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Clean and efficient energies for Europe

Socio-economic impact of energy research projects

Report of the Independent Expert Panel

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March 2001

EUR 19464

This report has been produced in the framework of the Impact Assessment by an independent panel of experts of Non-Nuclear Energy projects funded under the Fourth Framework Programme.

Special acknowledgements go to all the members of the panel and in particular to the Chairman and the rapporteur who carried out the bulk of the work.

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Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Official Publications of the European Communities, 2001

ISBN 92-894-1123-6

Printed in Belgium

PRINTED ON WHITE CHLORINE-FREE PAPER

Preface

Launched in 1994, the Fourth Framework Programme (FP4) covering research and demonstration aimed to improve the security of energy supply and to reduce the impact of the production and use of energy on the environment, in particular CO_2 and the other greenhouse gases. Other important EU objectives were also addressed including strengthening the technological basis of the energy industry (e.g. employment and export potential), improving European social and economic cohesion and contributing to co-operation with third countries. It also supported research on overall energy RTD strategy in the inter-disciplinary area of energy-environment-economy.

Six years after the Programme's launch, at a stage when most of the projects have been completed, and the Sixth Framework Programme is being planned, it was considered appropriate to assess not only the scientific and technical quality of the completed projects, but also their impact on society, the economy and the environment.

The present analysis was organised to allow quick feedback for the preparation of the new Framework Programme. This was achieved by convening a panel of ten experts from different Member States. Using questionnaires, project final reports and direct contacts where necessary, the Panel investigated the expected overall impact by examining the scientific and technical results as well as the social and economic impact of a sample of about 90 already finished Non-Nuclear Energy projects, most of them three years ago (time necessary to expect some concrete results), representing in total a €84 million investment by the Commission. The contribution to Community policies, particularly emphasised in the present Framework Programme, as well as the Programmes's addition to European Added Value were both explored.

The results of this impact assessment of about one-fifth of the projects funded under the Non-Nuclear Energy Programme of the Fourth Framework Programme for the period 1994-1998 (better known as JOULE), were analysed and critically reviewed and are presented in this report.

Among the main conclusions of the report, it is worth noting that the vast majority of the examined projects have developed new technical advances. Furthermore, the commercial leverage of funded research projects is positive and its major non-commercial impact is on the improvement of the environment and particularly on CO_2 emissions. The social and economic impact remains, in general, limited, but could be improved through better understanding and application of the European Added Value principles.

The Fifth Framework Programme made a further step towards refocusing European energy research and aiming to provide effective responses to the major challenges facing European society.

It is important to fully exploit the experience and the results from the research undertaken under the FP4 since the knowledge generated relates directly to the objectives of the next Energy Research Programme. It also provides the groundwork for launching effective and innovative approaches to implementing the "European Research Area". Based on the present pilot exercise, the remaining projects of the Non-Nuclear Energy Programme of the FP4 will be assessed to provide a full picture of the impact of the Programme.

Finally, the present pilot exercise should help to provide a methodological base for other research programmes to develop quick-response, feedback to decision-makers to allow for the development of better informed research policies and actions. It should also help to bring more quickly the results and socio-economic implications of European research to European citizens, companies and institutions.

Jean-François Marchipont

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1. Executive summary

This report is a pilot impact analysis of some 90 research projects representing an €84 million investment under the European Union's Fourth Research Framework Programme on Non-Nuclear Energy (NNE), 1994-1998. The Programme covers research on renewable energy sources (solar, wind, biomass etc.), on the rational use of energy and improving energy efficiencies.

The report's objective is to provide the European Union with rapid, timely feedback on the socio-economic impacts of Community funded research, which will permit it to undertake effective adjustment of on-going Research Policy and Programmes. A panel of 10 Experts undertook an impact interview and analysis of each research project, as well as overseeing an extensive written questionnaire from each project co-ordinator. The results of this exercise are currently being presented in two separate reports:

a. The social and economic impact of the projects (present report)
b. Report on the achievements of each individual project.

The European energy industry, with a turnover of over €650 billion per annum, employs several hundred thousand people in energy related activities with an impact on many European policies: transport, environment, quality of life, industrial competitiveness and economic development. The energy industry has a major bearing on all European citizens, companies and institutions.

The major finding is that the impact of energy research related to new sources of energy is strongly conditioned by the political structure of the energy market. As long as there is no "full pricing" of traditional fossil fuels to include external costs (environmental costs, pollution costs, health care costs, etc.) as well as other more direct subsidies, the impact of such energy research will be relatively weak. Conversely, research on improving efficiency in the use of traditional fossil fuels is likely to have a much greater commercial impact and, indeed, impact on environmental issues. The initial indications of commercial leverage from the EU research funding spent on the projects point very much in this direction.

Looking at the main initial outputs from the projects:

1. A majority of projects (89%) managed to develop a new technical advance (new tool, technique, pilot, prototype, product, service, etc.) from their research. This high level of tangible output is encouraging. Inputs to intellectual property rights were acknowledged in one-third of the projects. This is also strongly welcomed and indicates the beginning of a base for industrial exploitation of the technical advances.
2. Only some 10%-15% of projects report new products or services. The energy field is dominated by marginal improvements in existing products, processes and techniques. In the Policy area, 25% of the projects claimed to have an input to the development of technical standards along with 10%, which claimed to affect regulations or directives. These standards and regulations help to promote energy saving, improve the market penetration of energy-saving devices and develop an environment for a competitive energy market.
3. While indicators of dissemination (publications, presentations) were high, interviews with projects led to a major concern about its actual effectiveness. Important research knowledge stayed within traditional academic and sectoral bounds. Technology transfer was poor. This requires a radically new approach to research diffusion and commercialisation by the NNE Programme.

In selecting the Non-Nuclear Energy projects, social and economic impacts were not among the main selection criteria. The criteria were predominantly technical, and this is reflected to some extent in the socio-economic findings:

1. The major immediate/short-term impacts centre on increasing competitiveness through relatively conventional means: cost reductions, increased productivity, lower unit energy consumption, and annual savings. This is consistent with projects developing marginal improvements on existing technologies and energy sources.
2. Impacts related to new or expanding markets are, as might be expected, relatively weak at the end of the project. Prospects improve when viewed three years down the road. The contribution to the two core issues of entering new markets and improving financial viability is seen as somewhat weak.
3. There is some suggestion that in the longer term, the projects may provide a better base for companies moving into EU and Global markets – rather than simply improving their ability to exploit local and regional markets. The larger the expected market return, the more likely the project is to be seeking EU or global markets.
4. Projects are strongly aligned with EU Policy and are expected to have a strong impact on the environment. Most obviously, they will contribute to the Kyoto declaration on CO_2 reduction as well as to the Green Paper Towards a European strategy for the security of energy supply and the White Paper Energy for the Future – the Energy Efficiency Action Plan.
5. Expected employment impact of the projects is not strong, although nearly half expected some "minor" impact on the economy at large in the longer term. Apart from the safety issue, the NNE Programme does not impact on Quality of Life issues such as education, health care, culture, the elderly, and gender equality.
6. European added value from the projects is good. However, even stronger Programme focus and cross-project co-operation would further strengthen European added value.

There are two main recommendations for improving the impact of Energy research.

1. At Project level: Improve the commercial viability of the project by strengthening project structure and management, and
2. At Programme Level: Stronger and more strategic programme management and better coordination with Member States.

In summary, of the Non-Nuclear Energy research projects examined thus far:

- The vast majority – some 89% – of the projects have developed new technical advances.
- The commercial leverage of funding the research projects is positive. The potential for commercial returns is very weak immediately after the project ends, but strengthens somewhat with time.
- The major non-commercial impact of the projects is on the improvement of the environment and particularly the reduction of CO_2 emissions.
- The direct impact on employment levels is not likely to be high, at least in the short term. Successful projects achieve such impact through commercialisation of outputs.
- The social and economic impact remains, in general, limited.
- Better understanding and application of European Added Value principles would strengthen the socio-economic impact of the Programme.

2. Energy in Europe

This report reviews the impact of some 90 of the first-finished research projects funded through the European Union's Non-Nuclear Energy Programme (NNE) of the Fourth Framework Programme (FP4) in the period 1994-98. As such, it covers about 20% of the total projects funded. The remainder will be assessed in follow-up reports. Within the 90 projects, there is an over-representation of research on renewable energy sources and in particular, wind energy. The total funding for the 90 projects was €84 million, giving an average EU support of €0.93 million per project. A number of projects included partners and activities outside of the EU.

An innovative methodology

A major problem in traditional EU R&D impact analysis has been the long time required before information on project impact could be obtained and used as feedback to adjust the Research Programmes. In addition, socio-economic analysis has also been weak or neglected. The innovative methodology of this report corrects these defects.

Rather than allocate the whole project to one contractor when all projects are finished, a Panel of ten experts from different Member States was gathered together as the early launched projects were finishing. Each Panel Expert drew up a total of about ten individual project reports based on the project's own Final Report along with phone, e-mail or face-to-face interviews with the project coordinator. The draft reports were then submitted to the coordinators for further comments. These short, standard format, individual project assessments are being published by the Commission in a separate report. At the same time, project coordinators, sometimes with the assistance of the Expert, completed a detailed socio-economic impact questionnaire. The close contact with the project coordinator ensured a high 98% response rate.

This impact analysis is based on an analysis of these questionnaires and of the individual project assessments, along with round-table discussions and formal inputs from the Experts.

Given the speed and flexibility of the approach, and particularly the timeliness in providing feedback on research outcomes to Programme Management, the Commission services are considering undertaking similar impact exercises. In this context, a best-practice manual, based on feedback from the Experts and the Commission's own experience will be made available with detailed methodology, questionnaire, structured interview and reporting sheets.

2.1. The importance of energy in the EU

Energy: a major European industry

The European Union is consuming an increasing amount of energy. The Community production is insufficient for its requirements. Imports are increasing and the external dependence ratio for energy is increasing.

The current energy demand is covered by 41% oil, 22% gas, 16% coal (hard coal, lignite, and peat), 15% nuclear and 6% renewables. If nothing is done, the total energy picture in 2030 will continue to be dominated by fossil fuels: 38% oil, 29% gas, 19% solid fuels, 8% renewables and 6% nuclear, with overall environmental pollution increasing by more than 15% compared to 1990 figures. The CO_2 emissions per capita are expected to increase from 8.1t of CO_2 in 2000 to 9.7t by 2030, while the CO_2 to GDP ratio is expected to fall from 473.9t of CO_2 in 2000 to 321.4t of CO_2 by 2030.

The energy industry represented about 9.8% of Community GDP in the early 1990s. Currently the figure is about 10% of GDP and, following a peak of over 11% in 2014-16, is expected to fall back to about 8.5% by 2030. Over the same period, the Community population will increase from about 365 million to more than 384 million people, while the energy consumption per capita will increase by 70% to 9986 kWh/inhabitant. It is expected that the Import Dependency ratio will increase from 47.2% in 2000 to above 70% by 2030.

