomass material and the applied method of manufacture. As pellets become ever more popular as a source of fuel it is evident that an alternative source of raw material other than wood (sawdust, virgin timber and forest thinnings) is necessary. In order to facilitate the safe storage of pellets low moisture content (about 8% wet basis (wb)) is required. A bulk density of more than 700 kg m^{-3} should be achieved for wood pellets. The bulk density of miscanthus pellets are approximately 650 kg m^{-3}. The quality of miscanthus pellets are compared to that of wood pellets with any resulting issues identified.

A method is presented to determine the physical properties of five wood pellet products available to Irish consumers. The physical properties of ground particles and the process variables during pelletising (pressure and temperature), affect the overall quality of pellets achievable from that process. Testing of the pellet properties (particle distribution, bulk density, durability, moisture content, calorific value and ash content) was conducted in accordance with CEN Technical Committee TC335 standards. Of the wood pellet samples, it was found that pellet sample 1 and pellet sample 3 were of the highest quality. The results achieved from the identical tests conducted on the miscanthus pellets identified miscanthus sample 1 and miscanthus sample 4 to be favourable with those obtained for the wood pellets. While the ash content of wood pellets are low (less than 1% overall), an average ash content of 2.1% was attributable to the miscanthus pellets. The chlorine content of miscanthus pellets may also be of issue at 0.1% on average with only 0.04% on average present in wood pellets.

Wave Energy Conversion - The Oscillating Water Column

R K Sykes, A W Lewis and G P Thomas

Hydraulics and Maritime Research Centre and Department of Applied Mathematics, University College Cork, Ireland.

Ireland's primary energy consumption in 2006 was 15.9 Mtoe. 32% of this was used in electricity production which is equivalent to 5.92TWh electricity. The theoretical total annual wave energy in Irish waters was recently estimated to vary between 11.3 and 460.6TWh per year, approximately dependant on the water depth and distance from shore. At the lowest this seems like a very enticing figure, the percentage of which converted depends fundamentally on the number of converter devices deployed, with a ceiling determined by geographical, economical and social issues, and the effectiveness of the device. Numerous devices have been proposed utilising various methods of converting this renewable energy to usable energy. Recently two such quarter scale devices have been tested in the Marine Institute test site in Galway Bay, one of which was an oscillating water column (OWC). A generic OWC comprises a chamber whose mouth is submerged and which is vented through a turbine to atmosphere; the variation of water level within the chamber forces air in and out of the turbine. Fixed coastal mounted OWC have been constructed in a small number of sites around the world with mixed success but recent interest in Ireland has focused on a floating version. Research is currently being carried out to examine the physics of a generic floating device enabling further development and optimisation. The OWC is essentially a resonant device tuned to a particular frequency of wave. When excited at this frequency the potential power production is greater than at other frequencies. As such it is appealing to understand the factors affecting the frequency of such a resonance. Work has been carried out to date to initially study the variation of pressure within a fixed OWC at varying frequencies which will be presented. It has already been fruitful in advising device developers of potential pitfalls in using water column elevation measurements in early stage trials to estimate power production.

Abstracts for Poster Presentations

Grass For Biorefinery: A Scoping Study On The Alternative Use Of Grassland Biomass In Ireland

S O 'Keeffe, R Schulte, P C Struik

Teagasc Johnstown Castle and Wageningen University, The Netherlands

Under the combined enforcement of the Kyoto protocol in 2005 and the EU biofuel Directive (2003/30/EEC) Ireland must move towards a more bio-based economy and find indigenous alternatives to fossil fuel, in order to reduce its CO_2 emissions and remain competitive. One bio-resource which Ireland has readily available is grass. Approximately 80% of Irish agriculture is grassland based, maximum yields ranging between 12−18 t DM ha^{-1} yr^{-1}, grass has the potential for energy production or other purposes.It has been predicted that global warming will result in elevated grassland yields, making grass an even more attractive bio-resource for the future. In addition, recent CAP reforms may promote some segments of the agricultural industry to reduce stocking rates, leading to a potential surplus grass, readily available for alternative use.One option for alternative grass utilisation is "Green biorefinery", an integrated concept using green biomass to produce a range of products, including high value biochemicals which can be used to substitute raw petrochemicals, e.g. lactic acid (plastic production, polylactide (PLA)), proteins (animal feed, beauty industries), ethanol (biofuel). Lower value products can be made from the grass fibre cake such as building material or energy generation. Using the three pillars of sustainable agriculture, agronomy, socio-economics and environment as the research framework, the objective of this project is to establish if green biorefinery will be a viable and sustainable option for farmers. The agronomic assessment is a combination of field trials and modelling work, with the aim of establishing a baseline on the potential quantity and quality of the grass material available. The economic models used to assess those regions where biorefinery would be most attractive as an alternative source of income are being developed through modelling both field trial and census data. The environmental assessment will focus mainly on the nitrogen efficiency of the system, using a combination of the N-cycle (Nitrogen) model and data from field work to identify the environmental implications of a biorefinery system, positive or negative, and compare this with today's predominant grass based farming systems.

