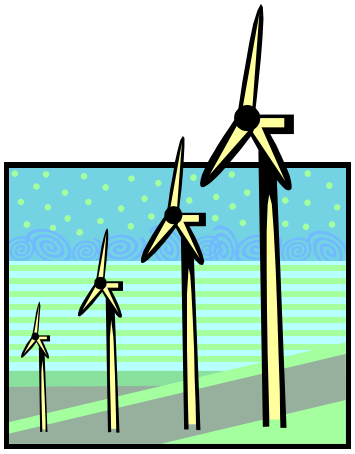
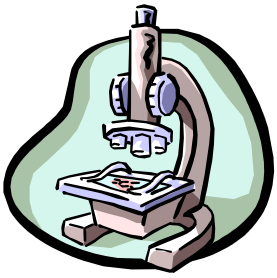
Energy Research, Development and Demonstration Activity in Ireland - a Strategic Review

VOLUME ONE





Department of Communications, Marine & Natural Resources
Roinn Cumsarsaide, Mara agus Aomhainni Nadurtha

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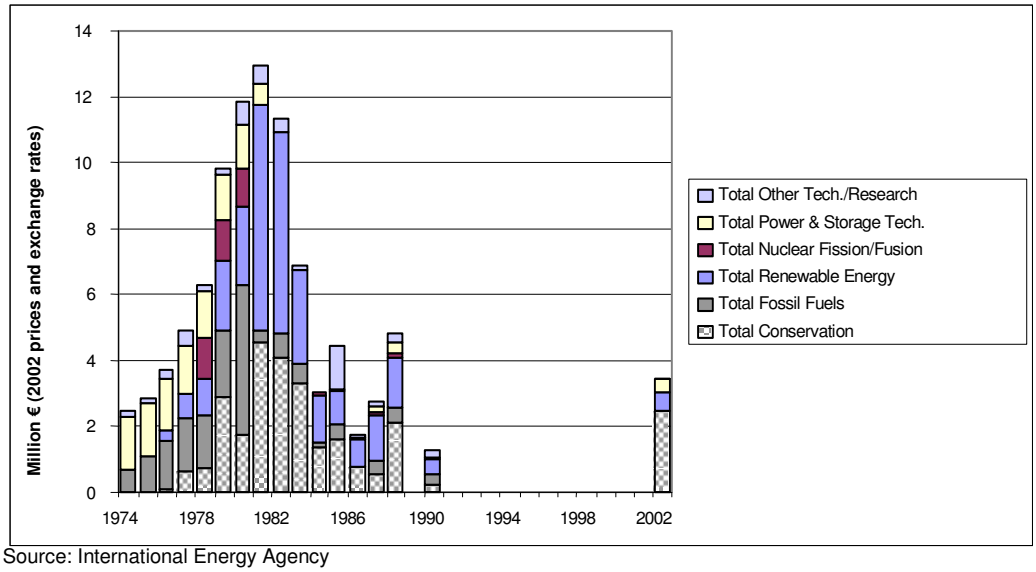
Introduction

A milestone report on European energy research, development and demonstration (R, D & D) by McMullan & Strub [1] highlighted the importance of high quality, co-ordinated, focussed, long term activities, well aligned with policy objectives, to the goal of obtaining economic competitiveness. This was to underpin the design of early EU research and demonstration programmes. During the 1980s there was strong alignment between national and EU programmes viewed from the perspective of the Irish research effort; work supported by national funds was often also able to participate in and be supported by EU programmes, and vice-versa. This provided useful gearing for limited national programmes.

Ireland spent a total of € 94.6 million [in 2002 prices and exchange rates] on government energy R, D & D between 1974 (after the first "oil shock") and 2002. 31.5% of the total energy R, D & D budget in this period was allocated to renewable energy projects. The overall trend of government R, D & D expenditures for renewables peaked in the early 1980s and declined notably after 1983, and there was no significant funding between 1990 and 2002.

Government Energy R, D & D Budgets 1974-2002



Source: International Energy Agency

Disclaimer: Ireland has a firm "no nuclear" policy; the reported nuclear-related activity between 1978 and 1980 was not supported from Irish government funds.

[1] Achievements of the European Community First Energy Research and Development Programme, JT McMullan, A. Strub, July 1981

Review of Current Energy R, D & D

Preamble

It has been a number of years since a coordinated picture of energy research, development and demonstration work being carried out in Ireland has been available. This is related to the much reduced level of such activity after 1988 when government funding for this activity was drastically reduced, and no resource was deployed to maintaining records of activity. In order to assess current national capability and inform any decisions about future investment, a project was undertaken, with Sustainable Energy Ireland (SEI), to compile an inventory of energy R, D & D projects in Ireland. Every effort was made to follow the methodology of the earlier reports to allow for meaningful comparison. A summary of the results follows; project listings are contained in the Appendix.

Headline Findings

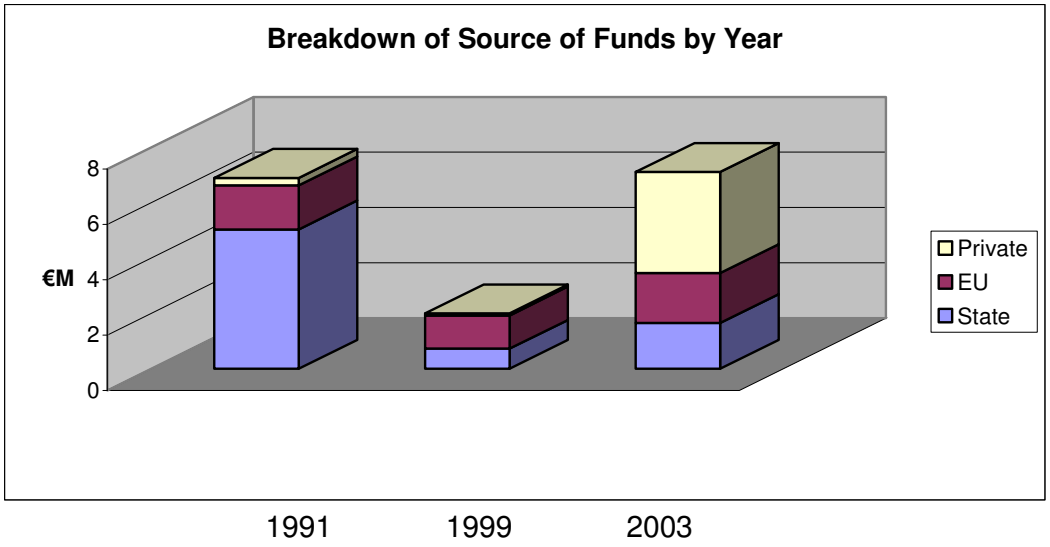
The volume of identified energy research carried out in 2003 amounted to €7.1M, spread over 81 projects in 50 organisations. The scale of projects varied from €5k to €1.1M, with the average project expenditure €88k. Approximately 23% of this sum was provided from public funds, either on a project basis or as part of a block grant. 26% was provided from EU programmes, with the remainder from private or internal sources. Of the 81 projects, 35 were part-funded by the EU, 46 were supported only by State funds and 5 received funding from both EU and State sources.