Given such circumstances, the EU has to act. The proposed Sixth Framework Programme and the European Research Area are the main tools on which the new research policy and priorities will be developed. With such large financial and environmental stakes, it is essential that the lessons and results of previous research are fully utilised so that the EU acts in an intelligent and comprehensive fashion. The present work provides this background. It synthesises the preliminary results and findings of the first-finished projects supported by the European Commission, under the Non-Nuclear Energy Programme.

Table 1. The European Union's total energy balance: 1995-2000-2030

	1995	2000	2030	Tendency 1995–2030 annual % change
EU Energy Primary Production (Mtoe)	742.9	781.0	482.5	-1.2% pa
Net Imports	647.8	697.8	1175.2	1.7% pa
Total Gross Energy Consumption	1365.0	1441.1	1595.1	0.4% pa
Final Energy Consumption (by sector)	884.9	962.3	1141.3	0.7% pa
- Industry	246.0	256.7	285.4	0.4% pa
- Transport	274.5	316.0	355.2	0.7% pa
- Tertiary and Domestic	364.3	389.7	501.0	0.9% pa
CO_2 Emissions (Mt)	3029.0	3063.0	3730.0	0.6% pa
Of which Electricity and steam production	1161.6	1086.9	1671.3	1.0% pa
Of which in Energy branch	58.9	55.8	35.4	-1.4% pa
Population (million)	371.7	376.5	383.7	0.1% pa
GDP (in €000 million 1990)	5677.0	6462.0	11605.0	2.1% pa
Energy Intensity indicators (1990=100)				
Industry (energy on value added)	94.8	88.9	59.3	-1.3% pa
Residential (energy on private income)	97.1	91.5	61.7	-1.3% pa
Tertiary (energy on value added)	102.0	97.5	75.9	-0.8% pa
Transport (energy on GDP)	101.5	102.6	64.2	-1.3% pa

Source: PRIMES

It is also worth noting that:

- Between 1990 and 2000, the Energy Intensity increased by average 0.6% per year.
- From 1997, the transport sector contributed 50% to the total increase of the Final Energy Demand, the balance arising from the tertiary-domestic sector.
- By combining the forecast of the European economy growth and the return to long-term average temperatures, the short-term energy outlook has predicted a rise of 1.3% in the Primary Energy Demand from 1999 to 2001.

Energy and the European citizen

The production, transmission and consumption of energy affect the lives of all Europeans, not simply in their personal consumption of energy, but through a number of direct and indirect paths.

Figure 1: Energy: the common factor in European policies

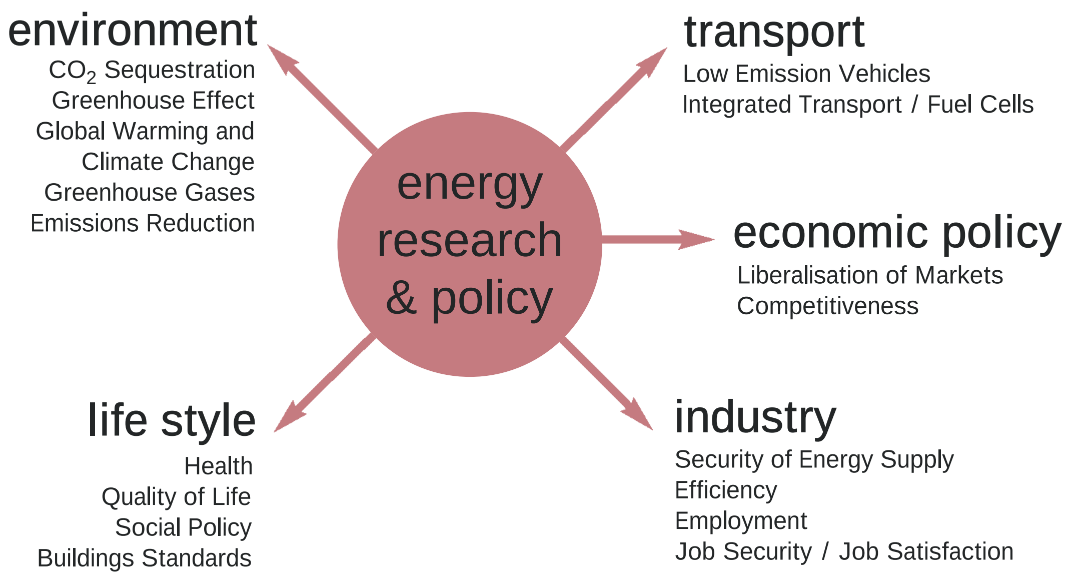


Figure 1 shows the wide influence energy issues, including energy R&D, can have in supporting EU policies and contributing to the well-being of European citizens, companies and regions.

- Environment policies are directly dependent on energy policies. Some forms of energy are more "environmentally friendly" in terms of emission of particulates and noxious gases than others. The production of greenhouse gases, such as carbon dioxide and methane, and their effect on the environment are of particular concern. Carbon dioxide accounts for 65% of greenhouse gases and its reduction and sequestration are a priority. Resulting issues such as global warming and climate change are closely associated with energy production. Energy generation and transmission systems can also have a major impact on the visual aspects of the environment.
- Transport is steadily rising in both absolute and relative terms – with implications for health and the environment. At the same time, transport policies are closely tied to what sources of energy are available – the electric car depends on the effectiveness of new fuel cells, some of which are being developed within the NNE Programme. Changing efficiencies and costs in energy sources affect transport possibilities.
- Life Style: The quality of life of the European citizen is affected at many levels by "energy issues", ranging from pollution and health issues, to building regulations and the energy efficiency of homes.
- Economic Policy: Competition, openness and liberalisation of European energy markets are central in economic efficiency. New energy technologies help break open closed markets and challenge old monopolies.
- Industry: In economic terms, the improved efficiency of energy production and use supports and creates employment in many sectors of the economy, through the development of new products and processes and enhanced competitiveness of all industries. Increased security of sustainable energy supply through new sources and modes of production and distribution provide for industrial and political stability.

These considerations of industrial competitiveness, environmental protection and human health, emphasise the importance of improving our methods of energy generation, storage, transmission and usage in our lives. Such improvements must be sought and developed by researchers in universities, research institutes, companies and regional and national authorities. It is these facilities across Europe, which the NNE Programme draws together and supports in carrying out more effectively and efficiently such research.

2.2. The political and economic context of energy research[1]

In assessing ways of improving the socio-economic impact of Energy research, a number of “outside” factors must be considered. The political, economic and social environment, into which the research flows, strongly conditions its impact. This environment changes over time and varies between European regions. Some of the important factors include:

- The domestic availability and cost of the different sources of energy: coal, oil, gas, nuclear power as well as the renewable energy sources (RES). High oil prices dramatically increase the economic benefits of research. Gas held at low prices makes RES uneconomical and its research ineffective. Government policies on pricing and taxing energy sources are critical in the effectiveness of energy R&D.
- The rate of growth of demand for electricity and other energy sources. The national policy framework for renewable energies with various supports, subsidies, credits, of course, make RES more viable and makes research undertaken much more useful.
- The physical nature of a region. The type of energy need and solution may vary not just with climate, but also with population density, historical infrastructure, etc. The same energy research can have very different levels of impact across Europe.

Thus, improving the impact of energy R&D is not simply a matter of running more efficient research programmes. It requires R&D objectives to be located within and attached to strong and stable, politically determined energy policies. This is not an easy matter. For example, the main barrier to the use of RES is cost, despite the reductions achieved through EU, Member State and private sector research (wind energy costs have been halved in the last decade). Yet RES usage is faced with Government subsidy and support for competing conventional fuels, especially coal and nuclear energy. The lack of political will to ensure full-cost pricing, particularly the negative environmental and health costs, when determining the cost of competing energy supplies hinders the development of clean energy sources and hence the effectiveness of any RES research.

In the fiscal area, the cost of money disadvantages projects with high start-up but low running costs, such as RES. Such costs can also marginally disadvantage any efficiency gains from R&D work. Similarly, high up-front costs of RES integration into the main electricity networks are particularly disadvantageous.

The liberalisation of electricity markets and the subsequent drop in unit costs of energy from traditional fossil fuels have caused further difficulties in adopting, initially more expensive, “clean” fuels. At the same time, some energy R&D outputs require a far more flexible, receptive and open market if they are to succeed. Governments and regional authorities and, indeed, energy utilities need to become more flexible and organisationally open to new sources of energy and financially more sophisticated in assessing their potential.

Finally, relatively weak information networks disadvantage both directly and indirectly the use of RES and the impacts of any R&D undertaken.

In summary, clean energy R&D may be efficiently undertaken and academically and technically excellent, but may have minor impact because it is being undermined by changes in much broader-canvass energy policies. It requires R&D objectives to be located within and attached to strong and stable, politically determined energy policies. It is essential to bear this in mind while reading the following Impact Assessment.

1. *This analysis draws in part from Ellis J., (1996). Why Promote Renewable Energy, OCED Observer, No. 201.*

2.3. The challenges for EU energy research

Renewable energy and energy efficiency have been an issue within the European Union since the 1970s. The concerns for energy security and the heavy dependence on oil – the "oil shocks" of 1973 and 1978 – which were the main initial factors in developing energy policy are, of course, still relevant today with continuing fluctuations in oil prices. They have, however, been joined by environmental concerns with acid rain emerging in the 1980s and climate change in the 1990s. Although the knowledge of greenhouse gases and the greenhouse effect has been known and addressed by scientific circles for many years, it started to attract strong public attention only in the 1980s. Added to this has been a desire to develop flexible and diversified forms of energy supply, which would better support the differing requirements of regional development across Europe.

Objectives of the Non-Nuclear Energy research programme

The Non-Nuclear Energy Programme of FP4 – the Fourth Framework Programme for Research and Technological Development – covered both a research and development component (JOULE) and demonstration projects (THERMIE). It aimed to address three central issues:

- Improving security of energy supply i.e. ensuring durable and reliable energy services at affordable cost and conditions;
- Protecting the environment by reducing the impact of the production and use of energy, in particular the emissions of CO_2; and
- Encouraging the rational use of energy.

The NNE Programme also aimed to contribute to the achievement of other important EU objectives such as:

- Strengthening the technological basis of the energy industry – with benefits for the economy, employment and export potential, improving social and economic cohesion. In this context, it aimed to also support the liberalisation of the energy market, which was and is continuing to take place within the EU.
- Contributing to co-operation with non-EU (in particular PECO – Central and Eastern European countries – and developing countries).