Design And Extension Of Innovative Complex Biogas Systems

M Poschl and S Ward

UCD Biosystems Engineering, University College Dublin, Earlsfort Terrace, Dublin 2

Renewable biomass could play a decisive role in the development of sustainable energy for Ireland. There are several sources of feedstock materials for biomass plants, and these are not confined to farmers and agricultural cooperatives. Waste streams from the food industry and bio-waste from local authorities are potential feedstocks. Prices for alternative input feedstock are competitive, but the fermentation process of these materials requires optimisation. Different input materials from different clusters of customers require individual technology for biogas plants. This research is evaluating the requirements of different applications which will result in variations in the design of biogas plants, each to match the feedstock inputs. The initial step involves questioning different operators and manufacturers of biogas plants. There are three main clusters of customers for biogas plants: (i) farmers looking for solutions for the waste management for liquid manure and residues of cultivation fields; (ii) farmers producing specific renewable resources operating biogas plants representing an alternative income option to classical farming; and (iii) food industry with focus on waste management for residues of food production. In all cases the requirements for running a biogas plant and the efficiency of biogas plants are similar: design and extension of biogas plants regarding input material, simple operation of the plant, high reliability associated with an average yield of energy. Consequently the technology of components is standardised, hence knowledge is available at a system level. As a result many different manufacturers of components are able to enter the biogas market. As a result of high demand and poor harvests prices for grain on the international market have increased considerably. Biogas plants operated by expensive grain are not viable at present resulting in reduced demand for biogas plants. Reduced subsidies for biogas plants will come into effect in 2009. In this study, initial pilot interviews with different experts from associations, consulting institutions and biogas experts: and with different operators and manufacturers of biogas plants have shown that biogas plants have to be designed technically more effective to generate efficiencly running biogas plants without the same level of subsidies. This circumstance postulates a higher understanding of process engineering of a variety of input materials, appropriate sensor technology, appropriate software algorithm for controlling the data of the fermentation process, highly efficient technology for preparing substrates and utilising end substrates and concepts for optimised usage of heat and biogas for feeding into gas network. Discussion of the results of the pilot interviews with the manufacturer of biogas plants have shown that manufacturers of biogas plants with a main focus at system level without knowledge regarding single components would not be successful on the biogas market. Based on these pilot interviews and discussion we will develop a questionnaire to enlarge the survey to about 50 operators and producers of biogas plants.

Optimisation Of Luminescent Solar Concentrators Using A Ray-Trace Modelling Approach

M Kennedy, S J McCormack, J Doran and B Norton

Dublin Energy Laboratory, Focas Institute, School of Physics,
Dublin Institute of Technology, Kevin St, Dublin.

One approach to decreasing the cost of electrical energy production by photovoltaic (PV) solar cells, is to concentrate more light onto a given area of PV cells. A Luminescent Solar Concentrator consists of a luminescent species, such as quantum dots (QDs) or luminescent dyes, doped in a clear flat polymer plate. As incident light passes through the plate, photons are absorbed by the dye/QDs and subsequently re-emitted isotropically. The plate acts as a wave-guide and a large fraction of the emitted photons are transmitted to one edge, where a PV cell is attached. Other concentrator systems based on lenses and mirrors can only concentrate direct light, i.e. they can only operate in clear weather conditions. These imaging concentrator systems often require expensive solar tracking in order to operate efficiently. LSCs, however, concentrate both direct and *diffuse* light – a significant advantage in Ireland where, due to the prevailing cloudy weather conditions, more than 50% of total annual solar irradiation is diffuse. Solar tracking is not required for LSCs. A ray-trace model has been implemented to predict the electrical output from LSC devices, and model predictions are shown to compare well with measurements taken from fabricated devices. The model can be used to determine the optimum LSC geometry. Single and multiple dye/QD systems can be modelled, as well as combinations of QDs and luminescent dyes, to determine the likely optimum combination of luminescent species to use in the polymer plate.

