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Impact assessment of non-nuclear energy projects implemented under the Fourth Framework Programme

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EUROPEAN COMMISSION

CLEAN, SAFE AND EFFICIENT ENERGY FOR EUROPE

Impact assessment of non-nuclear energy projects implemented under the Fourth Framework Programme

Synthesis Report

Directorate-General for Research

2003 Directorate-General for Transport and Energy EUR 20876/2

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From 1994 to 1998, the European Union's non nuclear research and demonstration energy programme was dedicated to improving the security of energy supply, encouraging the rational use of energy, protecting the environment by reducing the impact of the production and use of energy, in particular the emissions of CO_2 and strengthening the technological basis of the EU's energy industry. Nearly 1 billion Euros were spent to contribute to those objectives.

This publication presents the main results of a major impact assessment of the energy research and demonstration part of the 4th Framework Programme in the field of research, technological development and demonstration. It is the first time that such an in depth evaluation - carried out at programme, sectoral and project levels – is done. It examines the overall impact of the projects in the different fields (energy RTD strategy, rational use of energy, renewable energies and fossil fuels) in terms not only of the technologies developed but also in protecting the environment and creating a sustainable economy, as well as other socio-economic effects, such as employment and education.

The results of this assessment can easily be read in the light of the actual energy policies of the European Union. Those policies aim at opening energy markets to competition, with a view to increasing efficiency of energy production and supply and enhancing the competitiveness of the European industry, reducing greenhouse gases and pollutant emissions (Kyoto), increasing the security of energy supplies, improving energy efficiency and increasing the use of renewable energy sources. It also provides a most appropriate feedback and advice for improved management of energy RTD programme and projects.

The European Commission role on energy research and demonstration during those years has been decisive: By supporting the development of European consortia, the Community has promoted the development of scientific and technical capacities leading to excellence in many fields and to the formulation and the exploitation of new concepts by the European industry.

The assessment is also showing that – after completion of the 4th Framework Programme finished projects- progress remained to be done in many aspects, such as the integration of renewable energy sources into the economy and the daily activities of EC citizens, the participation of small and medium enterprises in research activities, the dissemination of results and the market exploitation before and after the completion of new technologies.

The lessons learnt from this ex-post analysis are to a large extent valid throughout the diversity of the successive Framework Programmes. They will contribute to enhance the impact and efficiency of RTD activities. The 6th Framework Programme of the European Community for Research, technological Development and Demonstration activities (2002- 2006, co-managed for the energy sector by the two Commission Directorates General for Energy and Transport and for Research) is already taking into account - in its structure and priorities - several of the conclusions of this study in order to help integrating the very often fragmented European research activities into a true European Research Area.

F. Lamoureux

A. Mitsos

A pilot impact assessment of 90 finished research projects from the Fourth Framework Programme – Non Nuclear Energy Projects was carried out in 2000. The current report deals with the results of the assessment of the remaining projects: research, demonstration and support measures. A panel of independent experts was contracted by the Directorates-General for Research and Transport and Energy (TREN) to perform this task during 2002. A total of about 700 projects were assessed.

THE IMPACT ASSESSMENT PANEL

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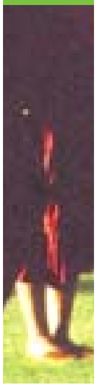


The impact assessment of the Fourth Framework Programme (FP4) Non Nuclear Energy (NNE) Projects (1995-1998) was initiated in 2000 by DG Research. A panel of ten independent experts was appointed to assess about 90 completed research projects as a pilot exercise. The outcome of this was the publication of two reports:

- "Clean and Efficient Energies for Europe, Results of Individual Projects", EUR 19465/1. This report presents a two-page summary of each assessed project, including sections on its objectives, problems to be solved, project results, benefits to the economy and society, plus information about the project consortium.

- "Clean and Efficient Energies for Europe, Socio-economic Impact of Energy Research Projects", EUR 19464. In this report, an assessment of the impact of the projects is presented based on a detailed analysis of project results and a statistical analysis of a questionnaire which was completed by each project coordinator and verified by the expert.

In 2001, a core group of four independent experts was appointed to develop a methodology, in collaboration with DGs Research and Transport and Energy (TREN), and to prepare a detailed instruction guide and a new questionnaire, based on the experience of the pilot exercise, for the completion of the assessment of the remaining 4FP-NNE projects, to include research projects, demonstration projects and support measures.

In 2002, the group of independent experts was increased to a total of 38. The experts were appointed by both DG Research and DG TREN to assess the remaining projects. The assessment produced a number of outputs including:

- A Synthesis Report on the Impact of the NNE Programme (the current report);

- An Executive Summary of the Synthesis Report (an independent, stand-alone report);

- Five Thematic Reports:
  - Fossil Fuels,
  - Rational Use of Energy,
  - Renewable Energies,
  - Socio-Economic Research & Modelling, and
  - Complementary & Support Measures.

- Summaries of all the individual projects assessed (only available on CORDIS because of its size).

During recent years, the Commission has been devoting increasing attention and resources to the evaluation of its funded research[1], including impact analysis. The objective of such evaluation is to:

- Increase the necessary transparency of Commission activities;

- Give a better understanding of Framework Programme spending to Member States, the European Parliament and the European Council;

- Obtain the necessary understanding to develop more effective research pro-grammes in future – in technical, economic and social terms; and

- Influence and inform public opinion on the results from and need for scientific research.

This current synthesis report represents the work of the 'Core Group'. It is based mainly on:

- A questionnaire survey of near 700 projects;

- Five, in-depth, Thematic Reports – themselves based on near 700 individual project interviews;

- Individual expert summary reports; and

- Documentation and data provided by the NNE Programme.

(1) Communication to the Commission from Mrs Schreyer in agreement with Mr Kinnock and the President. "Focus on results: strengthening evaluation of Commission activities". European Commission, 2001, Brussels.

1 ENERGY RESEARCH IN EUROPE

1.1 Introduction

This report is an impact assessment of the research and demonstration projects and associated support measures undertaken under the European Union's (EU's) Fourth Framework Programme (FP4) during 1994-98 in the area of Non Nuclear Energy (NNE). The NNE Programme, which received funding of almost €1 billion, covered a very broad area, ranging from improving efficiency in the use of fossil fuels, to developing renewable energy technologies, to energy uses in transport, buildings and industries, and on to areas such as modelling and strategic studies. The programme[2] covered two main types of projects: research projects, which were selected for scientific quality, with the technologies at a pre-competitive stage, and demonstration projects, where the objective was to show the commercial feasibility of a particular technology. The programme was complemented by support measures covering mainly dissemination activities, as well as some strategic actions and projects targeted towards small and medium-sized enterprises (SMEs).

The report has two core objectives:

- To better understand how to develop and operate future EU research and demonstration programmes and projects; and
- To increase the transparency of EU activities, providing information to individuals, researchers, and to industry as well as to the Member States, the European Parliament, and the European Commission itself.

Box 1-1: The impact assessment methodology

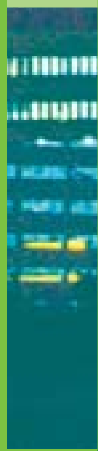
The impact assessment was carried out by a team of independent experts comprising:

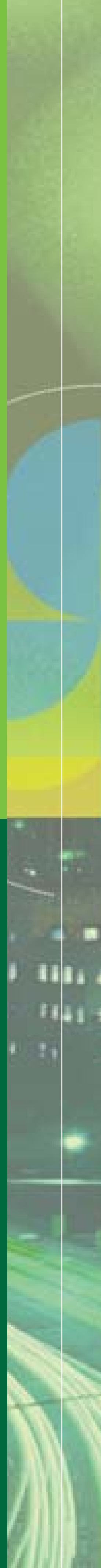
- A Core Group ensuring overall coordination of the assessment;
- A group of five thematic coordinators and two associate coordinators, to coordinate the work in their respective areas (Rational Use of Energy, Renewable Energy Sources, Fossil Fuels, Socio-Economic Research and Modelling, and Support Measures); and
- Twenty-seven experts charged with the evaluation of individual projects.

The impact analysis was organised into three main phases:

- An assessment by independent experts of the impact of near 700 projects. This consisted of a telephone or face-to-face interview with the project coordinator and a review of outputs, most commonly the final project report, as well as the administration of a questionnaire with about 200 questions for the research and demonstration projects and about 100 questions for the support measures. Individual project assessment summaries were written and are available on CORDIS (www. xxx.zzz). A report on their overall findings was then produced by each expert (usually by sub-sector: wind, solid fuel, etc.).
- An assessment of the impact of the five main sectors based on the material from the first phase: Rational Use of Energy (RUE), Renewable Energy Sources, Fossil Fuels, along with two smaller areas, Socio-Economic Research and Modelling (referred to as RTD Strategy), and Support Measures. The expert who had acted as the coordinator during the first phase drew up a report for each sector. These sectoral reports are published as separate documents.
- The final phase: the current report was based on the five coordinators' reports along with a statistical analysis of the questionnaires.

(2) The research programme was referred to as JOULE. The demonstration projects were referred to as Thermie A and the support measures as Thermie B.





1.2 The importance of energy in the EU

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

Figure 1-1: Energy: the common factor in European policies

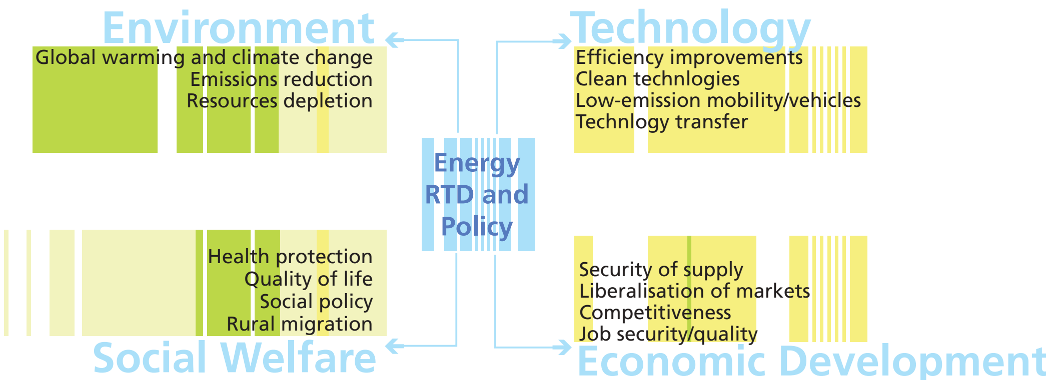


Figure 1-1 shows the wide influence energy research and technological development (RTD) issues can have in supporting EU policies and contributing to the well-being of European citizens, companies and regions. Considerations, such as industrial competitiveness, environmental protection, and human health, emphasise the importance of improving methods of energy production, storage, transmission and usage in our lives. Such improvements are sought and developed by analysts, researchers and engineers in universities, research institutions and companies. It is these facilities across Europe which the NNE programme draws together and supports in carrying out such research more effectively and efficiently.

1.3 The political and economic context of energy research

In assessing ways of improving the impact of energy research, a number of extramural 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 renewable energy sources. High oil prices dramatically increase the economic benefits of research. Gas held at low prices makes renewables uneconomical and its research ineffective. Government policies on pricing and taxing energy sources are critical in the effectiveness of energy RTD.
- The rate of growth in demand for electricity and other energy sources: the national policy framework for renewable energies, with its various supports, subsidies, and credits, naturally make renewables more viable and the research undertaken much more useful.
- The physical and economic nature of a region: the type of energy needs and the solution may vary not just with geography and 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 RTD is not simply a matter of running more *efficient* research programmes. It requires RTD objectives to be located within and attached to strong and reasonably stable, politically determined energy policies. This is not an easy matter. For example, the main barrier to the use of renewables is cost. Despite the reductions achieved through EU, Member State and private sector research (wind energy costs have been halved in the last decade), use of renewables still relies on government subsidy and support to be able to compete with conventional fuels, especially coal and nuclear energy. The lack of political will to ensure full-cost pricing, particularly the negative environmental and health costs of fossil fuels, when determining the cost of these competing energy supplies hinders the development of clean energy sources and hence the effectiveness of any research on renewables.

In the fiscal area, the cost of money disadvantages projects with high start-up but low running costs, such as renewables. Such costs can also marginally disadvantage any efficiency gains from RTD work. Similarly, high upfront costs for the integration of renewables 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 RTD 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 more sophisticated financially in assessing their potential.

Finally, relatively weak information networks disadvantage, both directly and indirectly, the use of renewables and the impacts of any RTD undertaken.

To summarise, clean energy RTD work may be undertaken efficiently and be academically and technically excellent, but may have only a minor impact because it is being undermined by changes in much broader-canvas energy policies. This requires RTD objectives to be located within and attached to strong and stable, politically determined energy policies. It is essential to bear such issues in mind while reading the following impact assessment.

1.4 The Non Nuclear Energy RTD Programme (1994-1998)

Renewable energy and energy efficiency have been issues within the European Union since the 1970s. The concerns over 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 the 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 knowledge of the greenhouse effect has been known and addressed by scientific circles for many years, it only started to attract strong public attention 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. These concerns over the sources and reliability of the 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.

It was in this context of concerns over energy supply security and pollution that the EU set up the NNE Programme as a part of the Fourth Framework Programme (FP4), running from 1994-98. The main objectives, detailed in Box 1.2, were:
- Improving security of energy supply;
- Reducing the environmental impact of the production and use of energy; and
- Encouraging the rational use of energy.

The programme was organised around four priority sectors:
- Policy and strategy research (RTD Strategy);
- Rational and efficient use of energy (RUE);
- Use of renewable energy sources (RES); and
- Better use of fossil fuels (FF).

Three operation tools or activities were used to undertake the programme:
- Research projects;
- Demonstration projects; and
- Support Measures.

Box 1-2: The Non Nuclear Energy (NNE) Programme objectives

The Non Nuclear Energy Programme in FP4 – the Fourth Framework Programme for Research and Technological Development – covered both a research and development component (JOULE – administered by DG Research), and demonstration projects (THERMIE – administered by DG Energy until 2000 when DG Energy merged with DG Transport to become DG Transport and Energy – DG TREN). 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 CO_2 emissions; 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 also aimed to 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).

The European context and European added value

In general, the areas covered by the Non Nuclear Energy Programme (NNE) have also been addressed by the majority of Member State research programmes, although with different priorities. For instance, the NNE Programme gave a stronger focus on renewable energies, with 44% of the overall research and demonstration budget, compared to 31% for the national programmes(3). In the same way, fossil fuels have received greater attention in the NNE Programme with 25% of the budget compared to 12% in national programmes. Rational use of energy received about the same share of the overall budget both at the national level and in the NNE Programme (30%).

In addition, the priorities at Member State level are also quite diverse reflecting resource availability (greater focus on biomass in Finland, Austria and France), industrial competitiveness and experience (e.g. wind in Denmark and Spain), or government priorities (e.g. renewables in Germany received four times the budget of that for RUE, whereas in France RUE received 50% more than renewables).

Even if there is currently little or no formal coordination between the EU and Member State programmes, there is often ad hoc working together as national research activities take part in some of the EU programmes and the same companies and institutions are involved in both the national and EU-funded projects.

In addition, it is usually expected that EU RTD programmes will achieve such benefits as:

- Improving the quality and speed of research by drawing together the resources of the different Member States;
- Undertaking research which would be difficult or impossible to undertake by a single Member State;
- Inducing technology transfer between different European regions and states which would not have taken place within the national programmes alone;
- Providing a regional development dimension to research by drawing the technologically weaker regions into strong research consortia, or by having a strong consortia extend its work to weaker regions; and
- Developing RTD approaches that will contribute to EU-wide approaches in areas such as standardisation and legal requirements, which in turn will produce more unified and more viable commercial markets.

These factors contribute to 'European added value' which is usually seen as the *raison d'être* of most EU programmes. In addition to the more technical benefits of working together across the EU, as outlined above, European added value is expected to deliver political, economic and social added value. For example:

- While co-operation between the existing 15 Member States is almost taken for granted, there is a strong responsibility on the part of EU programmes to fully integrate the New Accession States into research structures as a part of the political stabilisation of the Union.
- There is a need, particularly in the energy and environment fields, for the development of a global EU approach to certain issues ranging from energy security to a collective response to Kyoto requirements. Joint RTD activities are expected to offer major support in responding to such issues.
- In terms of EU social progress, RTD activities are expected to provide a basis for drawing together and exploring EU collective solutions to concerns such as safety at work in energy industries, and the environmental, general health and comfort issues related to energy production, use and consumption.
- More obviously, at the level of economic competitiveness, there is an expectation that RTD activities will translate not only into products and services to be made available both within the EU and globally, but also that the RTD will contribute to lowering internal Union barriers to trade – both visible (e.g. formal legal requirements and standards) and invisible (traditions and local habits and customs) – and so create a more viable common EU market.

So it can be seen that NNE projects are being asked to deliver on a complex set of objectives which go far beyond a simple technical solution to a technical question. While it is necessary to have good technical research skills, the requirements for a successful, high-impact project are likely to be much broader.

1.4.1 Overview of projects

The NNE Programme had a total budget of €971 million, around €460 million (47%) of which was allocated to DG Research to undertake research projects and €517 million (53%) to DG Transport and Energy (DG TREN) to carry out demonstration projects and support measures. This budget was used to part-fund nearly 1 900 projects:

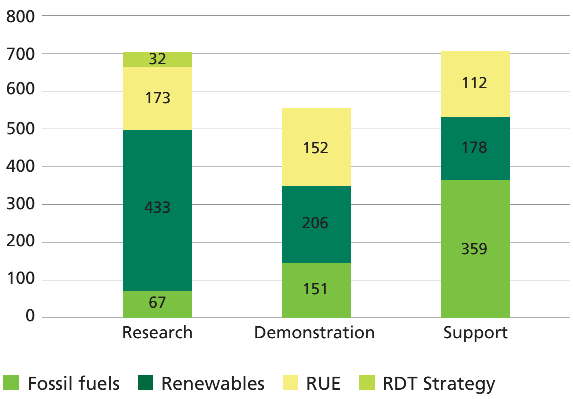
- 705 research projects (38% of total projects);
- 509 demonstration projects (27%); and
- 649 support measures (35%), but making up only 7% of the total budget.

(3) Data for national programmes derived from IEA evaluations.

Figure 1-2, below, provides a breakdown of the number of projects by sector and activity.

- Of all the research and demonstration projects, renewables provided more than half (53%), followed by rational use of energy (RUE) with 27%, fossil fuels (17.5%), and RTD strategy projects (2.5%).
- Of all the research projects, 60% were on renewables, 25% on RUE, 10% on fossil fuels, and the remainder on RTD strategy.
- Of all the demonstration projects, renewables accounted for 40%, rational use of energy for 30%, and fossil fuels for 30%.

Figure 1-2: Number of research, demonstration and support measure projects(4)



About half of the support measures were dissemination activities and a quarter strategy projects; the remaining actions were targeted at small and medium-sized enterprises (SMEs). Dissemination projects covered the full spectrum of activities ranging from collection and collation of opportunities, through the identification of benefits and barriers, to the introduction of information to potential users via a wide range of delivery mechanisms (for more detail see Annex Figures A1 and A2). Strategic projects provided analysis of the role of demonstration and dissemination in global energy policy, and sought a clearer understanding of the interaction of socio-economic elements with energy technology demonstration and dissemination, as well as information on mechanisms that assist project deployment.

