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Non-Nuclear Energy Research in Europe – A comparative study

Volume 1

STUDY

EUR 21614/1

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EUROPEAN COMMISSION

Non-Nuclear Energy Research in Europe – A comparative study

Directorate-General for Research
Sustainable Energy Systems

2005

EUR 21614

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Cataloguing data can be found at the end of this publication.
Luxembourg: Office for Official Publications of the European Communities, 2005

ISBN 92-894-9369-0

Printed in Belgium

PRINTED ON WHITE CHLORINE-FREE PAPER

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Foreword

Establishing a European Research Area (ERA) for Non-Nuclear Energy (NNE) is a challenging task. EU Member States, Associated States and the European Commission have to strengthen co-operation and coordination. But this requires a detailed knowledge of European energy research, e.g. of the features of national energy R&D systems and of existing multilateral cooperation schemes. This report describes, compares and analyses the energy RTD systems of 33 European countries, including for the first time the ten new Member States. It provides a synthesised picture of actors, structures, priorities and priority setting processes and gives some recommendations on how co-operation within European NNE research could be stimulated.

It goes without saying that implementation of a NNE-ERA needs the strong commitment of all countries involved. This has been reflected in this study by integrating energy experts and decision makers from Member and Associated States in all phases of the project. People were asked to provide feedback on the country studies placed on the internet, and three workshops with the broad participation of policy-makers, programme managers and scientists were held to address specific issues related to European NNE research. Finally, the results of the study were put up for discussion in a validation workshop among high-level officials responsible for shaping energy research in their respective countries.

The implications of a NNE ERA go even beyond Europe. One of the driving factors for increased cooperation within Europe is the need to maintain or even improve its position vis-à-vis its competitors, in particular the United States and Japan. Thus it seemed appropriate to complement this study with a senior expert's independent analysis of the policy implications coming from the report. Mr David Irving, retired high-level official of the UK's Department for Energy with many years experience in the International Energy Agency and in Committees of the European Union, agreed to reflect on Obstacles, Opportunities and Options to build an ERA for NNE.

This project does not mark the end, but the beginning of a process. It should provide the basis for discussions on the future of NNE research in Europe and show ways how co-operation within Europe could be improved.

Brussels, April 2005

Executive Summary

The European Commission (Research DG) has commissioned a study into synergies in the area of Non-Nuclear Energy Research and Technological Development (NNE-RTD). This study was to address the needs and benefits of implementing a European Research Area (ERA) in the field of NNE. It aims at providing decision-makers in Member States, Associated States and the EC with improved knowledge and understanding of NNE-RTD policies and activities in Europe, and on ERA-related issues. This should help them to undertake more and co-ordinated initiatives in the preparation, implementation and dissemination of RTD in the NNE field.

The study was carried out by Technopolis between September 2003 and September 2004. It consisted of 33 country studies and three workshops relating to, respectively, 1. general policy issues, 2. the consequences of the arrival of the new Member States and 3. the construction of an ERA in NNE-RTD and for national policy mixes in NNE-RTD.

All Member States and Associated States fund and perform RTD activities related to NNE. However, there is an enormous variety between countries in

- levels of funding
- research priorities
- the way in which in each country's NNE-RTD priorities have evolved over time, with regard to
  - ▷ the budgets invested
  - ▷ the way in which priorities have shifted within countries
- the way in which NNE-RTD is prepared and implemented.

The only multilateral cooperation schemes for energy research are either provided by the European Commission, through the RTD Framework Programmes or the European Technology platforms (ETP), or by the IEA, through the Implementing Agreements.

The main observations and conclusions of the study are as follows.

Variable levels and trends in funding

IEA figures allow us to estimate[1] that all ERA countries (excluding the EC) together spend around **one billion euros per annum** on NNE-RTD (public funding). The European Commission budget (Framework Programme) for NNE-RTD is about **one-fifth** of this sum. The European Framework Programme therefore represents the biggest single budget for NNE-RTD in Europe. Also according to IEA statistics, Japan spends about the same as the sum of all ERA countries' NNE-RTD expenditures, whereas USA expenditures on NNE-RTD would be at least twice as much.

While the sum of ERA country budgets has decreased over the past ten years, the EC budget has increased. Therefore, overall, no significant decrease in public funding of NNE-RTD can be observed.

Within the ERA four groups of NNE-RTD investors can be distinguished:

- The 'heavy investors' of Italy, Germany and the Netherlands, spending the equivalent of over $140 million per annum over the past ten years

[1] IEA figures are given in USD not in euros.

- The ‘upper medium investors’ of France, Switzerland and Sweden, which in 2003 spent just over $100 million per annum, with overall budgets being on the rise over the past five years
- The ‘medium investors’ of Finland, Norway, UK, Spain, Austria and Denmark, which in 2003 spent between $20 and 80 million per annum
- The ‘low investors’ (all other countries) spending $10 million and below.

This picture changes considerably if NNE-RTD investments on GDP are considered. In that case Finland, Sweden, Norway, Switzerland and the Netherlands rank first, followed by Italy, Austria and Denmark. Big *absolute* spenders such as Germany and France have a relative spend in the order of magnitude of countries like Ireland, Spain and Greece.

Visions against which NNE-RTD is justified relate, in particular, to greenhouse gases and their devastating effects on the economy and society. NNE-RTD is further motivated by three closely interrelated aims, i.e. the support to national energy and/or energy technology endowment and support to national industrial sectors; by energy independence and security issues; by longer-term RTD policies, especially relating to the hydrogen society and more generally the contribution of energy RTD to policies of sustainable development.

A variable geometry of research priorities with an emerging concentration on fuel cells and PV

The presence of dedicated NNE-RTD programmes is variable. There is a sharp distinction between, on the one hand, the EU-15 Member States plus (most) Associated States, and, on the other hand, the new Member States. One-third of the 33 ERA countries did *not* have any form of dedicated NNE-RTD programme (i.e. either relating to individual aspects or overarching) by the end of 2003 – these are the ten new Member States, plus two other, small, countries.

An analysis of current research priorities shows that there is not one single NNE-RTD theme which has the same priority for all 33 countries. Thematically speaking, the NNE-RTD ERA has a **variable geometry**. Even though a great thematic variety exists, in general shared priorities between ERA countries are emerging at present. These are power and storage technologies, in particular **fuel cells**, and **photovoltaic solar**. To a lesser extent there is an interest in biomass and conservation. Other NNE-RTD priority themes are shared by a limited number of countries only.

Different implementation structures and policy mixes

Countries generally implement NNE-RTD in four distinctive ways:

- Through a dedicated energy agency often also covering environmental issues
- Through a technology agency which manages energy RTD programmes
- Directly falling under the responsibility of the relevant ministry
- Through the main national research organisation of a country in the area, which acts de facto as an agency.

No natural evolutions within countries, from one setting to another, have been observed. For most countries the system of governance of NNE-RTD has been in a steady state for the past ten years. In many ERA countries however, the governance of the RTDI system as a whole is currently under revision. This may impact the way in which NNE-RTD is organised in the future (e.g. mergers of agencies).

Concerning private sector involvement, the most privileged parts of the policy cycle where private stakeholders are involved are the programme preparation stage and the programme implementation stage. No specific SME-oriented measures aimed at promoting NNE-RTD could be identified, whereas at the same time SME involvement is viewed in many countries as crucial for the NNE sector, both traditionally and in the future. SME-oriented measures are generic in nature (soft loan schemes, tax incentives etc) and not linked specifically to NNE-RTD.

The development of evaluation practice is varied and heterogeneous. There are some good practices emerging, originating mostly in the administrations in the north of Europe and trickling down to the southern and eastern countries.

Weak international co-operation outside the Framework Programme, other EC initiatives and the IEA

With the exception of the Nordic Energy Research programme, there is no systematic or consistent multilateral co-operation in RTD *outside* the regular EU programmes or the IEA Implementing Agreements. However, in 2004 several technology platforms were prepared, in the field of hydrogen and fuel cells, for PV and for biomass. Also a European Wind Academy, linking institutes in four different European countries, has recently been set up.