To achieve these goals, it financially supported RTD projects in four different "Research Priority Areas":

- AREA 1 – ENERGY RTD STRATEGY. The objective of this area was to develop global and European energy RTD strategy that integrated all energy related dimensions, particularly environment and economic development at a world, regional and local level.
- AREA 2 – RATIONAL USE OF ENERGY (RUE). This area aimed to reduce energy consumption and stimulate market penetration of innovative efficient and clean technologies, as a part of reducing dependency on external supply of energy products, and improving the impact of the use of energy in the environment. It covered actions on energy efficiency in areas such as buildings, industry and transport as well as the development of fuel cells.
- AREA 3 – RENEWABLE ENERGIES SOURCES (RES). This research aimed to support and stimulate the introduction of renewable energies into the energy system. These sources were seen to offer substantial advantages from the point of view of environmental protection, CO_2 emissions and long-term security of energy supply. The work also supported the more general integration of Renewable Energies (RES) into the economy and everyday life of society. The area included solar energy (thermal and photovoltaics), wind energy, biomass and waste as well as hydroelectric plants, wave power plants and geothermal energy and storage devices.
- AREA 4 – FOSSIL FUELS. This research sought to reduce emissions and to increase efficiency of fossil fuels as well as improving the economic viability of fossil fuel-based power plants. Reducing the environmental impact of coal-based energy conversion systems was a key issue.

These concerns for the sources and reliability of European energy supply were crystallised, at least in the public's mind, by the Chernobyl Disaster of 1986, which seemed to rule out nuclear fission as the major source of energy for the foreseeable future.

As an integral support to the European Union's efforts to deal with recurring energy crises, the Framework Programme for the period 1994-98 developed four Non-Nuclear Energy research priority areas:

1. Policy and strategy research,
2. Rational and efficient use of energy,
3. Use of renewable energy sources, and
4. Better use of fossil fuels.

The research undertaken during FP4, and reviewed in this impact analysis, represents a reserve of knowledge, insight and skills already available to the EU, its industry and its citizens in dealing with current and future issues and problems. It is closely related to the energy research objectives of the current Framework Panel (see box), and should be fully exploited in this context.

In addition, at the same time as undertaking energy related research, the EU is seeking to develop more effectively its overall research capabilities and infrastructure through the "European Research Area (ERA)" initiative, by:

- Increasing co-operation and exchange of good practices etc;
- Improving efficiency and integrating national research efforts;
- Encouraging efficient common management of energy research resources;
- Reducing unnecessary redundancy of RTD efforts and research facilities;
- Discouraging duplication of research efforts, where not necessary.

Current EU Non-Nuclear Energy research

In the Fifth Framework Programme, non-nuclear energy research is organised around two Key Actions. It is worth noting that the project's socio-economic impact is among the main project selection criteria.

- ACTION 1 – CLEANER ENERGY SYSTEMS, INCLUDING RENEWABLES. This aims to minimise the environmental impact of the production and use of energy in Europe. Research will investigate cleaner, most notably renewable, energy sources, as well as help reduce the environmental impact of existing fossil fuel use.
- ACTION 2 – ECONOMIC AND EFFICIENT ENERGY FOR A COMPETITIVE EUROPE. This aims to provide Europe with a reliable, efficient, safe and economic energy supply for the benefit of its citizens, the functioning of society and the competitiveness of its industry. Action will need to be taken at every stage of the energy cycle – production, distribution and final use – to improve efficiency and reduce costs.

Research and technological development activities of a generic nature are also being carried out, including the study of the socio-economic aspects of energy within the perspective of sustainable development (impact on society, the economy and employment).

It is thus expected that the Commission could act as a catalyst, maximising the European Added Value and where scientific excellence remains the most important issue to the benefit of the industry of Europe and its citizens.

The experiences and results of the Non-Nuclear Energy research projects provide not only a store of knowledge relevant to current energy concerns under the Fifth Framework Programme, but also indications as to how best to achieve a European Research Area within energy research, particularly in the development of targeted research agendas and network infrastructures.

3. The socio-economic benefits

3.1. Results of the NNE research programme

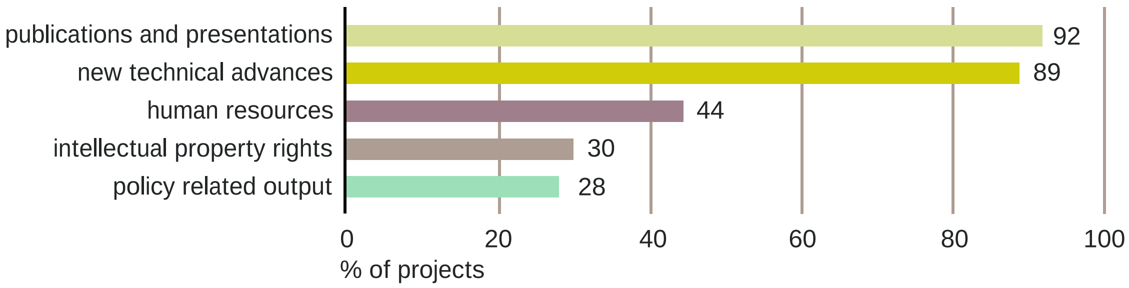
This section examines the immediate outputs from the research programme. These initial outputs do not, as yet, represent economic or social benefits or impacts. They are the raw material, which, when commercialised through companies or brought into use through other institutions, bring tangible benefits. For example, outputs such as patents or new products have no impact until they become part of the commercial processes, which bring them into everyday use in energy generation or in energy consumption. These outputs are, in a sense, the first step in turning research into social and economic benefit.

The questionnaire circulated to the 90 projects (88 returned) is the main basis for the quantitative analysis. There is a heavy bias towards projects involved in the Renewable Energy area (66%) compared to Rational Use of Energy (25%) and Fossil Fuels (6%). This strongly influences the following analysis, but will be compensated for in further Impact Analyses within the NNE Programme. The low numbers prevent comparative analysis across the three areas, for the moment.

Project coordinators were asked what were the main outputs from the research within their own organisation. Figure 2 shows the main outputs. The key message is that:

89% of all projects created new technical advances

Figure 2: Research outputs from projects

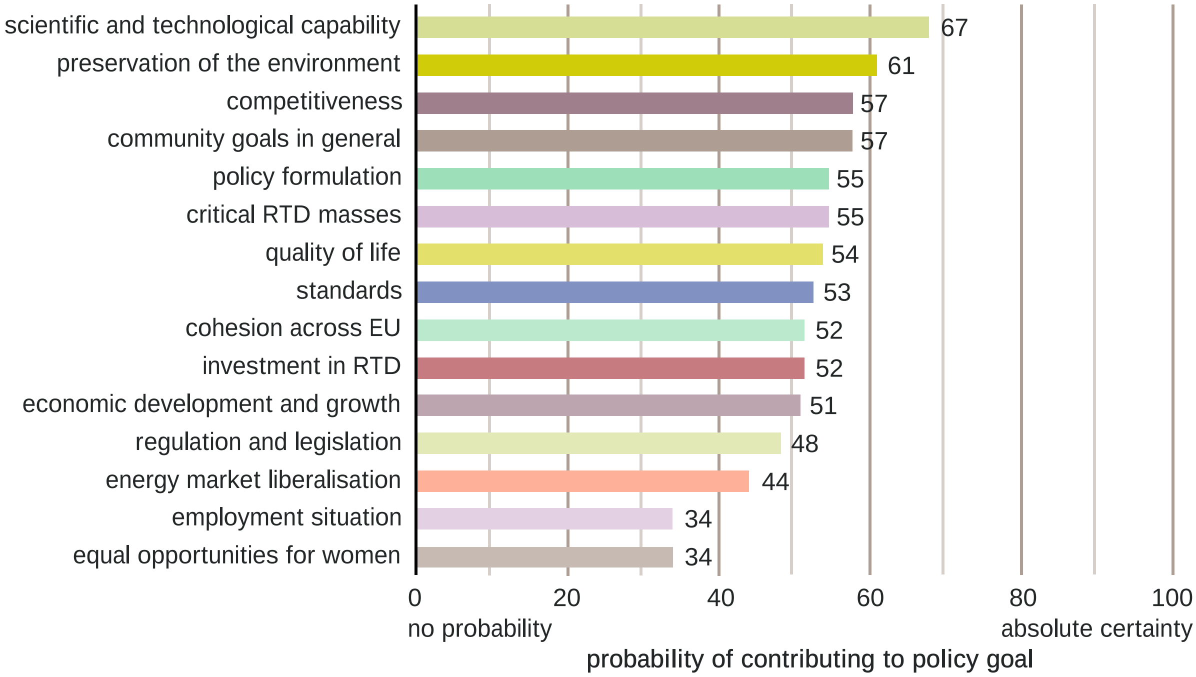


This high level of tangible output within the project is encouraging. The recognised development of human resources occurs in just under half the projects. This is an area which might be substantially improved by a stronger approach within the Programme. Inputs to intellectual property rights were acknowledged in one-third of the projects. This is also to be welcomed and indicates the beginning of a solid base for industrial exploitation of the technologies. Roughly one-quarter of projects provided an output related to the development of policy. Nearly all projects had provided some form of publication or presentation.

Contribution to policy goals

The Research Framework Programmes are intended to achieve a wide range of high-level policy objectives. These were drawn up as a list of 15 objectives to which the individual project coordinators indicated the probability (0 to 10) of contributing over the next three years at a local, regional, national, European and global level. Figure 3 shows the distribution of probabilities indicated by the project coordinators.

Figure 3: Contribution of research to policy objectives



The pattern of probabilities is, thankfully, very much what might be expected from scientific research aimed at use of renewable energy sources and energy efficiency.

The two goals that receive the highest probability are: 1) Improved scientific and technological capability, and 2) Improved preservation of the environment. That is to say, the projects view their own immediate contribution as being along the same lines as that expected by the Programme.

A second group of less strongly held objectives include areas such as standards, competitiveness and RTD investment. Employment creation, while it applies to a relatively large number of projects is relatively low in terms of the overall probability. This spectrum of interests strongly centred on the technical, less so on the commercial, and least on the social, is probably to be expected from "research-focused" projects.

However, as we suggest in our chapter on Improving Impact, some refocusing of projects and Programme, at least towards the commercial domain, could lead to much greater socio-economic impact.

Finally, it should be said that the projects also contribute to current, more specific EU energy policy objectives, most obviously in the following areas:

- EC White Paper "Energy for the Future: Renewable Sources of Energy" and the RES Directive. Support for the EU objective of doubling the contribution of RES to EU energy sources by 2010 can be seen in many projects.
- Energy Efficiency Action Plan: Especially the projects with big energy-saving potential are definitely in line with this EU action plan.
- The Green Paper on Energy, which asks for a clear action in favour of an energy demand policy.

Policy and programmes: the example of fuel cells

EU policy objectives are best answered by a "Programme" of connected projects. Within NNE projects, there are integrated project groups, which work together to deliver policy goals: research on fuel cells, wind power, solar power, biomass, integration of renewables and so on. These groups come together to give additional strengths to the research undertaken. Take the example of fuel cells.