The present impact assessment survey focused on a sample of almost 700 projects, consisting of about 400 research projects (58% of the total programme), 74 demonstration projects (11% of the total) and 215 support measure projects (31%).

Renewables make up 56% of the assessed research and demonstration projects (see Table A1 in Annex). If support measures are included, the share of renewables is around 50%. Wind and photovoltaic attracted the largest number of projects: about 14% each of the total number of the assessed research and demonstration projects. They were followed by biomass (10%), RUE in industry (9%), renewables in buildings (9%), clean technologies for fossil fuels (8.5%), RUE in buildings, and hydrocarbons (8% each). If support measures are included, photovoltaic ranks first, followed by hydrocarbons and RUE in buildings (11% each), then wind (10%), RUE industry (9.5%), biomass (8.5%) and clean technologies (8%).

The survey results provide a good picture of the sectors targeted by the research and demonstration projects. Half of them are related to some extent to electricity production, either decentralised or centralised, from renewables or fossil fuels. About 19% of the projects targeted the household and service sectors ('buildings') and are related to RUE or the use of renewables. Three sectors come in third position with about the same percentage of projects (17%): industry (RUE, cogeneration, biomass use), heat production and fuels. A surprisingly low fraction of projects (8%) is related to the transport sector (RUE, fuel cells, bio fuels), despite its growing importance in increasing energy demand and CO_2 emissions. Energy storage technologies and concepts attracted the same amount of projects as transport.

1.4.2 FP4 project inputs: the budgets

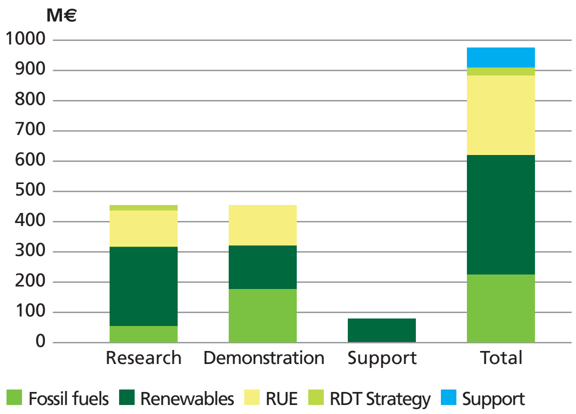
Most of the EU contribution to the Programme was devoted to research and demonstration – around €900 million or 93% of the total EU NNE budget, the rest being spent on the support measures (see Figure 1-3 and Table A2 in Annex). This budget was split almost equally between research and demonstration projects.

The European Commission supported, on average, 57% of the total eligible cost (ranging between 54% and 64% depending on the area) for research. This resulted in an average leverage ratio of 1.8 for the Commission effort: in other words, for each euro spent by the Commission, the research budget was multiplied by 1.8. For demonstration projects, the leverage effect was higher at 2.6: the average EU support was around 38%. In fact, these leverage ratios are higher, as the survey showed that the financial commitments of the partners exceeded the level of costs defined in the work programme in about 30% of the research projects and almost half of the assessed demonstration projects. The average cost excess was estimated at 40% for demonstration and around 20% for research projects.

(4) NNE Programme; estimated for support actions from the assessed projects.

Renewables attracted around 40% of the total EU contribution, followed by rational use of energy (27% of EU budget) and fossil fuels (24% of the contribution). A small amount of the budget was spent on modelling and socio-economic studies (2%) and on support measures (7%). For research projects, very high priority was given to renewables with 58% of the EU budget, followed by RUE (28%), fossil fuels (11%) and socio-economy and modelling (3%). The EU contribution to demonstration projects was more evenly distributed among the three main areas with, however, a higher amount going to fossil fuels (41%), and RUE and renewables accounting for 30% and 28%, respectively.

Figure 1-3: EU budget for the Non-Nuclear Energy Programme

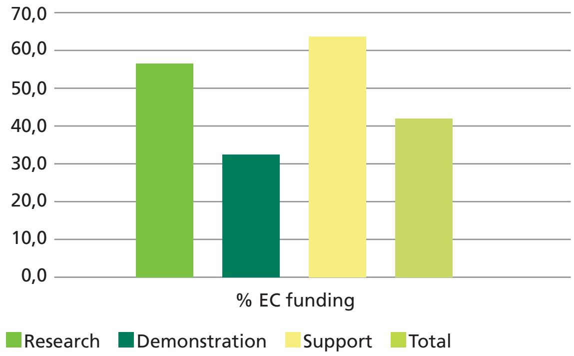


The average eligible cost[5] of research and demonstration projects was about €1.2 M per project, with demonstration activities costing on average twice as much as research projects (respectively €2.1 M and €1.1 M per project) (see Table A2 in Annex).

- Demonstration projects on fossil fuels were the most expensive (€3.9 M on average), followed by RUE (€2.5 M per project). Projects on renewables had an average unitary cost below the average (€1.9 M).
- In research projects, the average cost was highest for RUE (€1.3 M) and lowest for socio-economic and modelling studies (€0.7 M), while fossil fuels and renewables projects on average cost €1.1 M.
- In terms of EU funding, the average contribution was higher for research projects (57%) than for demonstration projects (37%).

The average cost of support measures was much smaller than for research or demonstration projects (by a factor of 7 compared to research and a factor of 17 for demonstration). The average cost was about €160 000, with an EU contribution of about €102 000. Strategy projects were somewhat larger than the average at about €200 000, and SME projects somewhat smaller at about €140 000. The EU contribution to the different areas averaged about 65% of the costs – a little higher in the SME area and lower in the Strategy area.

Figure 1-4: EU contribution to the eligible cost of projects (%)



1.4.3 Project outputs

Research and demonstration projects

The survey listed seven main types of outputs from the research and demonstration projects, as follows:

- New processes, services, tools and techniques, paper and policy documents
- New products, demonstrators, prototypes, pilots
- Exploitation products (e.g. patents)
- Follow-up demonstration projects (other EU programmes including national and regional levels)
- Publications in refereed journals (peer reviewed)
- Production of electronic outputs (reports, data sets, codes, shareware, or other software items made available via the web, CD-ROMs, etc.)
- Finally, presentation and dissemination of results (e.g. books, papers, reports, seminars, conferences, radio, TV, etc.).

Figure 1-5 presents the percentage of projects with tangible outputs.

- About **90% of the projects disseminated their results.** Although this number is very high, it also means that for 10% of the projects there was no dissemination at all.
- More importantly, about **70% of the projects produced new products, processes or services.**
- About half of the projects made available their results or outputs in an electronic format.
- Finally, one-third of the demonstration projects resulted in exploitation of the results in the form of patents or other means.

(5) The eligible cost represents that part of the total project cost that is eligible for EU funding; for research projects, total cost is close to the eligible costs; for demonstration, total cost is much higher than the eligible cost.

Figure 1-5: Research and demonstration project outputs

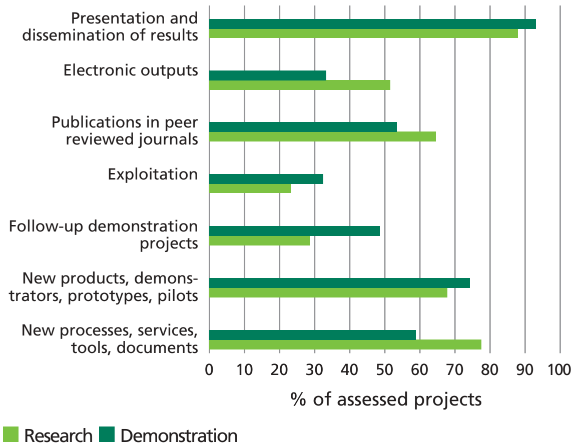
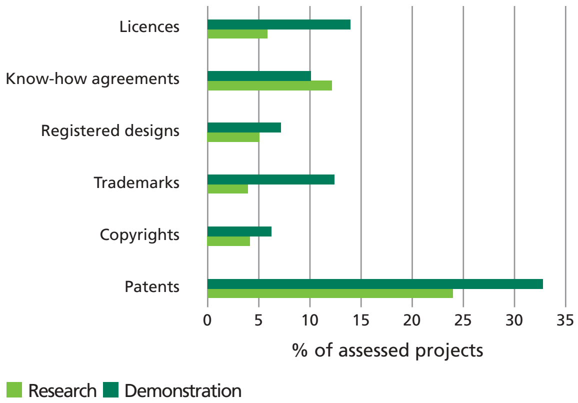


Figure 1-6: Intellectual property rights of research and demonstration projects



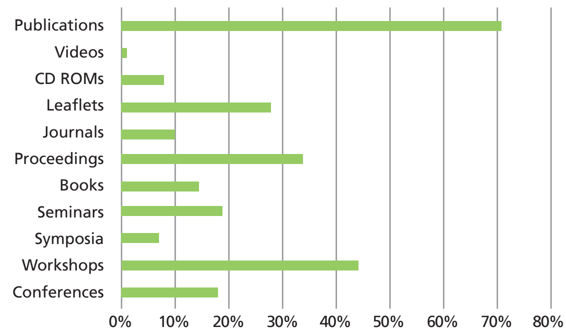
The exploitation of results can be differentiated according to the mode of exploitation: patents, copyrights, trademarks, registered designs, know-how agreements and, finally, licences. Figure 1-6 indicates the percentage of assessed projects that have declared an exploitation of results by type. **Patents arrive first, followed by licences and trademarks.** As expected, in general, there was better exploitation of the outputs of demonstration projects than of research projects: twice as many licences and trademarks and 50% more patents (in percentage of projects). However, research was more successful for know-how agreements.

Support measures

As the focus for support measures was more on dissemination, there is a breakdown of outputs by type of dissemination activity classified in four categories: conferences, workshops, symposia, and seminars (Figure 1-7). Close **to half of all projects organised a workshop** and between 15% and 20% organised a conference, with a large audience. As expected, dissemination activities organised more events than the other types of support measures (see Annex Figure A3). The total number of participants in events organised by all the support measures during the Non-Nuclear Energy Programme is estimated (using the assessed projects) at 75 000, of which close to 60% were involved in the dissemination projects. On average, **each event attracted 170 people**.

About 70% of support measures produced some kind of publication, ranging from books and leaflets to CD-ROMs and videos (Figure 1-7). However, **some 30% did not achieve good dissemination** of their results, which is surprising for this kind of action. On average, for projects with publications, around 3 400 items of published material were distributed. This represents a total distribution for the full programme of 1.5 million documents. Proceedings were the most common, followed closely by leaflets. The production of electronic media (CD-ROMs or videos) is rather low (6% and 1% of the projects, respectively).

Figure 1-7: Percentage of support measures with publications and events



CHAPTER 1

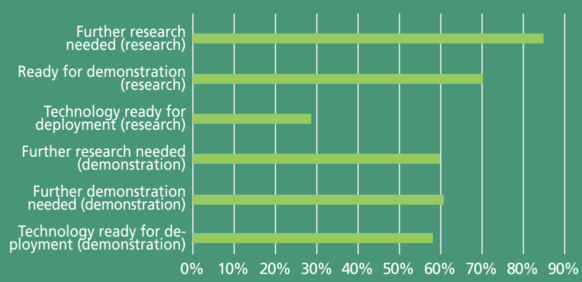
2 SCIENTIFIC AND TECHNICAL RESULTS

This chapter looks at the scientific and technical impacts of the projects. As a first step, the degree of maturity of the projects at the end of the Programme will be discussed. Then, the technical results and outputs will be presented. Finally, a third section will consider the economic aspects of the scientific and technical impacts. The results presented below are based on the survey carried out during the impact assessment on research and demonstration projects. It does not cover support measures.

2.1 Status of project maturity

The impact assessment tried to evaluate the degree of maturity of the research and demonstration projects on their completion to see how far research projects are from demonstration, to what extent research and especially demonstration projects are ready for market deployment, or when they will reach such maturity.

Figure 2-1: Degree of maturity of research and demonstration projects



With respect to research activities, large numbers were ready for demonstration (71%), although it turns out that additional research is still required for 84% of them (Figure 2-1). For those projects not yet ready for market penetration, it is expected that on average they will take five years to reach market maturity.

Although close to 60% of the demonstration projects are ready for market deployment, additional research or demonstration is still required for 60% of them. Such a result, which may be seen as contradictory, probably means that, although the technology can be commercialised, additional research or tests are necessary to improve their technical performance or cost effectiveness. Wind and solar PV are typical examples of technologies for which additional research and demonstration are still necessary although they are already on the market. The market deployment for projects not yet ready is assessed at about four years, i.e. one year less than for research projects.

A larger number of research projects felt that they solved practical problems that would impact on the everyday lives of EU citizens – almost 60% compared to about 30% for demonstration. In that case, deployment on the market was expected in about two and a half years after the end of projects for demonstration activities and slightly above five years for research.

2.2 Technical results and outputs

According to the impact assessment, about two-thirds of the projects achieve their objectives completely. For the remaining third, the coordinators estimated that, on average, 70% of the objectives were fulfilled.

Overall results

Most of the research and demonstration projects focused on the improvement of already existing technologies or techniques (72% for research, slightly more for demonstration projects, 76%) (Figure 2-2). Consequently, it was considered that the projects resulted in significant advances over the state of the art that had hitherto existed for 87% of the research projects on existing technologies and 81% for demonstration projects. In other words, 60% of the projects, either research or demonstration, resulted in significant technical advances.

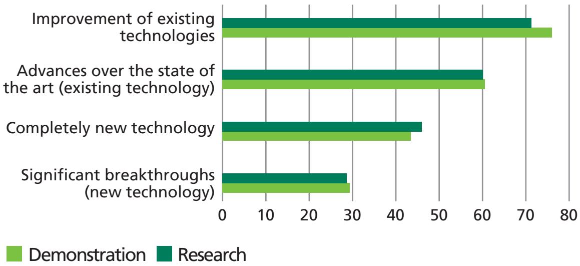
According to the project coordinators, some 40% of the projects aimed to demonstrate or develop a completely new technology or technique, with about 70% of these resulting in significant breakthroughs. In other words, 30% of all projects implied a technological breakthrough.

Examples of technological breakthroughs in the field of renewables include the use of biomass feedstock within fluidised beds, and achieving an efficiency of 9.3% for photovoltaic cells using flexible thin film. In the field of fossil fuels, the following examples can be quoted: real-time dynamics data while drilling, removal and installation of complete deck-units technology for offshore platforms, and the gasification of biomass and use of the gas produced in existing coal-fired power stations.

Scientific impacts

The scientific impacts of the Programme can be measured by the number of applications for patent protection and the number of scientific publications.
According to the survey, applications for patent protection during the life of the project accounted for about one-quarter of research projects and 15% of those who did not apply have indicated their intention to file an application for a patent once the project ends (Figure 2-3). Altogether 34% of the research projects assessed resulted in an application for patent protection. If these results are extrapolated to the whole programme, this means an effective number of about 180 patent applications resulting from the research programme (and a total of 240 patent applications, including the intention to make an application).

Figure 2-2: Technical outputs of research and demonstration projects



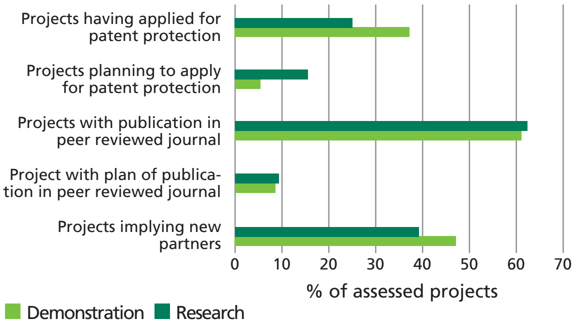
For demonstration projects, the rate of application for patent protection is higher (37%) as they are, by definition, more concerned with technology deployment: in addition, 5% of those not applying intended to do so at the end of the project. Consequently, the Programme resulted in 210 patent applications (and a total of 220 with planned applications).

It can be concluded that, in total, the entire NNE Programme resulted in about 400 applications for patent protection (ranging from 390 to 460, depending on the number of intentions turning into actual applications).

The results of about 60% of the projects have been published in a peer-reviewed scientific journal. This represents a minimum of about 800 articles for the whole research and demonstration programme (more, of course, if several articles were written); if publication plans are included, this concerns 70% of the projects (or 900 articles) (Figure 2-3).

The impact of the programme can also be assessed through the enlargement of the research and demonstration community. About 40% of the projects have brought in new players who previously had not been active in EU research or demonstration activities, with an average number of three new partners. This implies the involvement of about 1 600 new players in the whole programme.

Figure 2-3: Scientific impact of research and demonstration projects



Demonstration projects led to the deployment of hardware on the market in about 60% of the assessed projects; in three sectors (transport, electricity and heat generation), hardware was a main component (respectively in 80%, 75% and 67% of the projects). For research projects, hardware deployment was weaker (27% on average).

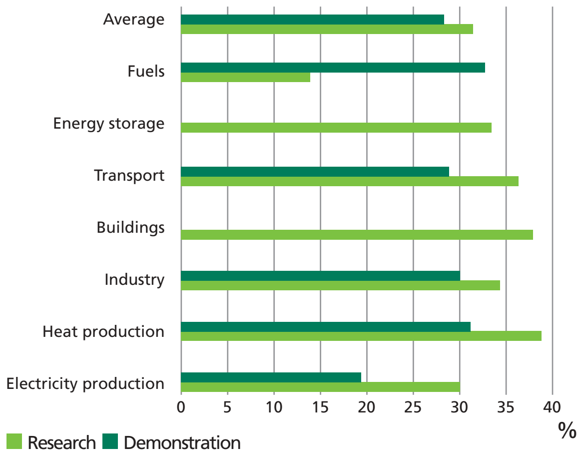
On average, about 70% of the demonstration projects included the deployment of a prototype or pilot: however, in two sectors – transport and heat generation – prototypes and pilots played a more dominant role (100% and 83 % respectively of projects with prototypes and 80 and 83% respectively with pilots). Prototypes were used in about 60% of the research projects and pilots in slightly less than half. The use of prototypes and pilots was the lowest in transport research projects and the highest in industry and heat production.

A majority of projects implied the development of new techniques or new concepts: more than 80% for demonstration projects and about 70% for research projects (Table A3 in Annex).

Energy efficiency gains
Finally, as a way of quantifying the technical success of the projects, the impact analyses considered the energy efficiency improvement brought about by the projects. Indeed, about 60% of the projects aimed, to some extent, at energy efficiency gains; this is far larger than for those projects classified as pure projects of rational use of energy. Figure 2-4 summarises the average efficiency gains, by sector, as evaluated in the survey. The sectors covered relate both to end-use sectors – industry, transport, buildings – and to energy supply – production of electricity or thermal energy, fuel conversion as well as energy storage.

The average efficiency improvement is around 30%, ranging from 13 to 38%. Apart from two types of projects – research projects on electricity generation and demonstration projects on fuels – experiments in all other sectors average efficiency gains around or above 30%, which is a very encouraging result.