Source of Funding	**€**
Funding by Government or State Agencies	1,645,437 **(23%)**
EU funding	1,812,149 **(26%)**
Private or own sources	3,642,916 **(51%)**
Total	7,100,502

The last survey of expenditure on energy R, D & D consistent with this review was carried out in 1999. The total expenditure in 1999 (in 2003 money) was almost €2.0M over 60 projects, of which 36% was provided from public funds, either on a project basis or as part of a block grant. Most of the remaining 64% was provided from EU programmes, with only a very small contribution from the private sector.

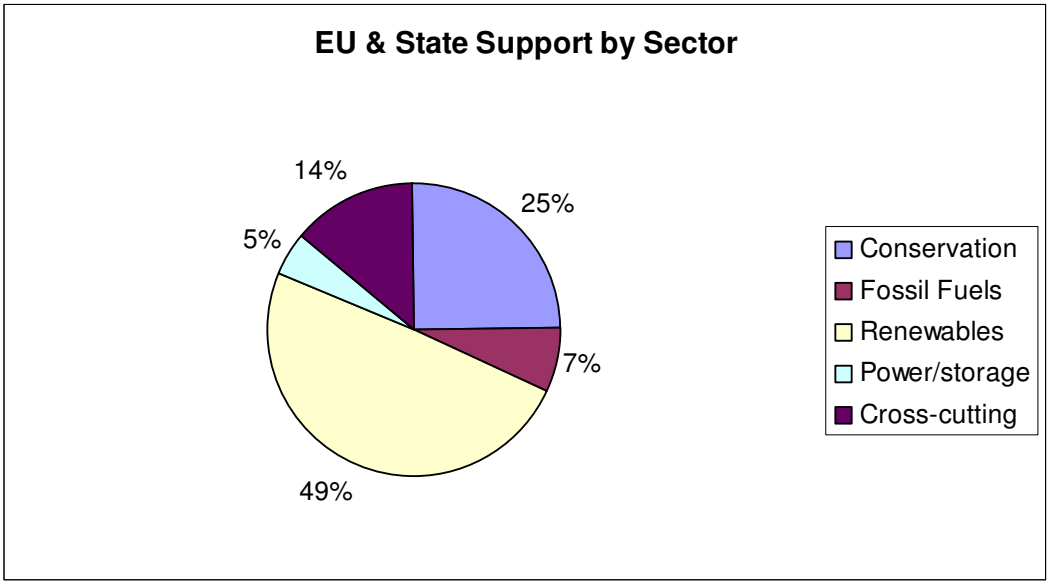
1999 was in fact a particularly low year for publicly-funded energy R, D&D. In 1991 (again in terms of 2003 money) the total was €6.9M, of which 73% was provided from State funds and 23% from EU programmes.

It can thus be seen that State funding has climbed from 1999 levels but has not reached 1991 levels. EU funding has increased marginally. "Private" or "own funds" has now become the most significant source of funding (51%).



Renewable energies received the largest portion of State funds (60%) and of EU funds (39%). Most activity was in wind and biomass, but there was also significant work in wave, photovoltaic and geothermal energy.

Sector	State Funding	EU Funding
Conservation	€254,643	€596,024
Fossil Fuels	--	€231,125
Renewable Energies	€985,498	€714,863
Power & Storage Technologies	€120,895	€445,594
Cross Cutting Technologies	€284,401	€225,243



Substantial work was reported on energy applications for buildings and some on transport, while there were also many projects concerned with system integration issues. For the first time since such inventories were compiled, no work was reported on energy conservation in industry.

One energy economics project and one socio-economic project were reported.

As part of the Department's "all-island" energy initiative, efforts were made to obtain comparable data for Northern Ireland. Some information was obtained, although not in the timescale or format which allowed for inclusion in this study. It has been agreed that a coordinated North/South effort will be made to collect relevant data in 2005.

Summary lists of projects by organisation and sector are included in the Appendix; full project details are contained in a separate volume, available on request. The full projects inventory is also available from Sustainable Energy Ireland (**www.sei.ie**).

Capacity for Energy R, D & D

The methodology of the survey means that a number of reservations must be entered. These are spelled out in full in the Appendix, but the main points are:

- only those with an assumed activity were polled for information
- some organisations known to be active did not submit returns, in spite of reminders
- the data submitted has not been verified
- "private" funding may be overstated, due to inappropriate allocation by respondents

While this approach has yielded a view of current research *activity*, on its own it does not give a clear picture of *capacity* to undertake energy research work on a continuing basis. Correspondingly, a review of published information and personal knowledge was used to form a picture of national capacity, and this is summarised below. It is not claimed to be complete and the author accepts full responsibility for any errors or omissions in this part of the report.

Institution	Research Unit	Subject Area
University College Cork	Hydraulics & Marine Research Centre	wave energy
	Sustainable Energy Research Group	wind energy modelling
	Sustainable Energy Research Group	energy storage
	Sustainable Energy Research Group	fuel cells
	Sustainable Energy Research Group	energy policy
University College Dublin	Energy Research Group	energy in buildings
	Energy Research Group	passive solar
	Dept of Planning & Environmental Policy	energy economics
	Energy Conversion Research Centre	refrigeration/heat pumps
	Electricity Research Centre	wind energy
	Electricity Research Centre	power system dynamics
	Electricity Research Centre	electricity market structures
University College Galway	Department of Chemistry	combustion chemistry
University of Limerick	Wave Energy Research Team	wave energy
NUI Maynooth	Department of Electronic Engineering	wave energy device control
	Department of Electronic Engineering	electrical load forecasting
Trinity College Dublin	Dept of Mechanical & Manufacturing Eng	heat exchangers
	Dept of Civil, Structural & Environmental Eng	eco-transport
Dublin City University	Dept of Mechanical & Manufacturing Eng	heat transfer
Dundalk Institute of Technology	Centre for Renewable Energy	wind energy
	Centre for Renewable Energy	biomass
	Centre for Renewable Energy	energy policy/economics
Cork Institute of Technology	Department of Engineering	fuel cell control
Tipperary Institute of Technology	Sustainable Rural Development Dept	biomass
Sligo Institute of Technology	Dept of Civil Engineering	energy in buildings
ESRI	Energy Policy Research Centre	energy economics
	Energy Policy Research Centre	energy forecasting
	Energy Policy Research Centre	energy markets

The recent Ministerial announcement on an all-island energy market included, within an agreed framework, "improved organisation of energy research through the emergence of an all-island network of academic and industry expertise", and so efforts were made to form a comparable view of the relevant capacity in Northern Ireland. Based on information supplied by the Department of Enterprise, Trade and Investment, Northern Ireland, a view of research capacity in Northern Ireland was formed, as follows:

Institution	Research Unit	Subject Area
Queen's University Belfast	Electric Power & Energy Systems	control of power systems
	Electric Power & Energy Systems	power systems engineering
	Electric Power & Energy Systems	energy sytems engineering
	Electric Power & Energy Systems	machine design and control
	Hydraulics Research Group	wave energy
	School of Mechanical Engineering	internal combustion engines
University of Ulster	NI Centre for Energy Research & Technology/Centre for Sustainable Technologies	refrigeration/heat pumps
		energy in buildings
		photovoltaic systems
	NI Centre for Energy Research & Technology/Centre for Sustainable Technologies	combustion technology
		synthetic fuels
		CO2 capture technologies
Department of Agriculture & Rural Development	Horticulture & Plant Breeding Station	Biomass

Some common skills sets exist and there are some links between research teams North and South; one formal linkage between the Electric Power & Energy Systems Research Group at Queen's University Belfast and the Electricity Research Centre at University College Dublin is known to exist.