Fuel cells technology, by directly converting chemical energy into electric energy, attains higher efficiencies than burning fuels. Fuel cells are also much less noisy, have less polluting emissions, are small in size and relatively easy to move around and replace. Potentially, fuel cells could substitute for large parts of today's combustion systems and make a contribution to energy reduction, decrease exhaust gas emissions, and improve the diversification of the energy supply and sustainable development in general. NNE projects tackled these European policy objectives from a number of angles:

- Firstly, there are many forms of fuel cell. Programme projects explored efficiency and effectiveness across a number of differing technologies including basic solid oxide cells, molten carbonate cells, polymer electrolyte membranes, cells working at different temperature cells and so on. One project explored biomass gasification/gas turbines/fuel cell interfaces, another investigated coal gasification for high temperature fuel cells. It is unlikely one Member State's research could explore such a wide terrain.
- Secondly, fuel cells need to be operated in a number of different situations. Solid Oxide Fuel Cells have major potential in stationary applications in the utilities, industrial, commercial, building cogeneration, large-scale electricity production. Different fuel cells are needed for transport, automobiles and mobile applications. Again, a network of projects explored many of these technologies, drawing together research expertise from across the EU.
- Thirdly, a certain number of common problems face fuel cells: the fundamental chemistry of the degradation processes of cell components, improving fabrication techniques, reducing pollutants, developing appropriate purity and quality levels of active components, safety issues, and so on. Undertaking this research, across a number of cell technologies and operational situations, provides major potential for research synergies, exchange of information and cross-fertilisation of ideas – and more effective research.

While fuel cell systems are recognised as a key technology for CO_2 reduction, greater fuel efficiency compared to internal combustion engines, near zero emissions of harmful emissions like NOx, CO, particulates, etc. investment costs are generally still too high to compete with existing infrastructural investment in traditional technologies, current weak emission regulations, and approaches to fossil fuel taxation.

Publications and communication of results

Looking at the breakdown within *Publications and Presentations*, analysis shows the area to be dominated by grey literature (over 80%) and public presentations (over 90%). Over 60% had published in refereed journals. Under half the coordinators had made project information and outputs available electronically: this is an area that should be made compulsory and coordinated by the Commission. Some of the public presentations were on mass media such as radio and television, bringing their research to a much wider audience.

This said, interviews indicated that the communication of the results could be radically improved. Many of the research outputs stayed within the knowledge bounds of very specialised research, sectoral, or commercial groupings, whereas their results may often be applicable in other technology areas. Technology transfer was poor. Professional project management, as discussed in the recommendations, should be aimed at supporting the project not simply in project coordination and operation, but also in the diffusion and impact requirements and ensuring that these are adequately undertaken. Good project management can be the difference between success and failure in the delivery of the technology to the market place.

As we have seen, energy use is a strongly political issue. There is a need for projects to build around themselves, at a local and particularly at a national level, in each Member State, "Champions" who will be able to create awareness of the benefits of the research within the media and within energy policy and wider political circles. Similarly, there is a need for politicians and MEPs to take an interest in the research activities and to promote them at government level. The benefits of a strong linkage across the research / national policy interface is to be seen in a project on offshore wind farms.

Human resources

The coordinators were asked if the research work had contributed to qualifications being gained by participants. 44% of coordinators indicated this to be the case. While this is encouraging, it might be further strengthened by a more explicit "research skills development policy" within the Programme as a whole.

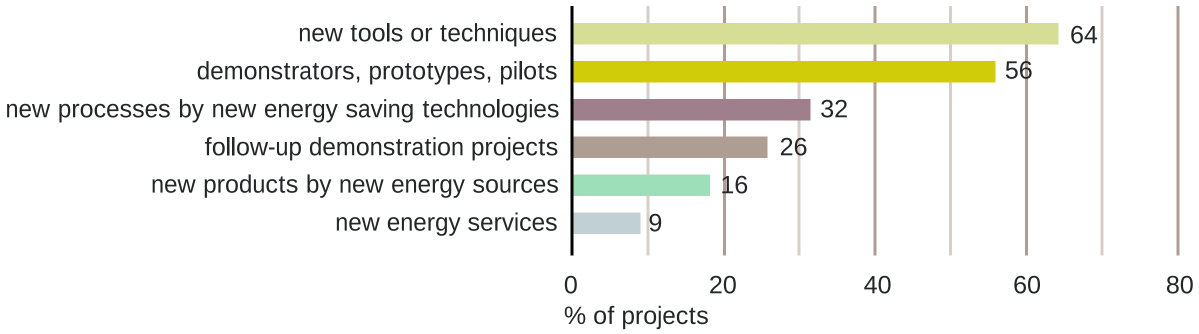
Intellectual property rights

Closer examination of the IPR area shows that 25% of the projects expected the research would lead to one or more patents. 10% of projects expected outputs related to copyrights, trademarks and registered designs. About 7% indicated that licences had been issued with an average of 6 licenses from each of these projects. Again, just at the end of the project, this is a solid output.

New Technical Advances developed

Figure 4 details the nature of the New Technical Advances. The main sub-categories are new tools or techniques along with demonstrators, prototypes and pilots: both types of output were reported from over half the projects. The low level of new energy services and new products from new energy sources (10%-15% of projects) probably reflects the technological and economic barriers to innovation in this area. The energy field is dominated by marginal improvements in existing products, processes and techniques. These new processes, products and components (better designed turbine blades, more efficient fuel stack, new chemical processes, new materials, new photovoltaics, etc.) increase the industrial capacity of Europe, as well as improving the efficiency and performance of energy devices. Many projects related to monitoring and control have contributed to increasing the efficient use of existing technologies, making energy production cheaper and reducing consumption.

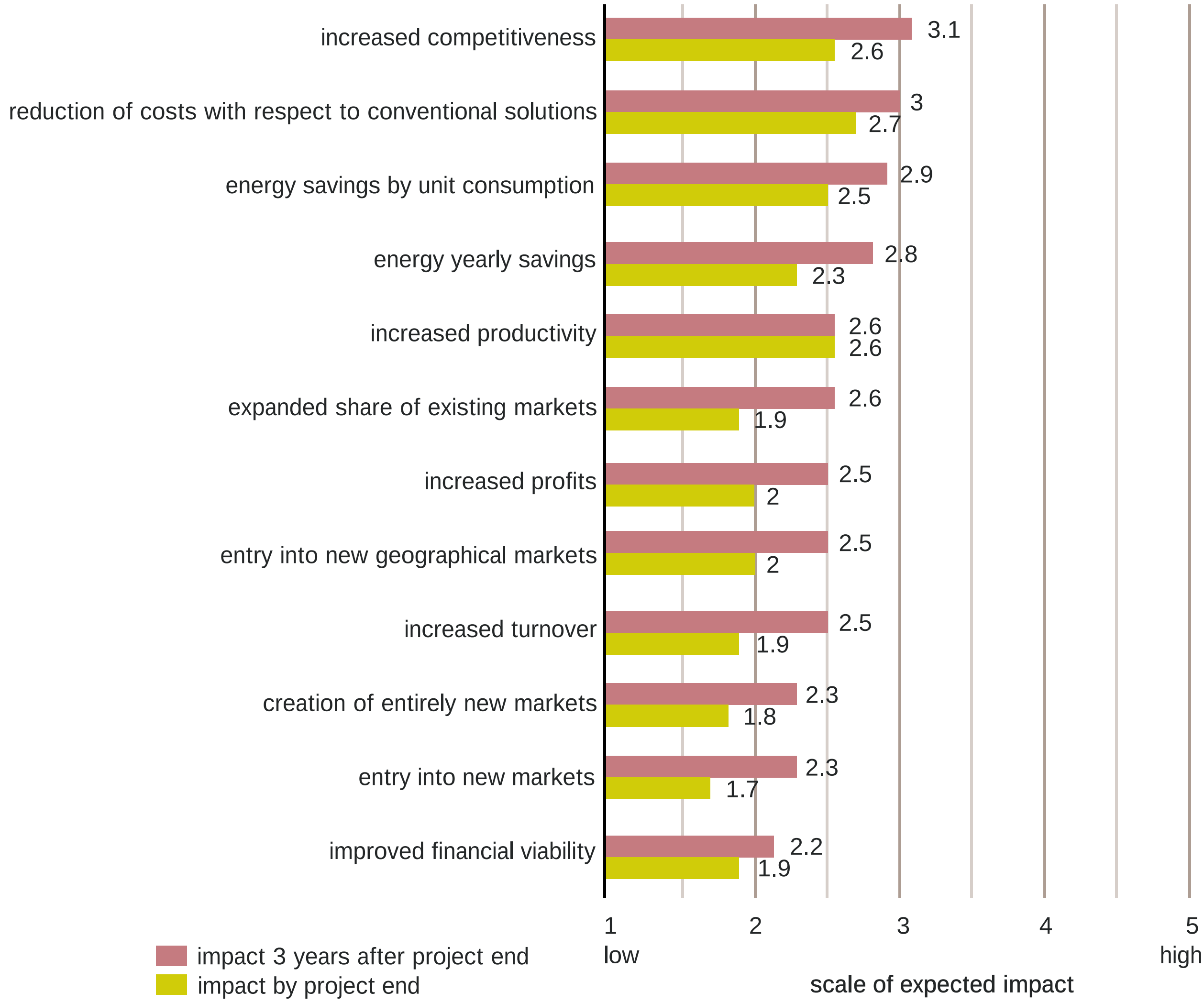
Figure 4: Outputs within New Technical Advances



3.2 Economic impacts of the programme

Each project was rated as to the likelihood of obtaining downstream economic impacts within the coordinator's organisation as a result of project participation, together with an indication of the relative scale of the impacts, at the end of the project and then three years on. Figure 5 shows the relative scale of the different forms of economic impact.

Figure 5: Relative magnitudes of different forms of economic impact



The major immediate, short-term impacts, expected by coordinators from their projects centre on increasing competitiveness through relatively conventional means: cost reductions, increased productivity, lower unit energy consumption, and annual savings. This is consistent with the trend seen earlier of projects developing marginal improvements on existing technologies and energy sources.

Impacts related to new or expanding markets are, as might be expected, relatively weak at the end of the project. Market impacts are expected to be relatively more important three years down the road. However, overall, the two core issues of new markets and improved financial viability are seen as the weakest of the economic impacts. This was of particular concern to the Experts and is also addressed later in the section on Improving the Impact of Energy Research.