Through its successive non-nuclear energy research programmes (NNE, JOULE, ENERGIE), the European Framework Programme has been the major driver of multilateral research co-operation in NNE in Europe. As a consequence, national policy-makers appear to find it very hard to think *beyond* the Framework Programme when asked to think about multilateral co-operation. **The different ERA countries should be made aware that NNE-RTD bi- or multilateral co-operation outside the sole Framework Programme should become increasingly a part of the national policy mix and that such co-operation within ERA should be sought much more actively.**

Barriers to the further completion of an ERA in NNE-RTD

The following barriers for further development of ERA could be identified and should be removed:

- National priority setting **so far has not taken into account the priorities of other countries**. Hence priorities are not explicitly shared between countries, and only loosely coordinated through the Framework Programme. However, **common priority setting has recently started to gain an increased interest through initiatives such as the ERA-NETs and ETPs**. Shared thematic RTD priorities (which may be complementary) are thought to be the most important reason for working together. Differences in the structure of the national policy mix or in national research infrastructures are found *not* to be barriers to international co-operation. It is recommended that more systematic and regular benchmarking of NNE-RTD policies, programmes and priorities takes place
- Apart from in some smaller countries more dependent on the Framework Programme, there is **no synchronisation of the priority setting process** with EU programmes or with each other. In order to be able to integrate evolutions and priorities in other countries, priority-setting processes should be more **synchronised** between countries

- No dedicated budgets exist as yet for trans-national research. National administrations are only starting to become accustomed, through the ERA-NET concept, to the idea of increased coordination and opening of national programmes, let alone to sharing budgets. National policy instruments, policy processes and priorities *remain very national* and foreign participation is most of the time impossible: even in bilateral programmes national teams are paid by national authorities, as in the case of Eureka. In some countries, legal barriers may exist preventing foreign participants from participating in national programmes. It is recommended that ERA countries reserve budget lines for participation of foreign participants in national NNE-RTD programmes. Eventual legal barriers should be removed. This notwithstanding, legitimate reasons will continue to exist for countries to promote purely national RTD programmes.

The urgent integration of the new Member States

During the course of this study, ten new Member States joined the European Union. Their integration into the NNE-RTD ERA is of particular importance. Most new Member States have a well-trained researcher population but weakly developed energy policies and, often, weakly developed or virtually nonexistent energy RTD infrastructures. The challenge for the new Member States to create synergies in NNE-RTD in Europe is to follow a diversified strategy, including mobility of researchers to and from the rest of Europe, partnering with other European countries on more basic research where the new Member State has a clear need and the other state has something to offer; and establishing innovation or technology transfer programmes in specific areas, to be accompanied with competence building, training programmes and local development.

Where to go from here?

From the current state of affairs, the study points at three ways to go, simultaneously.

- First, a **joint top-down coordination** from the side of the ERA States *and* of the Commission is recommended. This requires a more strategic approach in which forces join together to decide upon the themes that should be pursued at European level, and those that could benefit from multilateral or bilateral co-operation *outside* the framework programme
- Second, the synergies detected in NNE-RTD themes across countries also hint at the need and possibility for a more **bottom-up approach in which two or more countries join forces to launch common calls for proposals**. Relevant areas for this are those where a small number of countries are highly involved with a certain type of area: fossil fuel RTD is an example. It could also be areas where many areas have a low priority. Also this approach does not exclude the previous one but can be implemented in conjunction with it. There is an increasing experience with such co-operation in other research areas where the need for more European bi- and multilateral co-operation is felt (e.g. information technologies, transport). A mechanism that has proved its validity and is as yet not applied to NNE-RTD would be the *Eureka Cluster*. Also, IEA Implementing Agreements are a good vehicle for multilateral co-operation in Energy RTD and may also contribute to the reinforcement of the ERA
- Third, with a view towards the new Member States – but not only in that direction – much more attention should be given to the mobility of doctoral and especially post-doctoral researchers in the area of NNE-RTD. Today many examples of bi- or multilaterally organised mobility programmes between European countries exist (the French Programme d'Actions Intégrées, for instance), but such programmes are organised in a disciplinary fashion. Mobility focusing on NNE-RTD is virtually absent, although recent initiatives such as the European Academy for Wind Energy may constitute a change in this regard.

For all three types of activities to be realised, however, and in order to actively promote such a strategic approach it is a prerequisite that the ERA countries should be much more systematically, and better, informed about their mutual needs and assets, for instance through an **observatory** for NNE-RTD and a better exploitation of the possibilities offered by the IEA in terms of monitoring national NNE-RTD budgets and policies.

Reflections of a senior expert

Introduction

A reliable and secure energy supply is an essential prerequisite for a successful economy, whether at the local, regional, national or global level. The price of energy, especially of oil, is one of the main determinants of the state of the world economy. However, the European citizen has come to take his energy supply for granted – the lights always go on when the switch is thrown, there is always fuel available for his car, his workplace can be kept warm in winter or cool in summer. The fundamental importance of energy to the daily life of the citizen is seldom thought about, understood or appreciated.

This general air of public complacency is only disturbed when there is a temporary blackout or a disruption to transport fuel supplies, when there is a very strong reaction having repercussions at the highest political level. But once the crisis, usually very short lived, has passed society returns to its normal pattern of behaviour without giving much thought to its energy needs.

But matters are not as straightforward as they may appear to the citizen. Europe is facing major energy challenges. First, Europe faces a major challenge to meet its Kyoto commitments, and will be unable to do so unless it can tackle problems in the energy sector, which is the major source of greenhouse gas emissions. Second, Europe is very reliant on imports to meet its energy needs. This reliance is predicted to rise to 70% by the end of the decade. The environmental and security of supply issues pose very real threats to the rather comfortable assumptions on which so much of our daily life is based.

These challenges facing Europe are to be felt at both the level of the Union, and at Member State level. Although the balance between these two pressing priorities (the environment and security of supply) may differ from Member State to Member State, all need to act to address these challenges. A vigorous programme of R&D would appear to be an essential component of any strategy that Europe, or its Member States, should adopt to meet these challenges.

The United States clearly sees energy R&D as a main plank in its attempts to reduce its import dependence and respond to environmental concerns. Indeed, the US has been criticised in some quarters for an over reliance on the ability of technology to solve these problems. Japan has also invested heavily in the energy R&D over recent years in response to its own security of supply and environmental concerns.

The European Research Area: a new feature for European energy research

The Commission proposed, and the Council and Parliament readily supported, proposals for the development of a European Research Area (ERA) that would allow Europe as a whole to gain the full benefit of the excellent, but somewhat dispersed and uncoordinated, research that is undertaken in the Member States. It was perceived that our major global competitors, USA and Japan, have been able to develop more coherent research programmes than Europe, whose efforts have sometimes seemed fragmented.

During the course of the Sixth Framework Programme a number of initiatives have been undertaken that are intended to help build the European Research Area. For example, one of the new instruments introduced in FP6 – networks of excellence – is designed to encourage the development of networks of researchers throughout Europe and collaboration in the solution of common problems.

These various initiatives are general in the nature, covering the whole spectrum of research and scientific endeavour. However, it may be there are dangers of a "one size fits all" approach in such generic actions and that some more targeted, sectoral action may be necessary to underpin the general cross cutting initiatives.

In this context, the Commission has commissioned a study of energy R&D in the Member States in order to understand better what is going on at national level, and see what action over and above the general actions, if any, may be needed in the energy sector to stimulate the development of the ERA in energy.

This study was carried out by Technopolis and is annexed. There have been similar attempts in the past, such as the SENSER project which started in March 1996 and lasted 2 years and PSI which started in March 1998 with duration of 28 months. But this study is the most recent and the only one that has attempted to survey the work going on in the new Member States and the Associated States and to assess broadly the potential of ERA in energy and the obstacles to make it a reality in this field. It therefore provides new insights, lessons and recommendations relevant to this changing context .