This overview of island capacity for undertaking R, D & D does not include very significant activity in the commercial semi-State bodies such as the Electricity Supply Board and Bord na Mona in the Republic of Ireland and the private-sector Viridian Group in Northern Ireland. It is known, for example, that Bord na Mona carries out research and development in the energy area to the value of €617,000, which is commercially sensitive, and it is probable that there are other substantial programmes which are not reported.

Having regard to Ireland's current and anticipated future requirements, a gap analysis does not identify major subject areas where no capacity exists (except possibly in some fuel supply areas such as liquefied natural gas where arguably that work need not be done in Ireland). It should be noted, however, that an appreciable amount of work, particularly commissioned research studies, was undertaken in whole or in part by non-Irish organisations. This is not of itself a weakness provided that there exists a strong national coordination function which can ensure appropriate adoption of the outputs from such work.

The analysis does indicate that the resource is frequently shallow, with some "centres" comprising just one or two key people on short-term contract arrangements, working on projects with lifetimes of only a few years.

Case Study: Experience of UCD Energy Research Group – EU Route

The UCD Energy Research Group is a good example of the "fight or flight" response in action, in the context of the absence of long-term national energy research support programmes. In the early 1980s the Group established a solid platform of work in the area of energy and buildings, in particular passive solar. This was done with university funding and small R & D support from the then National Board for Science and Technology. Once established, the Group applied, successfully, for funding from the EU's energy research programmes (DGXII). These latter programmes provided sustained high levels of support (50% or greater, often 100% of relevant "additional" costs), and successive DGXII programmes exhibited strong continuity, so a continuing stable research group was able to function over a prolonged period of time, independent of regular national support. This became significant when national R & D support dried up in the late 1980s, and most other national energy R, D & D work foundered. The Energy Research Group has been both a successful centre at a European level in its own right, as well as a participant in several European-wide networks of collaborative research.

Role of DCMNR, SEI, CER, etc. in energy R, D & D

The role of the Department of Communications, Marine and Natural Resources (DCMNR) with respect to energy R, D & D is to ensure coordination of relevant energy R, D & D work, to foster the creation and maintenance of appropriate national capacity in this area, to influence the shape of and participate in the leveraging of resources from the Seventh EU Framework Programme and other sources, and to do all of this having regard to the all-island dimension and in particular to the All-Island Development Framework (November 2004).

This of necessity requires that R, D & D should be clearly in support of wider national energy, environmental and/or economic policy objectives, and this has traditionally meant a focus on issues capable of being dealt with in the short term. More recently, and in line with changes to the national approach to science and technology as expounded in the government's recent policy document on enterprise [2], a more strategic view is forming of the place of R, D & D and innovation and the importance of effective and efficient coordination.

The role of Sustainable Energy Ireland (SEI), under the aegis of DCMNR, is to implement aspects of the Green Paper on Sustainable Energy and the National Climate Change Strategy as provided for in the National Development Plan. It manages programmes which:

- assist deployment of new, appropriate technologies
- raise awareness and provide information on best practice
- fund R, D & D projects
- stimulate preparation of necessary codes and standards
- publish statistics and projections on sustainable energy

SEI contracts research work through advertised calls for proposals within defined programmes. SEI was only established in 2002, and significant disbursement of allocated funds is just beginning. SEI programmes can support capital costs, but specifically for project-related costs and not normally for R, D & D facilities *per se*.

The Commission for Energy Regulation (CER) has as part of its remit a role to encourage research and development into renewable, sustainable and alternative forms of energy. To date, CER has not promulgated any significant measures to address this, although several initiatives are under consideration.

[2] 'Ahead of the Curve, Ireland's Place in the Global Economy' Enterprise Strategy Group, July 2004 (http://www.forfas.ie/esg)

The main utility companies commission research into areas particularly appropriate to their business.

The Economic and Social Research Institute (ESRI) has, since it was founded, conducted regular policy research in the energy sector, and established an Energy Policy Research Centre in 1990 to produce relevant energy research, "with the aim of informing policy-making and societal understanding". It currently undertakes work on energy demand forecasting, carbon taxes and electricity markets.

How Energy R, D & D is Managed in Certain Other Countries

The way energy R, D & D is managed in other countries was considered. Utilising IEA and national publications and personal contacts, a desk study of this process was conducted. Arising from this, two very different but most appropriate models with apparent application to Ireland were examined in further detail, and structured interviews were held with senior staff of organisations in the UK and the Netherlands.

UK

The picture in the UK has changed dramatically in recent years. Formerly, there was a "dual strand" approach to supporting and coordinating energy R & D. At one level, the relevant government department(s) provided significant institutional funding directed at institutions such as the former Energy Technology Support Unit (ETSU) to carry out directed research (technical and techno-economic studies, systems analysis work, etc.) as well as to manage national R, D & D funding programmes (e.g. energy demonstration programmes). At another level, the major research councils (NERC, SERC, etc.) managed significant sectoral (e.g. environmental) research programmes, where the work was usually carried out in universities or in research institutes such as the former Central Electricity Research Laboratory at Leatherhead. Such institutions also competed for and utilised funding from EU programmes.

More recently, in line with the privatisation of utilities in the UK and opening of energy markets, ETSU has re-invented itself as a commercial services organisation and the utility research institutions have largely disappeared; government spending in this area has reduced significantly. Universities and other research bodies continue to look to the research councils and EU for programmatic support. The research councils have sometimes provided capital funding, but not on a consistent or sustained basis. Bodies such as the Energy Saving Trust and Carbon Trust have emerged in recent years to support relevant demonstration projects as an aid to market development.

Earlier this year, the UK government announced the creation of the UK Energy Research Centre as an important component of its Sustainable Development Strategy. The UK ERC will provide leadership in energy research and assist in giving coherence and coordination to the energy research agenda. Crucially, it is intended to coordinate the work of environmental, engineering, economic and social scientists and act as the hub of a national energy research network linking universities, research institutes, etc. It is to act as a "virtual" organisation, with a very small core, but will undertake a small programme of work at the centre to meet the planning deficit now apparent. This work will concentrate on energy & environmental modelling to support policy making and will study the impact of new supply and demand side measures on energy markets. It is therefore a relatively low-budget affair, requiring £8 – 12 m over 5 years, and will be funded from allocations of three of the major research councils.

The Netherlands

In the Netherlands, there has long been a strong separation of functions between the policy making ministries and the implementing agencies.

ECN has been a strong national energy agency for more than 25 years, with block funding from government and multi-annual programmes. Within a well-defined policy remit from government, ECN undertakes a large programme of laboratory-based and desk research in-house on a range of projects from very technical matters to techno-economic analysis in support of national policy questions, as well as coordinating national programmes on behalf of the Dutch government. It has consistently received EU funding on a competitive basis as a European centre of excellence. ECN has wide flexibility in its programme measures and has supported capital costs whenever required.

EU/IEA

The EU has funded energy R,D & D work through a number of programmes and mechanisms since the 1970s. Simplifying the picture greatly, EU programmes are slow to develop, precisely defined, very bureaucratic but large. Several EU Directorates-General support energy work, with clear distinctions between short term and longer term projects, although efforts are being made to coordinate these through current and planned Framework Programmes. EU programmes have been very successful at building and maintaining networks of expertise across Europe, and in supporting very large integrated projects with multi-national partners. Some EU programmes provide funding for capacity-enhancing infrastructure, and others for mobility of expertise.