Investigating Energy Solutions For Sustainable Aquaculture

L Dimache, J Lohan, B Allen, N Burke, M Greene and F Fitzgerald

Sustainable Energy Research Group, Centre for Sustainable Resource Development, Galway-Mayo, Institute of Technology, Dublin Road, Galway, Ireland

Irish aquaculture production has recently begun to shift from "flow-through" to "re-circulation systems". The main advantage of this development is that operators can maintain complete environmental control, minimise water usage, reduce and control effluent output, achieve full traceability and gain market access. In a re-circulation aquaculture system, pumps are used to circulate water through the entire system, water temperature is controlled using either heaters or chillers and water quality is maintained through a series of biological and mechanical filters. All these components combine to generate high energy consumption and profitability is therefore heavily dependent on energy management protocols and unit cost. Alongside labour and feed, energy costs are one of the most economically draining expenses associated with inland aquaculture. Renewable energy systems offer the potential to reduce energy costs. This project aims to profile the energy requirements of the aquaculture industry and to build a prototype demonstrator facility that employs suitable sustainable energy sources such as solar, geothermal and wind energy in combination with energy efficiency measures such as insulation and heat recovery. This presentation will deliver an inventory of energy needs in Irish inland aquaculture industry, possible solutions to satisfy these needs within the Irish context and climate and an overview of the demonstrator facility being constructed during 2008.

Development Of A High Temperature Wind Tunnel And Numerical Simulations To Optimise The Layout Of A Sofc Micro-Tube Reactor

V Lawlor, C Hochenauer, G Buchinger , A Olabi, S Griesser, B Corcoran and D Meissner

Department of Eco Energy Engineering, Upper Austrian University of Applied Sciences, Department of Manufacturing and Mechanical Engineering Dublin City University, University of Leoben, and Tallinn Technical University

Producing electricity at high temperatures in a Solid Oxide Fuel Cell (SOFC), at temperatures currently around 850 to 1000 °C but aiming at 500 to 600 °C, is an ever more emerging possibility for efficiently producing electricity that is friendlier to the environment. The operational conditions that help or hinder the electrochemical production of this electricity, whilst also maintaining the high operational temperatures, are fundamental to the realization of high yields of electricity whilst maintaining a high energy-efficiency and are as yet unknown. For fuel cells to have any market value in the future and to be truly environmentally friendly, they must operate as efficiently as possible. One of the critical problems for scaling single cells up into larger reactors is the induced effects of gas supply, fluid dynamics, heat transfer and stresses which then affect each cells performance within a multi-cell reactor The type of fuel cell being developed by this group is the Micro tubular SOFC. There are two major benefits of using micro tubular SOFC's over the larger versions pioneered by Siemens Westinghouse, the first being the volumetric power densities and the second being the high thermal shock resistance. There is a stark increase in power density compared to the normal sized SOFC tubes in the order for example of up to 10 times the power per volume, if an example of a 2mm diameter micro tubular cell is compared to a larger diameter normal sized cell. Computational Fluid Dynamics (CFD) offers a unique tool to theoretically explore in far greater intensity and wider scale the nature and effects of the species depletion gradients and the temperature profiles and flow regimes within micro-tubular reactors. In order to reach conclusions about all the possible multi physical unknowns, it is critical to find measurements for these phenomena for validation purposes. We describe the construction of a worlds first, small scale, high temperature wind tunnel for a wide variety of flow rates. Analytical and simulation results for natural convection flows within arrays of cylinders have been investigated and the two methods compare favorably with the CFD giving a lot of detail. This project is out of its infancy stage and experience has been gathered in raw CFD simulations, excluding the electrochemistry.