The policy-makers' perceptions about energy R&D

In the light of some of the above considerations and earlier studies, there are a number of assumptions made, and preconceptions held, about the state of energy R&D in Europe. The Technopolis report has allowed the validity of these assumptions to be tested (especially of 3 major ones) against new data.

- One assumption to be tested is that energy R&D is a high priority. It has always been a component of the Framework Programme and the question of climate change and greenhouse gas emissions has come right to the top of the political agenda in the last decade. Even if security of supply has been a less urgent issue in the past few years, and in general out of the public eye, it might still be expected to remain an issue in the minds of policy-makers and long term decision makers
- As noted, the problems of environment and security are common to all and are not susceptible to national solutions. It might therefore be expected that there would be a high degree of commonality in the energy R&D priorities in the different Member States, bringing with it the risk of duplication of effort.

One way of reducing the risk of duplication of effort is international collaboration. Indeed this is one of the underlying motivations of the ERA. International collaboration in energy R&D is well developed, given that the energy sector has a unique vehicle to allow collaboration. The Implementing Agreement mechanism established by the International Energy Agency (IEA) provides a means for countries to work together. Details of this system can be found at www.iea.org under "technology".

- Few, if any, other sectors have a comparable mechanism. Since this system has been in place for more than 25 years, and successfully motivated collaboration across a range of energy technologies, it might be expected that establishing an ERA in energy should be easier than other sectors that did not have the advantage of such a history of collaboration.

The findings undermine cosy assumptions

The Technopolis study shows that some of these tacit assumptions that policy-makers may have are ill founded. They show that there is no room for complacency. Energy R&D in Europe is far from healthy. Prospects for the early establishment of a European Research Area as it relates to energy are not good.

Energy R&D has insufficient priority

The first conclusion to be drawn is that energy R&D is not being given the priority it merits. There appears to be a gap between political rhetoric and delivery of new research. Technopolis reports that the ERA countries together spend about €1 billion on energy R&D, about the same as Japan but half that of USA. The Technopolis report points out that that the sum of ERA country budgets has decreased over the past decade.

The energy budget in Framework is higher in current euro terms than it was 10 years ago, but this may be misleading. It takes no account of the THERMIE demonstration programme that was not part of the Framework programme. When the demonstration programme was integrated into Framework, the budget was increased to make allowance for this. The overall budget for energy R, D&D did not increase as the Technopolis report might imply. Moreover, the sharp 20% decline in NNE funding from FP5 (c. €1 billion) to FP6 (c. €800 million) should not be overlooked.

The annual spend by the Commission during FP5 represents about 20% of the total spend in ERA countries. Although the budget has fallen in FP6, the Commission's budget remains higher than any of the individual Member States. Although some Member States appear to invest heavily in energy RTD, the majority do not and a number (mainly the new Member States) appear to have virtually no national investment in energy RTD. Technopolis reports that, if GDP is taken into account, the only Member States that could be regarded as heavy investors are Finland, Sweden and the Netherlands (and the latter two have recently announced cut backs). This all appears in stark contrast with the USA that has increased its budgets over recent years and announced major new initiatives in, e.g. hydrogen and carbon sequestration, whilst Europe remains dormant.

But a direct comparison of the energy R&D budgets in Member States with those in USA and Japan is bound to show substantial differences and may be misleading. Perhaps a better metric of interest in energy R&D is the proportion of GDP that is committed to energy R&D. IEA data (Energy Policies of IEA Countries 2003, Table B4 p.397) suggests that the ratio of non nuclear energy R&D for both USA and Japan per thousand units of GDP is about 0.25, and has been stable at around this level for many years.

R&D/GDP excluding nuclear research

	1994	1995	1996	1997	1998	1999	2000	2001	2002e
US	0.29	0.26	0.24	0.20	0.22	0.22	0.20	0.25	0.25
Japan	0.22	0.22	0.22	0.21	0.25	0.24	0.25	0.25	
Austria	0.13	0.13	0.13	0.13	0.13	0.12			
Denmark	0.26	0.24	0.20	0.23	0.25	0.23	0.23	0.22	0.10
Finland	0.48	0.55	0.49	0.67	0.64	0.57	0.44	0.41	
France	0.04	0.04	0.04	0.03	0.04	0.04	0.05	0.06	
Germany	0.07	0.06	0.08	0.06	0.05	0.06	0.08	0.07	
Italy	0.15	0.16	0.14	0.12	0.13		0.14	0.15	
Netherlands	0.42	0.35	0.36	0.38	0.36	0.34	0.26	0.35	
Norway	0.34	0.26	0.23	0.20	0.19	0.25	0.21	0.21	0.22
Portugal	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01
Spain	0.09	0.07	0.07	0.06	0.05	0.05	0.04	0.04	0.04
Sweden	0.30	0.23	0.21	0.23	0.21	0.27	0.29	0.33	
Switzerland	0.44	0.43	0.40	0.37	0.34	0.34	0.28	0.29	0.31
UK	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.02	0.02

Source: IEA statistics

It is perhaps surprising to see that some countries in Europe (e.g. Finland, Netherlands, Sweden and Switzerland) have achieved levels above this and Norway (0.22) is at a comparable level. But the majority of Member States show investment levels/GDP of less than half that in US and Japan.

Taken overall, Europe is seen to be devoting far less of its GDP to energy research than either the USA or Japan. And this is not a marginal difference, but is by a factor of 2 or more.

European energy R&D lacks focus

The Technopolis study confirms that there are many areas of common interest, especially in renewables and rational use of energy. But in spite of this there is no single priority shared by all. Within the renewables sector, for example, the emphasis may be on wind, biomass, solar or marine, depending on how the country in question views its resource and research capability.

This may explain why it has been difficult to get the FP to focus on a limited set of priorities. Although there is general support amongst Member States for the principle of focus and prioritisation, the selection of these priorities will always prove difficult whilst national priorities remain so diverse. But whilst the FP continues to be the biggest single programme in Europe, dwarfing most national programmes, the research community will continue to press their own lines of research as ones that require EU support.

The divergent approaches that exist between the Member States serve to weaken what is already an under resourced energy research effort across Europe. This should be a cause of concern to the policy maker, especially when comparison is made with our principal competitors, USA and Japan. In both these countries we see a clear identification of national priorities and the commitment of the necessary resources to deliver objectives.

In the USA, the Department of Energy is responsible for very large energy research programmes and some 11 national laboratories. It is true that some of this effort is directed towards defence purposes, and that the major science programme supported by the Office of Science within DOE includes topics not immediately thought of as energy related, such as computing and biotechnology. But even discounting this work, US energy research is on a scale that dwarfs what exists in Europe. Japan has also concentrated its programmes in a single ministry, again providing a degree of coordination and focus that is not evident either in Europe as a whole, or even within the individual Member States.

The result is that there are only a few niche areas where Europe can still claim to be up with the international competition in terms of energy technology. Europe may still have a world lead in wind and biomass, but in terms of many conventional technologies (gas turbines, clean coal) there is a concern that we may be slipping behind and that Europe is struggling to keep up with its competitors in some of the emerging technologies such as fuel cells and PV.

The consequences of underperformance by European energy R&D

Policy-makers need to consider whether the current effort will be sufficient to meet the environmental and supply challenges that are facing Europe. One option would be to leave USA and Japan to take the risks inherent in developing the new technologies we need, and then buy it in. But this could result in Europe being put out of the race and to miss the opportunities associated with the opening of new markets linked to advanced technologies.

Putting aside the environmental and security of supply challenge, policy-makers also need to consider whether Europe can afford to leave the market for energy technologies to our competitors to exploit. Much is made of the rapid expansion in energy use in China, India, Brazil and other emerging economies, and the threats this poses both to the environment and to the availability of energy. But with this threat comes major opportunities for exports of technology and "know how" that USA and Japan are ready to exploit. Unless Europe pays attention to its energy R&D base, it will be ill equipped to compete in these expanding markets.