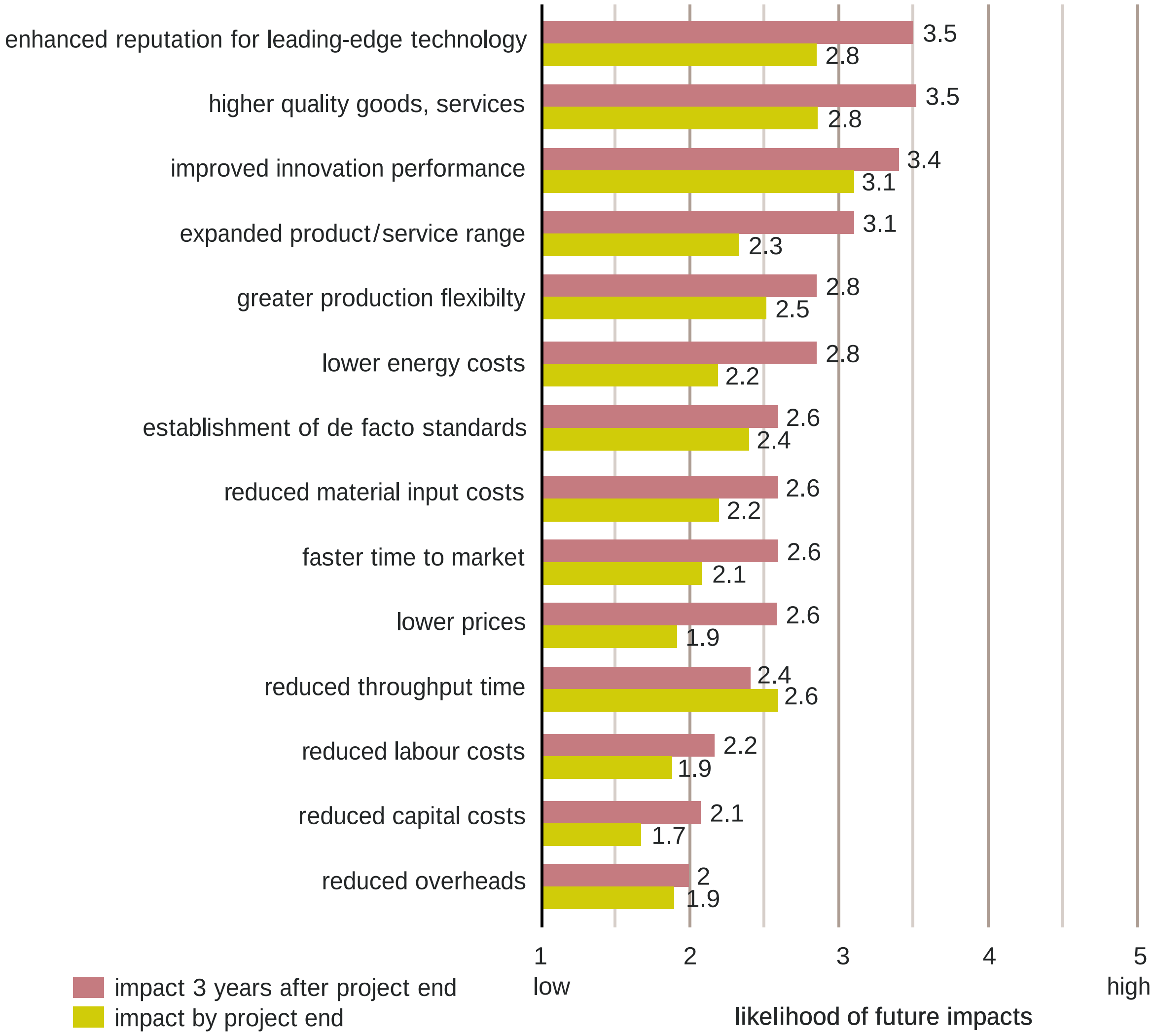
Cost reductions in solar power

Solar power is the most obvious source of sustainable energy. It also helps to preserve resources, prevent the greenhouse effect due to CO_2 emission and provide energy without any significant environmental impact. The problem, under current taxation regimes, is its cost. The high capital investment costs dissuade many. Research projects focused on a number of cost-reduction approaches.

- Research explored moving away from traditional solar cells to new, low-cost optical concentrators. The work was very much at a pre-competitive stage but promised potential cost reductions as the technology reaches industrial scale.
- A key issue in the viability of solar power is connecting it to the commercial electricity grid – if the power cannot be sold into the distribution system, it will always be a niche technology. Research explored miniaturisation and associated cost reductions for a low-cost inverter, to turn DC to AC current to be fed into the grid. Commercialisation of the inverter is still some time away.
- Achieving a more efficient heat transfer between the solar field and the actual process where the energy is needed, will help the competitiveness of solar energy. Solar thermal power plants based on parabolic trough collectors represent one of the most successful means of solar electricity generation. The use of direct steam generation in the absorber pipes of the solar collectors was explored by research to reduce costs and improve performance levels.
- Solar power generation plants are restricted by the potential capital costs per kW and electricity costs per kWh of such a generating system. These are perceived as the primary barrier to any large-scale installations. In addition durability, reliability and efficiency characteristics need to be improved for acceptance by commercial customers. The project aimed to build a prototype solar thermal power plant using a fixed hemispherical mirror bowl system with a tracking receiver-engine: a system able to drive gas turbines. Again, cost factors still militate against commercialisation of the research.

Project coordinators were then asked about the routes to any expected improvement in competitiveness. Again they were asked to estimate the relative strength of the different paths to competitiveness immediately after the project and then three years on. The results are shown in Figure 6.

Figure 6: Routes to enhanced competitiveness

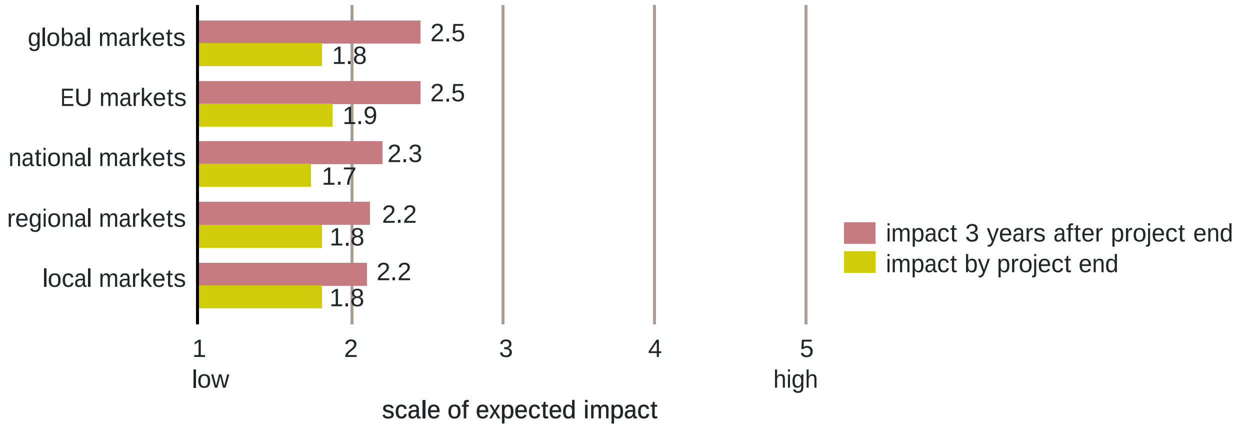


The factors seen as having the strongest impact on competitiveness included improved innovation performance, reputation for leading-edge technology along with higher quality goods and services. Factors showing relatively stronger impacts after three years included lowering of prices and an expanded product and service range. The influence of reducing labour costs, capital costs or overheads on competitiveness was judged to be relatively low. Overall, these responses remain consistent with a picture of the main immediate impacts being related to direct technological benefits and the longer-term impacts being related to the introduction of new and improved products and services and direct market effects.

The project coordinators were then asked to indicate the relative scale and timing (at the end of project and three years on) of commercial returns in their different markets. This is shown in Figure 7. There is some suggestion that in the longer time frame the projects may be providing participants with a better base for moving into EU and global markets – rather than simply improving their ability to exploit local and regional markets.

And this would make sense, since participants are preferentially operating within the projects at a EU level rather than a local level. But care should be exercised in placing too much reliance on the figures.

Figure 7: Commercial returns in different markets



Energy efficiency in the petrochemical and chemical industries

Across Europe, conventional distillation processes consume massive quantities of energy and financial resources in the petroleum, petrochemical and chemical industries. One research project set out to examine the thermal coupling of distillation columns.

Efficient thermal and mechanical coupling in distillation plants would create substantial energy savings, capital reduction and/or yield improvements. But this requires 1) design procedures to allow a wider range of designs to be examined and 2) work on hydraulic design of thermally coupled columns. Both issues were addressed during the research project.

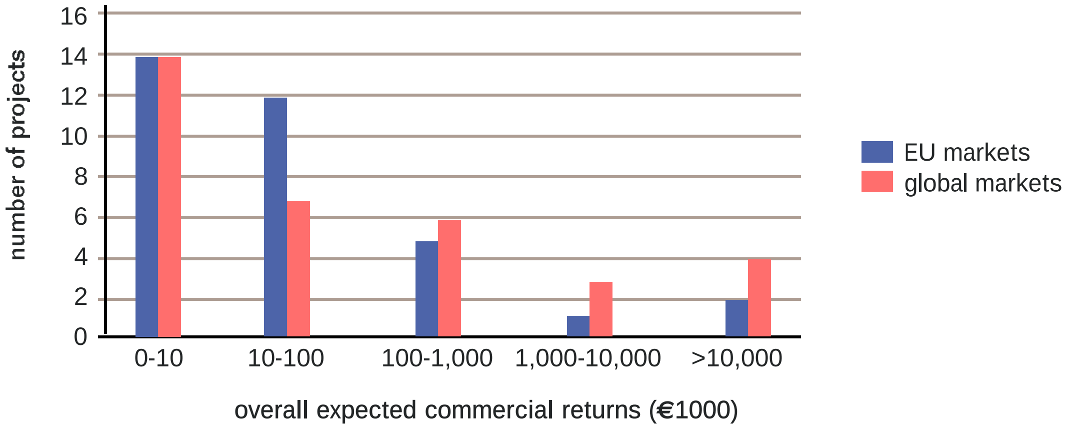
The research focused on Dividing Wall Distillation (DWD) column technology and showed its success on a commercial scale. Test run results demonstrated that energy saving in excess of 30% could be achieved while complying with the required product specifications. The project also indicates that the dividing wall columns are no more difficult to control than conventional columns and that control can be achieved using standard techniques.

Following the research, the project team developed a comprehensive technology transfer and training strategy to brief industry throughout Europe. This included a plan for marketing, seminars, conference presentations, software licensing and public training courses for engineers to publicise the results and facilitate the acceptance of the technology in new industrial developments or retrofitting to achieve energy savings, capital reduction and yield improvements.

As a result of the project, a large food company with the co-operation of a large petroleum company has developed DWD technology into commercial reality with increased turnover and expanded markets. Several companies are currently evaluating this technology for commercial distillation applications.