Figure 2-4: Energy efficiency improvements resulting from the projects(6)



EU leadership and networking
One of the objectives of the projects was the drawing together of efforts by partners from different Union countries so that EU leadership in certain areas will be enhanced. This is obviously true for wind energy. The project coordinators estimate that EU technical competitiveness was significantly enhanced in the subjects covered.

Having multiple partners involved in the projects should stimulate networking. About half of the research projects included the integration of research facilities in project activities and enhanced networking. This dimension was less evident in demonstration projects with only 34% concerned. The degree of integration of research facilities in project activities was estimated at 58% for research and 32% for demonstration projects. Networking was improved in about half of the projects.

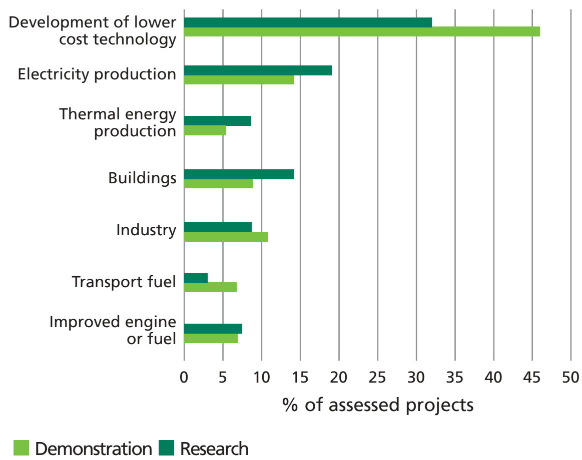
(6) Only sectors with more than four projects with valid answers in the sample were considered.

Key technical and scientific results:
- Two-thirds of the projects achieved their objectives completely.
- About 60% of the projects produced significant advances when compared to the state of the art, and 30% resulted in technical breakthroughs.
- The Programme resulted in about 400 applications for patent protection, more than 800 articles in peer-reviewed journals, and the involvement of 1 600 new players, not previously involved in NNE Programme RTD activities.
- About 60% of the projects aimed at energy efficiency improvements and resulted in average gains of 30%.

2.3 Economic aspects of scientific and technical impacts

Cost reduction
The development of lower-cost technologies, compared to previous, similar applications, was achieved in almost half of all demonstration projects and one-third of research projects. This cost reduction applied either to the cost of production of the electricity or thermal energy produced or to the energy expenditures of final consumers case of RUE projects (Figure 2-5). The number of projects aiming at lower cost is the highest for projects related to electricity production and buildings. On the other hand, less than 10% of the projects in the transport sector – either on transport fuels or improved engines – resulted in lower costs.

Figure 2-5: Projects resulting in cost savings



On average, the reduction achieved in the energy costs was 25% – slightly more for demonstration, with 29% (Figure 2-6). This result is fairly similar for the different sectors – in the range of 21 to 27%, except for projects on improved engines, where it was only 12%. The highest reduction was achieved in electricity generation, with the same success for research and demonstration projects, at 27%.

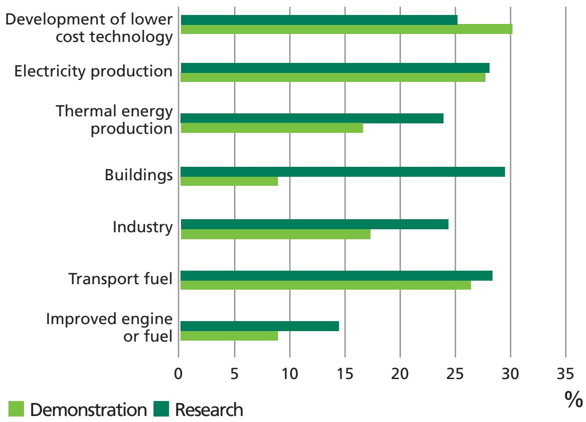
Return on investments

In about half of the demonstration projects, the partners expected a positive return on investments within the short to medium term; for research, because of the different nature of the projects, only 27% expected such a positive return. On average, for all research and demonstration projects, such an expectation was mentioned for one-third of the projects. It was estimated that on average this impact would be achieved about four years after project completion.

Co-operation with industry

In general, co-operation with industry was considered to be very positive. For 70% of research projects and almost 60% of the demonstration projects, the implementation of the projects resulted in strengthening the co-operation between RTD and industry. Actually, industry provided half of the total cost of demonstration projects. Of course, this figure was lower for research activities – about 30%. For the exploitation of results, the funding of industry increases to two-thirds of the costs, with very similar numbers for both research and demonstration projects.

Figure 2-6: Average cost reduction for projects resulting in cost savings



Key results:

- Almost half of the demonstration projects and one-third of research projects led to cost reductions;
- The programme resulted in a significant contribution to developing EU leadership;
- Positive return on investments was expected from the partners in half of the demonstration projects and one-third of the research projects; and
- Co-operation between industry and RTD was strengthened as a result of the Programme in more than 60% of the projects; industry provided half of the cost of demonstration activities.

CHAPTER 2

3 SOCIO-ECONOMIC IMPACT

This section looks at the socio-economic outputs and impacts of the projects at two levels:

- The overall macro-level impact on EU policy goals; and
- The micro-level impact on project consortia.

It then looks at three key issues:

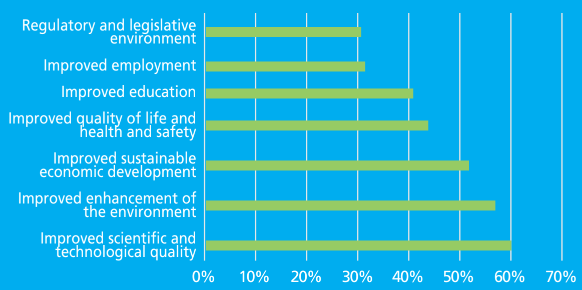
- The nature of the technical improvements;
- The nature of the environmental impacts; and
- The expected commercial returns.

This analysis uses a simple impact indicator which is based on survey answers[7], and is shown as a percentage of the figures on the horizontal axis. Roughly speaking, 0% means that no project had any impact and 100% means all the projects had a highly positive impact.

3.1 Impact on EU policy goals

Figure 3-1 below shows the responses of all project coordinators in the survey sample regarding the impact of their project on EU policy goals.

Figure 3-1: Impact of projects on EU policy objectives



Improved sustainable economic development

Overall, only 8% of project coordinators felt that their project had no impact in improving sustainable development – 63% felt that they had some impact and, indeed, 13% felt that they had a highly positive impact. Only 5% felt that issues of economic development were not applicable to their project. Whether the projects were explicitly aimed at economic development or not, the project coordinators recognised it as a legitimate impact issue – unlike, as we shall see, employment growth. There is little difference in impact between the sectors. Similarly, there was also little difference between activities, save that the support measures had a somewhat stronger impact. The lack of variance between activities and sectors may indicate a weakness in this question. It may also point to potential difficulties in asking for simple declarations of commercial potential in project proposals and their subsequent evaluation. It is unlikely that proposers, and much less evaluators, have a clear view as to how the proposed research translates into wide-scale commercial impact. More important to evaluation is probably the correct structuring of the project and the consortium to permit the exploration and availing of commercial possibilities during the lifetime of the project.

Improving employment

Over one-third of the project coordinators either found the question not applicable or too difficult to answer. Only 38% of project coordinators felt that they had made an impact in this area, and the strength of such impacts are relatively weak. The proportion of these projects with a "highly positive impact" is also very low, probably indicating yet again difficulties in judging future impact. By sector, Renewables and RUE tend to have the strongest impact, while RTD Strategy projects have a very weak expected impact. Overall, by activity, there is very little difference between the research, demonstration and support measure categories.

Asking project coordinators about the employment prospects of their work is extremely hazardous. Given the major uncertainties between a piece of research and the generation of a job, many project coordinators

(7) Project coordinators were asked to indicate the impact of their project on seven EU policy goals. The impacts were rated on a scale –1, 0, 1, 2, indicating negative impact, no impact, positive impact and highly positive impact, respectively. Projects were also permitted to offer two further responses "not applicable to project" – if the policy goal was deemed not relevant to the project work, and "impact too difficult to assess" – if assessing the impact was too complex an issue to be able to respond. The impact indicator is simply the number of projects indicating "positive impact" plus the number indicating "highly positive impact" with a weighting of 2, divided by the total number of projects indicating no impact, positive impact and highly positive impact. This gives an impact index ranging from 0 (no project had any impact) to 2 (all projects had a highly positive impact). This index was normalized by dividing by 2, then expressed as a percentage.

feel it is either an inappropriate question or one too difficult to answer. The low impact levels probably reflect these difficulties more than any strong statement about lack of job creation. Since coordinators can say very little about the employment-creating effects of their projects some three years after completion, it is likely they can say even less at the project proposal stage. Including "employment creation potential" as a proposal evaluation criterion presents difficulties.

Improved quality of life and health and safety

Over half the project coordinators (55%) saw themselves as making a contribution to quality of life issues. By sector, quality of life issues are seen as being particularly well addressed by RTD Strategy projects. By activity, the short-term support measures were regarded as having the greatest impact on quality of life, with dissemination and SME activities the strongest.

Improved education

One-third of the project coordinators considered this question not applicable. Along with the impact on regulatory issues, this was the highest number considering the issues as unrelated to their work(8). This said, over half saw themselves as contributing to the objectives. By sector, RUE project coordinators saw their projects as having the highest educative impact. But by activity there were major differences. Support measures – particularly dissemination projects and RUE projects – had very high educative impacts. Research projects, while weaker than support measures, had considerably stronger impacts than demonstration projects, probably due to the postgraduate research work being undertaken therein.

Improving the environment

Over half the projects are seen as having made a positive impact on environmental issues and a further quarter a "highly positive impact". Only 6% saw this objective as not applicable to their project. This is obviously one of the key areas in which the NNE Programme is having an impact.

All sectors witnessed a strong impact. However, RTD Strategy and RUE projects had particularly strong impacts, while the fossil fuels projects had relatively weak ones. There were fewer differences in expected impact between activities, although the short-term support measures regarded themselves as the strongest. Within activities, RUE project coordinators saw themselves as consistently strong. All types of support measures seemed to have the same high impact expectation – even in fossil fuels projects where it was a little low in research projects and remarkably low in demonstration projects.

Improving scientific and technological quality

Scientific and technological quality is where the project coordinators see the impact as greatest. Over half the projects were considered as making a positive impact on S&T quality and a further 30% a "highly positive impact". Only 7% are seen as having no impact. All sectors have a consistently high impact on S&T quality, with RTD strategy projects having the highest impact. Looking at activities, research projects have the highest impact, followed by demonstration projects. The more immediate support measures have a lower impact.

Within activities, all research sectors have very high impacts, with fossil fuels projects achieving the highest impact indicator of the whole assessment. Similarly, within the demonstration projects, the fossil fuel project coordinators see their projects as making the strongest contribution to S&T quality.

Regulatory and legislative issues

Impact on regulatory and legislative issues is another aspect project coordinators find difficult to answer: about one-third think that it is not applicable to their project. In all, about 30% of project coordinators felt that their project had some impact in the area. The only sector which had a strong – indeed a very strong – impact was RTD strategy. This is not surprising as most of them deal directly with such issues. Research and demonstration projects had a uniformly low impact in this area. Support measures were a little stronger in their expected impact.

- The strength of the projects lies in two areas: improving scientific and technical quality, and environmental impact. Projects make a valuable contribution to economic development.
- The impact on quality of life and education issues was less strong. Employment and legislative issues were the two areas where the impact was weakest, with many indicating that the question was not applicable. In addition, many project coordinators found the employment question was too difficult to answer.

3.2 S&T, environmental and commercial impacts

This section reviews the impact of the projects on specific issues within three areas:

- Improving S&T quality and enhancing the environment – these are the two main areas of impact, and
- The commercial impact of the project – an area seen as of particular importance in diffusing the benefits of the project.

(8) Indeed, as one might expect, there is a strong negative correlation (-0.85) between projects indicating that an issue is not applicable (N/A) and the level of impact the project has in that area. There were also weaker negative correlations between level of impact and finding the question too difficult to answer (TD) or simply not answering the question (DNA).

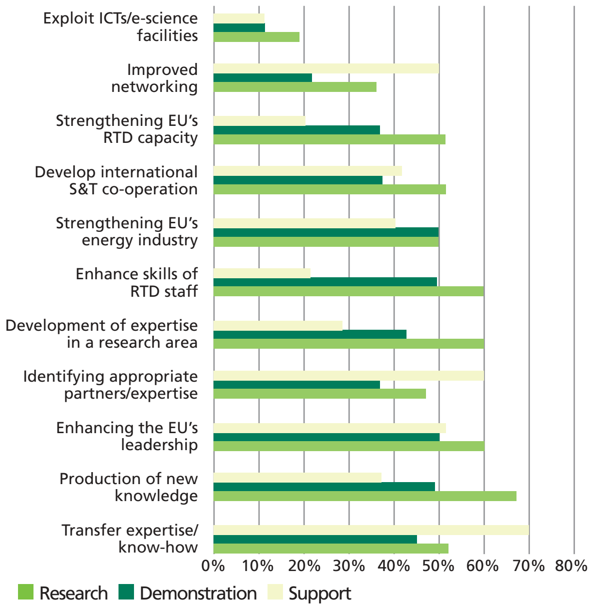
3.2.1 Impact on S&T quality

Figure 3-2 below shows the impact of the projects broken down by type of S&T impact and by activity. Most notable are the different patterns of impact generated by the various programme activities.

- Research projects, as might be expected, excel in the production of new knowledge, enhancing EU leadership, skills and expertise.
- Demonstration projects emphasise more the strengthening of EU industry.
- Support measures are strongest in the transfer of expertise and know-how as well as linking partners and networking.

All in all, it is the technological/scientific impact pattern of a well-tooled research programme in which the composite activities did what they were expected to do: research created new knowledge, demonstration acted more closely with industry, and support measures networked and transferred knowledge and expertise. This, of course, does not indicate the level of synergy and coherence between the activities – this we must search for elsewhere.

Figure 3-2: Type of S&T impact by activity



Project coordinators were asked about the impact before and after project end. Of course, there were consistent increases across all impact types but these were not large – possibly due to the vagueness of the question. The areas showing the strongest increase were in enhancing potential EU leadership and the eventual transfer of technology/expertise/know-how from the project. Breaking the impact down by sector shows few differences.

Programme activities deliver a logical structure of research impacts:

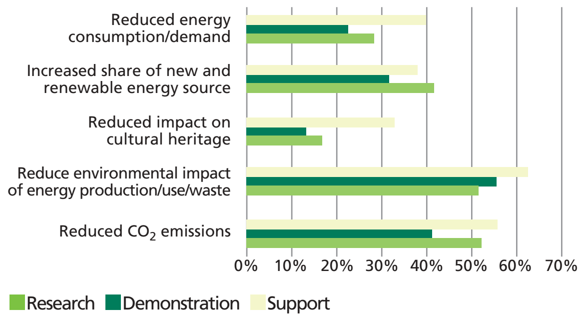
- Research projects are particularly strong in the production of new knowledge and expertise;
- Demonstration projects emphasise strengthening EU industry; and
- Support measures excel in technology transfer and networking.

3.2.2 Environmental impacts

Figure 3-3 below shows the expected impact of the various programme activities (research, demonstration and support measures) on key environmental issues after the project end. It is notable that the major overall impact of the Programme is in reducing pollution – both by the reduction of CO_2 emissions and by reducing the environmental impact of energy production and energy use. Reducing energy consumption and increasing the share of renewables in energy supply are weaker impacts.

Care should be taken in making comparisons across programme activities. Support measures are aimed at having an immediate, short-term direct impact. Research and demonstration projects, which seem to have a lower impact, have a broader and longer-term set of objectives than support measures.

Figure 3-3: Type of environmental impact by activity

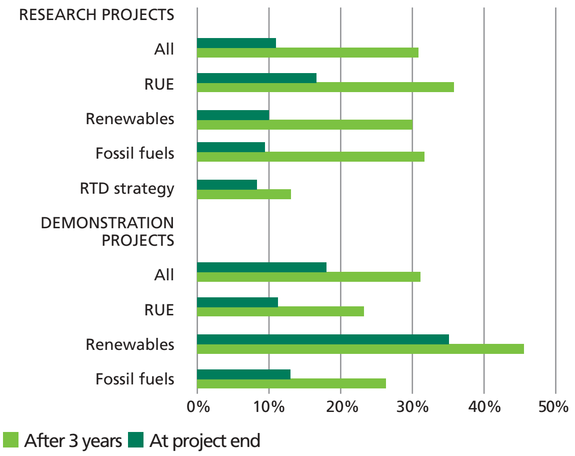


- The Programme's major environmental impact is in reducing pollution and CO_2 associated with energy production.
- The Programme's smaller and more immediate support measures are particularly effective.
- Research and demonstration activities look towards new, more efficient technologies and operate with a longer time horizon.

3.2.3 Expected commercial impact

The expected overall commercial impact from research and demonstration projects by sector is shown in Figure 3-4 below(9). The pattern resembles other overall impact indicators with research projects having a weaker general impact at project-end than demonstration projects, but strengthening substantially over the following three years. Again, it is not obvious that the similar magnitudes after three years for research and demonstration projects are not a statistical artefact.

Figure 3-4: Expected commercial impact by sector



Within research projects, RUE projects are claimed to have the strongest commercial success both at the end of the project and after three years, although RES and, in particular, fossil fuel projects catch up substantially. RTD Strategy/Modelling projects have weak commercial expectations both immediately and after three years.

Within demonstration projects, the pattern is very different with RES projects expecting the larger commercial returns at both project-end and three years on. While the commercial expectations for both RUE and RES projects improve over the three-year period, they remain some way behind RES projects. However, sample numbers and confidence are somewhat weaker in demonstration RUE and RES projects.

Figure 3-5: Expected commercial impact by location and activity

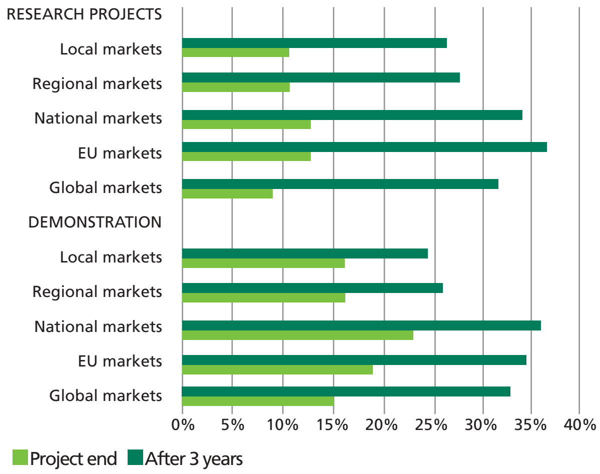


Figure 3-5 above shows the expected markets for the projects' commercial returns.