The upcoming Seventh Framework Programme for Research and Development (FP7) offers an opportunity for leveraging research in Ireland; however this is dependent on:

- Irish R, D & D priorities being a sub-set of those for Europe
- The existence of strong coordination and critical mass in Irish energy R, D & D.

The International Energy Agency (IEA) has concentrated on building collaborative projects between appropriate centres of expertise. It does not act as a source of funds, but complements the project work with technology reviews and reviews of member states national policies, offering advice to government where appropriate. Previous and recent experience of participation in relevant R & D Implementing Agreements has been highly positive, with international focus on situations of importance to Ireland (e.g. dynamic effects of wind power on grid stability). Again, this has only been possible where strong national capacity has been in place.

How R, D & D is managed in other sectors in Ireland

Enterprise Ireland

Enterprise Ireland (EI) is the state agency responsible for the development of Irish industry. EI has three strategic priorities:

- Technology Innovation
- Business Development
- Internationalisation

EI aims to bridge the gap between innovation and internationalisation and works with the research community and with their clients to exploit the benefits of technology innovation.

EI has a number of relevant support programmes – a research, technology and innovation programme for companies, and a commercialisation of research mobility programme for third level researchers. Research is contracted through competitive processes.

SFI

Science Foundation Ireland (SFI) was established in 2000, as a sub-board of Forfás, to administer Ireland's Technology Foresight Fund. SFI provides awards to support scientists and engineers working in biotechnology and information and communications technology development who are most likely to generate new knowledge, leading edge technologies, and competitive enterprises in the fields.

SFI programmes are aimed at attracting the best relevant brains to come and work in Ireland. SFI makes grants based upon the merit review of distinguished scientists; such grants can be very large (c €5M). Collaboration grants are also available. SFI is also intending to support a National Centre for High-End Computing, which will be a virtual centre linking and enhancing existing research facilities.

EPA

The Environmental Protection Agency's main relevant support programme is the Environmental Research, Technological Development and Innovation (ERTDI) Programme, which is run in a similar manner to EI programmes, with published calls for tenders in specific subject areas. It also has programmes of support for young researchers and has a National Environmental Research Centre of Excellence, which is an IT-based information and research facility. The ERTDI budget is €32M to 2006, and approximately 8 staff administer it.

Marine Institute

The Marine Institute's functions are *"to undertake, to co-ordinate, to promote and to assist in marine research and development and to provide such services related to marine research and development, that in the opinion of the Institute will promote economic development and create employment and protect the environment."* (Marine Institute Act, 1991) . To that end the Institute operates a marine RTDI programme in much the same way as EI and EPA, disbursing NDP funds and facilitating linkages to international programmes. It also undertakes significant coordination functions regarding marine-related research in Irish universities and Institutes of Technology, and publishes a guide to "who does what" in these institutions.

The Marine RTDI measures in the NDP total €53M in the period to 2006, and include specific provision for the upgrading of key national marine laboratories and facilities to provide necessary capacity and infrastructure to support planned activities. Projects in Northern Ireland have been supported. The staff complement is about 140.

COFORD

COFORD, the National Council for Forest Research and Development, was established to:

- establish research priorities
- operate funding protocols
- coordinate forest research activities
- improve research competence
- foster links between education, research and industry

In 2003, it undertook these functions with 5 staff and a budget of €1.7M.

The Forestry RTDI measures in the NDP total €15M in the period to 2006.

The Energy-related RTDI measures in the NDP amount to approximately €223M; for most of this SEI is the implementing agent. SEI has a staff of 42.

Sector	RTDI Spend 2000-6	Administering Staff
Environment	€32M	8
Marine	€53M	140
Forestry	€15M	5
Energy	€223M	42

IEA Observations

The International Energy Agency undertook a review of Ireland's energy policy in 2003 [3]. In this review, the IEA drew attention to the Programme for Government, which committed the government to work "to ensure that Ireland develops a world class research capacity", to "recognise the importance of encouraging a dynamic research culture" and to "build the capability of firms to carry out and manage R & D in Ireland".

The IEA Review also stated that "anecdotal evidence suggests that private expenditure on energy R & D was...quite low", and suggested cooperation with the private sector through "shared cost" programmes.

The Review's Recommendations for R & D were:

"The government of Ireland should:

- *Prioritise activities on a limited number of projects and concentrate resources on them with a view to meeting national energy policy objectives*
- *Engage in active participation in R & D activities at the international level, including participation in EU and IEA programmes*
- *Stimulate cooperation between the public and private sectors in R & D areas, such as demonstration projects in the transport sector"*

3 "Energy Policies of IEA Countries – Ireland 2003 Review", OECD, 2003 (http://www.iea.org/textbase/nppdf/free/2000/ireland2003.pdf)

Conclusions and Recommendations

The declared [4] value of energy research, development and demonstration activity in Ireland in 2003 amounted to some €7.1m. There were 81 projects undertaken by 50 organisations. Public (State plus EU) funding is once again approaching 1991 levels, after more than a decade of insignificant levels of support. Very significant levels of private sector / own budget funding have been leveraged by the public funding, and this is suggestive of improved "value for money" considerations in 2003 as compared with earlier periods of significant activity. The value of having this detailed picture of R, D & D activity has been demonstrated in other sectors (e.g. Marine).

It is recommended that an inventory of projects should be published on an annual basis.

Many of the current players, other than parts of the ESB family and the main universities, did not feature in previous inventories. Restructuring of state agencies and periods of little national support have removed some previously established actors from the scene.

A key feature from the examination of current project activity is that energy research "centres" in Ireland are very small, comprising a few key people, of whom only a subset are not on short-term contracts.

It was notable that in UCD there are three separate entities calling themselves research centres in the energy area (the Electricity Research Centre, the Energy Research Group and the Energy Conversion Research Centre).

These last three observations suggest that continuity of work and developing appropriate national capacity is very vulnerable to the absence of consistent funding over a number of years; in this respect the continuity afforded by the NDP should improve matters in the period to 2006. Study of projects supported in the period 2004 – 2006 will establish whether or not this is the case.

SEI programmes, implemented through competitive processes of proposals or tenders, have helped to create highly relevant expertise delivered utilising existing capacity, or have provided limited means of enhancing capacity through the acquisition of additional personnel or equipment.

The wider picture of energy projects currently underway shows that some of this work is not particularly well aligned with national policy; it is stand alone in nature, related particularly to the capability of the particular establishment and/or source of funds available, and is therefore very vulnerable. Some national excellence exists, thanks to EU rather than national support mechanisms, and this is not in any way coordinated with national requirements.

[4] Some organisations did not submit returns

Therefore, although national coordination and focus on meeting policy objectives has improved since the time of the IEA review due to SEI programmes going live, more needs to be done in this area.

It is recommended that dedicated resources be committed to coordination of energy R, D & D – more detailed recommendations follow.

As is seen from review of the projects reported, multi-disciplinary projects are becoming more prevalent than in the past. Also, although some work on energy economics and socio-economic work related to energy was reported, most of the national work known to be in this area was not captured by this review. As work on emissions trading, energy taxes and the use of fiscal instruments to promote technological options becomes more important, there is no logic in maintaining separation between technology-focussed and economics-related R & D.

It is recommended that any coordination solution should include all relevant R, D & D activity, whether technical or not.

The current energy R, D & D support mechanisms do not easily provide for activities involving significant new human or capital infrastructure.