Figure 8, provides a frequency distribution of the 32 projects that gave an estimate of the likely overall commercial return from the research in the global and EU markets. Most projects, as might be expected, are at the lower end of the scale. However, as projects increase in size they move into the global market place.

Figure 8: Expected commercial returns after 3 years



An attempt to estimate the commercial returns from the projects was undertaken to provide an indication of the "leverage effect" of the EU funding. Given certain assumptions, the leverage effect for this first lot of projects assessed was found to be in the order of 3 (€84 million input leads to about €250 million output) but this will be modified when the total number of projects will have been analysed. Looking at the distribution of potential financial returns, it is clear that a few very successful projects compensate for a large number of projects that provide a small or negligible return. And, indeed, this is typical of all research programmes, but any major conclusion on this issue should be carefully drawn and on the basis of available information on all projects and not just a segment.

The leverage effect of the Community contribution is positive.

About 25 of the 90 research projects in this Impact Analysis relate to the use of wind energy. As a grouping, they illustrate the effectiveness and the value added of a well-focused, European-wide research effort. Figure 9 discusses the key issues addressed within the research, as well as the form of the "Research Agenda".

This approach of developing an integrated Research Agenda targeted at the key technical problems of a sector, has much to recommend it as part of a model for the proposed Targeted Research Initiatives discussed under the European Research Area. The research approach provides an effective workable model if allied to:

1. A stronger effort at developing cross-project co-operation and information sharing,
2. A stronger programme direction on horizontal issues such as training, project management, commercialisation and intellectual property rights, and
3. Greater linkage to national and regional energy policies.

Figure 9: Wind energy research: an integrated research agenda

The Wind "Research Agenda" indicates the coverage of the projects included in this Impact Analysis. They tackle a number of key issues, which are holding back the commercial development of wind energy in Europe. Within each issue a number of important specific problems have been addressed by the research. Of course, not all research projects have been a success: new materials for rotor blades proved too expensive, software models proved insufficiently robust, standardisation proved more difficult to achieve, and so on. However, the projects have advanced European knowledge and the European wind industry's technology and commercial viability.

Looking at the impact within the key issues

European Level Adoption.

- Design for complex terrains
- Operation in hostile environments
- Efficient wind farm layouts
- Wind energy production in cold climates
- Standardisation of design and testing / Structural reliability analysis

The increased penetration of wind energy generation in Europe faces a number of problems common across a number of EU regions. These common problems have been particularly well addressed by research projects examining icing in northern latitudes and mountainous areas, operation in particularly hostile climates, and in difficult terrains. Such research also assists companies in developing larger markets. General work on wind farm layouts also has a common application across regions.

Local Acceptability.

- Design tools for reduced noise,
- Airfoil testing in wind tunnels,
- Subjective noise emmission
- Visual design

Wind farms can be big noisy places and subject to the not-in-my-back-yard syndrome. Acceptability by local communities is of major concern as the number of wind farms increases. Research on designs to reduce noise and visual impact addresses these problems.

Linking to the Grid.

- Prediction of power from grid-connected wind farms
- Combined wind power source
- Dynamic control of network voltages
- Assessing productive capacity of wind farms
- Avoiding electrical flicker

Once generated, integration of wind energy into the traditional electricity supply, the Grid, can pose problems. Research tackled basic problems related to voltage fluctuations, to prediction of the amount of energy that can be supplied as the weather changes and, if necessary, supplementing the energy supply from other sources.

Scaling-Up.

- Design to avoid buckling in large blades
- Scaling up for the design of large blades
- Scaling up for stall regulation systems
- Cost effective avoidance of lightning damage.

As wind energy becomes more acceptable, not only do the size of wind farms increase but also the size of the wind turbines and towers. This scaling-up presents difficulties as the size of blades increase, the towers and blades become more exposed to the elements such as lightning and there is the need for more sophisticated control systems. These problems are again addressed by research projects.

Efficiency, Monitoring and Control.

- Improved manufacture and quality of blades,
- New materials for blades
- Design to avoid stall induced vibrations
- Soft rotors for flexible coupling
- Structural health monitoring
- Measuring fatigue loads using monitoring methods
- Passive wind turbine control devices
- Smaller towerhead mast / erection without crane
- Bottom mounted off-shore wind convertors

The main barrier to increased use of wind energy is cost. Many projects tackle challenges in improving manufacturing; designing and developing new, lighter blades and mast-towers; more efficient ways of coupling turbines to changing winds and so on.

Safety.

Includes contributions from projects on icing, lightning, structural soundness, system monitoring, etc.
Many projects made a direct contribution to safety regulations from their work in areas such as icing, lightning strikes and structural soundness of constructions.

3.3 Social impacts of the programme

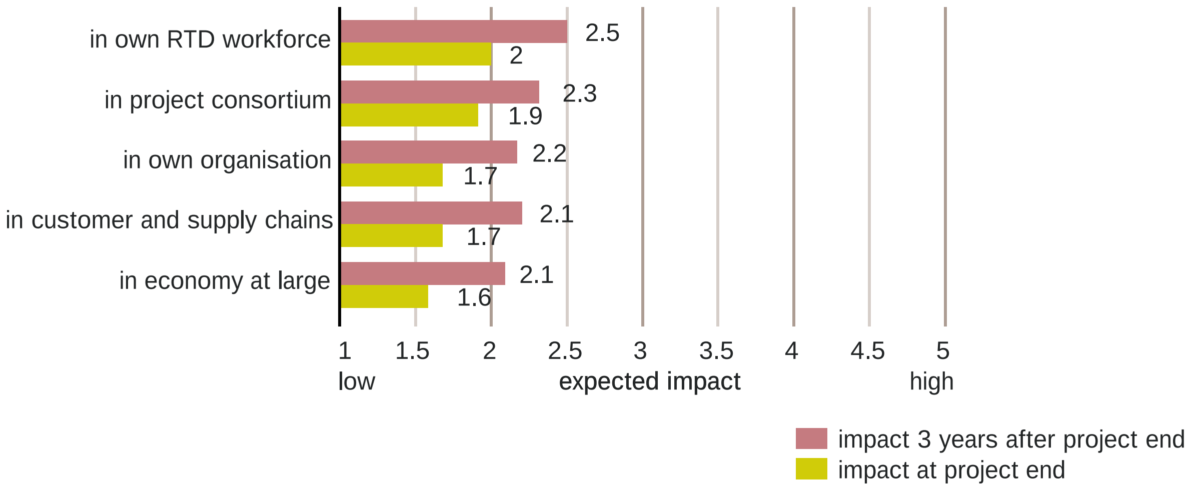
In addition to the high-level policy goals, four specific areas of social impact were investigated: Employment, Quality of Life, Environment and Support for the Development of Standards, Regulations and Policies. Overall, the highest social impact was again reported in the area of **environment** and the lowest in **quality of life**. In the following sections, the four areas are discussed in detail.

The social and economic impact was in general limited.
However, it should be noted that this issue was not among the main selection criteria for projects in FP4.

Employment

Figure 10 shows the project coordinators' assessment, as verified by the independent experts, of their project's employment impact and the location of these effects. Employment growth takes place primarily within the organisation's own RTD workforce (67% of projects). Nevertheless, employment increases, even three years after the project are finished, are expected to be "minor". Some 44% of the projects expected a "minor" impact on employment growth in the economy at large: an effect, however, which may be significant in numerical terms.

Figure 10: Locations and strength of the employment impacts of projects



However, at a local and regional level, the projects have helped to protect existing jobs, even if they did not contribute to an immediately observable employment growth. In addition, investment in improving the technological efficiency of energy sourcing, transformation and utilisation is important, not simply in maintaining the employment of those directly involved, but also of the industries which use such energy, and the regions which host such companies.

Anticipated, sustainable employment growth could be seen in the participation of small and medium enterprises (SMEs), companies with a small number of employees, in the start-up phase and in the first years of their existence. They can be seen as innovation catalysts, as well as a motor of employment growth.

The direct impact on employment from research projects at local level seems small unless the final product is commercialised.

Biomass and employment

Electricity generation from biomass (such as forestry and agriculture residues) potentially offers, environmental benefits, socio-economic benefits from re-deployment of surplus agricultural land and energy independence. It is also strongly supportive of EU policy in areas such as Agriculture, Energy and Regional Development as well as having the potential to support Employment policies, as seen in some of the research projects.

Biomass is very much a regional energy source. There have been various research implementation studies of small-scale biomass power plants, of combined coal and biomass waste examined technically and commercially feasible, assessing fuel resources, planning constraints, environmental and social impacts, sales potential, etc. Success in this type of research can contribute to employment in a number of ways. As these technologies develop:

- Direct employment occurs in rural communities supplying biomass,
- A regional network develops with SMEs working on the supply, construction, installation, operation and maintenance of plant and equipment
- Localised small-scale heat and power supply from biomass supports local efficiencies in developing local enterprise, as well as local security and diversity of energy supply.
- At a wider level, EU manufacturers and suppliers of biomass electricity technology become players in the world market.

Examples of research include:

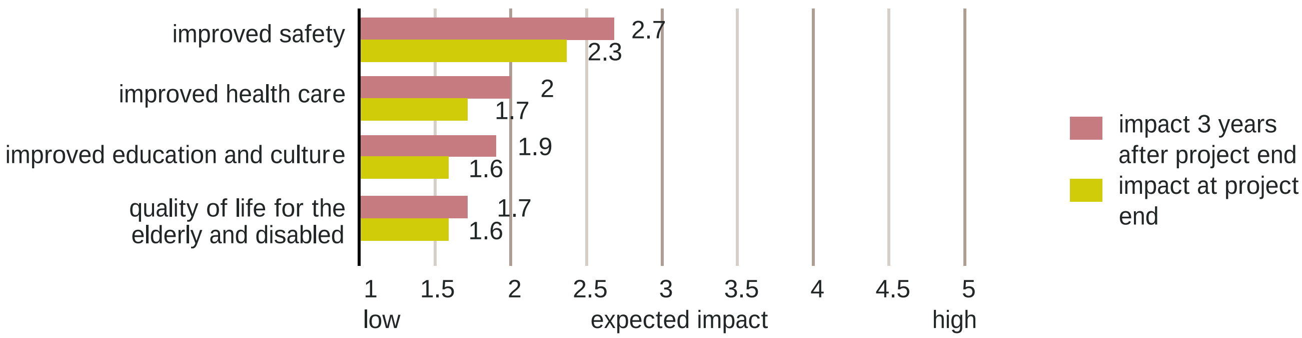
- Storage of biomass as bio-oils (biomass is usually burned or gasified on-site), which will support wider commercial developments. Not only might such research lead to the wider use of biomass but also the wood, petrochemical and cosmetic industries could incorporate bio-oil to their fabrication processes, generating a larger added value and employment.
- Small-scale, wood combustion systems such as stoves, home-heating systems and boilers where thermal efficiency could be increased and emissions lowered. Again, both manufacturers and users will benefit from such research. The first fireplace insert based on this research will soon be on the EU market, creating jobs and lowering pollution.