- For research projects at project-end, national and EU markets are somewhat stronger than local/regional markets on one side or global markets on the other. This pattern is seen in all sectors. The only sector with any confidence in global markets is the RUE projects. For RTD Strategy projects, commercial expectations are negligible outside 'EU markets', where they are, in fact, very strong.
- For research projects after project-end, despite strengthening, the overall pattern remains fairly stable but with greater percentage improvements in EU and particularly global markets than in local and regional markets. While all sectors show this pattern more or less, the major contributors are fossil fuel projects with large expected improvements in EU and global markets. RES projects are somewhat outside this pattern where expectations rest initially in EU then national markets. Global markets remain relatively weak. The commercial prospects for RTD Strategy projects remain generally weak and focused mainly on EU markets.
- For demonstration projects at project-end, national and EU markets are relatively strong. However, at the sectoral level, RES and RUE projects see themselves as having the strongest immediate impact in national, local and regional markets, while fossil fuel projects focus on national and Union markets.
- For demonstration projects after project-end, while all sectors strengthen expected impacts, this strengthening further emphasises the difference between fossil fuel projects, which now look to global and EU markets even more than to local or regional markets, and the RUE and RES projects which further emphasise local, regional and national markets.

(9) Support measures were not asked this question.

- RUE research projects and RES demonstration projects seem to have the strongest commercial potential. RTD Strategy projects have the weakest commercial potential.
- Research projects are initially strongest in national/EU markets. In time, the EU and global markets strengthen.
- In demonstration projects, fossil fuel projects tend towards EU and global markets, while RUE and RES projects emphasise local, regional and national markets.

3.3 Impact on project consortia

The research and demonstration projects (but not the support measures) were surveyed for the socio-economic impacts on the project consortium, that is to say the project partners. The project coordinator was asked(10):

- The scale of the *impact at the project-end*, by indicating the strength of different categories of impact on the project consortium; and
- The scale of the *impact three years after* the project had finished.

The overall programme

Looking at actual strength of impact at project-end within the consortium, we find:

- The strongest impacts relate to the innovative capabilities of the consortia.
- Strong impacts were then seen in areas relating to improving business position and competitiveness and the development of entry into national and international markets.
- Weaker impacts were associated with the actual financial benefits of any innovativeness or improved business presence: increasing financial viability and turnover were not seen as strong impacts from the work undertaken.
- Weakest impacts were seen in the whole costs area: reducing capital or labour costs, reducing overheads, etc.

Three years after the project-end there was very little change in the ranking of inputs. However, the benefits of the innovativeness and business capability gained during the project started to become more evident. At the end of three years, we find:

- The largest proportional increases in impact in areas related to markets: entry into new and international markets, and increasing market share.
- Strong increases in areas related to financial viability and profitability.
- Areas related to innovative capability have not increased very much and the categories of "qualifications gained" and "enhanced reputation" have essentially stayed static.

To summarise, the major impacts on the consortia involve improving their technical innovativeness, and improving staff qualifications and the reputation of the participants. These types of benefits are, by and large, delivered in full by the end of the project. There is no sizeable increase in impact over the following three years. In fact, they might more correctly be called outputs of project participation, rather than impacts.

The impact on business capacity is quite strong at project-end, but grows over the following three years. Improvements in market position and in financial viability and profitability are weak at project-end but grow significantly over the following three years – but they are still not ranked as strongly as innovation or business capacity related impacts.

All in all, the data provides a coherent picture of partners obtaining high levels of technical innovativeness during their participation in the project. Good business capacity is built up during the project and afterwards. Over the three years following project-end, these then translate into improvements in market position and start to show up as financial viability and profitability.

Comparing research and demonstration projects

Very different impact patterns can be found between research and demonstration projects, which reflect their different organisation and objectives. Demonstration projects have a stronger immediate impact – mostly due to impact on cost factors – but in the following three years increases are less pronounced than those in research projects. In fact, overall impact indicators at the end of three years are not significantly different for research and demonstration projects. Whether this is a statistical artefact or a true indicator of similar impact is difficult to say.

At project-end, research projects showed very high innovativeness impact and good impact on business capacity (including new and higher-quality products and services), but were weaker in market and financial impacts and weakest in cost issues. Demonstration projects, while indicating strong innovativeness, also show much stronger cost impacts (reductions with respect to existing processes, reduced material costs and reduced capital costs) than research projects.

Looking at some of the individual impact categories – again at project-end – the strongest impact for both research and demonstration consortia is, in fact, "enhanced reputation". Participating in EU projects is a high-profile activity and, in itself, is good for the partners who recognise the benefits. Research projects also rate "qualifications gained" highly followed by the innovativeness categories of "improved innovativeness",

(10) The project coordinator was also asked to estimate the likelihood of certain types of impact occurring. It was to have been a measure of the confidence in a particular impact actually occurring. Unfortunately, this indicator was highly correlated (0.98!!!) with the expected impact after three years. Hence, its utility is negligible and it is not used in the analysis.

"higher quality goods, services", and "expanded product/service range". For demonstration projects, "qualifications gained" drops down the ranking, while "reduction of costs with respect to conventional solutions", is higher, closely followed by the innovativeness categories and then the other cost categories. It is interesting to note that the impact of research projects shows a large drop when moving from the innovativeness categories to other areas. This is not the case with demonstration projects where there is a much more even impact across categories.

Three years after project-end:

- Research projects see a major strengthening of impact on the consortia, particularly in addressing markets (international markets, entirely new markets, strengthening domestic markets) and in cost factors. However, while impacts related to innovativeness increase relatively little after project-end, they are still regarded as the dominant impact – followed now by market impacts. Cost and financial improvements remain at lower levels.
- The pattern is very different for demonstration projects. The level of impact expected increases relatively little – the average of the impact indicators increases by 26% for demonstration projects compared to 83% for research projects. The strongest demonstration project increases are in the area of strengthening markets and overall profitability and viability. Innovation increases are next to negligible, but are still seen as most important, along with strong cost reductions.

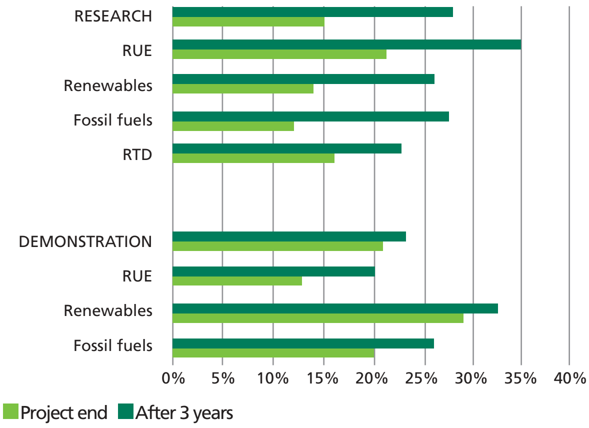
The difference between research and demonstration projects is striking – they are truly different tools:

- Demonstration projects deliver strong immediate innovation and cost-reduction impacts. But there is relatively little increase in impact levels over time, except in the area of improving market penetration and a steady improvement in cost savings.
- Research projects see much weaker impacts at project-end, although indications of improved innovativeness are high. Over time, the indicators of research project impact increase to the same levels as those of demonstration projects, with very strong increases in markets and cost improvements. How far this "drawing level" is a reality or a statistical artefact is difficult to tell.

Comparing impact across sectors

Figure 3-6 below shows the average of impact indicators for research and demonstration activities broken down by sector.

Figure 3-6: Overall impact on consortia by sector and by activity



Looking at research projects

Looking at the differences between sectors within research projects, we find that all research projects indicate essentially the same major impacts: improved innovation performance, enhanced technical reputation and qualifications gained. The exception is the RTD Strategy sector which rates expanded product/service range as the most important immediate impact of their projects. This said, RUE projects are remarkable for their immediate impact on energy savings at the end of the project. The other types of projects rate immediate energy savings as very low. Instead, renewables and fossil fuel projects indicate a wider range of improvements in their products and services as their major impacts.

Looking at impact on markets, RTD Strategy projects see their work as having quite a strong impact on market performance indicators with the tools and techniques which they have developed – but as we have already seen, this is essentially for EU markets. Other sectors were somewhat less hopeful as regards market impacts. RUE emphasised expansion in national and existing markets, while fossil fuel projects stressed that their work would lead to entry into new markets – be they geographical- or technology-based markets.

For all sectors, the least important immediate impacts revolve around capital and labour costs as well as material input costs. The only cost factor which research projects see themselves as having a reasonable impact on is costs with respect to conventional solutions. This said, RUE has a reasonable impact on material input costs.

After project-end, certain changes can be seen:

- RUE projects now see energy savings as their number-one impact, while in other types of projects the impact ranking accorded to energy savings has actually dropped.
- In RUE and fossil fuel projects, while technical innovativeness remains the major impact, there is a noticeable strengthening of market-related impacts.
- RTD Strategy impact rankings remain fairly stable.

In fact, all sectors point to market improvement indicators, particularly international markets, as having the greatest proportional increases. Fossil fuel projects also emphasise very strong improvements in cost factors and financial viability and profitability. RUE projects, while seeing improvements in market and cost improvements, also point to improvements in energy savings and financial viability. RTD Strategy projects, in particular, see a very strong percentage increase in the setting of standards. While showing good percentage increases in all sectors, in absolute terms, cost factors remain low impacts.

- All sectors see technical innovativeness as the main impact on their consortium.
- RUE projects have a particularly strong impact on energy saving.
- Cost factors are very weakly impacted by research projects in all sectors.
- Market factors show, proportionally, the largest impact increases once the project has finished.

Focus on demonstration projects

Generally, RES projects consider themselves to have the strongest impact at project-end, followed by fossil fuel projects, then RUE projects. RUE projects strengthen considerably after the end of the project, but the ranking remains the same. A ranking of the impact indicators at the end of the demonstration project shows:

- RUE projects' impact indicators are strongest for energy and cost issues. Market indicators are consistently low.
- RES projects also emphasise energy savings, but below the reputation and qualifications indicators.
- Fossil fuel projects emphasise the innovation indicators. The ranking strongly resembles that of the fossil fuel research projects, rather than other demonstration projects. Indeed, energy-saving indicators receive a low ranking, similar to research projects.

After the project-end, all sectors retain much the same ranking of impacts. RUE projects show large increases in improving profitability and market share but, in absolute terms, market indicators remain very weak. RES projects also show a noticeable improvement in market indicators. And fossil fuel projects still resemble research projects, rather than other demonstration projects.

- RUE demonstration projects are remarkable for their immediate and longer-term impact on energy savings and cost.
- RES projects also have a strong impact on energy savings, but put somewhat greater emphasise on the market dimensions.
- Fossil fuel demonstration projects are peculiar in that their impact profile resembles more closely those of research projects.

4. IMPACTS OF PROGRAMMES BY SECTOR

4.1 Socio-economy Research and Modelling

The Socio-economic Research and Modelling sub-programme was a small, specialised set of policy research projects linked to the production and utilisation of energy, along with the development and application of new models for the analysis of medium- and long-term energy-environment-economy scenarios. Their objective rested on the need for the definition and implementation of a global strategy for energy RTD. Most of the projects undertaken were, to a large extent, inspired and guided by the intense debate around the Kyoto Protocol.

The implementation of the Kyoto Protocol will emphasise a growing need at European Union level for specific decisions concerning the enforcement of policies that aim to reduce greenhouse gas emissions. Any policy mix to be considered must take into account a number of interrelated issues and requires the use of a number of new or improved tools that FP4 started to provide.

Thus, modelling tools had to be adapted to include the EU commitment to diminishing its greenhouse gas emissions by 8% of their 1990 level by 2008-2012. Energy efficiency modelling had to be improved and renewable energy sources introduced more accurately in data banks. Results of technical research and of the ExternE project, in particular, were able to provide good data for the models and enabled the analysts to use realistic and coherent estimates of impacts and costs.

The research provided a better understanding of the non-technical barriers to the implementation of energy efficient and renewable energy technologies, and ways to overcome these barriers, as well as associated recommendations.

The energy modelling allowed model-based analysis on energy technology dynamics and energy policy modelling. They also improved and extended the large-scale energy-environment-economy models to examine and quantify different policies targeted at greenhouse gas (GHG) abatement, as well as the economic implications of European directives. Such accurate modelling can help to guide policy along the most effective and efficient routes. With modelling, the costs, benefits and feasibility of different approaches can be examined and the possible solutions better explored before potentially expensive policy is adopted. Box 4-1 gives an example of a particularly successful project on modelling.

Finally, these results provide a tool for the consistent evaluation of policy measures in terms of their different implications for individual EU countries, sectors and consumers, at the level of detail needed to support concrete policy-making. This possibility is accomplished by the use of an extended version of a general equilibrium model which was developed on behalf of the Commission for DG Research.

The projects were well suited to the objectives outlined. However, they were too disparate to allow the development of a proper overall cohesive synthesis, as each model is a world in itself and does not easily lend itself to direct comparison with the findings of other models. The number of projects was too low to permit important and diversified advances in knowledge.

Box 4-1: A success story in modelling: Demand Side Management in European Electricity Markets

The project focused on domestic electricity use for lighting, refrigeration/freezing and space heating. The results of past and present energy efficiency programmes were combined with extensive market and consumer studies as the basis for quantifying and analysing the long-term environmental, economic and commercial impacts of various possible government and utility energy strategies and actions. The impact of such strategies and actions on the environment was assessed using market penetration and cost-benefit models.
The results of the modelling process showed that by simply putting energy efficiency measures into house-

holds, it would enable the particular countries involved to meet their Kyoto emissions targets at a fraction of the cost of any other measures. However, if the measures set out by the study team were applied to other household energy uses, the positive environmental results would be much greater since approximately 85% of household energy use is accounted for by non-electricity consumption. It also indicated that CO_2 abatement through such energy efficiency measures is between three and 20 times more cost effective than renewable energy approaches.

In addition, the project analysis suggested that the standards for appliances and building energy efficiency should be raised annually. Direct and tax-based incentives to retrofit all existing housing stock were also indicated. The analysis showed the weaker energy efficiency role of utilities in liberalised markets and the consequent need for strong government initiatives. There is great scope for meeting Kyoto Protocol targets through simple, effective efficiency measures.

The results obtained by teams in numerous EU countries are now available to every European country for the development of their own national climate action plans and energy policy planning, for instance. In turn, the results also triggered the implementation of programmes in various Directorates-General (DGs), such as the Special Action Programme for Vigorous Energy Efficiency (SAVE) for energy efficiency. With the results of its research on EE and RES, the EU can now securely advocate a strong climate stabilisation policy. The European Climate Action Plan states that 40% of the Kyoto target can be achieved by energy efficiency, and RES could help fill the gap and displace fossil fuels. These potentialities, however, ought to be better known and promoted within the EU because not enough is being done to actualise them. The EC has a critical role to play in gradually phasing out perverse subsidies to polluting forms of energy and in translating RTD results into action if the appropriate investments are ever going to be made.

The key messages:
In the field of RTD Strategy, the number of projects was too low to permit important and diversified progress. Since they are tools to be used to decide on future technical research, a greater emphasis should be given to upstream policy research.

The involvement of potential users and NGOs at an early stage of project development would ensure that the tools developed are fully adapted to the needs, largely used afterwards, and that the results are widely disseminated, thus improving the Programme's impact.

The methodologies which were developed in the projects and gave leadership to the EU in this field need to be monitored and nurtured. This requires continued support to regularly improve and update these models. There is also a crucial need to disseminate the information within a short time frame while it is relevant and useful.

To reach coherent decisions, all energy RTD projects, nuclear or otherwise, should be selected by the same process and compete fairly, as the relevance of some energy production projects promoted by the EU would seem to be at odds with modelling results.

The tools developed by RTD are designed to help decision- and policy-makers take enlightened decisions. The EU should ensure the follow-up of the results to see that they are consistent with its own programmes and to enhance the investment made in RTD.

4.2 Rational use of energy

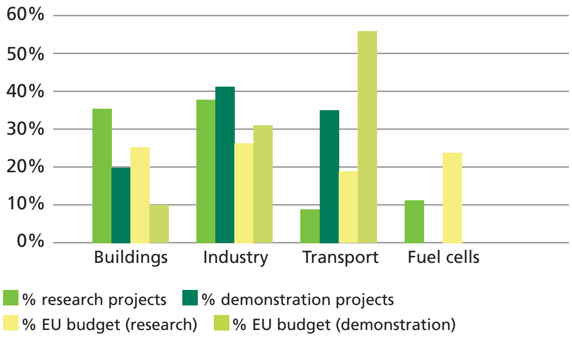
Rational use of energy was and is the major issue to reduce energy consumption and, at the same time, GHG (green house gas) emissions in Europe. In most Member States, its potential ranks higher than renewable energy sources. The underlying reasoning is easy to understand: rational use of energy can be applied in building stock and in existing industries, offering immense potential in short- and mid-term energy saving. Rational use of energy means less input to achieve a given output (i.e. production of goods or the conditioning of space or processes) or – vice versa – more output with a given amount of energy input. Although rather simple from a methodical point of view, attaining these objectives requires the application of new and/or enhanced techniques during the complete life cycle of the 'energy consumer', be it a building, an industrial process or a transportation system. The various phases, from planning and engineering design through construction and installation and on to operation and production, require a combination of the research and demonstration approach.

The projects assessed in this field covered 98 research and 14 demonstration projects in four sectors, buildings, industry, transport and fuel cells, and accounted for a EU contribution of €98 M for research and €14.9 M for demonstration. Though transport and fuel cells represented only 25% of the number of assessed projects, they made up almost 50% of the EU budget, which means that these sectors had the larger, more complex, and relatively more expensive projects. The average EU contribution was about €1 M per project. Industry took up the greatest budget share in the research sector (about 27%) while transport took the first place (56%) for demonstration (Figure 4-1).

Almost half of the RUE projects focused on the development of new or enhanced components in the different sectors and 18% dealt with process optimisation in industry. As a rough estimate, nearly 70% of the research projects hit, or came near to, their technical targets, which appears to be fair and is surely better than what can be expected considering the inherent risks of research.

Demonstration projects did better in achieving about 90% of their technical objectives, but fell short in closing the gap to the markets. Only about one-third produced commercially viable results, e.g. products/solutions with commercially acceptable payback periods, i.e. of less than three years in industry and less than seven years in buildings. Project coordinators estimated that an average of another three years (time-to-commercialisation) would be necessary to enter the market with the developed products.

Figure 4-1: Assessed projects on rational use of energy



4.2.1 Buildings

RUE in buildings has achieved a mature state and is not a field for radical innovation. After so many years of research, progress here is incremental and aims mainly at improving existing techniques for newly erected and/or retrofitted buildings – the latter being a vastly more attractive field. Specific research dealing with indoor air quality and the adequate maintenance of ventilation plants in buildings went beyond energy efficiency and contributed positively to the quality of life and health.

The research projects here covered the following fields: methodological approaches (e.g. provision of climatic data, engineering software for buildings), components with improved energy gain factors, either for heating, ventilating and air-conditioning systems (e.g. burners or heat pumps) or for the building envelope (e.g. 'smart windows'), more efficient processes (solar driven or desiccant cooling)(11), and improved control systems/strategies ('intelligent' or adaptive controls). Further issues concerned indoor air quality (e.g. determination of the requirements of ventilation rates and development of measurement techniques) and, finally, new design concepts for buildings, integrating architecture, technical equipment, and control aspects, altogether.

About three-quarters of the projects involved the deployment of new techniques or new concepts and 80% involved practical research.

Most of the projects delivered improved components and prototypes, but did not come near to a state required for commercial deployment. However, since researchers and industry have been working intensively in this area at national and international levels for many years, an easy and surprising technological breakthrough could not, realistically, be expected.