The establishment of an energy ERA could be part of the answer

In order to remedy the problems that have been exposed by the Technopolis study, it is clear that policy-makers will need to consider making additional resources available to support energy R&D. But that alone will be insufficient. Increasing national R&D budgets in each of the Member States by x % would not solve the problems of diverging priorities and its counterpart, the duplication of effort. Indeed, increased budgets could merely serve to reinforce these differences of approach if all that Member States were to do is "more of the same".

If Europe is to gain the maximum benefit from its current investment in energy R&D, there needs to be greater coordination and cooperation between the research communities in the Member States. Synergies between national programmes must be identified and exploited. Duplication of effort must be eliminated. Of course, these are principles that are at the heart of the concept of a European Research Area. An Energy ERA would contribute greatly to the development of energy technologies that will address our environmental and security concerns, and provide Europe with a suite of technologies that can compete in global markets.

What is getting in the way?

Few would seek to argue that greater coordination and cooperation is likely to lead to improved results. But if this is such an obvious solution, why has it not been pursued? What stops Europe maximising its potential? What could be done to remove these obstacles? The Technopolis report has provided data that helps identify some of these obstacles.

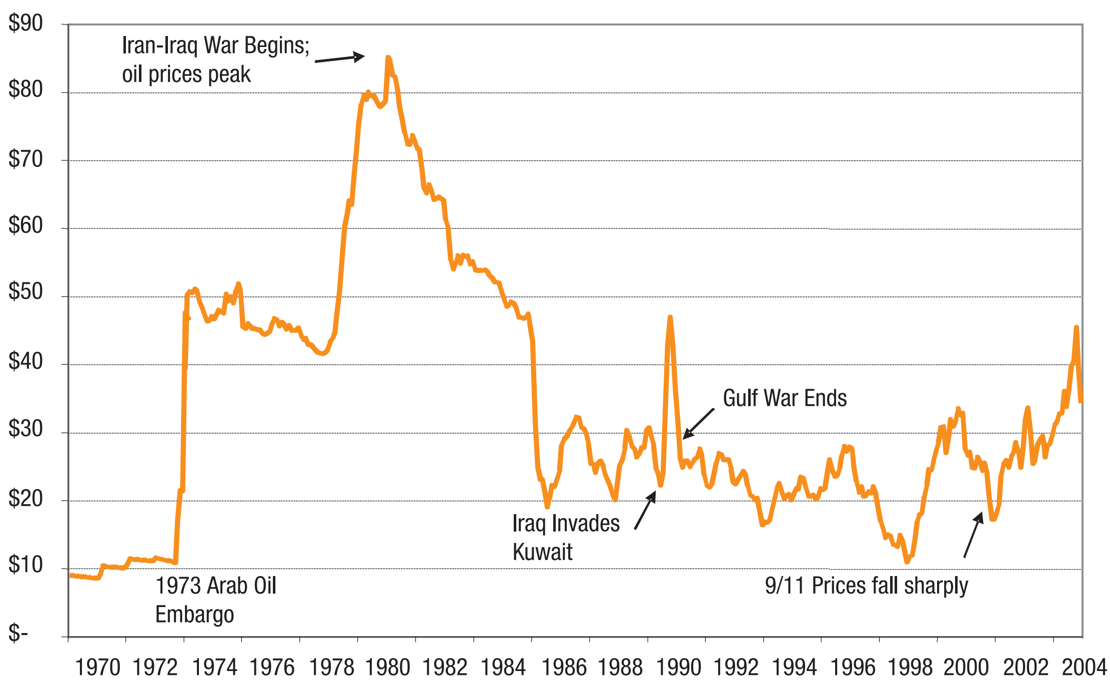
Energy prices have been too low to stimulate R&D

One obstacle to greater investment in energy R&D seems to be that the price of energy is too low. It may seem perverse to argue that energy in Europe is too cheap, but it is undoubtedly the case that while energy prices remain low in historical terms, and the citizen does not experience any sudden price hikes or supply shortages, the incentive to invest in energy R&D is reduced. Other areas of research, e.g. health, biotechnology, will be given priority by both the public and policy-makers. A low price of energy reduces the incentive to invest in more energy efficient equipment. Renewable energy can only penetrate the market if it is subsidised. The reduced market demand for these technologies has a knock back on the research effort.

Data taken from a US Department of Energy web site shows the way oil prices have fluctuated over the past 30 years (http://www.eia.doe.gov/emeu/cabs/chron.html). The graph below shows the price in real terms, i.e. with allowance for inflation and is expressed in terms of 2005 dollars.

Real World Oil Prices, 1970-2005

(Prices adjusted to $2005)



Source: EIA

Although oil prices have now again reached those seen during the first oil price shock, they have only done so after a steady rise, quite unlike the experience in 1973, and are still considerably less than the highest prices of the early 80s.

The dramatic increase in oil prices during the first oil shock in the 1970's led to a considerable increase in energy R&D budgets across the globe. The decline in price in real terms during the latter years of the last century has been mirrored by declining R&D budgets, which both the IEA and Technopolis have noted. It is too early to say whether the recent price rises will again spark an increase in energy R&D as it did in the `70s, although there are no signs yet to indicate that this will happen. It is however quite apparent that environmental concerns, which have only really emerged as of importance in the last decade and which Technopolis notes is now the main driver of energy R&D in Europe, has not provided the same incentive to energy R&D as past oil shocks have done.

Policy-makers need to consider whether they have been lulled into a false sense of security by a protracted period of relatively stable energy prices, and whether the response made to the environmental challenge has been sufficient when compared to the response to price shocks. Research, by its nature, cannot provide instant solutions.
It is therefore difficult to understand the rationale by which policy-makers have responded to a long term problem (climate change) with a less ambitious programme of research than was put in place to combat an immediate (and as events turned out, short term) problem of oil supply.

European energy research lacks focus; Dispersion of policy and management responsibilities may not help

A second factor that may have hindered coordination of the research effort in energy is that, as Technopolis has confirmed, the national programmes are run by different agencies throughout Europe. It is only in the minority of cases that the lead is taken by the Science or Research Ministry. As a consequence, policy initiatives such as the establishment of ERA may not percolate back to those responsible for energy research at national level with quite the ease that it does for other areas of research where responsibility is more centralised. It could be that there is a failure in communicating the advantages of ERA in the special circumstances that exist in the energy sector.

The fact that energy R&D is often managed at national level by energy or environmental agencies, or by energy, environment or economic ministries may also have the consequence that the role of research in solving the problems facing the energy sector may not be fully appreciated. It is the case that in several instances R&D is but part of a wider programme that includes support for demonstration, market deployment, dissemination, as well as elements of and public awareness and information. Within such a structure, it is not altogether surprising that that R&D does not always get a prominent profile.

The situation is further complicated by the fact that in some Member States elements of energy policy are devolved to regional or local authorities. Although research tends not to be a devolved responsibility, associated issues such as demonstration and dissemination often are. All this serves to increase the difficulty of getting a consistent and unified approach to energy technology policy.

This complexity is even to be observed in Brussels, where both DG RTD and DG TREN have responsibilities in energy R, D&D and manage different aspects of the non nuclear energy component of the Framework Programme. Although the two Directorate- Generals have been working together on the same programme for some time, there is still a discernible difference between the two parts of the energy programme, something that the independent observers of the project evaluation process have mentioned in their reports.

This heterogeneity has evolved over many years and is too deeply entrenched to be easily undone, even if this was thought desirable. Policy-makers should therefore consider ways to improve communication between the various agencies and organisations involved in sponsoring energy R&D throughout Europe with a view to disseminating messages about the advantages of greater coordination and cooperation.

An improved network of agencies and institutions responsible for energy research would also allow dissemination of best practice, especially with regard to matters such as programme management and evaluation. The Technopolis report found that the quality of evaluation practice varied widely, and there is clearly scope for the weaker programmes to learn from the better ones.

Little real European collaboration outside Framework

There have, of course, been many different networks established over the years that brought agencies responsible for energy R&D together. The Technopolis report draws attention to the IEA Implementing Agreements that have proved to be very successful vehicles for collaborative R&D, not only between EU Member States but also between Europe and countries such as US, Japan, Canada and Australia.