Unlike biotechnology or ICT, there are few sustained support mechanisms to attract and retain key skills in the energy area

Many research teams are sub-viable by international standards and not sustainable over the medium to long term. However, initial data from Northern Ireland suggests that some complementarity exists which could be developed on an all-island basis, where cross-border funding should be available.

It is recommended that new instruments and measures are employed to create sustainable research teams in appropriate areas. Cross –border support mechanisms should be investigated for certain energy areas, for example electrical power systems, the built environment and refrigeration/heat pump technology. Multi-annual support programmes are essential to maintaining capacity.

It is recommended that a close examination of energy-related education and training be undertaken.

The mechanisms utilised to support energy R,D & D in other countries do not demonstrate any one model of best practice which might easily or quickly be applied in Ireland. However a number of key lessons have emerged:

- While increased coordination of national activities was achieved by different means in different countries, in no country was there a single super Energy Research Centre charged with carrying out (as opposed to coordinating) all relevant energy R, D & D.

- New institutions are not required for measures or instruments which can be undertaken by existing organisations.

- Particularly programmatic organisations cannot easily manage new instruments or capital grants for capacity building.

- Increased collaboration and fast response to national capacity deficit issues can be addressed by the creation of small coordinating structures, with multi-annual funds for targeting expertise and providing capital support.

It is recommended that no single national energy research centre, charged with undertaking all energy R, D & D in Ireland, should be established, but that a structure for enhanced coordination and support (including relevant capital funding and long-term programmatic support) be established. This will have implications for undergraduate and postgraduate curricula in the context of developing sustainable capacity in the education system in particular and the economy in general.

The Dutch model of an expanded national energy agency with enhanced internal capability could work in Ireland, but would need more flexibility in funding support mechanisms than SEI or any Irish agency other than SFI currently enjoys. Clear policy guidelines would have to be established.

An alternative solution for Ireland would be the creation of an Irish Energy Research Centre based on the UK model; with a strong national and international coordination function and a capability for undertaking specific energy systems modelling and other technology impact assessment work to inform policy making. Such an umbrella function would sit less well on the Irish energy community than the UK, because of the dominant position of SEI in energy R, D & D matters. However, this function could work if it were charged with coordination and direct management of those functions currently not undertaken within SEI. There is the COFORD precedent in Ireland for this approach.

It is recommended that one of these two options be selected to improve the coordination of and enhancing the ability to create relevant, sustainable capacity in energy R,D & D.

It is recommended that the new structure be charged with positioning Ireland's energy R, D & D community to optimise participation in the new EU Framework Programme, relevant IEA activities and opportunities that will arise in the context of the new national science policy agenda.

It is recommended that the new structure be mandated to pursue relevant all-island work in association with relevant parties in Northern Ireland.

APPENDIX

INVENTORY OF ENERGY

RESEARCH, DEVELOPMENT & DEMONSTRATION PROJECTS, 2003

Summary Listings

Methodology

Energy planners, designers, suppliers and developers of energy products and services, researchers, local authorities, communities and other organisations in Ireland assumed to be involved in energy Research, Development and Demonstration (R, D&D) were asked to provide details of projects in progress in 2003. The data were collected by SEI through questionnaire survey. A total of 81 positive responses was obtained. While considerable efforts were made to obtain comprehensive data, it did not prove possible to obtain full data from some organisations, and complete coverage is not claimed. No attempt has been made to estimate unreported expenditure.

Data received have not been verified and are reported in good faith. No responsibility for the accuracy or precision of project details is assumed. The quality of returns received varied greatly, with important details missing in many cases. This led to apparent inconsistencies in some parts of the summary tables. In a few cases, the actual expenditure in 2003 has been estimated from the total project funding reported.

In the text and summary tables, “State funding” is taken to mean funding from a specific external agency or another public body, rather than the undertaking organisation’s own budget, but excluding EU, industry, or other external funding.

The sector definitions and associated coding are those agreed between IEA Member States. The IEA code is used in the project code on each project report, and for indexing. The complete IEA code is given here (from IEA /SLT / CERT (98)1).

Group I: Conservation

- 1.1 Industry
- 1.2 Residential and commercial
- 1.3 Transportation
- 1.4 Others

Group II: Fossil fuels; oil, gas, coal

2. Oil and Gas
   - 2.1 Enhanced Oil and Gas
   - 2.2 Refining, transportation and storage
   - 2.3 Oil shale and tar sands
   - 2.4 Others
3. Coal
   - 3.1 Production, preparation and transport
   - 3.2 Combustion
   - 3.3 Conversion
   - 3.4 Others

Group III: Renewable Energy Sources

4. Solar
    - 4.1 Heating and cooling
    - 4.2 Photo electric
    - 4.3 Thermal electric
5. Wind
6. Ocean
7. Biomass
8. Geothermal
9. Total Hydro
    - 9.1 Large (>10MW)
    - 9.2 Small (<10MW)

Group IV: Nuclear Fission and Fusion

10. Nuclear Fission
11. Nuclear Fusion

Group V: Power and Storage Technologies

- 12.1 Electric Power Conversion
- 12.2 Electricity transmission and distribution
- 12.3 Energy Storage

Group VI: Cross-cutting Technologies and Research

- 13.1 Energy Systems Analysis
- 13.2 Others

In this Volume, only the summary tables are included. The full inventory, including project returns, is contained in Volume Two, which is available from the Chief Technical Advisor (Energy) at DCMNR. The inventory is also available through the SEI website www.sei.ie.

List of projects by organisation

Organisation	Project Code
Arsenal Research	
Campaign for take-off for renewable heat pumps in Ireland	8.1
Balcas Kildare Ltd	
Manufacture of wood pellets with biomass CHP	7.1
Ballymun – Regeneration	
Regen-Link	4.1.2
Bord na Mona	
FP6 feasibility study	5.8
The Brattle Group	
Study on renewable energy in the new electricity market	13.2.3
Brian P O'Connor & Associates Ltd.	
Energy management and development bureaus	1.4.1
The integration of the measurement of energy usage into road design	1.3.1
Brothers of Charity Services	
Refurbishment of 16 residential buildings	1.2.1
BSRIA	
Study on domestic hot water solutions in Irish housing	1.2.3
Carbery Housing Association Ltd.	
RENASE (Renewable Energy Against Social Exclusion)	13.2.5
Centenary Co Op	
Energy Resource and Efficiency Study	7.14
Century Homes Ltd	
The Century Homes Formula 1 House	1.2.2
Clearpower	
Fermoy wood pellet manufacturing plant feasibility study	7.3
Callan Pellet Heating System (PHS)	7.2
Resource study for RVO/animal fats	7.13
Comharchumann Inis Meain Teo	
Inis Mean Wind-Desalination Plant with Load Management	5.9
Cork Institute of Technology	
FP6 feasibility study	12.1.2
CSA Group	
Community ownership of wind energy projects	5.1
Geothermal energy exploitation in Ireland	8.3
Danish Energy Authority	
CTO for active solar thermal energy in Ireland	4.1.1
Dublin City Council	
Sustainable Urban Revitalization of Europe / RES Energy Concept	1.2.10
Dublin Transportation Office (DTO)	
National Climate Change Strategy (NCCS) economic analysis sub-group	1.3.2
ESB National Grid	
More advanced control for sensor operation of isolated power systems with increased renewable energy (MORE CARE)	12.2.1