For new buildings, the design issue doubtlessly has the highest potential: if followed up subsequently, office buildings in half of Europe could be operated with a specific primary energy consumption (i.e. heating and electricity for ventilation and lighting) of less than 100 kWh per square metre without loss of comfort standards. This would represent energy savings of between 50 to 70% compared to today's average energy consumption level. The basic idea is to use natural air convection, thermal storage of a highly insulated building and daylight to provide comfortable conditions without much auxiliary energy being needed. If cooling is required, mechanical ventilation at night using cold outside air induces comfortable office temperatures. In addition, renewable energies may complement this scheme: season-al heat storage in the ground or solar-driven, absorption or desiccant cooling plants for the summertime. The design of such buildings/systems requires great skill and inter-disciplinary teamwork by architects and engineers and the use of sophisticated computer models. Here, innovative building design influences progress in computer-simulation techniques and vice versa.

According to the assessed projects, the average energy savings obtained is 37% for research projects; this gain is much higher for demonstration (61%), but only concerns three projects, which cannot be regarded as representative.

Some of the research projects (about 15%) aimed at lowering the cost of energy use in the buildings, with an average cost reduction of 28% (36% for electricity and 16% for thermal energies), while some of the techniques developed implied higher investment costs.

4.2.2 Industry

RUE in industry has a high potential in Europe and is, in many cases, on the verge of profitability. By concentrating on generic techniques (e.g. soft tools such as software, methodological approaches and/or common

(11) Including processes with reduced global warming potential by substituting CFHC refrigerants with ammonia or other less obnoxious working media (e.g. propane, butane).

devices like heat exchangers, separation techniques, etc.) a huge replication potential was opened up. The industrial projects show that energy efficiency techniques can be combined with 'process intensification'. The efficiency of plants that are more compact in turn leads to lower investment costs. This again improves the international competitiveness of European industry, not only for the operators of the efficient processes, but also for the manufacturers of energy efficiency equipment. Target markets are the EU Member States and non-EU markets (mostly Central and Eastern Europe as well as the developing countries).

In industry, major efforts were devoted to 'generic' techniques such as enhanced separation and distillation processes, process engineering to improve processes or to introduce new ones, design of common components (heat exchangers, furnaces, ovens and kilns) and other equipment for energy efficient operation and compact installation, control strategies and sensors and modelling(12). All this can be classified under the term *process intensification*, which means designing processes in a way that they run with less pollution and greater energy efficiency on more compact and therefore (often) less costly equipment.

About 75% of the projects implied the deployment of new techniques and/or new concepts, as well as practical research in industrial processes.

About 60% of the projects were related to a specific branch with a representative participation of industry. This mixture of branches and approaches was intended to create the greatest potential for replicating successful technologies in other branches and even transsectoral, e.g. in the transport or building sector.

Many of the industry projects uncovered a high potential for waste heat recovery, for the use of energy saving components and process intensification, and demonstrated it. Thus, with a share of nearly 30% of energy consumption in the EU, the industry sector promises the best mid-term impact by applying these techniques, theoretically. In practice, however, innovators face a rather conservative clientele: as long as energy is relatively cheap, hardly any manager would dare to experiment with a 'new' system at the risk of a two-day production standstill, which would probably cost more than the actual value of the energy saving for a whole year. Furthermore, industry managers are willing to invest in energy saving equipment and measures only when the technique is proven and the payback period is typically not longer than three years. This means that the return on the investment must be guaranteed here in much shorter terms than in the building sector, for instance.

Process intensification can reduce capital investment and operating costs (energy, maintenance) and, at the same time, innovative and successful industry projects can strengthen the international competitiveness of European manufacturers.

The energy savings realised in the various projects and areas range from zero to 40%. On average, the efficiency gain was 34% for research projects and 30% for demonstration. Various projects dealing with burners and heat exchangers identified and proved an average saving potential of about 12%. Higher efficiency gains were observed with the introduction of new distillation and separation processes in the chemical industries: here, up to 40% energy and/or product input savings were achieved, and the processes proved feasible for large-scale applications in the mid-term perspective.

Reduction of the energy cost was not a priority in most projects: only 10% of them resulted in a cost reduction – on average, that was 23% for research and 16% for demonstration projects.

4.2.3 Transport

RUE in transport was covered by ten research projects, dealing mainly with components: batteries, energy storage with flywheels, super capacitors, and batteries for vehicles. Five demonstration projects in urban transport were carried out. The aim here was to achieve a reduction in investment and operation costs by developing new, multi-purpose vehicles (passengers *and* goods) and inducing modal transfer from private to public transportation. The average research project had a volume of €4 M and the demonstration projects €4.6 M; the total EC contribution amounted to €28.4 M – i.e. around 25% of the total RUE programme budget. This alone shows the importance the EU attributed to this sub-sector – a sector in which approximately 32% of the total European energy consumption occurs.

Overall, 60 cities in Europe were involved in urban transport projects, attracting a lot of public attention. Not surprisingly, the compound transport projects achieved very good and visible results.

All demonstration projects implied prototyping, which was also the case in almost 40% of the research projects. Compared to the other RUE research projects, the survey shows that less projects focused on new techniques or concepts (only 50% compared to more than 70% for the other sectors.
CENTAUR was one outstanding project, probably showing the highest degree of multi- and inter-disciplinary partnerships in urban transport (Box 4-2).

(12) For example, CAPE (Computer Aided Process Engineering) tools for "Energy Synthesis" (SYNEP), CFD (Computational Fluid Dynamics) and so-called Expert Systems (EXSYS).

Overall, the transport-related projects covered both the improvement of urban public traffic as well as the development of low-emission electric vehicles for private transport, and gave promising results.
The average energy efficiency improvement observed for the research projects was 36%; for demonstration, the gain was slightly lower (29%). According to the survey, only about 5% of the projects resulted in a decrease in fuel costs.

Box 4-2: Two RUE success stories

Ten cities participated in the CENTAUR[13] project (Barcelona, Bologna, Bristol, Dublin, Graz, Las Palmas, Leipzig, Naples and Toulouse). The total energy savings resulting from the measures implemented (e.g. hybrid buses, information systems) rose from over 250 toe per site per annum after the first year to almost 800 toe per site per annum over a five-year planning period.
Another project involving hybrid bus comprised a bus fuelled with biogas driving an internal combustion engine which loads the accumulators for the electric wheel motors. This was undertaken in Uppsala, Malmö and Bolzano. It achieved significant reductions in pollution (CO2: -30%, CO: -60%, NOx: -50%) and, in addition, received good ratings from the users (80% of those interviewed considered the buses to be good, and the accessibility of the hybrid buses was increased by 50%). Due to their large volume and the participation of so many cities (clustering), these projects incurred enough critical mass to be perceived by a broad public. The multi-national, interdisciplinary, and even trans-sectoral approach from modal traffic planning, from new vehicles to new services, created perceivable European added value.

4.2.4 Fuel cells

Fuel cell research was the topic of 13 projects, focusing on basic research into materials and processes, and ranging from prototyping of components to the construction of pilot plants, both for stationary (household or small-scale CHP – combined heat and power generation) and for mobile (portable and automotive) applications, operated with different fuels (hydrogen, natural gas or methanol) as well. No demonstration projects was performed on fuel cells which is not surprising since fuel cells were not sufficiently developed for practical pilot installations at that stage.

Most of the projects were successful in reaching their technical goals – partially, at least – as far as power output, fuel efficiency, and compactness/weight and durability were concerned, the far target being a fuel cell with a volume of 1 litre and a weight of 1 kg per kW_e. Not so effective were the efforts made to narrow the gap to market introduction, a cost range of €100 to €200 per kW being the goal here. Researchers in industry expect that fuel cells will not gain momentum during the course of the next ten years. Then, they may have a brighter future in stationary applications than in automotive applications. Apparently, fuel cells will not be the magic remedy for a carbon-free production of electricity and/or automotive energy, at least not in Europe where renewable resources for producing hydrogen are limited. Furthermore, hydrogen is an unwieldy fuel for vehicles because of the pressure required in the tanks (at least 200 bar or 200 times the atmospheric pressure). To extend the operating range of the car, high-pressure tanks were developed (for pressures up to 700 bar). These devices pose many problems regarding safety regulations in passenger transport and at refuelling stations. With methanol fuel cells, the ultimate fossil conversion efficiency is estimated to reach 27%, which is low compared to today's best internal combustion engines.

All this may be the reason behind some companies either terminating fuel cells development or freezing it. Indeed, firms hesitate to invest in research and technology development with horizons beyond three years. Here, the typical 50% subsidies from the EU or national programmes may not be a sufficient stimulus. According to expert opinion, what is needed is more *basic research*, mainly in materials (catalysts and MEA - membrane electrode assemblies) and production processes.

The key messages:

- RUE in buildings has achieved a mature state, where certain, but incremental progress can be expected. Specific research dealing with indoor air quality and the adequate maintenance of ventilation plants in buildings went beyond energy efficiency and contributed positively to the quality of life and health.
- RUE in industry has a high potential in Europe (and an even higher in developing countries). In many cases, it is on the verge of profitability and "process intensification" has a huge replication potential. Projects here helped to increase the international competitiveness of European industry, not only for the operators of the efficient processes, but also for the manufacturers of energy efficiency equipment.
- By far the greatest compound impact regarding energy savings, pollutant abatement, social effects, and European added value could be observed from the clustered demonstration projects in transport. More than 60 cities were engaged in concerted actions to develop, demonstrate and operate clean and efficient urban transport.
- Fuel cell research leapt ahead in technical progress, but is bound to need possibly another ten years to become commercially viable for everyday mobile and/or stationary applications.

(13) CENTAUR: Clean and Efficient New Transport Approach for Urban Rationalisation; in addition to the ten cities involved, Krakow will follow as an eleventh.

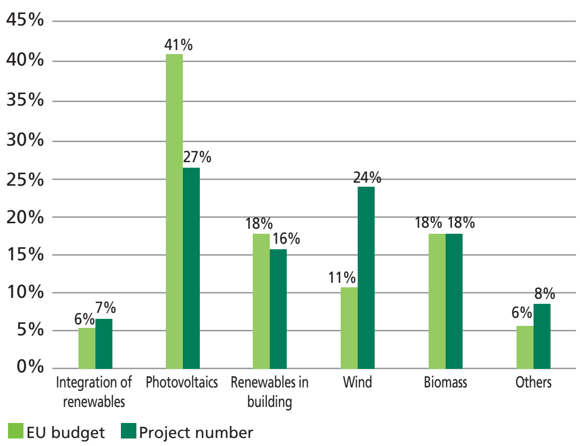
4.3 Renewables

The European Union wants to increase the use of renewables, mainly as a way of reducing GHG emissions and meeting its Kyoto target. The White Paper on Renewable Energy, adopted by the European Commission in 1997, was the EU's first strong commitment in that area. It was followed by the adoption in 2001 of the European Directive on the Promotion of Electricity from Renewable Energy Sources in the Internal Electricity Market, fixing a target for the EU of 12% of gross consumption of renewable energy in 2010.

The 268 projects assessed on renewable energies, 17 of which were demonstration projects, covered six areas (Figure 4-2):

- Integration of renewables into everyday life and in the energy market;
- Photovoltaic (PV), with a focus on the reduction in the cost of PV systems and an increase in energy conversion efficiency to make them competitive in the electricity markets; demonstration projects to raise awareness and confidence in PV generators;
- Renewable energies in buildings covering the development of sustainable energy use in buildings (e.g. improved indoor living and working conditions), and demonstration of active and passive solar tech-nologies for heating, cooling and lighting;
- Wind energy, with a focus on the improvement of wind turbine reliability, public acceptability and cost reduction to increase market penetration of wind energy in the EU;
- Energy from biomass and waste, with the development of new technologies to allow the use of less expensive and more environmentally friendly biomass; and
- Other renewables, such as wave, solar thermal energy, geo-thermal and storage.

Figure 4-2: Assessed projects on renewables



Pilot plants and prototypes were designed, manufactured and tested in many of the projects. Others dealt with the development of simulation models and software programmes to predict and simulate the performance of new plants and technologies.

Some of the assessed projects achieved significant breakthroughs. Projects dealing with bio-fuels made from biomass and waste achieved the use of waste as feed-stock for energy conversion, for example, in fluidised bed reactors. Significant break-throughs and encouraging results were also obtained by some photovoltaic projects significantly improving the efficiency of multicrystalline silicon cells and the technology and manufacturing processes of thin-film cells, leading to a cost reduction for photovoltaic energy. For instance, an efficiency of 9.3% was achieved for photovoltaic cells using flexible thin film.

The integration of renewables into buildings offers a great potential both for using clean energy and energy savings. Renewables in buildings opened a new market for enterprises not previously active in the energy area. With the integration of renewable energies, especially photovoltaic, some companies found a market niche for their products.

Investigation into the application of wind energy on unconventional sites might contribute to a wider market penetration of wind energy in the future. Basic research in wind energy led to a better understanding of the behaviour of windmills under various conditions and to improved designing tools. Enhanced wind forecasting and a qualified and controlled wind field database, which is widely used for planning wind energy plants, have improved the chances of a wider market penetration by wind energy.

Research efforts into renewable energies found that to achieve a broad dissemination and market penetration for renewables, a suitable legal and organisational framework has to be put in place. Besides this, a comprehensive awareness of the benefits achieved by enhanced information tools (e.g. internet platform) is regarded as a basis for a wide market penetration.

4.3.1 Integration of renewable energies

In general, the projects related to the integration of renewable energies aimed at establishing a long-term, stable market place for renewables.

To achieve the full benefits, renewables must be thoroughly integrated into the economy and the daily activities of EU citizens, as well as within the EU energy system.

One major conclusion to be drawn is that the integration of renewables into everyday life of society and into the energy supply structures requires an adequate legal and organi-sational framework along with an awareness within society of the benefits of renewables. Guaranteed availability of cheap biofuels and adequate legislation to allow for the 'valorisation' of the sector at the start of investment in renewable energies are considered to be some of the most important factors for the integration of renewables. Integration into every-day life of society has been addressed poorly.

To help establish a real sustainable energy supply, integration of renewables into everyday life should be thoroughly investigated in future programmes, for example by putting greater weight on questions concerning the benefits to society of renewable energies in everyday life, acceptance of the end-users and the conditions of acceptance (i.e. socio-economic and social aspects) with regard to the installation, operation and use of renewables. If a technology is widely accepted, a demand will be created that might help to develop renewable energy markets.

Future funding should also be spent on investigating the best suitable legal and organi-sational conditions for renewable energies – this could be an interesting subject for an integrated project.

4.3.2 Photovoltaic

The overall aim of photovoltaic projects was to achieve a major cost reduction per kWh generated as this is an essential prerequisite for increasing the market share of PV-generated electricity substantially in the European electricity supply. The high generating cost of PV is the result of high plant cost, in particular, the PV cells and other system components needed (such as a DC/AC inverter). To reduce module cost to the target of 1 €/Wp (against costs of around 4 €/Wp at the time), the PV projects focused on the development of cheaper manufacturing processes for existing cells, the improvement of cell efficiency in the existing technologies, and the research and development of new materials and technologies for cells and modules that can achieve higher efficiencies and/or cheaper manufacturing processes.

In general, PV research projects often led to noteworthy technical advances. Even where projects did not achieve their original goals, they were often reported as having built up some knowledge that could be useful to the scientific community, and could also prove helpful in shaping follow-up activities. All technology oriented PV projects showed some success in improving cell efficiency and identifying improved materials and processes for cell and module production.

The following results can be highlighted from the PV research and development projects.

For multi-crystalline silicon cells using industrial process technology, cell efficiency was improved from 12.5% to a range of 15.5 to 17.5%. Cell efficiencies as high as 17% were reported in pilot production lines. Improved cell tabbing combined with high module fill factors (77%) resulted in PV modules with a record power for multi-crystalline silicon above 90 W each or on XX cm^2. This is an important milestone for the efficiency breakthrough of industrial multi-crystalline PV module production.

High impact results included the development of processes and the design of manufacturing equipment allowing for the transfer of thin-film CIGS (Copper-Indium-Gallium-Di-Selenide) technologies from laboratory to indus-trial scale without significant loss of cell efficiency. Different technology concepts were further developed and competition between them is expected to speed up market development and lead to more competitive products. The results from one of these projects have already been used for setting up a pilot production line (Box 4-3).

New concepts, such as molecular solar plastic cells which achieved an increase of efficiency from 1% to more than 3%, appear very interesting. These successes triggered a major growth in research activities into molecular solar plastic cells. This technology seems to have a potentially huge impact on the energy supply of consumer goods (e.g. chip cards), but developments are still at an early stage and a real market product remains a long way off.

Box 4-3: A photovoltaic success story: demonstrating the manufacturability of CIGS technology

Whereas conventional multi-crystalline silicon technology has long dominated the photovoltaic module market, thin-film cell technology offers the highest potential for future cost reduction. Among the materials considered for thin films, a few projects used CIGS (Copper-Indium-Gallium-Di-Selenide) and different industrialisation concepts were successfully developed. As an outstanding example, the EUROCIS-M project, which brought together experts from Germany, Sweden, France and Finland, demonstrated the manufacturability of CIGS technology[14].

Modules with 12% efficiency were produced in a commercially viable process which even offered the potential to reduce total production costs for large-scale manufacturing to less than €1/Wp in the long run (against the cost of about €4/Wp). Moreover, even higher efficiencies were reached on smaller modules.

(14) This project was coordinated by ZSW (Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg) of Germany; the pilot plant was set up at Würth Solar, a company established in Marbach, Germany.

Research was also carried out on replacing cadmium to reduce toxic waste.

The results from the project were used in 1999 to set up a pilot production line in Germany. In 2002, this line had the capacity of several hundred kilowatts-peak of modules and provided about 25 jobs. There are plans to expand the capacity up to 10 MWp per year in the future. CIGS solar cells from this company have already been used in major photovoltaic installations.

This an outstanding example of a research project that has contributed substantially to Europe's progress in thin-film photovoltaic up to the stage of industrial application. Its success has to be seen as a result of the long-term effort by a whole series of projects which started in 1985.

4.3.3 Renewable energies in buildings

Projects on renewables in buildings aimed at strengthening and expanding the direct use of solar energy in buildings and designing more efficient buildings, while keeping a high indoor air quality and good use of daylight.

Economic aspects, in general, were given special consideration in these projects. For instance, when replacing parts of the overall building and its components with renewable energy devices, the aim was to offer alternative solutions that could compete, from the cost standpoint, with conventional solutions while bringing significant energy savings by better use of daylight and electricity generation by photovoltaic modules.
Great effort was also placed on improving and validating physical models. Heat transfer phenomena are now much better understood and the related correlations and coefficients have been enriched.

Results to be highlighted were achieved by one project which improved the visual comfort and succeeded in reducing energy consumption for lighting windowless areas by means of intelligent and optimised systems, combining daylight and artificial light from sulphur lamps. A pilot unit was operated to demonstrate the achievements in living conditions. This project was a very good example of collaboration between universities and industry.