All of EU-15 and several of the Associated States such as Norway and Switzerland have long been members of the IEA, and participated in a range of Implementing Agreements. It is recognised that, of the new Member States, only Hungary and the Czech Republic are IEA members, so the Implementing Agreement mechanism may have been less accessible to them. It should however be noted that the restrictions on participation in Implementing Agreements by non IEA countries have been reduced considerably over the last few years, so the new Member States could have participated had there been real interest. And although Hungary is an IEA member, it does not participate in a single Agreement.

For EU-15 and Associate States who are members of the IEA, one observes a well established tradition of multilateral international collaboration. In spite of this the Technopolis report has identified little or no collaboration outside the IEA framework. Moreover, although the IEA Implementing Agreements have enjoyed considerable success in promoting collaboration between countries, the Implementing Agreements have not been sufficiently attractive to the new Member States to encourage them to participate to any significant extent. It is thought however that this is due to the fact that few of the new Member States have any significant energy programmes to bring into an international collaboration rather than any failing on the part of the Implementing Agreement mechanism.

In addition to IEA collaboration, other networks, such as the OPET, EnR and various ERA NET networks have been established in the energy area. But in spite of this long tradition of interaction between national programmes and agencies, Technopolis found that there was very little if any “systematic or consistent” collaboration between programmes within Europe, with the notable exception of the Nordic Energy Research Programme.

There is collaboration within the Framework Programme (FP), but this seems to be result of a `bottom up’ impetus – the legal requirement for research teams to form a consortium of partners from different Member States.
There is little evidence to suggest that the FP is having a `top down’ effect in bringing national programmes closer together or to influence them towards a focus on common priorities.

Having said that, it is recognised that the FP serves a different function for those Member States with very small or no national programmes. In these countries it may be the most important or even the only source of support for energy research. In such circumstances the FP will serve to bring researchers operating at the national level together, and the FP will have strongly influenced the profile of work being done in the country. The FP could even be said to have become, by default, the national programme in such Member States.

Opening up national programmes

Technopolis noted the lack of any significant move to open up national programmes, which has been seen as a key element in building the ERA. In general, national programmes do not proactively encourage cross border collaboration, e.g. by ring fencing a portion of their budgets for such projects. There is some evidence of modest attempts to promote collaboration in a few countries, e.g. the Netherlands, but these seem very much the exceptions to the rule.

It is not clear why this insular attitude should be so prevalent, but one factor may be that energy R&D programmes have an industrial policy objective in many countries. That is to say the programmes are motivated by finding solutions to energy problems but also to encouraging the domestic industry to find this solution in order to gain competitive advantage. This could explain the reluctance to open programmes to other nationals, and why there is duplication between the national programmes.

The fact that so many energy R&D programmes are managed outside the science/research ministries suggests there may be something in this analysis. If it is correct, the establishment of an ERA in energy will be very difficult to develop, certainly more so than in areas of more basic research.

The contrast with fusion

In this context, it is noted that perhaps the best example of research coordinated at European level, and a field where there a European Research Area could be said to have long been established, is nuclear fusion. This could be classed as an energy programme and makes the contrast with the experience in non nuclear energy all the more striking. But fusion is very basic and fundamental research which is not expected to result in commercial energy production for 40 years. In that respect it is much more similar to other areas of research and science covered by the FP than the research conducted in non nuclear energy which for the most part is concerned with incremental improvements of known technologies, and large part driven by the need to reduce costs.

Moreover fusion is a research project that, by general consent, is beyond the capability of a single Member State to “go it alone”. In contrast, non nuclear research does not require the same level of resources and there is no constraint on Member States pursuing their own national priorities.

The new Member States must be involved

The Technopolis report confirmed that energy R&D is not well established in many of the new Member States. This is a matter that should worry policy-makers. If the ERA is to succeed it must be a research area that encompasses the whole of Europe, not a subset of Member States and Associated States with well developed national programmes.

It is clear from the Technopolis report that many of the new Member States are starting from a very low baseline in terms of energy R&D. This is a major challenge, but also a great opportunity. Few of the new Member States have the heritage of a strong energy R&D programme, but nor are they locked in to a multiplicity of structures that have evolved over many years in EU-15, and which have led to the lack of focus to which Technopolis have drawn attention. Europe therefore has the opportunity to help the new Member States to put in place energy R&D programmes that are focused and prioritised and which benefit from the experience of others in terms of programme management and evaluation.

But a network of well coordinated and focused energy RTD programmes in the new Member States will not evolve naturally. A well resourced and planned programme of action is needed. Policy-makers should reflect on how this should be done. Possible options include encouraging EU-15 energy research programme mangers to mentor their counterparts in a new Member State; ring fencing some Framework money to support research in the new Member State, co-funding their national programmes; encouraging participation in mature national programmes by researchers from the new Member States (a very limited and specific opening up of national programmes as called for by ERA); and more targeted use of Marie Curie to promote the development of the research capability in the new Member States.

The overall object of any such programme, which should be financed from the Framework Programme, would be to help the new Member States develop their energy R&D capability and to do so in a way that ensured they were integrated into the European Research Area from the start.

Obstacles, opportunities and options

It is very evident from the Technopolis report that we are a long way from establishing an ERA in non nuclear energy RTD. There are many obstacles to progress, some of which will require significant effort and resource to overcome. There is no discernible pressure from within the energy research community to set up an ERA, possibly because it feels it has all it needs via the IEA. There is wide variation in the structure of the national programmes in the Member States. Even within the Commission, there is division of responsibility for energy RTD.

But it is also clear that ERA could provide many opportunities for Europe. It would allow Europe to get the best from its investment in energy R&D. Europe could respond to new challenges in a unified way, as the USA and Japan have done. It provides the opportunity to integrate the new Member States into the Union in a practical and meaningful way.

Against this background, and the Technopolis report, it seems reasonable to conclude that an ERA in non nuclear energy RTD will not just “happen”, if sufficient time is allowed for its evolution.

If this is correct, policy-makers appear to have three basic options:

- To accept the status quo
- To seek alternative ways of achieving ERA objectives
- To pursue the ERA option more vigorously.

These are now considered in a little more detail.

- **Accept the status quo (option A)**

  The obstacles to the creation of an energy ERA are considerable. Ministers in the Member States, the Council, the European Parliament, the Commission and other decision makers do not appear to have regarded energy R&D as a sufficiently high priority to increase (or even maintain) budgets. In that respect there seems to be a mismatch between the political rhetoric about the need to meet the climate change challenge and the resources directed to energy RTD. There has been no discernible public pressure for greater research effort on energy over the last 10 or 15 years.

  It could also be argued that coordination and cooperation already exist through the IEA mechanisms, and that trying to establish an ERA in energy would duplicate that which already exists. To attempt to go beyond the cooperation obtained through the IEA would be forcing collaboration beyond that which the energy research community wants or needs. The voluntary nature of the Implementing Agreements means that the "supply and demand" for cooperation can be balanced.

  There has been no "bottom up" call from the energy sector for an ERA, and there is little if anything in the Technopolis report that could be interpreted as such a call – if anything, the contrary. Imposing an ERA on an area that has not shown interest in the potential benefits could be counter productive.

  Such considerations could lead to the conclusion that the cost and effort of creating an ERA in energy is not justified. Accepting the status quo is, of course, the easiest option since no further action is required, and consequentially it is also the cheapest, at least in the short term.

  But before taking this "easy option" policy-makers should first consider whether they are satisfied that all is well in European energy research and that it can be left alone. The evidence from Technopolis and elsewhere strongly suggests that it is not. Energy research budgets and national programmes appear to be under pressure and in general decline. Certainly they have not been strengthened to meet the challenges of climate change. As Technopolis has noted, there is virtually no national energy R&D effort in the new Member States.

  Moreover policy-makers should consider the risks of inaction – Will Europe fall further behind US and Japanese competitors? Can the twin challenges of climate change and the need to ensure energy security for Europe be met without new technologies? Can Europe be a player on the world stage without a capability in energy research? Will the short term savings outweigh the long term costs of inaction?