In all, renewable fuels accounted for less than 2% of the European Union primary energy requirements in the mid 1990s, but research on advanced biomass power technologies, as well as a new emphasis on short rotation crops and forest could change this pattern. Electricity production through a biomass integrated gasification gas turbine may be the best short-to-medium term option for introducing this renewable resource into commercial energy channels. To limit transportation costs and negative effects, biomass needs to be processed locally, requiring small- and mid-size generation units and the viability of such units has been enhanced by research in this Programme. In addition, indirect issues such as the increased amounts of ash and associated heavy metal pollution from use of renewable energy sources, have also been addressed by research.

Quality of Life

Figure 11 shows possible areas of impact of the projects, along with an assessment of the strength of these impacts – immediately after the project, and then three years on.

Figure 11: Type and strength of the Quality of Life impacts of projects



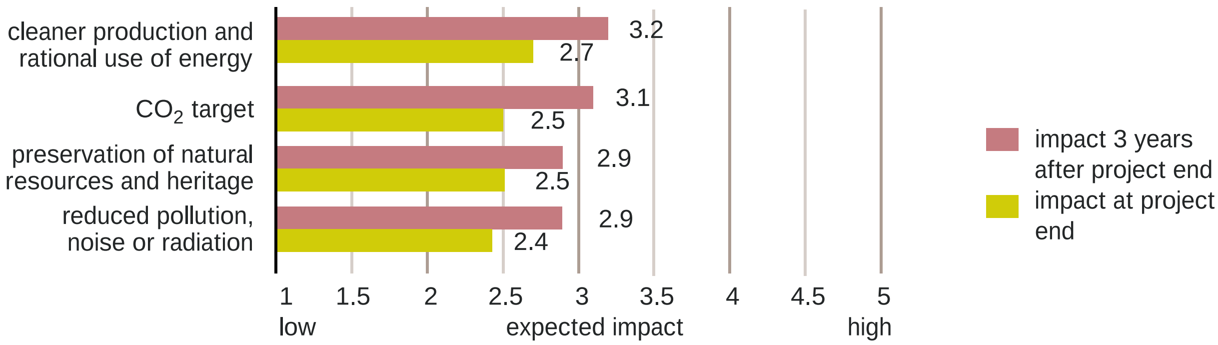
Within this area of Quality of Life, 'improved safety' is mentioned most often and is seen as having the greatest impact. Here, projects focused on issues such as improving structural strength and icing and lightning strikes on wind turbines have, as a matter of course, indicated safety implications and sometimes formalised these as proposed regulations. Since "Health and Safety" is a horizontal issue across all projects, it would be useful for the Commission to require all projects to comment on any Health and Safety implications of their research in their Final Report. Indeed, since one research project was effectively halted by a national Health and Safety Authority, the NNE Programme might remind projects that such already existing regulations will have implications for their own research.

Impacts on health care, education and culture and the elderly and disabled are simply not strongly relevant to the NNE Programme. Nevertheless, several projects have possible relevance to these topics. For example, many projects would have had a strong educational potential if they had been associated with dissemination strategy including schools, institutions of higher education or vocational training. Similarly, projects seen from a more radical perspective could be exploited to provide cheap energy for the elderly, both in urban areas and in isolated rural areas. More creative and well thought out dissemination and exploitation strategies could create impacts on a much broader level.

Environmental impacts

Figure 12 shows the project coordinators' expectations in the area of Environmental Impacts. It provides an assessment of the strength of the project impacts across a number of areas, immediately after the project ends and then three years into the future. The expected impacts in these Environment areas are rated stronger than in other social impact areas.

Figure 12: Locations and strength of the environmental impacts of projects



The response rate for the sub-areas varies from 52% to 73% of the projects. The strength of impact is very similar across the sub-areas (CO_2 emission target, Cleaner production, Reduced pollution, Preservation of natural resources) at the end of the project and again after three years.

Much of today's energy-using equipment was designed and installed in an era of relatively low energy prices, when there was little incentive to focus on energy efficiency. The commitment to emission reduction provides a new context. Each new capital investment offers an opportunity for cleaner and more climate-friendly power plants, industrial processes, buildings and vehicles to replace existing stocks.

The EU's NNE Research Programme is contributing to the possibility of these changes through, for example:

- Thermal and mechanical coupling distillation technology, which reduces energy consumption and capital expenditure with yield improvements, and has been proven on a commercial scale.
- New heat recovery systems with low cost and small size were developed, with a potential impact on energy savings of about 10% (or 45 Miot CO_2/a) of the total industrial energy consumed by industry in the EU.
- Similarly, manufacturing processes making extensive use of hot water streams, such as pulp and paper, brewing, textiles, food and beverages and dairies can now make significant energy and water savings with the results of EU funded research

Kyoto, CO_2 emissions and research

At the UN Climate Conference in Kyoto, Japan in late 1997, global and regional reduction targets were debated and defined. Carbon dioxide is the main greenhouse gas, accounting for around 65%. A binding agreement was made, committing the industrialised countries to reduce their emissions of greenhouse gases by 5.2% relative to the 1990 levels, by the years 2008-2012. The EU as a whole has to reduce emissions by 8%. To meet this goal, a number of EU countries will need to reduce emissions more than the average and will need to co-operate to achieve this. The research undertaken by the NNE Programme will provide an important platform, both for pan-European co-operation, and for introducing the technologies needed to meet the Kyoto targets. Many projects across all areas of the NNE Programme will make contributions to CO_2 reduction.

CO_2 reduction and European added value

Projects that develop wind energy work towards a direct reduction of CO_2. But undertaking this research at a European level can also be the most sensible course of action for academics and industrialists. For example:

- Icing patterns in wind turbines were assessed at a European level along with the implications for their design, operation and safety. While, of course, such work is important at a local level, a European overview is fundamental in developing an integrated market of sufficient size to be able to launch the wind energy sector as a fully commercial and competitive reality.
- The exploitation of wind power in complex terrains across Europe was examined by another project. This better understanding will also help to increase the penetration of wind energy into the total energy balance right across Europe. At the same time, cohesion across the EU will be supported as technology from the Northern European industry will be implemented, operated and maintained regionally in the South.

There is no doubt that environmental pollution is the key challenge for energy production, but the environment can be affected in other ways. The visual environment created by energy generation can be important. Research examined two areas. The visual impact of wind farms needs to be minimised for social acceptability, while at the same time not reducing technical efficiency. A more positive challenge was faced by the visual impact of solar panels. Here, people are largely proud to flaunt such "greenness" and the research issue became how to integrate them technically and aesthetically with existing domestic and commercial architecture as demand grows. "Designer" solar panels may help to overcome the continuing relatively high cost factor.

The major non-commercial impact of the projects is the improvement of the environment and particularly the reduction of CO_2 emissions.

Fossil fuels: increasing efficiency means environmental benefits

The surest and most effective way of decreasing CO_2 emissions, reducing pollution, safe-guarding the environment and improving the quality of life within Europe, is simply increasing the efficiency with which we use fossil fuels – thus reducing the energy waste in industrial processes, transport, commercial and domestic uses. Given the time horizon for the large-scale commercial use of wind, wave and solar energy, the research undertaken on saving traditional fossil fuels may prove to be the most effective of all. Indeed, there are some early indications from the projects that fossil fuel projects may also provide the greatest commercial leverage from EU research investment.

In general, the more efficiently we use energy, the safer is the environment. Here research projects have included:

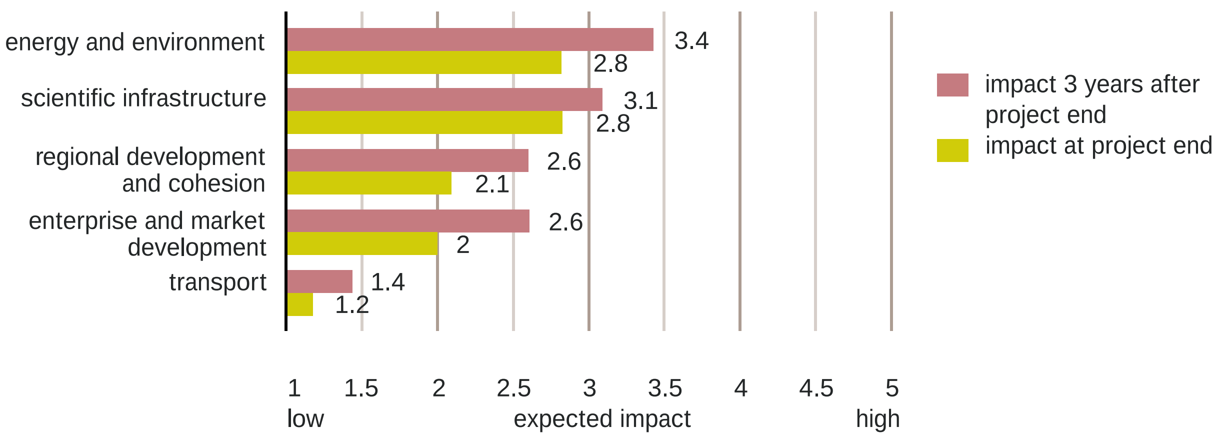
- Ultra high temperature heat exchangers working with clean and dirty fuels.
- Optimum management systems for combined heat and power facilities
- Expert system controls for high temperature industrial processes
- Heat recovery from high temperature furnaces, kilns, etc.
- Design methodology and software tools for energy efficient processes
- Combined minimisation of water and energy in the pulp and paper industry and food and drink industry
- Reduction of energy consumption in the production of alumna
- Gas recycle reactor separator for methane conversion
- Melt crystallisation for separation processes in industry
- Increasing efficiency and new materials for heat pumps

By simply saving on energy and reducing the need for energy production, these and other similar research projects have a direct beneficial effect on the environment. They also contribute to the competitiveness of their users by reducing energy costs.

Standards, regulations and policies

Figure 13 shows the project coordinators' expectations in the area of Standards, Regulations and Policies. It provides an assessment of the strength of project impacts across a number of areas, immediately after the project ends and then three years into the future. The data show that the major impacts on standards, regulations and policies will take place in the areas of energy and environment and in scientific infrastructure. Enterprise, regional development and transport are rated less strongly.

Figure 13: Impact on the development of standards, regulations and policies



Safety characteristics of renewable fuels, wastes, low-rank coals

The safety aspects of fuel storage, handling and feeding are important issues in conventional plants as well as in the development of new energy production technologies. Knowledge of basic handling and safety-technical characteristics of fuels and fuel mixtures is of great significance to the design of handling and feeding equipment and safety systems, and to the assessment of explosion and fire hazards.