Successful technical achievements were the design and manufacture of devices for measuring the energy output of thermal solar systems, prevention of stagnation conditions, and the design of new solar thermal collectors. Several prototypes were built and tested.
Other projects developed innovative solar facades for buildings (e.g. by combining a double envelope for the building with an air channel to reduce thermal losses in winter and overheating in summer). Different PV facade concepts were developed, and two of them have good chances of commercialisation.

Research projects focusing on the integration of renewables may have important spin-offs in conventional components for ventilation and lighting, and these projects may be a catalyst for the further introduction of energy performance standards in Member States' building codes.

4.3.4 Wind Energy

The general objective of wind energy projects was to stimulate a wider penetration of wind energy within the European Union by decreasing the cost of wind-generated electricity and improving wind turbines in relation to reliability and public accepta-bility (e.g. noise and visual intrusion). Another objective was to help the European wind-turbine industry to maintain its position as world technology leader.

The main results are the development of new tools and a better understanding of the aerodynamic and structural behaviour of wind turbines operating at different conditions. These tools will facilitate the improvement of future designs. Several projects dealt with improving aero-dynamic computing models to simulate the detailed flow behaviour experienced by a wind turbine. New tools were also developed for the prediction of noise emissions, along with new aerodynamic profiles to reduce aerodynamic noise. The development of standards and certification methodologies was covered by six projects.

Highly innovative and optimised components for large wind turbines were developed: blades, generators, electric brakes, hydraulic yaw systems, control systems, etc. Complete new wind turbines have been designed, manufactured and tested. However, no major scientific and technical breakthroughs were achieved as that technology is already quite mature.

Achievements from three demonstration projects include technical improve-ments and the possibility of connecting plants to weak local grids, which requires specific developments. Wind parks were erected on land in extreme climatic conditions, and offshore, which required special designs and technical considerations. All the demonstration projects involved new concepts and techniques which led to improvements when compared to previous typical efficiencies.

Among many very interesting and innovative results, the development of models for wind power forecasting and the establishment of a well-documented wind database receive a special mention and should help wind energy achieve a broader market penetration and better acceptance on the part of utilities.

Because of tremendous growth in the wind turbine market in recent decades, the objectives for future projects should properly address public acceptance issues and related technical problems such as noise reduction.

4.3.5 Energy from biomass and waste

The projects on biomass and waste were primarily aimed at improving the technical, environmental and economic viability of gasification, combustion and co-combustion of biomass as well as biogas production and use. Included among them are three projects that dealt with pyrolysis. Because of a certain lack of fundamental knowledge in this field, the pyrolysis projects were more orientated towards basic research.

Most of the projects revealed improvements in the energy conversion technologies with regard to biomass and waste.

Very interesting results have been achieved on the interaction between fuel and bed material in fluidised beds, and on the treatment of exhaust gases for emission abatement. Much of the work has been devoted to the study of the properties of different biofuels, ranging from bark and other wooden residues to sewage sludge, as well as meat and bonemeal.

Many projects demonstrated successfully the energy conversion from biomass and waste with existing, more or less modified technologies such as combustion, gasification and fast pyrolysis. Pilot plants have been installed and tested. In some cases, the results led directly to marketable technologies or products, especially if large research institutes and industrial enterprises were part of the consortium.

The majority of pilot plant projects revealed and specified the needs for further research to be done before commercialisation would be possible.

For small-scale applications it will probably be important to develop biofuels with well-defined properties so that these fuels can be used with a minimum of operational or environmental problems at low costs. For medium-sized and large plants, important opportunities lie in developing technologies to handle environmentally problematic waste streams (since these give high income to the plant), and in intelligent process integration that can improve the economic viability of the plants. Environmental performance of the plants will, to an increasing extent, probably be achieved by integrated measures. Such measures should be investigated further.

The technology enabling the use of biomass and waste for energy conversion is basically available throughout the overall provision chain but is not yet fully commercially viable. The primary focus of future EU-funded programmes should therefore be on developing today's state of the art into commercially viable biomass to energy systems. However, there should still be an opportunity for funding highly innovative solutions, for example when there is potential for particularly high added value from the system.

The main achievements of the biomass projects were the successful use of waste streams and various biomass feedstock within fluidised beds for energy conversion, and measures to avoid negative interaction of bed material and feedstock. Biomass and waste are considered to be promising energy sources as substitutes for fossil fuels by biomass and waste within conventional technologies.

4.3.6 Other renewables

Projects on other renewables covered geothermal, energy storage, and energy from waves.

An efficiency improvement of 40% was realised in one project using geothermal energy. Although the experts were satisfied with this technological progress, some R&D work is still needed to investigate the underground conditions at the depth required to reach a sufficient temperature for electricity generation and to reach market maturity and economic fully.

The development of energy storage systems is a necessary condition to help market penetration of renewable resource. Energy storage technologies should be focused on in future programmes. However, the improvement of these technologies should not be overemphasised. Combinations of different renewable energy sources within the same region, or even within the European electricity market will have some of the same features as electricity storage.

The key messages:

- For the most part, renewables are neither integrated into the economy, nor in the daily activities of EU citizens, nor into the energy supply system. Such integration requires an adequate legal and organisational framework. Guaranteed availability of cheap biofuels and adequate rules to allow 'valorisation' of the sector at the start of investment are considered to be some of the most important basics for the integration of renewables.
- A number of projects achieved major cost reductions per unit of electricity generated, through various ways: for example, increasing efficiency of energy conversion devices, reducing the production cost of equipment, using cheaper feedstock, and adapting conventional equipment to use renewable energy sources.
- In general, the direct social and economic impacts of the projects have been limited. However, almost all projects showed indirect impacts. Most of the new and

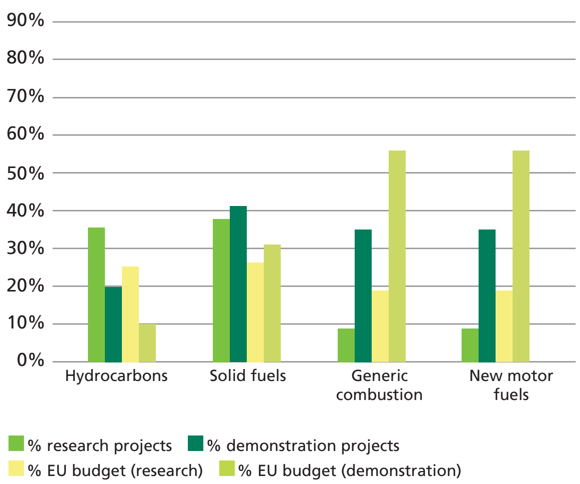
improved devices, materials and integrated systems have serious market penetration potential with significant European added value. There are also indirect social impacts: when the research effort reaches the expected targets, the social impact will be significant, as far as it concerns enhancement of employment and quality of life, particu-larly in rural agriculture areas, as well as the reduction of environmental impacts.

4.4 Fossil fuels

Fossil fuels have been and will continue to be key energy sources for the EU. In the long term, oil will remain a dominant energy source for both the transport sector and the petrochemical industry, as alternatives are still far from a significant market deployment. Gas resources are well diversified and will take an increasing market share in the EU energy supply. Finally, coal is the world's most abundant fossil fuel. It accounts for about 15% of the energy used in the EU and more than 30% worldwide. Forecasts suggest that coal will remain a substantial source of energy. However, growing environmental awareness is leading to the need to develop new clean coal technologies. Therefore, the development of technologies related to fossil fuels, as considered here with the support of EC Programmes, is crucial in achieving objectives for the security of supply, environmental protection and for putting European technology ahead of the US.

The fossil fuel projects involved in this impact assessment covered 34 research and 43 demonstration projects, corresponding to an overall EC contribution of €79 M. Most of them concerned hydrocarbons: almost 90% for demonstration (72% of the budget) and 44% for research (Figure 4-3).

Figure 4-3: Assessed projects on fossil fuels



4.4.1 Hydrocarbons

The North Sea oil and gas reserves are recognised as being of strategic importance within the EU. The exploration and production industry has been under pressure to maintain and improve the high level of exploitation of these reserves, and to reduce investment costs and gain a better return on such investments. This has driven the need to introduce improved, more efficient methods for the location, development, operation and depletion of reservoirs in the North Sea. There has also been a need to improve overall environmental compliance for all activities. At the same time, there has been an increasing demand to explore and utilise what were previously regarded as marginal fields, containing fractured and heterogeneous reservoirs. Consequently, in order to address these issues, the research projects assessed were designed to develop concepts for relevant new technologies.

The hydrocarbon projects assessed were aiming at improving the drilling efficiency, offshore exploration in complex geological conditions, strengthening floating production equipment, and at designing simulation tools for reservoir evaluation. In the field of storage and transport, safety has been the number one priority.

The assessed research projects on hydrocarbons can be divided into three separate problem-solving groupings.
- Better estimation and **mapping of reserves**, with emphasis on economic viability for investment in development, production and exploitation;
- Development of techniques and methodologies to improve the overall efficiency and **effectiveness of reservoir management** (development of new and improved modelling techniques with the prime outputs being to better estimate the potential of recoverable reserves through improved exploitation strategies and systems); and
- Finally, development of techniques, equipment and methodologies to improve operational **performance of production units**.

In the hydrocarbons projects, the scientific and technical objectives were highly complex and extremely challenging. It is a credit to the research consortia that some 80% of the overall scientific and technical requirements were met. The advances achieved were reflected in the high quality of the scientific data gathered, in the techniques, methodologies and prototypes developed.

The assessed demonstration projects on hydrocarbon technologies covered exploration (improved accuracy in seismic and reservoir modelling, new and improved seismic techniques), drilling technologies, production (new and improved technologies for efficiency and safety in operations, with emphasis on offshore operations), pipelines (new welding technologies), and operations and decommissioning of offshore platforms.

Most of the demonstration projects were totally successful and a small percentage partially so. The advances achieved were considerable and can be summarised as follows:

As regards exploration projects, significant innovations have resulted in the ability to see real-time dynamics data while drilling – a major breakthrough in drilling. Indeed, this technique is very cost effective since the required data is obtained while the drilling operation is going on, which means that no time is lost by stopping the drilling. Other innovations occurred in new concepts in drilling and work covering operations, in significant developments in Seisbit technology, in technical improvements in seismic pulse, in improved software tools to predict core properties – another major breakthrough – and finally, in technologies related to logging tools that will contribute to reservoir characterisation.

In production, innovative technical advances were made on the development of a standard procedure for the assessment of fatigue loads on floating production storage and offloading vessels and innovative software to be used to determine accurately the system strength and resistance of offshore platforms under extreme loads, thus preventing major disasters in offshore operations.

Pipeline welding was another area where technical concepts were developed. However, as the result of some failures, the welding technology developed could not advance to industrial application.

The innovative technology for the decommissioning of a complete deck unit offshore in adverse weather conditions, demonstrated in the open seas and proven, is one of the most successful stories in industrial technology (Box 4-4).

The technical success of the projects resulted in improvements in hydrocarbon exploration and exploitation technologies that will contribute to further development of the EU hydrocarbons industry, with positive effects on the domestic and export markets, and on European excellence in energy technology that has been recognised throughout the world.

Those projects where the new technology could be added to existing products and services have been the most successful in contributing to technical developments in the oil and gas industry. In the work completed on inspection techniques and structural integrity, these have added to existing knowledge and services offered and stimulated follow-up on projects to complete the work where necessary. In some cases, the EC partnership has remained in existence and has become recognised as a world leader in their field.

All of the projects reviewed have achieved most of their objectives and several achieved 100% of their objectives. Even where projects did not realise their full objectives, lessons have been learned and elements of the technology commercialised. In some projects, technology has been developed and transferred into other industry sectors. Other projects have been assigned low priority because the technology has moved on.

Box 4-4: A fossil fuels success story: installation and decommissioning of complete deck units in the open seas

The development and demonstration of this successful innovative technology was funded in part by the EU, under two demonstration projects in 1994 and 1996.

The Smart-Leg method extends the limit for deck installation and removal, allowing heavier decks to be installed or removed in more severe environmental conditions. The innovative technology utilises a conventional barge with specific equipment to cancel wave-induced movements. Surge movements are first neutralised using lateral shock absorbers. Jacks with no-return valves between the deck unit and the barge then block the deck unit in the lift position.

The technique was successfully demonstrated in a commercial application in 1997, when a 4 500-tonne six-legged deck was installed on a jacket offshore of Nigeria, during a period when more severe swells were experienced. The technique also showed considerable cost savings as heavy lift vessels are no longer required. The efficient decommissioning of heavy deck platforms has a direct impact on the environmental safety of the seas.

This European innovation has proven European engineering excellence once again and has been recognised by the Offshore Northern Sea Committee, the French Academy of Sciences, the French Civil Work Association, the American Society of Mechanical Engineers, and the Civil Engineering Research Foundation as a highly significant breakthrough. Among the many awards received, the technology was given the "special meritorious award for engineering innovation" and the "innovation award", a most important award in technical and engineering societies.

4.4.2 Fuels

The research projects on generic combustion have contributed to the improvement of performance of internal combustion engines (especially diesel engines), and improvement of engine technologies.

Results from the projects were of the same nature, globally: testing, developing databases, diagnostic tools or equipment, numerical simulations and computer models. In particular, development of computer models was considered as a pertinent result by quite a few projects. As these models were developed to analyse specific questions, it is particularly difficult to appreciate their contribution to the general progress observed since 1995 in the field of engine design and combustion optimisation.

As a result of these projects, enhanced numerical codes have been developed, along with optimisation of further engine design and concepts. The results of the systematic programmes of measurements provided new information of immediate assistance in the design of direct injection gasoline and diesel engines, adding to a general improvement in engine efficiency.

Apart from the improvement of engine technologies, specific studies have been set up to increase the volume of motor fuels produced per unit of charge and their quality in the refineries. Continuous reinforcement of fuel specifications to adapt them to the severe environmental constraints expected in the future was and remains the most important challenge facing the refining industry. Improvements in existing technologies and development of new ones are the most consistent answers to this challenge. Results from all these projects were quite dispersed. They concerned development of new catalysts to improve gasoline production, less noxious soot emissions from diesel engines, characterisation of engine exhaust particulates, fuel and lubricant effects on engine pollutant emissions, and improved hydrocarbon production from methane or natural gas.

For the research projects on clean technologies for solid fuels, the emphasis was on the development of system components for improving environmental performance and energy efficiency (minimising CO_2 emissions through improvements in the cycle efficiency, and other pollutants, including SO2 and NOx, through better capture and control systems). Almost all the technical objectives were achieved and once again high-quality scientific and technical results were obtained. This sector has a relatively mature technological base and, as such, no breakthrough was expected, although the innovations achieved were significant.

The objectives of the assessed demonstration projects on solid fuels were to improve environmental conditions and efficiency of coal utilisation for power generation. The technologies demonstrated pertained to the utilisation of lignite and municipal solid wastes by co-gasification in a fluidised bed. The experience gained has contributed to technical development in this area (i.e. the suitability of the gasification process with an efficient and non-polluting use of brown coal and municipal solid wastes at commercial scale).

The key messages:

- The paramount importance of hydrocarbon exploration and exploitation was addressed successfully by the projects. The innovative technologies developed have proven to be of exceptional value, where methods and techniques have been demonstrated and, in a majority of cases, used by the industry. The increase in productivity and the cost savings have been outstanding.
- In the hydrocarbon industry, environmental impacts have been one of the most talked about topics and a target for some of the projects. The results obtained in the safety of pipelines and in the decommissioning of oilfield and offshore platforms, and the technologies developed and implemented, have had the most beneficial impact on the environment and the best return on investment of taxpayers' money.
- Coal is the world's most abundant fossil fuel. The projects on new clean technologies have achieved positive results with an overall economic impact, and improvement in efficiency and environmental performance of fossil fuel electricity generation.
- The results obtained in the development of new, more efficient and less polluting engines are of direct use to the European authorities for improved quality standards regarding the reduction of emissions in the urban areas, and for guidance in future legislation on automotive pollutants.

4.5 Support measures

The support measures comprised relatively small actions aimed at supporting the development of the overall Programme: studies, information exchange, dissemination, socio-economic analysis, training actions, evaluations, etc. Almost 60% of those assessed were "dissemination" projects which covered the full spectrum of dissemination activities. A second group of projects, referred to as "strategy" projects, provided analysis on the role of demonstration and dissemination in energy policy. A final group targeted "Small and Medium-Sized Enterprises" (SMEs) (See Box 4-5). These projects were spread across the three main sectors: fossil fuels, renewable energy sources and rational use of energy.

Box 4-5: Support measures

The support measures (sometimes referred to as "THERMIE B") aimed at supporting the development of the overall Programme through studies, information exchange, dissemination, socio-economic analysis, training actions, evaluations, etc. They were divided into three areas:

- **Strategy:** these projects provided analysis on the role of demonstration and dissemination in global energy policy, and sought a clearer understanding of the interaction of socio-economic elements with energy technology demonstration and dissemination, as well as information on mechanisms that assist project deployment.
- **Small and Medium-Sized Enterprises (SMEs):** these projects included 1) generation of awareness and presentation of information; 2) development of interaction of SMEs with markets and other organisations; and 3) analysis of markets and development of solutions to obstacles and provision of frameworks for action.
- **Dissemination:** these projects accounted for almost 60% of the total. They covered the full spectrum of activities associated with effective dissemination, and ranged from the collection and collation of market and technical opportunities, through the identification of benefits and barriers to technology introduction, to information to potential users, via a wide range of delivery mechanisms.

The survey examined the geographical regions where support measure projects targeted their work. European-level work occupied nearly half the projects and was particularly strong in strategy projects. SME activities had a strong local element to their work and dissemination projects a relatively strong extra-European dimension.

Turning to the type of organisation targeted by the support measure projects, overall the most frequently targeted organisations were government bodies, SMEs, energy agencies and energy companies. The public, non-energy companies and politicians, along with financial institutions, were relatively infrequent targets. Strategy activities tended to be more broadly targeted, while SME activities were less so.

Looking at the "Impact on EU policy" analysis from the questionnaire, the impact of the support measures and their perceived relevance was greatest in the economic and environmental areas, and weakest in the education and employment fields. This ranking of the importance of impacts holds fairly well within the three activity areas. However, there are relative differences:

- Strategy projects regarded themselves as relatively strong in employment creation and in affecting regulatory issues, when compared to the other two activities.
- Dissemination activities saw themselves as relatively weak in potential employment creation but strong in education and improving the project participants' scientific and technological abilities.
- SME activities regarded themselves as relatively strong on health and safety issues and economic development but weak on education.

Looking in more detail at the impact of support measures on EU objectives:

- **On economic development**. In the short term, the most notable impact arises from the contribution to co-operation with non-EU countries, followed by a general contribution to competitiveness. In both the short- and long-term contributions to liberalisation, cohesion and productivity issues are relatively weak. In the long term, whilst co-operation with non-EU countries remains an important impact, the beneficial impact on competitiveness, security of energy supply and, in particular, productivity will strengthen.
- **On employment**. The impact on employment is expected to be longer term and outside the institution undertaking the project. The impact of the projects on gender equality is likely to be negligible in both the short and long term.
- **On quality of life/health and safety**. The major impact has been in improving the public's understanding of and involvement in new energy developments.
- On education. The major impact is on training in industry. The contribution to basic education or university education is much weaker. The pattern remains much the same in the short and long term.
- **On the environment**. Overall, the support measures seem to be more effective in – or at least more focused on – the reduction of emissions, pollution and waste, rather than the reduction of energy demand or changes in the supply of renewable energies, where the impact measures are weaker.
- **On scientific and technical improvement**. The projects are remarkable for the very strong and rapid technological transfer effects. Reduction of pollution was the second strongest impact. The projects are also exceptional for their strong networking, bringing together expertise and specialists from both inside the EU and externally. More generally, the project coordinators felt they contributed to a broad improvement in EU technological leadership. Areas in which the impact was much lower included improving the EU's research or scientific base and the integration of ICT into projects.