  It is believed that any serious consideration of these questions would lead to the conclusion that the status quo is not such an attractive option as might at first appear. The overall message from Technopolis is that there are serious problems in European energy R&D that require attention, and although there is a debate to be had about whether an energy ERA can or should be established to address these issues, policy-makers need to take some action to close the gap with USA and Japan, and to ensure Europe has the technologies it needs to meet the environmental and security of supply challenges it faces.

If it is concluded that the status quo cannot be allowed to continue, then ways must be found to deliver the objectives of an ERA, either by establishing an energy ERA or by some other route.

- **Alternative ways of achieving the same ends – can we have an energy research area without ERA? (option B)**

The many peculiarities of the energy RTD scene in Europe (e.g. managed by many agencies, already established international collaboration mechanism) have been brought out in the Technopolis report, and mentioned again in this paper. It could be asked whether a `one size fits all' approach to the establishment of the ERA makes sense, especially when applied to a sector that appears to be different from many others. The present heterogeneous structure of energy R&D throughout Europe will make achievement of an energy ERA very difficult.

But if the ERA model is not to be applied to energy, are there other ways of achieving the same objectives – greater coordination, better focus, more uniform prioritisation, improved consistency of management and evaluation, etc.? These would seem to be worthy objectives in their own right, which would bring benefits to Europe, and if establishment of an ERA proves too problematic, it would seem desirable to pursue alternative routes to the same ends.

There are other ways of achieving ERA objectives without establishing an ERA, and some have been hinted at in this document and in the Technopolis report. But before taking this option the policy maker will need to be satisfied that there is a viable alternative way to achieve the same ends as ERA, and that the energy sector is sufficiently distinct to justify different treatment. The policy maker will also want to be assured that this is not a case of special pleading by vested interests and that the challenges faced by energy RTD are sufficiently important to merit finding solutions that other sectors do not seem to need.

A consequence of adopting this option would seem to be to place non nuclear energy R&D outside the mainstream of European research, which does not seem a desirable result given the challenges the energy sector faces. This also has a consequence that many would find unacceptable, namely that nuclear R&D would be firmly embedded in the European research effort, whilst non nuclear energy would be on the margins.

It is also the case that many of the actions that need to be taken under this option – improving cross border communication and exchange of experience between national programme managers; encouragement of joint projects; programmes to develop the capability and involvement of research in the new Member States; spread of best practice on programme management and evaluation; etc. – are the same as, or similar to, those that would be needed under option (c) below. The resources needed would also seem to be similar to those required under option (c), and so it seems unlikely there would be much difference in costs between these options.

One way that might offer savings would be to build on what already exists, i.e. the IEA Implementing Agreements, and to expand both the membership of, and resources committed to, this work. This might be acceptable to Member States who are also members of the IEA, but is unlikely to appeal to Member States who are not. Moreover, this would not be a "European" focused project like ERA, since the Agreements involve other international partners. It is also possible that the non European partners in these Agreements would resent or resist the Eurocentric nature of the Agreements that would inevitably result from an initiative to reinforce EU participation to such an extent.

- **Pursue the ERA option more vigorously (option C)**
  William Shakespeare observed "that a rose by any other name would smell as sweet". Option (b) would seem to deliver an ERA in all but name, and it has to be asked why the energy sector should want to distinguish itself from all other areas of research by having all the characteristics of an ERA, but not being part of the European Research Area.

  The establishment of an energy ERA would confirm the place of energy RTD in the mainstream of European research. Conversely, failure to do so risks marginalising energy RTD in the European context. The appeal from the energy R&D community for improved budgets is less likely to be heard if it is perceived to be obstructive or uncooperative in delivering wider policy objectives such as the ERA or the Lisbon Agenda.

  There are therefore very real advantages in the establishment of an energy ERA, rather than delivering its benefits by other means. However the evidence from Technopolis suggests that it is most unlikely that a continuation of current policies will achieve the ERA in energy. Something much more proactive will be required. It also seems probable that extra resources will have to be found.

  There can be no denying that the structure of European non nuclear energy RTD is very different to that for other areas of science and technology. As noted above, even in Brussels responsibility for energy RTD is divided between separate DGs. The obstacles to an ERA seem greater because it might require some considerable change to these structures, which are very well established. It could be argued that the generic model of ERA does not suit the energy sector and efforts to impose it will mean that money will be wasted in attempts to fit a round peg into a square hole.

  Policy-makers will only adopt option (c) if the need for a uniform model of ERA is essential and overrides other considerations, and if they are able to mobilise the additional resources that will be needed to take the proactive approach that will be necessary. As noted above, it seems that resources will be needed if Europe is to move beyond the status quo, and so there is unlikely to be much to choose between options (b) and (c) on this count.

Conclusions

The Technopolis study has provided a comprehensive picture of energy RTD throughout Europe and highlighted many of the issues that need to be addressed if an ERA in non-nuclear energy is to be established. The only certain conclusion to be drawn is that policy-makers still have a lot of work to do before the vision of an ERA can be realised.

Policy-makers should reflect on the Technopolis findings and the basic options before them. It may well be that their final conclusion is that action is needed to improve non-nuclear energy RTD in Europe, and that the status quo is unacceptable. The benefits of an ERA are clear, and would strengthen the European energy RTD effort. But is equally clear that, for historical and structural reasons, the "standard model" of ERA may be difficult to implement. It may not be appropriate in every respect.

Policy-makers may therefore conclude that a pragmatic approach is required, proceeding in the spirit of ERA without necessarily adhering in every respect and every detail. It would seem more important that the energy sector achieves the objectives of the ERA proposal and thereby gains the benefits, than that it is identical with the ERA in other areas. And although an "energy research area" may be different from all other parts of the European Research Area, this should be developed in a way that clearly identifies with the underlying ERA philosophy. Rather than seeking to draw attention to differences between an energy research area and the ERA, a pragmatic approach might lead policy-makers to label this initiative as part of the ERA. Taking the name of ERA will clearly identify the commitment of the energy R&D community to proceed in the spirit of ERA, and deliver much more focused, coordinated energy R&D at the heart of European research.

Introduction

This is the final synthesis report of the study into synergies in the area of NNE-RTD carried out by Technopolis for the European Commission (DG RTD).

To build the European Research Area[1], countries in Europe are expected to increasingly co-ordinate and eventually open up their research with/to other Member States, leading to improved scientific and technological capabilities, to enhancement of intra-European mobility, better networking and knowledge transfer, and a greater mutual recognition of the excellence of European research that could emerge as additional benefits.

The purpose of this study was to address the needs and benefits of implementing the European Research Area (ERA) in the field of non-nuclear energy (NNE). It should help to overcome obstacles to implement ERA deriving from a lack of or gaps in a common basis of knowledge and understanding of NNE-RTD policies and activities in Member States and Associated States, and would consequently allow improved co-operation and coordination of the various dimensions of ERA in energy.

The study aims at providing decision makers in Member States, Associated States and the EC with improved knowledge and understanding of NNE-RTD policies and activities in Europe, and on ERA-related issues with a view to helping them undertake more coordinated initiatives in the preparation, implementation and dissemination of RTD in the NNE field. This final report is widely distributed among relevant stakeholder groups in the field of NNE-RTD in Europe.

NNE-RTD is understood as covering the three components of research, demonstration and dissemination activities. Attention will be paid to these various components and to the changes affecting their balance.

The study proceeded as follows:

- 33 country studies[2] were carried out in the period October 2003 – December 2003 and submitted to a validation process during the summer of 2004
- three workshops were held on 27 and 29 April, and 28 May, respectively. Each workshop had a morning plenary session with a briefing on the study results and presentations by selected participants, and an afternoon session in which dedicated focus groups were held. The workshops covered the following three themes:
  - ▷ a general exchange of information
  - ▷ a discussion of to what extent the different country policy mixes constitute opportunities or barriers for co-operation
  - ▷ the integration of the new Member States.

A full methodological description of the study approach is annexed to this report.