Supergen II Bioenergy Marine Biomass Project: The Application of Macroalgae for Bioenergy Production

J Ratcliff and S Kraan

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One of the major limitations to utilisation of biomass in energy production is the large amount of land required to produce sufficient terrestrial biomass. This has lead to consideration of marine biomass resources which, in addition to being free of the land use conflict, typically have higher photosynthetic efficiency (6 - 8% compared to 1.8 - 2.2%). The macroalgae currently under consideration to be used for bioenergy purposes are kelps (*Laminaria* sp.) and wracks (Fucoids), which are fast growing marine plants that can attain considerable size in a single growing season. *Laminaria* dominated communities of the European coasts have an annual productivity of approximately 2 kg carbon per m^2, higher than, for example, temperate tree plantations and grasslands. The standing stock of kelp (*Laminaria hyperborea* & *L. digitata*) and the fucoids (*Pelvetia canaliculata*, *Fucus serratus* & *Ascophyllum nodosum*) will be estimated for the UK and Ireland by delineating areas of cover using aerial photographs and Admiralty Charts and calculating biomass using figures for kg m^{-2} obtained from the literature and from shore / SCUBA diving surveys. An effort will be made to provide separate estimates for *L. hyperborea* and *L. digitata*. The information will be input into a GIS. China already produces approximately 700 000 dry tons of cultivated kelps per year[4] and trials have demonstrated feasibility of cultivation of kelp in the temperate Atlantic (*Alaria esculenta* – 45 kg m^{-1}, *Saccharina latissima*[6]– 28 kg m^{-1}). Field trials to investigate the growth rates and maximum yields of several locally available species will be carried out in Connemara to establish cultivation and harvesting potential. Characterisation (elemental, proximate, CV, metal and nutritional analyses) and suitability for conversion routes of wet biomass (liquefaction, fermentation) or dry biomass (pyrolysis, combustion, gasification) will be evaluated and will be carried out by other partners in the Supergen project.

Issues Associated With Miscanthus Harvesting And Storage

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Miscanthus, a perennial C_4-grass which originates in East Asia is currently generating much research interest mainly as a new source of biomass (energy production) and fibre (building materials, geotextiles and paper). Harvesting techniques of miscanthus can be in the form of mowing and baling, mowing and chopping or mowing and bundling. To ensure year round delivery of quality miscanthus, conservation and storage is necessary. Storage can be in the form of outdoor or field storage, outdoor covered storage or roofed storage. Experiments were conducted at Oak Park in Carlow to quantify harvest losses and to determine the optimum method of storing harvested bales. Miscanthus stands were harvested using the mowing and baling technique (Taarup 4032 trailed conditioner mower and Lely Welger RP 235 baler). Bales from each of the miscanthus stands were collected and stored under three different conditions: Outdoors with no cover, outdoors capped with plastic and roofed storage. The moisture loss or gain due to storage conditions were recorded on a weekly basis. Loss of crop due to harvesting techniques was investigated and trampling of swarths by machinery resulting in material being left on the ground was a consideration. A one pass technique of cutting, swarthing and baling may be necessary to reduce trampling of the swarths. The average density of the miscanthus bales was 102.86kg/m^3. This could be increased by adjusting baler settings. Bales which were stored outside gained an average of 65% moisture, which was as expected, while bales stored outdoors capped with plastic lost on average 8.3% moisture. An average 17% moisture loss was seen for bales under roofed storage. Higher compaction density may enable the storage of bales under field conditions without big losses due to less absorption of water by the bales. In conclusion bales stored under cover or roofed storage is essential to ensure a year round supply of dry miscanthus.