- **On regulation and policy**. Overall, the impact is highest on policy implementation. Support measures do not assist EU policy or legislative development strongly but are more useful in policy implementation.

By comparing the expected short-term and longer-term impacts of the projects, some insight can be gained into the sequence of impacts. Most striking is the clear indication of employment growth as a long-term impact, both for the project partners and externally. Economic development benefits, such as increasing productivity and ensuring security of energy supply, are to be expected in the longer term. While projects have a strong impact on the whole area of environmental improvement, both short term and long term – the full benefits take time to realise.

The scientific/technical area stands out as the area for achieving impact in the short term. All areas of impact investigated under this heading, whether very strong technology transfer or weak strengthening of the research base, take place in the short term. If the projects do not impact quickly, then they are not seen as having much additional impact in the longer term. The education impacts of the projects are also rather restricted to the short term.

In looking at the administration of support measures, a number of pointers were observed towards the more effective management of support measures:

- Wherever possible, projects should strive to be self-sustaining on completion. The most successful projects were those designed from the outset to achieve self-sustainability. This provides leverage for the project action, reduces the need for further financial support, and magnifies the level of delivery of the benefits.
- Ensure project partners have a greater awareness and understanding of how the project outcomes are to be used. The ultimate success depends upon the capability of the recipients to appreciate the opportunities and deliver useful results. All projects therefore would benefit from a greater appreciation of the beneficiaries of project outcomes and a greater awareness and understanding of how the information is used.
- Future projects should ensure that impact assessment is a prominent element in their design. Effective assessment of a project's impact requires knowledge of how recipients have used the project end results. Details of recipients, information and beneficiaries of results should be an important element both identified and provided by the project. Provision of this information will ensure that the impact of a project has been considered and hence the usefulness and value to the target market. It will also make completion of a project or programme impact study easier to carry out.

Box 4-6: A permanent forum for renewables in the EU

The basic structure of a permanent forum for renewable energy sources in the EU was developed in terms of membership and mechanisms to allow enlargement of the organisational, political and financial resources and to ensure self-sustainability of the forum.

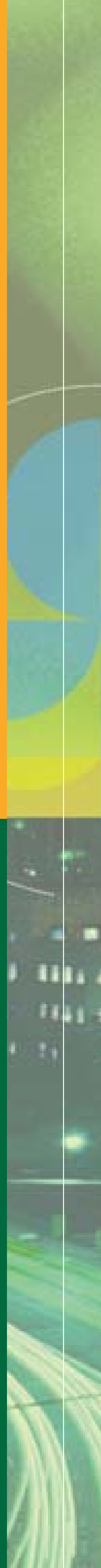
The project supported the identification and compilation of a database of major actors/groups active in the field of renewable energy sources who also had a potential interest in joining the forum. The potential members identified were contacted to discuss and seek their involvement, provided with a portfolio of information on activities on renewables in the EU, and urged to become members of the forum.

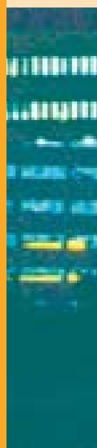
The project effectively engendered awareness amongst key players of renewable energy sources in the EU, helped to secure the forum as an important element in accelerating the use of these resources, provided associated benefits on employment and economic resource utilisation and, importantly, ensured that the forum was self-sustaining and would continue to undertake and develop the foregoing tasks on completion of the project.

The key messages:

- The support measures are effective activities for achieving short-term objectives. They are most useful in technology transfer to industry and in achieving the application of existing technologies as well as the implementation of already developed policy.
- In terms of management, a stronger focus on self-sustaining projects would improve impact. Precision and clarity regarding project objectives and beneficiaries and a rapid and efficient delivery are necessary for such short-term projects.

5 IMPROVING THE IMPACT OF ENERGY RESEARCH





This section reflects on what we have learned from the review of individual projects. It develops recommendations about how a programme such as the NNE Programme could be "improved". The more radical overview of the structural changes needed to produce a more effective energy programme comes in the following Chapter 6. To a large extent, although not totally, this chapter focuses on programme efficiency, while the following chapter concentrates on effectiveness.

5.1 Integration into EU and Member State concerns

Perhaps the strongest and most consistent message across the impact assessment is the absolute need to integrate technical research and demonstration activities with the political, social and economic structures of the EU and Member States – both strategically in the planning of the programme and operationally in the undertaking of the projects.

All Programme activities indicate that the more successful projects have engaged strongly with the non-technical, 'external' world. This is most obvious in the commercialisation of research and demonstration projects, but extends into areas such as impact on legislation and regulation, impact of energy modelling on policy, and so on. Successful research and demonstration, at least in energy, are as much social, economic and political experiments as they are technical experiments – and should be recognised *and financed* as such.

But there is a further dimension. The sectoral report on renewable sources of energy points to the need for *"an adequate legal and organi-sational framework and an awareness of the renewables' benefits within society. Guaranteed availability of cheap biofuels and adequate rules to allow the sector valorisation in the beginning of investment in renewable energies are figured out to be some of the most important basics for renewables' integration"*. It points out that this is an area which has been addressed poorly. There is a need for a *"greater weight on questions concerning the benefits of renewable energies in the everyday life of society, the acceptance of the end-users and the conditions of <acceptance with regard to the installation, operation and use of renewables"*.

While there is a responsibility on both project and programme to engage with the wider society, there is also a responsibility on the legislative and political structure to provide a framework in which energy research can be planned and undertaken.

Research and demonstration activities, perhaps in energy more than in any other field, are a joint endeavour both by those who carry out research, on the one hand, and those who operate the political, social and economic infrastructure on the other. Engagement from both sides is essential in the planning of the programme and the operation of the projects – if the impact of the research spending is to be truly effective.

5.2 Developing a programme identity and direction

There were many indications that the project teams felt isolated – that they were acting alone, and had little contact with other projects or the Commission. Of course, much has changed within the Framework Programme since these FP4 projects finished – but it is still useful to make a number of points.

A programme is not simply a collection of projects in the same research area. Coherence and synergy in their widest sense are necessary if the programme – as opposed to the individual project – is to have maximum impact. And much might have been done during FP4 to improve these factors.

In some ways, synergy is easier to tackle than coherence. The major suggestions from projects and experts were:

• Clustering or better linkage of projects. Many projects indicated that they would have benefited from much

closer links with projects in similar or contiguous areas. There are many approaches to clustering, often with strong benefits for programme coherence – as well as synergy.
- Information flow – between different projects, different activities and different sectors. Once again, projects and experts pointed to a weakness in this area.

Difficulties in programme coherence seem to arise at many levels:
- Despite a focused work plan, independent evaluation of proposals and selection of projects can lead to a loss of programme focus and even some unnecessary duplication of activities. Two possible corrective mechanisms were suggested: 1) A stronger role for Commission services in the selection of projects and/or 2) A system of strong feedback from project selection into the development of the next annual work programme to reorient it towards areas which have not been adequately covered. This latter mechanism has been shown to be most useful in maintaining focus. The associated publications are also helpful in developing programme identity.
- Support measures have a major potential to overcome some of the difficulties of programme coherence and to enhance it in their own right. There are many ways in which such projects can be used to tie projects into clusters, to develop programme identity, to develop information fora, in dissemination, etc.
- Projects and experts feel the public identity and presence of this Programme must be substantially strengthened. Given the nature of energy research discussed above, efficiency and effectiveness demand that it takes on a much greater extramural role in the public presentation and discussion of energy research. Such work, either directly by the Commission or through the projects – with the press, NGOs, media, government, parliaments, even with schools and public interest groups – is not a soft or inappropriate use of energy research money, but an essential part of the energy research process – as essential as instrumentation, chemical analysis, etc. Energy research is a profoundly social activity.
- Increasing the linkages between the Programme and its work programme on the one hand and the socio-economic concerns (legislative, commercial, policy related, political, etc.) of Member States on the other, promises, eventually, to develop a degree of RTD coherence at an EU level – with major added value for all concerned.

5.3 Project selection

Proposal evaluation has implications for programme and project quality as well as coherence. It appears that some of the difficulties for some projects might have been prevented had there have been a more rigorous evaluation phase of the proposals. Project failings included projects which were:
- Already covered or being covered at the same time in other EU or non-EU countries;
- Being too far away from technical or commercial viability at a mid-term horizon; and
- Lacking the prerequisites of available technologies or expertise in the consortium.

There is no doubt but that there is an element of perfect hindsight in such statements. But improvements in the call for tender/proposal evaluation phase might be helpful. A number of areas were mentioned:
- "The selection of evaluators should be done with prudence to assure technological and industrial knowledge, in order to establish evaluation criteria determining the future potential application of the innovative technology. The shelving of successful projects because of lack of a market is an academic exercise and definitely does not meet the programme objectives" – from the sectoral report on fossil fuels.
- Better information to potential proposers about current research and demonstration activities across the EU – possibly operated as a support measure – and a stronger requirement to have already explored and become familiar with the state of the art.
- Stronger requirements on partnership structures, as discussed in the next section.

Turning to project coordinators' responses to survey questions about "employment creation" and "economic impact" provides indications for future evaluation processes. Most obviously, since coordinators can say very little about the employment-creating effects of their projects three years *after* completion, it seems likely they can say even less at the project proposal stage. There is a difficulty with asking proposers about the employment-creating potential and in including it as an evaluation criteria.

In the area of "commercial impact", which coordinators see as a legitimate topic for their projects to address, asking for simple declarations of projects' commercial potential is insufficient. It is unlikely that proposers, and much less evaluators, have a clear view as to how the proposed research translates into wide-scale commercial impact. More important in evaluation is probably the correct structuring of both the project and consortium to permit the commercial possibilities to be explored and availed of during the project lifetime.

5.4 Creating research partnerships

Care with partnership formation is crucial to project success. Unfortunately, there seems to be no one simple or obvious rule for success – a number of points emerged:
- Developing appropriate partnership skill mixes is, of course, essential and, while differing from sector to sector, seems to be reasonably well understood. In addition, initial partnerships are formed which, in time, are seen to be not fully adequate. Where necessary, introducing a developmental axis, which would draw more partners in, was seen as useful. A broader use of subcontracting might both strengthen the project and involve SMEs and energy NGOs in a more appropriate and less bureaucratic manner.
- Large partnerships present particular difficulties. Some have pointed to the difficulty of their management, ranging from difficulties in knitting together disparate technical skills – or coping with rivalry from similar skills, right down to simply respecting reporting deadlines. The opportunity for "free riders" also seems to increase.
- Including, in the broadest sense, the 'end-user' *within* the project seemed to be important. The end-user ranged from policy developers in national, regional and local administrations for energy models, to appropriate commercial companies for exploiting new improvements in fuel cells, to energy NGOs as activists and publicists.
- Greater guidance and supervision from the Commission services on the formation of partnerships, their structure and functioning, might be helpful.

Then there were a number of particular issues:
- In demonstration projects, locating the work in industrial-scale demonstration plants was seen in the fossil fuel sectoral report as "very positive, as it reduces demonstration cost, reduces the perception of technical risks, improves availability, and represents an essential precondition for the commercial application of the technology".
- The choice of project coordinator is also important. The fossil fuel report found that "the more successful projects were led and coordinated by a research institute, but with strong and active industrial support plus focused input from high-quality universities. A key role of the institute is to bridge the gap between industrial requirements and the academic capabilities of the universities."

5.5 Project management

Project management was called into question from two aspects:
- The management of the projects by the Commission services, and
- The internal management of the project.

As regards Commission management, there was a call for greater contact with the project officer at a number of levels, ranging from cross-project information and attendance at project meetings to management advice. At the same time, for the benefit of the Programme as a whole, there is a need to reorient project officer effort from the detailed administrative management of individual projects to overall programme management and improvement. In this resource conflict, consideration might be given to the externalisation or centralisation of project officer administrative functions and a move of project monitoring from an administrative annual report system to a critical milestone approach. Strong, consistent, quality improvement systems could also relieve the administrative burden. Increasing the formalised input of project officer experience and insight into the development of programme management systems has been successfully launched in some parts of the FP – such techniques might also be helpful in the energy area.

As regards internal project management, difficulties relating to the need for consistent and dedicated manpower were observed. The task of coordinating a multinational research or demonstration project is enormous. There is a positive correlation between the size of the consortium and the problems that can occur in the course of the project. It was suggested that an independent professional project manager, neither engaged in the research directly nor employed by a member of the consortium, should be employed for the term of the contract.

5.6 Project funding and contracting

A common finding across programme activities was that project-funding mechanisms need to be matched to project requirements, if the project is to be effective.

- The pace and time horizons of much energy research are not those of the life sciences or information technology. Success horizons for many research and demonstration projects can be quite long – technologies, markets and social acceptance often change slowly. There are suggestions that funding of a consortium over longer periods may be helpful. This may occur in a number of guises; longer contracts for the same funding, repeat or periodic funding, and so on – but with the objective of maintaining a consortium and a certain research momentum.
- The RUE discussion on "research maturity", (fuel cells being furthest from market, RUE in buildings being market-ready) also has implications for financial structures – as well as partnership structure and impact expectations. Short-term, "catapult financing" may work with RUE in buildings, but not fuel cells.
- Another funding structure may need to be considered in the socio-economic area. Here, EU level models require to be regularly updated, a near impossible task using national funding structures. Similarly, EU level information and analysis from such work requires ongoing diffusion. This argues in favour of a constant EU funding structure. Such EU-level projects have few "markets" outside the Commission itself.
- Other projects need to be completed quickly. Support measures, in particular, emphasised the need for strong, well-planned and targeted activities delivered rapidly to "customers" who could use the results of the project. This requires rapid financial decision and payment structures.

At the level of ongoing projects, there was a need for contract flexibility.

- Experts pointed to the need to improve "the contractual arrangements that exist to permit modifications in the work programme to adjust, while the project is ongoing, to the industry requirements, economic climate and market forces changes, so no loss of time is experienced".
- Such flexibility may be all the more necessary in energy research and demonstration with, for example, the need for weather windows for trials – requiring work programme time schedules to be flexible. And there's the need for the project officer to approve appropriate changes to the time frame and associated finances, without delay – and without, of course, any change in basic budgets.

Finally, to avoid projects failing as a result of problems in reaching their technological targets or in their partner relationships, the introduction of an interim project evaluation or mid-stage project event was suggested where CEC officers and/or independent experts perform an intermediate evaluation. This could lead to an early halt of projects which do not have any perspectives, or it may help to change the team in order to conclude the project successfully.

A funding window for small projects and small enterprises with innovative expertise is also considered to be important for future EU funding.

5.7 Dissemination

Dissemination of information and results outside of the consortium is generally seen to be weak. It is too often seen as an end-of-project burden which occurs when the project is running out of energy, money and, possibly, commitment. There is a need for explicit planning and funding within the project consortium for a dissemination phase.

The actual shape of the diffusion phase may vary:

- Possible diffusion activities undertaken by the existing consortium may range from provision for training courses to workshops and seminars, to consultancy packages, depending on the needs of the project. Active development of a shared website from day-one for project management and dissemination was seen as a basic element.
- Diffusion of research results across the EU is, however, a special skill and it was suggested that, in many cases, this might be done best via a specialist commercial firm rather than the technically focused researchers themselves.

- An allied approach to support the major development of energy-related software and engineering systems was to form a specialist EU-level open-forum for such activities.
- In a similar vein, an information network, such as the OECD Caddet network, could serve as a model for other energy-related technical information.

Incentives and/or procedures for follow-up actions (dissemination and marketing activities, successor projects, etc.) should be envisaged for successful projects.

Finally, it might be reiterated that one of the most effective and sure forms of dissemination is the commercialisation of the project results. Those projects which reach commercialisation have a far greater impact than any other.

5.8 Impact assessment

Two issues must be addressed in improving impact assessment:
- Its integration into the ongoing management practices and systems of the programme; and
- Making it a coherent exercise across the whole of the Framework Programme.

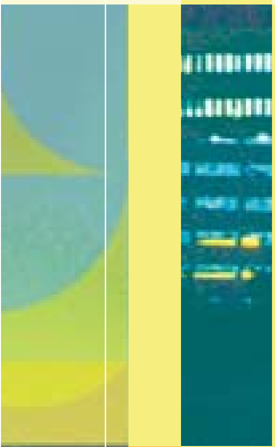
There is absolutely no doubt that the level of co-operation and quality of information from the projects were compromised by the ad-hoc nature of the impact analysis. Some projects pointed out that it was not part of their expected duties or formal contract to take part. Others objected to having been asked the same questions a number of times before. On the Commission side, there were difficulties in contacting the projects and locating assessment materials.

Therefore, there is a need to develop both project and programme management structures, which will:
- Make the collecting of project impact information a simple, regular and formal activity; and
- Make the use of impact assessment an explicit, regular part of programme management.

In terms of programme management, it has already been demonstrated that information from impact assessment can be integrated into improving proposal evaluation systems, improving partnership selection and management, and so on. The basis requirement is to interface the impact assessment with the programme's continuous improvement/quality improvement system.

This current impact assessment is at the forefront of FP work in the area, both in timing and scale. It has developed much experience and expertise. Other FP programmes are currently planning similar exercises, as well as planning for future FP6 project and programme impact assessment. Lifting impact assessment up to a coordinated Framework Programme level could have many advantages ranging from assessment costs, experience sharing and improving methodological approaches to comparability of results across programmes and better planning at a Framework Programme level. The experience gained by DG Research and DG TREN might be used to further such an FP-level approach. The very particular nature of the different research domains will, of course, always require a certain tailoring not only of tools and questionnaires, but also of expected assessment outcomes.

Summing up, the three key issues in the improvement of impact are:
- The absolute need to reorient and re-engineer both projects and programme to participate actively in the social, economic, political, legislative, and especially in the commercial framework of Member States and the EU. Energy research is a profoundly socio-economic activity.
- The need to build programme coherence and identity; making the projects more than the sum of their parts.
- Putting in place, by programme management, a continuous improvement system which covers management processes from setting work programmes to undertaking impact analysis.



6 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations are developed along the three major structural axes of the programme: content structure, activity structure and management structure. In each we reflect on their effect on Programme impact, and what changes would lead to a more effective and efficient programme. Finally, we formally review the fulfilment of the objectives of the Council Decision which set up the programme.

While these conclusions draw on our experience with projects undertaken during FP4, it is essential to recognise that the context of EU energy RTD has changed dramatically. Thus, our recommendations must be framed with the Sixth Framework Programme (FP6) as the background, while even looking towards its successor. In particular, we must recognise 1) the development of the European Research Area, and 2) The Lisbon and Barcelona objectives, which seek EU competitive leadership and an R&D investment level of 3% of GDP by 2010.