Organisation	Project Code
Development of a Next Generation Wind Resource Forecasting System for the Large-Scale Integration of Onshore and Offshore Wind Farms (ANEMOS)	5.5
Electrowatt-Ekono Oy	
Study on co-firing with biomass	7.4
ESB International Ltd.	
Sea Testing And Optimisation Of Power Production On A Scale 1: 4,5 Test Rig Of The Offshore Wave Energy Converter Wave Dragon	6.1
Establishment of a European thematic network on wave energy	
Evaluation of wind turbine foundations behaviour	5.2
Determination of realistic near shore Atlantic Wave Resource	6.2
Renewable energy resources in Ireland	13.2.1
Freshford 20:20	
Freshford alive – greenhouse digester project	7.5
Galway Energy Agency	
Optimisation to Building Regulation Part L 2002 Compliance	1.2.9
ILEX Energy Consulting Ltd	
Study on Operating Reserve Requirements as Wind Power Penetration Increases on the Irish Electricity System	5.10
Initiatives Architects Ltd	
New 12 Bed Home	1.2.8
Institute for Numerical Computation and Analysis	
The influence of mounting booms and towers on wind speed measured by anemometers	5.11
Iveragh Co Op	
Optimised Biomass CHP Plant & Wood Pelleting Plant	7.6
Kerry County Council	
Hybrid Renewable Energy Project Supplying Electricity to an Irish Local Authority	13.2.11
Marine Computation Services Ltd	
Deepwater flowline and riser insulation system	2.4
Matt Barnes / MB Solar	
FP6 feasibility study	13.2.4
National Microelectronics Research Centre	
Production and verification of the 2nd generation of AC modules (PV2GO)	12.1.3
High current/low voltage converters for environmentally friendly energy	12.1.1
Economical production of SiGe material for microelectronic and optoelectronic applications (ECOPRO-SiGe)	4.2
Cost effective, high throughput ribbon-growth-on-substrate solar cell technology (RGSELLS)	4.3
Intelligent Power Management products	12.1.4
National University of Ireland – Maynooth	
Integrated control of point-absorber wave-energy devices	6.3
O'Mahony & Pike	
FP6 feasibility study: Adamstown	1.2.4
PB Power	
Costs and Benefits of Embedded Generation in Ireland	12.1.5
RPS -- MCOS Ltd.	
Resource study for dry agricultural residues	7.12
RISO National laboratory	

Organisation	Project Code
Offshore wind and industry development	5.3
South Dublin County Council	
Clondalkin swimming pool	1.2.7
South Western Services	
Concerted Action For Offshore Wind-energy Deployment	5.4
Technical and economic evaluation of the feasibility of developing a small scale wood residue combined heat and power (CHP) plant with integrated wood pelleting technology in an Irish sawmill facility.	7.11
Bioheat II	7.7
REACT -- RE Action	13.2.7
SETREC -- Side effects of tradable energy certificates	13.2.8
European energy award	13.2.9
Sustainable Energy Ireland	
The Establishment of the OPET in Ireland	13.2.6
Sustainable Projects Ireland	
FP6 feasibility study: The Village	1.2.5
SystemLink Ltd	
GroundLink (ground source heat pump with improved COP)	8.2
Teagasc	
Quality Standard for Oil Seed Rape Oil as Vehicle Fuels	7.8
Stabilisation of biodiesel	7.9
Trinity College Dublin	
Sustainable freight distribution in an historic urban centre.	1.3.3
TU Wien	
Economic analysis of RE support mechanisms	13.2.2
University College Cork	
Establishment of a European thematic network on wave energy	6.5
Workshop series for Energie research fellowship holders	13.2.13
Economically Efficient Floating Device For Wave Power Conversion Into Electricity. Part I: Mathematical & Physical Model Testing	6.4
Energy Marie Curie fellowship holders conference series (EMCC)	13.2.12
A high resolution numerical wind energy model for on- and offshore forecasting using ensemble predictions	5.7
Wind Energy Producing Hydrogen for Fuel Cells	13.2.10
University College Dublin	
Museums Energy Efficiency & Sustainability In Retrofitted & New Museum Buildings	1.2.13
European thematic network on Practical Recommendations for Sustainable Construction	1.2.12
Analysis and Optimisation of Secondary Circuit Multi-Evaporator Refrigeration Cycles	1.2.15
Evaluation of Options for Reducing Irish Diesel Particulate Emissions	2.1.4
Influence of Urban Pollution on Effectiveness of Natural Ventilation	1.2.14
Analysis and Optimisation of Evaporative Cooling in Building Energy Applications	1.2.11
Power System Operation with competitive Electricity Markets and Increase Utilisation of Wind Energy	5.12
A Novel Diagnostic Method for Emissions Control in Diesel Engine Combustion Systems	2.1.3

Organisation	Project Code
University College Galway	
Combustion chemistry of novel ultra-clean potential diesel fuels	2.1.1
Mixed Air Steam Turbines Fired By Liquid Fuels	2.1.2
Western Development Commission	
Study of ownership models and financing of community renewable energy initiatives	5.6
Wexford Energy Management Agency Ltd.	
To establish the feasibility of Biomass CHP plant in County Wexford	7.10
Youngfield Workshops Ltd	
RERD&D of Microprocessor-Controlled Sunspaces	1.2.6

List of Projects by Sector

Sector	State funding	EU funding	Total
Group I: Conservation			
1.1 Industry			
1.1.1			
1.1.2			
1.2 Residential and commercial			
1.2.1 Refurbishment of 16 residential buildings	40,000		40,000
1.2.2. The Century Homes Formula 1 House	24,705		24,705
1.2.3 Study on domestic hot water solutions in Irish housing	9,385		9,385
1.2.4 FP6 feasibility study: Adamstown	7,500		7,500
1.2.5 FP6 feasibility study: The Village	7,383		7,383
1.2.6 RERD&D of Microprocessor-Controlled Sunspaces	5,000		5,000
1.2.7 Clondalkin swimming pool		112,000	112,000
1.2.8 New 12 Bed Home	22,500		22,500
1.2.9 Optimisation to Building Regulation Part L 2002 Compliance	5,000		5,000
1.2.10 Sustainable Urban Revitalisation of Europe / RES Energy Concept		5,060	5,060
1.2.11 Analysis and Optimisation of Evaporative Cooling in Building Energy Applications	10,000		10,000
1.2.12 European thematic network on Practical Recommendations for Sustainable Construction		15,000	15,000
1.2.13 Museums Energy Efficiency & Sustainability In Retrofitted & New Museum Buildings		411,352	411,352
1.2.14 Influence of Urban Pollution on Effectiveness of Natural Ventilation		17,612	17,612
1.2.15 Analysis and Optimisation of Secondary Circuit Multi-Evaporator Refrigeration Cycles	21,875		21,875

	Sector	State funding	EU funding	Total
1.3	Transportation			
	1.3.1 The integration of the measurement of energy usage into road design	50,295		50,295
	1.3.2 National Climate Change Strategy (NCCS) economic analysis sub-group	6,500		6,500
	1.3.3 Sustainable freight distribution in an historic urban centre.	44,500		44,500
1.4	Others			
	1.4.1 Energy management and development bureaus		35,000	35,000
	Total	**254,643**	**596,024**	**850,667**
Group II: Fossil fuels				
2	**Oil and Gas**			
	2.1 Enhanced Oil & Gas			
	2.1.1 Combustion chemistry of novel ultra-clean potential diesel fuels		57,000	57,000
	2.1.2 Mixed Air Steam Turbines Fired By Liquid Fuels		51,000	51,000
	2.1.3 A Novel Diagnostic Method for Emissions Control in Diesel Engine Combustion Systems		14,125	14,125
	2.1.4 Evaluation of Options for Reducing Irish Diesel Particulate Emissions		19,000	19,000
	2.4 Deepwater flowline and riser insulation system		90,000	90,000
3	**Coal**			
	Total		**231,125**	**231,125**
Group III: Renewables				
4	**Solar**			
	4.1.1 CTO for active solar thermal energy in Ireland	20,071		20,071
	4.1.2 Regen-Link	52,225	255,000	307,225
	4.2 Economical production of SiGe material for microelectronic and optoelectronic applications (ECOPRO-SiGe)		74,929	74,929