Irelands ¼ Scale Wave Energy Test Site

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A benign quarter scale test site for floating wave energy devices has been provided by the Marine Institute in conjunction with Sustainable Energy Ireland and the Department of Communications, Energy and Natural Resources. This site is located on the west coast of Ireland in Galway Bay off the Spiddal coast. It has a mean water depth of 23m and a tidal range of 4m. It is expected the provision of this site will encourage developers to progress to Phase 3 of the Ocean Energy: Development & Evaluation Protocol. The recent announcement of a significant financial package, totalling €26M shows the Government's belief that Ocean Energy will play a significant part in a future Renewable Energy mix. A non-directional wave recording buoy has been in situ since the test site's inception in late 2005. Analysis of this data has shown that for quarter scale devices the site can be highly energetic and comparable to the Atlantic Ocean off the west coast of Ireland. However there are some unique features of the test site due to its mix of local wind seas and long period swells that approach the site around the Aran Islands from offshore that will be presented here. As part of the Governments development of Ocean Energy, a grid connected full scale wave energy test site will be provided offshore of Frenchport, Mayo. This site is at the north western tip of Mayo and exposed to some of the highest levels of wave energy experienced along the western seaboard. Two Irish Wave Energy developers, Wavebob and Ocean Energy Ltd, have spent an impressive amount of time at sea in Galway Bay with reduced scale devices and their views as to what will be needed to progress to the next phase of testing at Frenchport will be detailed here. A study of the expected wave conditions at this site will also be presented. Issues associated with miscanthus harvesting and storage

Optimisation Of A Proton Exchange Membrane Fuel Cell: Flow Plate Design & Testing

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Fuel cells are electrochemical devices that offer a promising alternative to traditional power sources; electricity is produced from the reaction of hydrogen with oxygen, reverse process to that in the electrolysis of water. Fuel cells have applications in mobile and also in static applications, because of their high efficiency and reduced emissions. However more durable, less expensive materials and processes are needed to ensure these devices become commonplace in the transport and power generating sectors. The Proton exchange membrane (PEM) fuel cell, the type of fuel cell that the automotive industry is focusing on, is currently being used in many applications. However one of the biggest problems with this fuel cell is the high cost. New materials and manufacturing techniques are helping to increase the lifespan of these devices, reducing the degeneration of the membrane and ensuring that the cost of these devices can compete with current technologies. The PEM fuel cell combines the anode, cathode and electrolyte in one unit known as the membrane electrode assembly (MEA). The MEA has a catalyst bonded to the anode and the cathode to allow the electrochemical reaction to occur. Attached to the MEA are specially designed field flow plates, which have to meet the conflicting requirements of providing good electrical contact and easy passage and even distribution of the gases concerned, hydrogen to the surface of the anode and air to the surface of the cathode. Using simulation software and new test facilities much progress has been made to develop high performance field flow plates. This paper examines the developments of Proton exchange membrane (PEM) fuel cell research in DCU and the current research being undertaken in material design, manufacture and testing of a number of different test configurations.