6.1 The content structure of the Programme

The programme is structured along four major themes: renewable energy sources, rational use of energy, fossil fuels and a much smaller modelling and strategy area. The impact of all sectors was positive: cost reduction for renewables, and significant energy efficiency improvements, both for energy production and energy use. All projects contributed to the improvement of the environment and all included dissemination activities. Although all areas had a good impact on scientific and technological quality, fossil fuels seemed to have made the greatest impact.

Structurally, the division of the programme is somewhat arbitrary. For instance, projects on energy storage can be found in renewable energy sources as well as in the rational use of energy. In the same way, projects on clean and efficient combustion of solid fuels have some similarities with coal, found in the fossil fuel area, while in biomass it falls under renewables. Similarly, there are a lot of complementarities in projects in buildings that appear in renewables as well as in the rational use of energy. Development of efficient engines appears in both the fossil fuels area and in the rational use of energy.

Given that much of the NNE Programme took place before clustering became a recognised practice, two comments can be made:

- A more effective connection bridging projects would, of course, have been helpful in delivering a more effective programme.
- A more issue/problem-focused approach – for example, focus on 'energy and buildings' or 'energy storage' – would develop more coherent groupings of interest than the more conventional classification by energy sources.

6.2 The activity structure of the Programme

The activity structure of the NNE Programme comprised three sets of stand-alone activities: research projects managed by DG Research and demonstration projects and support measures managed by DG TREN[15]. Individually, each of these activities delivered what was expected from them. Research and demonstration projects provided strong impacts in improving the scientific, technological and innovative base of the EU, as well as safeguarding the environment. Demonstration projects provided immediate, end-of-project impact, while research projects provided a longer-term impact. Support measures were impressive in technology transfer and in helping to implement existing policy.

However, the projects were stand-alone. The initiation of the 'Industry-Research Task Forces' during FP4 had very little effect on activity structure; likewise, the first

(15) DG Energy at the time of FP4, which was merged later with DG Transport into DG TREN.

moves towards 'project clustering' only developed towards the end of FP4. The relative isolation of the projects is reflected in comments by the project coordinators seen in the sectoral reports.

While the Thematic Programme/Key Action structure of FP5 allied to the development of clustering went some way towards developing inter-project synergy and coherence, and the new FP6 instruments promise even closer project cohesion, the NNE Programme still offers a number of pointers towards future activity structure:

- Horizontal, 'natural trajectories' of complementary research can be seen across many energy areas. For example, in seeking mechanical and structural reliability in wind turbines, complementary development of the different components suggests the possibility of stronger advances than a series of stand-alone projects. Such possibilities indicate the development of an integrated suite of complementary research activities as the basic 'project'.
- Perhaps even more radical, the success of research and demonstration projects with a strong extramural dimension strongly suggests the development and explicit funding of energy RTD activities which go beyond the traditional scientific/technical bounds and expressly integrate, from the beginning, into the much wider social, economic and political environment of energy generation, transmission and utilisation.
- The last pointer can be further elaborated by looking at some of the projects which had *less* impact. Demonstration projects aim to show the commercial potential of near-market technologies – and sometimes there is very little technical innovation involved. The major barriers and requirements for the introduction of the technology relate not to the actual technology but to legislative and regulatory requirements, to tax regimes, to market ignorance, to the structure of existing supports to current technologies and fuels, and so on. In the face of such challenges, it is small wonder that some demonstration projects – particularly the technically inward-looking ones – have weak impact. In such circumstances, demonstration and sometimes research projects cannot be technical explorations of a neutral, non-judgemental world. They need to be allied, within the project, to legal, fiscal, taxation, publicity, and commercial explorations and struggles.

Looking towards FP6 and the ERA, there is major potential, particularly in the Integrated Projects, to fulfil the objectives of the NNE Programme even more effectively. Such major projects, if structured correctly, have the potential to draw Member States into reflection and action on renewable energies and rational use of energy in regulatory, fiscal and commercial areas, which the demonstration projects of the NNE Programme found difficult or felt was outside their scope of competence.

- Examine the feasibility of project structures which group sets of 'horizontally complementary' research needs.
- Ensure all projects have a strong extramural dimension.
- All projects should have explicit legal/tax/fiscal/commercial/publicity/political dimensions in their research and demonstration activities, as appropriate.
- Large projects should formally involve Member State administrations at a legal/tax/fiscal/political/publicity, etc. level, as appropriate.

6.3 The management structure of the Programme

Formalising extramural linkages

As we have seen consistently at the project level and in the sectoral reports, projects which have integrated into the external legislative/administrative/commercial/policy world of the Member States have had a greater overall impact than the purely scientific and technically focused projects. Looking forward to FP6, the issue is how can we best institutionalise such an extramural dimension at both project and programme level.

On the whole, the projects surveyed which gained high impact from coherence with and working with Member State policies, activities and programmes did so through their own initiatives and networks. Providing structures in which energy RTD work programmes could be discussed alongside Member State programmes (and then, at a later stage, allied to micro-level specialised fora – wind, fuel cells, energy modelling, etc.) might make a major contribution towards forming high-impact projects with strong extramural linkages built in from the beginning.

The suggestion, at EU work programme level, is to complement the Programme Committee structure with a "high-status" system which formally reviews and discusses Member States' energy RTD policy and programmes in an EU context. Here, it is suggested that the responsible Member State ministry(ies) submit their energy RTD policy and associated programmes, on a regular basis, to the Commission for discussion in the context of developing the Commission's work programme. While the narrow objective is to improve the type of individual proposal available for EU funding, the potential for developing synergy, dialogue, and joint projects between Member States is obvious, as well as the possible contribution of such a structure to the development of an energy ERA. The direct involvement of both DG Research and DG TREN in the EU energy RTD programme is a major potential strength in developing such a structure.

Internal management structures

As has been seen, the Programme's management structure is dominated by the division of activities between DG Research (research projects) and DG TREN (demonstration and support measures). There has been some concern that this limits the potential scope of projects and has created difficulties for innovative projects in accessing the Programme. The new FP6 presents major opportunities to build a stronger, strongly coherent management structure. Integrated Projects, with their need for team management across research, demonstration and support measures will provide the operational opportunity to overcome the traditional divide, which has been criticised by some.

Energy is a relatively small element within FP6. However, acting together, DG Research and DG TREN can be a powerful influence within the Commission within Europe and, indeed, globally, for high-impact, progressive and forward-looking energy projects and policy. The sharing of EU energy RTD responsibilities across two DGs should be seen as a major asset given the 'political-social' dimension of so much energy research.

- There is a need for DG Research and DG TREN to develop a close strategic and operational alliance to meet Council FP6 objectives and develop high-impact energy RTD programmes.
- DG TREN and DG Research should invite the ministries responsible for energy RTD within the Member States to submit their energy RTD policy and programmes on a regular basis for joint discussion.

6.4 Delivery on Council Decision objectives

While the Council Decision with its associated objectives setting up the NNE Programme came into operation nearly a decade ago, in 1994, it is important to comment formally on the level of achievement attained by the Programme. Below is a review the core objectives:

The two most striking Programme successes have been:

- "Strengthening the technological basis of the energy industry". The survey pointed to this as the strongest and surest outcome of the Programme. Only 7% of projects did not have an impact on the scientific and technical quality of energy RTD, while nearly one-third had a "highly positive" impact.
- "Protecting the environment by reducing the impact of the production and use of energy, in particular the emissions of CO_2". Again the survey points to a strong and sure success. Only 6% of projects did not have an impact on the environment, while a quarter had a "highly positive" impact. At a more detailed level, the two strongest environmental impacts were in 1) reducing the impact of energy production and use, and 2) reducing CO_2 emissions.

The objective of "Encouraging the rational use of energy" was well met, but the survey does not show as strong a programme impact as in reducing the effects of energy production and CO_2 emissions. However, the individual sectoral report indicates much success.

It is more difficult to comment on the objective "Improving security of energy supply" since the Programme contributed to this goal at a number of levels (from better planning and policy to energy efficiency), without having a specifically targeted set of projects. All in all, there is no doubt that a significant contribution was made, but it is difficult to rank it alongside the other more focused objectives.

- The NNE Programme has met the Council objectives set out in its 1994 Council Decision.

LISTS OF FIGURES AND BOXES

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GLOSSARY

AC / DC	Alternating Current / Direct Current
BMWi	Bundeswirtschaftministeriumg (German)
CAD	Computer aided design
CAE	Computer aided engineering
CAPE	Computer aided process engineering
CEC	Commission of the European Communities
CFB	Coal-fired Boiler
CFD	Computational fluid dynamics
CFHC	Chlorofluorohydrocarbons
CH_4	Methane
CHP	Combined Heat and Power Generation
CIGS	Copper-Indium-Gallium-Di- Selenide
CO	Carbon monoxide
CO_2	Carbon dioxide
CORDIS	Community Research and Development Information System
CRAFT	Co-operative Research Action for Technology Stimulation Measures for SMEs
DG	Directorate-General
DIR-MCFC	Direct internal reforming molten carbonate fuel cell
DMFC	Direct methanol fuel cell
DSM	Demand-side management
E-3	Energy-Environment-Economy
EAV	European added value
EC	European Commission
€	Euro
EE	Energy efficiency
EGF	Efficiency gain factor
EIB	European Investment Bank
ENGO	Environmental non-governmental organisation
ENV	Environment
ERA	European Research Area
ESD	Energy, Environment and Sustainable Development
EU	European Union, often referred to as the "Community" or the "European Communities"
FC	Fuel cell
FP4	Fourth Framework Programme
FPSO	Floating Production Storage and Offloading
GEM	General Equilibrium Model
GERTH	« Groupement Europeen de Recherches Technologiques sur les Hydrocarbures »
GHG	Greenhouse gas
GWp	Global warming potential
H_2S	Hydrogen sulphide
HCCI	Homogenous-charge compression-ignition (engine)
HTFC	High-temperature fuel cell
HVAC	Heating, ventilation and air-conditioning
ICT	Information and Communications Technologies
IEA	International Energy Agency (Paris)
IFP	Institut Français du Pétrole
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
IT	Information Technology

JOULE	Joint Opportunities for Unconventional or Long-term Energy
LP	Linear programming
MCFC	Molten carbonate fuel cell
MEA	Membrane electrode assemblies
MEMA	Mediterranean energy market appraisal
MIS	Management Information Systems
MPF	Market penetration factor
MS	Member States
NAS	New Accession States
NDT	Non-destructive Testing
NGO	Non-governmental organisation
NNE	Non-Nuclear Energy
NOx	Nitrogen oxides
OECD	Organisation for Economic Co-operation and Development
OJ	Official Journal of the European Communities
OPET	Organisation for the Promotion of Energy Technology
OWC	Oscillating Water Column
PDC	Polycrystalline Diamond Compact
PEM	Polymer electrolyte membrane
PM	Particulate matter
PO	Project Officer
POLES	Prospective Outlook for Long-term Energy Systems
PRIMES	PRIMES energy system model
PSI	Priority Setting Initiative
PV	Photovoltaic
R&D	Research and Development
RE	Renewable energies
REN	Renewable energies
RES	Renewable energy sources
RET	Renewable energy technology
RTD	Research, Technological Development and Demonstration
RUE	Rational use of energy
SAFIRE	Strategic Assessment Framework for Rational Use of Energy
SAVE	Special Action programme for Vigorous Energy Efficiency
SHS	Solar Home System
SMEs	Small and medium-sized enterprises
SO_2	Sulphur dioxide
SOFC	Solid oxide fuel cell
SPFC	Solid polymer fuel cell
SWD	Seismic While Drilling
THERMIE	**T**ec**H**nologies **E**u**R**opéenes pour la **M**aîtr**I**se de l'**E**nergie
TIP	Technological Implementation Plan
TREN	Transport and Energy Directorate
TTM	THERMIE Technical Management
UNFCCC	United Nations Framework Climate Change Convention
VOC	Volatile organic compounds
WP	Work Programme
Wp	Watt peak

ANNEX

Table A-1: Assessed research, demonstration and support measure projects by sector

Sector	Research	Demonstration	Support	Total FP4
RUE building	27	3	36	66
RES/RUE building	9			9
RUE industry	39	6	20	65
RUE transport	10	5	16	31
Fuel cells	13	0		13
General			10	10
RUE	**98**	**14**	**82**	**194**
Photovoltaics	63	7	10	80
Wind	60	3	3	66
Buildings	43		9	52
Integration of RES	18			18
Biomass	46	2	10	58
Geothermal	1	3		4
Small hydro		2	7	9
General			33	33
Others	15		3	18
Renewables	**246**	**17**	**75**	**338**
Clean technology	38	3	15	56
Hydrocarbons		38	43	81
Fossil fuels	**38**	**41**	**58**	**137**
Modelling	9			
Socio-economic	15			
Modelling & socio-economy	**24**			**24**
TOTAL	**406**	**72**	**215**	**693**

Table A-2: Cost of projects and EU contribution

	Eligible cost M ECU	Unit cost 1000 ECU	EU budget M ECU	Share of EU funding %	EU funding by sector %
Support					
Disseminatior	50	145	33	67	3.4
Strategy	33	196	21	63	2.1
SMEs	19	141	12	63	1.2
Total	**102**	**482**	**66**	**193**	**6.7**
Demonstration					
Fossil fuels	587	3887	188	32	19.4
Renewables	386	1874	126	33	13.0
RUE	376	2474	137	36	14.1
Total	**1349**	**8235**	**451**	**101**	**46.5**
Research					
Fossil fuels	79	1175	48	61	5.0
Renewables	466	1077	265	57	27.3
RUE	233	1346	126	54	13.0
Modelling	22	694	15	66	1.5
Total	**800**	**4292**	**454**	**238**	**46.8**
TOTAL	**2251**	**13 009**	**971**	**532**	**100.0**

Table A-3: Technical scope of research and demonstration projects

% of projects involving	Practical research	Hardware deployment	Prototype	Pilot	New technique	New concepts
Electricity production (research)	na	22	55	44	69	62
Electricity prod (demonstration)	na	75	50	75	75	85
Heat production (research)	na	32	65	53	71	70
Heat production (demonstration)	na	67	83	83	83	100
Industry (research)	76	27	58	58	71	78
Industry (demonstration)	83	8	75	58	75	75
Buildings (research)	82	34	63	45	74	78
Buildings (demonstration)	50	50	50	50	50	75
Transport (research)	37	10	39	20	52	52
Transport (demonstration)	80	80	100	80	100	80
Average (research)	**75**	**27**	**58**	**47**	**69**	**69**
Average (demonstration)	**78**	**58**	**71**	**72**	**78**	**84**

Figure A1: Geographical target of support measure projects

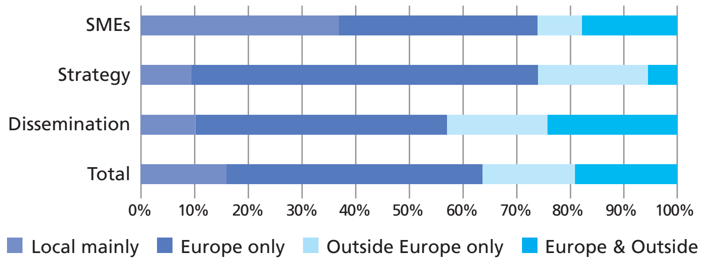
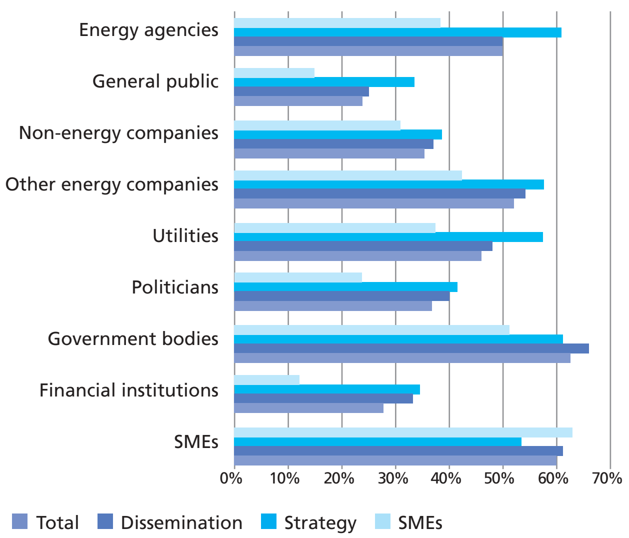


Figure A2: Organisational target of support measures*



** Because of multiple answers, the total is above 100%*

Figure A3: Events organised by support measures

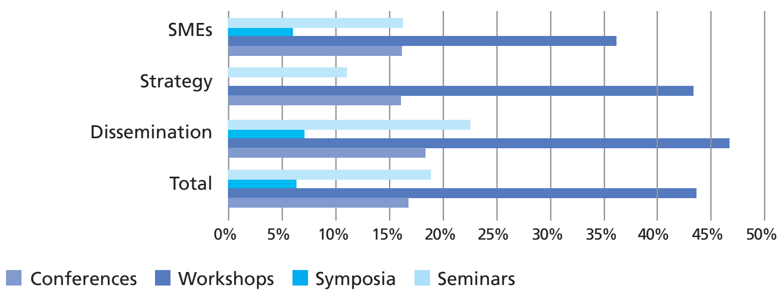
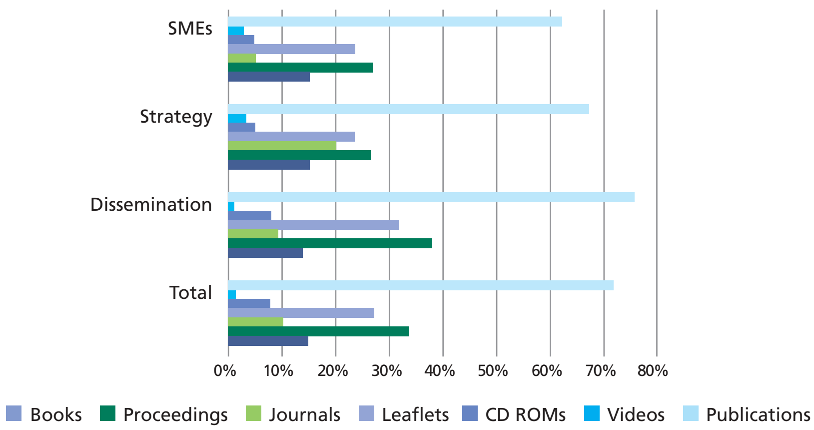


Figure A4: Production of outputs by support measures



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This publication presents the main results of a major impact assessment of the non nuclear research and demonstration energy projects from the Fourth Framework Programme (1994 – 1998). It examines their overall impact in different fields (energy RTD strategy, rational use of energy, renewable energies and fossil fuels) in terms of the technologies developed, and in protecting the environment and creating a sustainable economy, as well as other socio-economic effects, such as employment and education. Its main results can be linked to the actual energy policies which aim at reducing greenhouse gases and pollutant emissions, increasing energy supply security, improving energy efficiency, and increasing the use of renewable energy, as well as enhancing the competitiveness of European industry and improving the quality of life both within the EU and globally. An executive summary and a thematic report of this study are also available on the following website: http://europa.eu.int/comm/research/energy/index_en.html

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