[2] The founding document of the European Research Area is Towards a European research area - COM (2000)6 - 18 January 2000; for more information on the ERA see: http://europa.eu.int/comm/research/era/index_en.html

[3] 25 EU Member States, and eight Associated Countries.

The study results are presented in three dossiers, the latter two of which are available through the internet:

- the present final synthesis report
- 33 country reports[4]
- reports of the three workshops, including preparatory papers[5].

It was an integral part of the study to establish not only an information gathering exercise but, equally important, a process involving the relevant persons in the ERA countries. During the country studies many people were interviewed. The workshops were visited by around 80 officials from the energy authorities and ministries of a series of countries involved in the construction of ERA in the area of NNE-RTD. Also, a preliminary version of the final synthesis report was discussed during a workshop held in Brussels on 1 February 2005 with representatives of ERA states[6]. Comments made during that workshop and additional comments received in the week following were integrated in the present report.

After this introduction, this report contains the following chapters:

- an overview of NNE-RTD activities in the 33 ERA countries, in terms of NNE-RTD expenditures, motivations for conducting NNE-RTD, trends, implementation structures, lessons that can be drawn from national evaluations and current changes in NNE-RTD strategies, many of which occurred during the period in which the present study was carried out, which did not facilitate the work
- lessons from co-operation attempts of the (recent) past
- the integration of new Member States in the NNE-RTD ERA
- conclusions and recommendations.

The aim of this report is to give a detailed overview on each of these points. More detail can be found in the annexes and in individual country reports.

[4] All country reports were made available for validation on the website http://www.technopolis-group.com/nnertd/ and are still accessible on this site. To access the download page, log-in and password are both 'nnesynergy'.

[5] Also available on the website above.

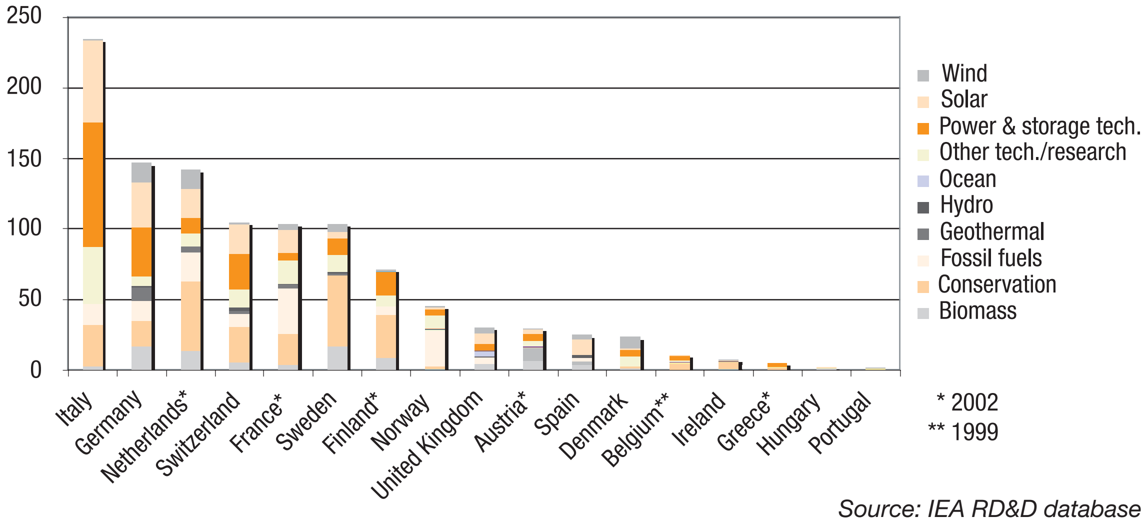
[6] A list of participants is annexed to the present report.

The state of NNE-RTD in ERA countries

ERA countries' activities in the field of NNE-RTD: a great variety in budgets and themes

All 33 countries that today take part in the construction of the European Research Area have NNE-RTD activities, to a greater or lesser extent, and in varying ratios with regard to the total energy research budget and as part of the total research budget.

Figure 1 – NNE-RTD budgets in selected ERA countries, according to technologies, 2003, million US$[7] (2003 prices and exchange rates)



Source: IEA RD&D database

Figure 1 allows us to distinguish four major groups of NNE-RTD investors[8]:

- The 'heavy investors' of Italy, Germany and the Netherlands spending the equivalent of over $140 million per annum
- The 'upper medium investors' of France, Switzerland, Sweden which in 2003 spent just over $100 million per annum
- The 'medium investors' of Finland, Norway, UK, Spain, Austria and Denmark which in 2003 spent between $20 and 80 million per annum
- The 'low investors', spending $10 million or lower and, in the graph, starting from Belgium and including Ireland, Greece, Hungary and Portugal; the other ERA countries not on the graph with the exclusion of Israel (not an OECD/IEA member), spend under the $1 million/yr level.

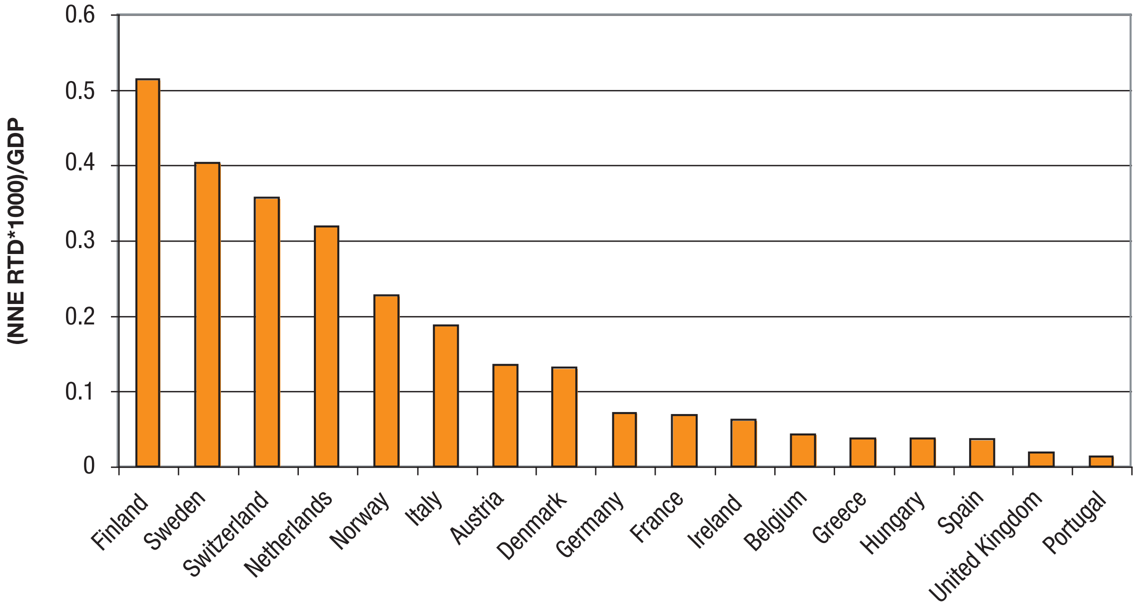
It is important to realise that even if for the third group total NNE-RTD expenditure is in some cases relatively low, for selected areas it can be significant. Denmark is the most prominent example of such a low but highly specialised spender. Its wind energy RTD expenditures are of the same order of magnitude as that of Germany and the Netherlands whereas the country spends virtually nothing on RTD in the other NNE areas apart from power and storage technologies. The necessary specialisation one can observe in some smaller ERA countries is an important feature to be borne in mind for the construction of an ERA in NNE-RTD.

[7] IEA data is in USD not in euro.

[8] Trends are discussed below.

If however one divides the NNE-RTD expenditures following IEA data by the latest GDP data provided by OECD/Eurostat, the picture changes totally. The Scandinavian countries Finland, Sweden and Norway, and Switzerland and the Netherlands show the highest NNE-RTD expenditure on GDP, followed by Italy, Austria and Denmark. Big absolute spenders such as Germany and France have a relative spend in the same order of magnitude as countries like Ireland, Spain and Greece.