	Sector	State funding	EU funding	Total
	4.3 Cost effective, high throughput ribbon-growth-on-substrate solar cell technology (RGSELLS)		41,249	41,249
5	**Wind**			
	5.1 Community ownership of wind energy projects	15,000		15,000
	5.2 Evaluation of wind turbine foundations behaviour	19,450		19,450
	5.3 Offshore wind and industry development	33,336		33,336
	5.4 Concerted Action For Offshore Wind-energy Deployment		23,898	23,898
	5.5 Development of a Next Generation Wind Resource Forecasting System for the Large-Scale Integration of Onshore and Offshore Wind Farms (ANEMOS)		47,786	47,786
	5.6 Study of ownership models and financing of community renewable energy initiatives	45,000	15,000	60,000
	5.7 A high resolution numerical wind energy model for on- and offshore forecasting using ensemble predictions		90,463	90,463
	5.8 FP6 feasibility study	7,500		7,500
	5.9 Inis Mean Wind-Desalination Plant with Load Management	26,363	27,750	54,113
	5.10 Study on Operating Reserve Requirements as Wind Power Penetration Increases on the Irish Electricity System	104,561		104,561
	5.11 The influence of mounting booms and towers on wind speed measured by anemometers	12,534		12,534
	5.12 Power System Operation with competitive Electricity Markets and Increase Utilisation of Wind Energy	100,000		100,000
6	**Ocean**			
	6.1 Sea Testing And Optimisation Of Power Production On A Scale 1: 4,5 Test Rig Of The Offshore Wave Energy Converter Wave Dragon	40,000		40,000

	Sector	State funding	EU funding	Total
	6.2 Determination of realistic near shore Atlantic Wave Resource	15,323		15,323
	6.3 Integrated control of point-absorber wave-energy devices	66,650		66,650
	6.4 Economically Efficient Floating Device For Wave Power Conversion Into Electricity. Part I: Mathematical & Physical Model Testing		38,000	38,000
	6.5 Establishment of a European thematic network on wave energy		37,600	37,600
7	**Biomass**			
	7.1 Manufacture of wood pellets with biomass CHP	25,000		25,000
	7.2 Callan Pellet Heating System (PHS)	8,980		8,980
	7.3 Fermoy wood pellet manufacturing plant feasibility study	16,510		16,510
	7.4 Study on co-firing with biomass	31,250		31,250
	7.5 Freshford alive – greenhouse digester project	40,900	41,799	82,699
	7.6 Optimised Biomass CHP Plant & Wood Pelleting Plant	35,000		35,000
	7.7 Bioheat II		13,389	13,389
	7.8 Quality Standard for Oil Seed Rape Oil as Vehicle Fuels	17,058		17,058
	7.9 Stabilisation of biodiesel		8,000	8,000
	7.10 To establish the feasibility of Biomass CHP plant in County Wexford	7,500		7,500
	7.11 Technical and economic evaluation of the feasibility of developing a small scale wood residue combined heat and power (CHP) plant with integrated wood pelleting technology in an Irish sawmill facility.	37,220		37,220
	7.12 Resource study for dry agricultural residues	25,924		25,924
	7.13 Resource study for RVO/animal fats	21,500		21,500

	Sector	State funding	EU funding	Total
	7.14 Energy Resource and Efficiency Study	10,500		10,500
8	**Geothermal**			
	8.1 Arsenal Research - Campaign for take-off for renewable heat pumps in Ireland	24,500		24,500
	8.2 GroundLink (ground source heat pump wth improved COP)	30,000		30,000
	8.3 Geothermal energy exploitation in Ireland	95,643		95,643
9	**Total hydro**			
	9.1			0
	9.2			0
	Totals	**985,498**	**714,863**	**1,700,361**
Group IV: Nuclear fission and fusion				0
10	**Fission**			0
11	**Fusion**			0
	Totals			0
Group V: Power and storage technologies				
12.1	**Electric Power Conversion**			
	12.1.1 High current/low voltage converters for environmentally friendly energy	6,114		6,114
	12.1.2 FP6 feasibility study	3,750		3,750
	12.1.3 Production and verification of the 2nd generation of AC modules (PV2GO)		16,330	16,330
	12.1.4 Intelligent Power Management products	29,850		29,850
	12.1.5 Costs and Benefits of Embedded Generation in Ireland	81,181		81,181
12.2	**Electric transmission and distribution**			
	12.2.1 More advanced control for sensor operation of isolated power systems with increased renewable energy (MORE CARE)		28,264	28,264
12.3	**Energy Storage**			
Group VI: Cross-cutting technologies and research				
13.1	Energy Systems Analysis			

Sector	State funding	EU funding	Total
13.2 Others			
13.2.1 Renewable energy resources in Ireland	98,271		98,271
13.2.2 Economic analysis of RE support mechanisms	29,760		29,760
13.2.3 Study on renewable energy in the new electricity market	82,192		82,192
13.2.4 FP6 feasibility study	5,883		5,883
13.2.5 RENASE (Renewable Energy Against Social Exclusion)	57,860	55,000	112,860
13.2.6 The Establishment of the OPET in Ireland	10,435	10,435	20,870
13.2.7 REACT -- RE Action		14,145	14,145
13.2.8 SETREC -- Side effects of tradable energy certificates		6,803	6,803
13.2.9 European energy award		17,229	17,229
13.2.10 Wind Energy Producing Hydrogen for Fuel Cells		15,000	15,000
13.2.11 Hybrid Renewable Energy Project Supplying Electricity to an Irish Local Authority		14,631	14,631
13.2.12 Energy Marie Curie fellowship holders conference series (EMCC)		53,400	53,400
13.2.13 Workshop series for Energie research fellowship holders		38,900	38,900
Totals	**405,296**	**270,137**	**675,433**
Overall Totals	**1,645,437**	**1,812,149**	**3,457,586**