The technical data produced through one project and the development and refining of methods for determining fuel properties will support industries involved in power production, such as boiler manufacturers, manufacturers of fuel handling systems, energy consultants, utility companies, and manufacturers of safety equipment. These industries will directly benefit from the information on the safety-technical characteristics created in this project.

The development of a "common language" across the various energy-related markets of the EU is important. The standardisation of energy-related components, systems, design and test procedures make for a better commercial dialogue and price-reducing competition between operators, designers, planners, etc. For example:

- The standardisation of the tests which are necessary to certify roofs and facades with integrated photovoltaic modules, as well as building products which have similar modules integrated into the structure, leads to much quicker, wider and cheaper adoption of the associated technologies. One research project has successfully undertaken EU-wide research in this area, examining the obstacles in national building and electrical codes and national testing systems and developing pre-standard guidelines for such systems.
- Standards and the certification of wind turbines have become increasingly important requirements for the industry. Certification is often a commercial necessity in order for a wind project to attract investment and insurance cover. In northern Europe, certification of wind turbines has long been required in order for wind projects to obtain building permits and/or to become eligible for subsidies. Rules and standards have been developed as the basis of certification and these have had a direct influence on the design procedures adopted by manufacturers. One project directly sought the development of guidelines and recommendations on the wind energy technology to be applicable by standardisation bodies, wind turbine designers and certification institutes, along with the implementation of a network of testing institutes in which uniform methods and procedures are used.

European Added Value

The concept or European Added Value was recently defined in a study[2] as:

"the value resulting from EU support for RTD activities which is additional to the value that would have resulted from RTD funded at regional and national levels by both public authorities and the private sector"

All projects are expected to bring European Added Value (EAV) to the overall RTD effort – it is their "raison d'être" from a EU perspective. That is to say, some **value** is **added** to the project, when carried out at a **European level**, which would be absent – or impossible – if a single Member State were to carry out the research on its own.

European added value was generated at a number of levels:

- The simple creation of multi-national teams generated added value through the sharing of technical, commercial and market information;
- The creation of specialist teams from across the EU brought, by and large, the best expertise together in the project and improved the quality of the research itself;

2. "Identifying the constituent elements of the European Added Value of the EU RTD programmes: conceptual analysis based on practical experience" made by a consortium of consultants, dated 20 November 2000.

- In a number of cases, the logic of the research required a pan-European dimension;
- Pre-normative research leading to much needed standards.

European added value also arose at the Programme level where the comprehensive breadth of research may have been difficult at a Member State level. Equally, the size of the Programme gave the potential for critical mass and economies of scale in the research undertaken.

This said, however, a more strongly stated explanation of EAV, elaborated within the specific sub-Programme context (RES, RUE, Fossil Fuels), in both the Work Programme and the proposal evaluation documentation would further strengthen the socio-economic impact of the Programme.

The definition of core-concepts and -indicators of European Added Value should therefore be developed.

Better understanding and implementation of the European Added Value principles would strengthen the socio-economic impact of the Programme.

Figure 14: Working closely with regional and national authorities

One of the projects with greatest impact worked closely with Government policy – an important approach to increasing research impact generally.

In Northern Europe, five shallow (under 10m) areas with no significant conflicts with other interests were identified as possible locations of large offshore wind farms. The energy policy interest in wind energy is primarily based on its ability to deliver large volume CO_2 reduction from power generation, cheaply. The local Government's goal is to install a total of 4,000 MW of offshore wind turbines in large-scale projects before 2030, (around 40% of the anticipated total electricity consumption). In 1996, it was established that this goal is technically feasible, but it was recommended that the technical and environmental effects should be investigated further.

It is this recommendation, and the other uncertainties, that the project addressed in a complementary way. The project showed that suitable areas are available for large-scale offshore wind farms and that a large wind potential is available on similar sites. It has provided the EC with suitable park layouts for wind farm projects of around 100 wind turbines and radically improved foundation designs compared to those previously available. Selection procedures for the preferred wind turbine design and operation are available. Grid connection of the first proposed large wind farms is possible with only minor reinforcement of the transmission system.

4. Improving the impact of energy research

This section examines how the socio-economic impact of energy-related R&D could be improved. It should, however, be remembered that energy R&D fits into a much wider political and economic framework. Most importantly, if traditional fossil fuels continue to be, for political reasons, subsidised or priced without account of their full environmental impact costs, then clean energy sources will continue to be handicapped.

There are two suggestions:

- To improve commercial viability of the project from the outset by strengthening project management allied to incentives to stimulate and reinforce market penetration,
- To ensure that the NNE Programme can select projects with high socio-economic potential and then support them adequately on the ground.

4.1 Improving the commercial viability of projects

For the great majority of the research projects examined, the route to delivering their economic and social benefits has been through commercial, market channels. If they did not reach the market then their impact has been very limited. They have remained as a stock of knowledge, of possible importance in the future.

This requires projects to have commercial skills; a requirement which is sometimes difficult to fulfil. The move in successive EU Framework Programmes has been away from funding research as “a useful activity” (FP3 to FP4) towards research as a more direct answer to society’s needs (FP4 to FP5) in which issues of impact are central. However, the structure and management abilities of research projects have not yet sufficiently kept pace with these changes. If research projects are to make a significant social and economic contribution to European development, structure and management must change.

The main changes required include:

- Commercialisation of research must be the goal of the project and of the project partners. Commercialisation is not another group's responsibility or another project. This requires a consortium coming together from the outset, already with a structure and relevant participants committed to commercialisation and a commercialisation strategy built into the proposal, should the research be technically successful. The likely commercial impact should have higher weighting at the proposal evaluation stage.
- A much greater flexibility to change project directions. In some areas, the technology and markets are changing rapidly. The research must consciously seek to adapt to these changes if it is to be commercially relevant and have maximum impact. This flexibility might be achieved by a broader initial research focus. Some projects are far too narrow – research for the sake of research – to have any significant social or economic impact. The field of action of a project needs to be sufficiently large so as to define a significant and important problem to which potential customers – government, local authorities or commercial companies – can respond. Interdisciplinarity will become more of an issue.
- Including professional project management as project coordinator would greatly strengthen projects. This management would initially support normal project coordination. It would also plan early for diffusion and commercialisation of results and finally ensure that they were adequately undertaken.

Not all energy research projects achieve their objectives through the market. Some are aimed at informing policy decisions or serving as a base for regulations or industry standards. Their “market” is not the commercial market, but rather that of Government and institutions and the general public. However, a similar, parallel reorientation of the projects from technical research efficiency towards economic and social impact is still required.

Finally, while the central issue for projects must be the support of energy-related objectives, the projects themselves must operate in line with, and support, wider EU objectives – in particular equal opportunities; both for women and for the disabled. Increasing the participation of both groups leads to a greater pool of available competence and hence better researchers and managers running the projects.

4.2 Increasing programme impact

While the NNE Programme has shifted formal objectives from pure research towards achieving research impact, neither project nor Programme structure and management have changed sufficiently. At the Programme level a number of changes would increase overall social and economic impact.

- The policies of national authorities have a major impact on the viability of energy R&D activities. Thus, the Programme and its projects should seek to involve and form synergies with the national authorities in Member States. This might go as far as seeking a level of co-funding from such authorities or other financial institutions. Links to national and EU technology transfer and commercialisation supports should be much stronger. There is a need for greater integration and support of the R&D Programme (financial, legislation, policy) with the policies and needs of Governments of Member States. It would be helpful if the Commission undertook initial, pre-proposal, development work, with Governments and potential participants to ensure that the best partners have the opportunity to come together to discuss issues and form partnerships to submit proposals. This might also be the time to explore cluster / network formation.
- Along with closer coordination with Member States, should come greater Programme focus on commonly agreed “critical issues” and “critical technical barriers”. This does not necessarily mean large individual projects but it certainly does mean more focusing, clustering and synergy between projects.

5. Conclusions

This report has examined the economic and social impact of some 90 energy research projects. The major finding is that the impact of energy research, particularly in terms of new sources of energy, is conditioned by the political structure of the energy market. As long as there is no “full pricing” of traditional fossil fuels to include external costs to health and the environment, as well as other more direct subsidies, the impact of such energy research will be relatively weak. Conversely, research on improving the use of traditional fossil fuels is likely to have a relatively greater commercial impact – and indeed impact on health and environmental issues. The initial indications of commercial leverage from the EU research funding point very much in this direction.

The main output of the research projects has been good, solid technical advances across a wide number of important areas in wind and solar energy, the use of biomass, the development of fuel cells, energy efficiency and work on fossil fuels. Some 89% of projects reported technical advances based on the research. Totally new energy-related products or services are, however, few. Mostly, it is marginal improvements in existing technologies.

The type of commercial impacts found reflects this pattern of marginal technical advances, looking towards cost savings and efficiency improvements. Indeed, it is difficult to expect more, given that the projects have just finished. The project coordinators see greater opportunities for exploitation of the technological advances within new markets after a number of years.

Indications are that the research projects should impact strongly on environmental issues. In particular, the more comprehensive research agendas developed across areas such as wind and solar energy and fuel cells should contribute to their penetration of the energy market and to reduction in CO_2 emissions. Projects will also impact on the setting of standards and development of regulations in the industry. Quite a number of projects will also impact indirectly on safety issues, despite few having such concerns as their main objective.

The employment impacts of research are notoriously difficult to discern. In the short term, at least as seen at project-end, the employment creating prospects are not seen as especially strong.

Thus, in summary, the research projects of the Non-Nuclear Energy Programme have given a good, firm base of technical advances across a wide area. The key issue now will be the ability of the projects to commercialise these advances.

European Commission
EUR 19464 – Clean and efficient energies for Europe – Socio-economic impact of energy research projects
Luxembourg: Office for Official Publications of the European Communities
2001 — 32 pp. — 21 x 29.7 cm
ISBN 92-894-1123-6
Price (excluding VAT) in Luxembourg: EUR 7

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KI-NA-19-464-EN-C

This report provides the results of a pilot assessment of the social and economic impacts of some 90 research projects launched under the European Union's Fourth Framework Programme on Non-Nuclear Energy, 1994-1998. A panel of 10 experts from different Member States undertook an impact interview and analysis of each completed research project, as well as overseeing an extensive questionnaire from each project co-ordinator. The overall results showed that the impact of energy research is limited by the political structure of the energy market. Until the internalisation of external costs associated with traditional fossil fules occurs, the action on new, clean, environmentally friendly sources of energy will be relatively weak. However, the majority of projects resulted in new technical advances, and intellectual property rights were established in one-third. This pilot exercise also provides a methodological base for other research programmes to develop rapid response feedback to decision-makers. This is important in obtaining better research targeting which will be more effective in responding to Europe's economic and social needs.

Price (excluding VAT) in Luxembourg: EUR 7

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L-2985 Luxembourg

ISBN 92-894-1123-6

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