Estimation of Point Rainfall Frequencies

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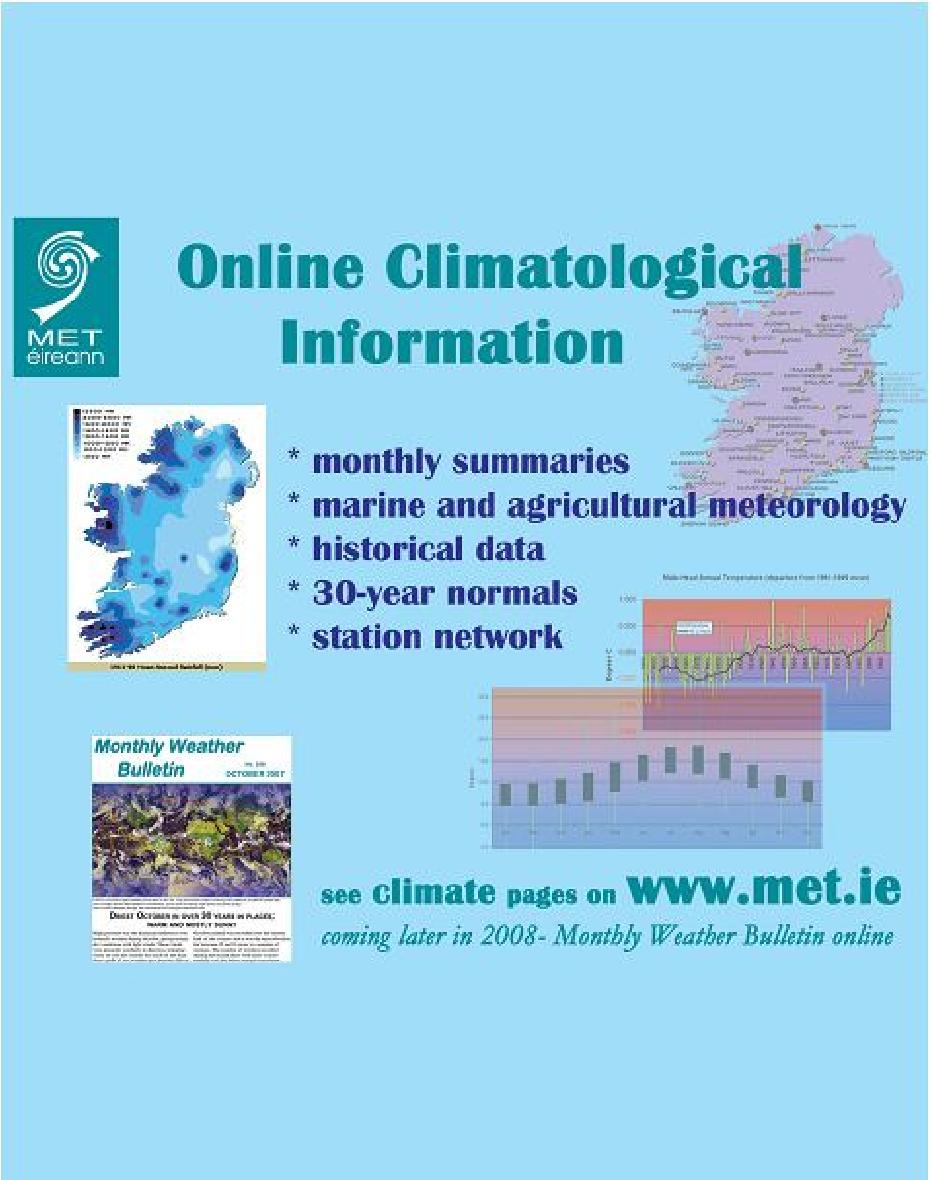
A depth duration frequency model is developed which allows for the estimation of point rainfall frequencies for a range of durations for any location in Ireland. The model consists of an index (median) rainfall and a log-logistic growth curve which provides a multiplier of the index rainfall. Rainfall station data were analysed and an index rainfall extracted, interpolated and mapped on a 2km grid. The model was fitted to series of annual maxima and the growth curve parameters were determined; these were also interpolated and mapped on a 2km grid. Computer applications were written to apply the model and produce gridded outputs of the return period rainfalls which can easily be mapped; an application for deriving rarity estimates was also developed. An account is also given of the reliability and probable accuracy of the model and the probable effects of Climate Change on extreme rainfalls.