Organisational Activity by Funding Source

	Own budget	State funded	EU funded	Privately funded	Total
Arsenal Research		€ 24,500			€ 24,500
Balcas Kildare Ltd		€ 25,000		€ 25,000	€ 50,000
Ballymun – Regeneration	€ 436,646	€ 52,225	€ 255,000		€ 743,871
Bord na Mona	€ 2,500	€ 7,500			€ 10,000
The Brattle Group		€ 82,192			€ 82,192
Brian P O'Connor & Associates Ltd.	€ 11,667	€ 50,295	€ 35,000		€ 96,962
Brothers of Charity Services		€ 40,000			€ 40,000
BSRIA		€ 9,385			€ 9,385
Carbery Housing Association Ltd.	€ 21,787	€ 57,860	€ 55,000		€ 134,647
Centenary Co Op		€ 10,500		€ 10,500	€ 21,000
Century Homes Ltd		€ 24,705		€ 24,705	€ 49,410
Clearpower		€ 46,990		€ 38,235	€ 85,225
Comharchumann Inis Meain Teo		€ 26,363	€ 27,750	€ 84,638	€ 138,751
Cork Institute of Technology	€ 1,250	€ 3,750			€ 5,000
CSA Group		€ 110,643			€ 110,643
Danish Energy Authority		€ 20,071			€ 20,071
Dublin City Council	€ 9,614		€ 5,060		€ 14,674
Dublin Transportation Office (DTO)		€ 6,500			€ 6,500
ESB National Grid	€ 76,050		€ 76,050		€ 152,100
Electrowatt-Ekono Oy		€ 31,250			€ 31,250
ESB International Ltd.		€ 173,044		€ 94,223	€ 267,267
Freshford 20:20		€ 40,900	€ 41,799	€ 95,737	€ 178,436
Galway Energy Agency	€ 5,000	€ 5,000			€ 10,000
ILEX Energy Consulting Ltd		€ 104,561			€ 104,561
Initiatives Architects Ltd		€ 22,500		€ 1,091,246	€ 1,113,746

	Own budget	State funded	EU funded	Privately funded	Total
Institute for Numerical Computation and Analysis		€ 12,534		€ 12,534	€ 25,068
Iveragh Co Op		€ 35,000		€ 35,000	€ 70,000
Kerry County Council	€ 1,075,242		€ 14,631		€ 1,089,873
Marine Computation Services Ltd			€ 90,000	€ 90,000	€ 180,000
Matt Barnes / MB Solar		€ 5,883		€ 1,960	€ 7,843
National Microelectronics Research Centre		€ 35,964	€ 132,508		€ 168,472
National University of Ireland – Maynooth		€ 66,650			€ 66,650
O'Mahony & Pike	€ 10,000	€ 7,500			€ 17,500
PB Power		€ 81,181			€ 81,181
RPS -- MCOS Ltd.		€ 25,924			€ 25,924
RISO National laboratory		€ 33,336			€ 33,336
South Dublin County Council			€ 112,000		€ 112,000
South Western Services		€ 37,220	€ 75,464	€ 107,460	€ 220,144
Sustainable Energy Ireland		€ 10,435	€ 10,435		€ 20,870
Sustainable Projects Ireland		€ 7,383		€ 4,961	€ 12,344
SystemLink Ltd		€ 30,000		€ 52,122	€ 82,122
Teagasc	€ 25,464	€ 17,058	€ 8,000		€ 50,522
Trinity College Dublin		€ 44,500			€ 44,500
TU Wien		€ 29,760			€29,760
University College Cork			€ 273,363		€ 273,363
University College Dublin		€ 131,875	€ 477,089	€ 186,875	€ 795,839
University College Galway			€ 108,000		€ 108,000

	Own budget	State funded	EU funded	Privately funded	Total
Western Development Commission	€ 5,000	€ 45,000	€ 15,000		€ 65,000
Wexford Energy Management Agency Ltd.	€ 2,500	€ 7,500			€ 10,000
Youngfield Workshops Ltd		€ 5,000		€ 5,000	€ 10,000

TOTAL	**€ 1,682,720**	**€ 1,645,437**	**€ 1,812,149**	**€ 1,960,196**	**€7,100,502**

Sectoral funding by funding source

	State funding	EU funding	Total
Group I: Conservation			
1.1 Industry			
1.1.1			
1.1.2			
1.2 Residential and commercial			
1.2.1	40,000		40,000
1.2.2.	24,705		24,705
1.2.3	9,385		9,385
1.2.4	7,500		7,500
1.2.5	7,383		7,383
1.2.6	5,000		5,000
1.2.7		112,000	112,000
1.2.8	22,500		22,500
1.2.9	5,000		5,000
1.2.10		5,060	5,060
1.2.11	10,000		10,000
1.2.12		15,000	15,000
1.2.13		411,352	411,352
1.2.14		17,612	17,612
1.2.15	21,875		21,875
1.3 Transportation			
1.3.1	50,295		50,295
1.3.2	6,500		6,500
1.3.3	44,500		44,500
1.4 Others			
1.4.1		35,000	35,000
Total	**254,643**	**596,024**	**850,667**
Group II: Fossil fuels			
2 Oil and Gas			
2.1 Enhanced Oil & Gas			
2.1.1		57,000	57,000
2.1.2		51,000	51,000
2.1.3		14,125	14,125
2.1.4		19,000	19,000
2.4		90,000	90,000
3 Coal			
Total		**231,125**	**231,125**

		State funding	EU funding	Total
Group III: Renewables				
4	**Solar**			
	4.1.1	20,071		20,071
	4.1.2	52,225	255,000	307,225
	4.2		74,929	74,929
	4.3		41,249	41,249
5	**Wind**			
	5.1	15,000		15,000
	5.2	19,450		19,450
	5.3	33,336		33,336
	5.4		23,898	23,898
	5.5		47,786	47,786
	5.6	45,000	15,000	60,000
	5.7		90,463	90,463
	5.8	7,500		7,500
	5.9	26,363	27,750	54,113
	5.10	104,561		104,561
	5.11	12,534		12,534
	5.12	100,000		100,000
6	**Ocean**			
	6.1	40,000		40,000
	6.2	15,323		15,323
	6.3	66,650		66,650
	6.4		38,000	38,000
	6.5		37,600	37,600
7	**Biomass**			
	7.1	25,000		25,000
	7.2	8,980		8,980
	7.3	16,510		16,510
	7.4	31,250		31,250
	7.5	40,900	41,799	82,699
	7.6	35,000		35,000
	7.7		13,389	13,389
	7.8	17,058		17,058
	7.9		8,000	8,000
	7.10	7,500		7,500
	7.11	37,220		37,220
	7.12	25,924		25,924
	7.13	21,500		21,500
	7.14	10,500		10,500

		State funding	EU funding	Total
8	**Geothermal**			
	8.1	24,500		24,500
	8.2	30,000		30,000
	8.3	95,643		95,643
9	**Total hydro**			
	9.1			0
	9.2			0
	Totals	**985,498**	**714,863**	**1,700,361**
Group IV: Nuclear fission and fusion				0
10	**Fission**			0
11	**Fusion**			0
	Totals			0
Group V: Power and storage technologies				
12.1	**Electric Power Conversion**			
	12.1.1	6,114		6,114
	12.1.2	3,750		3,750
	12.1.3		16,330	16,330
	12.1.4	29,850		29,850
	12.1.5	81,181		81,181
12.2	**Electric transmission and distribution**			
	12.2.1		28,264	28,264
12.3	**Energy Storage**			
	Totals	**120,895**	**44,594**	**165,489**
Group VI: Cross-cutting technologies and research				
13.1	Energy Systems Analysis			
13.2	Others			
	13.2.1	98,271		98,271
	13.2.2	29,760		29,760
	13.2.3	82,192		82,192
	13.2.4	5,883		5,883
	13.2.5	57,860	55,000	112,860
	13.2.6	10,435	10,435	20,870
	13.2.7		14,145	14,145
	13.2.8		6,803	6,803
	13.2.9		17,229	17,229

	State funding	EU funding	Total
13.2.10		15,000	15,000
13.2.11		14,631	14,631
13.2.12		53,400	53,400
13.2.13		38,900	38,900
Totals	**284,401**	**225,543**	**509,944**
Overall Totals	**1,645,437**	**1,812,149**	**3,457,586**