Information posters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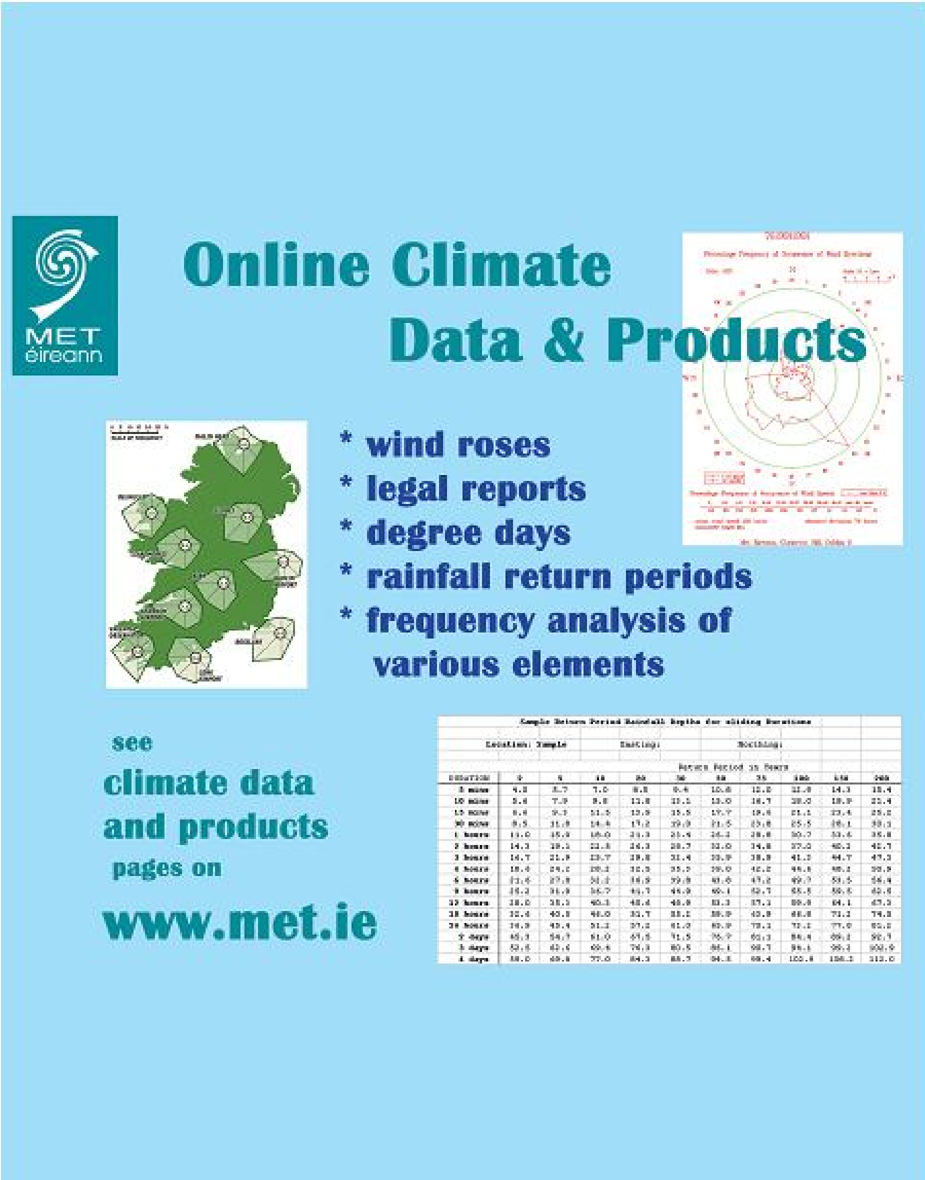
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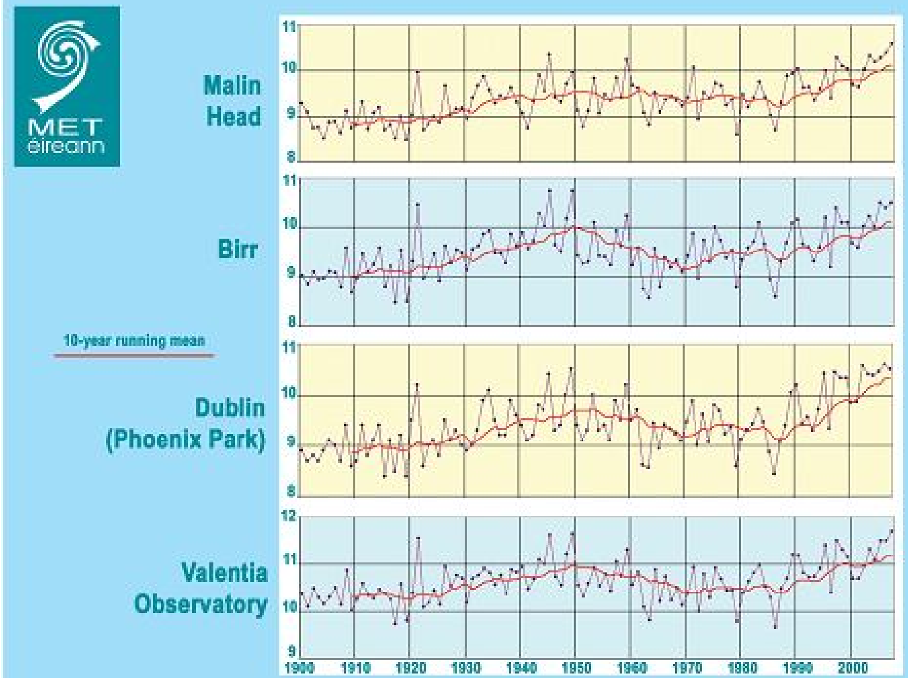

Mean annual air temperature (°C) since 1900