Figure 2 – NNE-RTD as a proportion of GDP (2002)



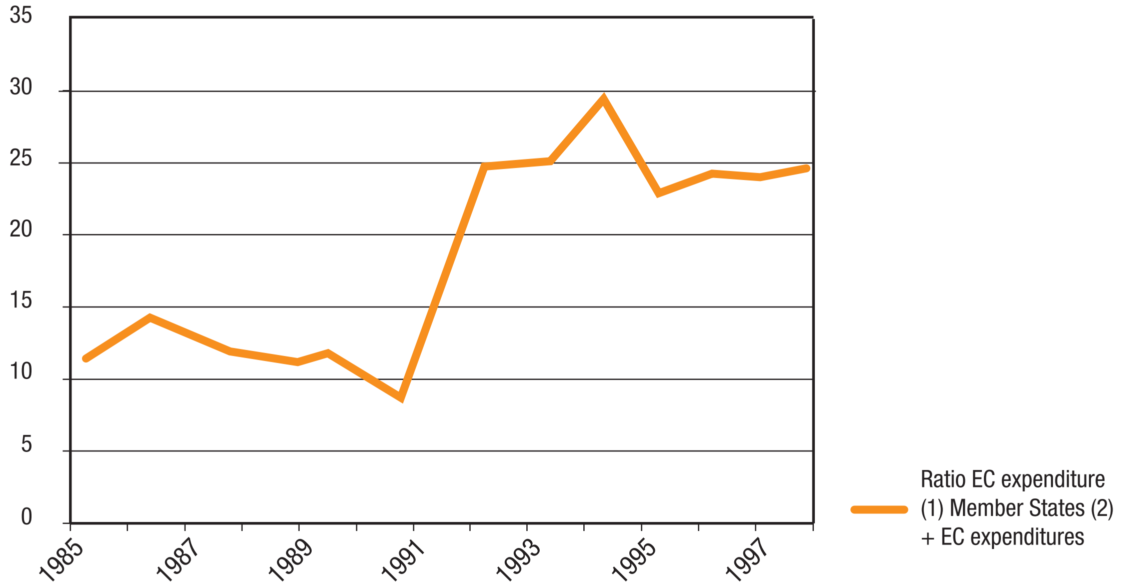
Source: IEA RD&D Database; Eurostat 2005

The values of the IEA data are nevertheless hard to compare between countries because of differences in the ways in which they are produced at national level. One can however presume that relative values and their dynamics are reliable. In later sections of this report we therefore limit ourselves to the analysis of relative shares within or relative changes between national NNE-RTD budgets, all by acknowledging the existence of the four groups of countries which appear from the IEA data and which are cited above.

It is important to compare this figure to the NNE-RTD expenditures of the European Commission. The average yearly expenditure of the Fifth Framework Programme (FP5) on non-nuclear energy RTD was €209 million, which is well over the expenditure of the biggest spender (Italy) cited above, and is one-fifth of what all ERA countries together would spend on NNE-RTD on a yearly basis. The Commission's NNE-RTD budget therefore[9] remains the biggest single budget for NNE-RTD in Europe.

[9] i.e. in comparison to the findings of the PSI project, and analysis of earlier years provided by the World Energy Council (see Figure 3).

Figure 3 – Share of EC budget on {EC+EU-15} budget 1985-2000



Source: World Energy Council/IEA Statistics

Three motivations for conducting NNE-RTD: energy endowment, security and the long term

Three major classes of motivations have been identified for supporting NNE-RTD:

- support to national energy and/or energy technology endowment (eg Norway for oil) and support to national industrial sectors (e.g. Denmark for wind), the two being intimately related
- energy independence and security issues, which have become increasingly urgent given current oil prices and for all countries involved in the European Research Area
- longer-term RTD policies, especially relating to the hydrogen society and more generally the contribution of energy RTD to policies of sustainable development (most developed in the Netherlands with the transition concept).

All countries have a mix of several if not all of these motivations (the examples given between brackets are non-exclusive). For NNE-RTD, Kyoto targets appear to be only one goal amongst others. This is understandable since, as the target year 2010 gets closer, targets increasingly concern the short term while research focuses on the longer term.

Correspondingly, most ERA countries make a distinction in their programmes similar to the one adopted by the European Commission in the SES Priority within FP6, namely between a short-term and a long-term RTD programme. Examples of this are Sweden which use the same distinction between a long-term and a short-term research programme; or the UK which in its 1999 report *New and Renewable Energy Prospects for the 21st Century* made a distinction between short-, medium-, long- and very long-term research.

Global warming is the main vision justifying NNE-RTD funding

The visions of the future in which NNE-RTD funding is justified converge between countries and concern the reduction of CO_2 emissions and decreasing the greenhouse effect. The way in which countries express this is however quite different, as exemplified by statements taken from some recent authoritative national policy documents.

The UK Energy White Paper (2003), which aims to promote a low carbon economy, opens quite dramatically:

> *In this century, without action to reduce emissions, the earth's temperature is likely to rise at a faster rate than any time in the last 10,000 years or more. In the UK, the risks of drought and flooding are likely to increase. Sea levels will rise, so that extreme high water levels could be 10 to 20 times more frequent on some parts of the east coast by the end of the century. Worldwide, the consequences could be devastating, especially in the developing world where many millions more people are likely to be exposed to the risk of disease, hunger and flooding. In addition, there is a risk of large-scale changes such as the shut-down of the Gulf Stream or melting of the West Antarctic ice sheet, which, although these may have a very low probability of occurring, would have dramatic consequences.*

The recent French *New Energy Technologies* (2003) report also focuses upon greenhouse gas emissions and warns that demand and supply may not match in the future:

> *In order to reduce greenhouse gas emissions linked to human activity by 2050 to a level that our planet is able to recycle naturally, and by taking into account the legitimate ambition of development of the [developing countries], it will be necessary for industrialised countries, and especially for France, to reduce their emissions by a factor of 3 to 5 by 2050. In itself this is a major challenge. But this challenge is even greater since over the period under consideration energy demand will continue to rise, even in countries like France, and it is not certain that the majority of this demand can continue to be satisfied, without immediately depleting accessible fossil energy sources[10].*

The Irish *Green Paper on Sustainable Energy* (1999):

> *[…] in line with thinking in the rest of the EU, it is the view of Ministers that responding to the climate change threat is the most daunting of the environmental challenges for fossil fuel use in the years ahead. Accordingly the Green Paper is mainly concerned with this environmental aspect of a sustainable energy policy for Ireland.*

Other policy documents available show similar wordings, all pointing at the necessity to reduce greenhouse gas emissions drastically.

Trends in NNE-RTD: a very heterogeneous picture

In order to understand recent trends in NNE-RTD, IEA data 1990-2002 were analysed for a selection of ERA countries. This analysis shows that trends vary greatly between countries, especially with regard to the following aspects:

- great differences in NNE-RTD expenditure per se: some countries dividing by 10 (Portugal) their expenditures while others double (Sweden) or triple (Hungary)

[10] T. Chambolle, F. Méaux, 2003, Nouvelles technologies de l'énergie, rapport du groupe de travail sur l'identification des objectifs et des axes de priorités pour la recherché française et européenne (our translation).

- the overall evolution of NNE-RTD expenditures: some drop continuously, some rise continuously, others show an erratic pattern, some are relatively stable
- a great variation over time in priorities for each individual country
- a great variation in priorities and their evolution between the different countries.

This indicates overall that priorities are set on a national level, and are not a mirror image of a common agenda on the European level.

Figure 4 – Trends in NNE-RTD expenditure (countries vs areas, 1990-2002)[11]

	Conser-vation	Biomass	Other tech./ research	Power & storage tech.	Solar	Fossil fuels	Wind	Geo-thermal
Austria	s	+	+	+	+			
Belgium	- -			-				
Denmark	- -	-	s	s	-		s	
Finland	- -	s		s				
France	+		+	+	+	-		+
Germany	s	+		+	-	s	s	+
Hungary		+			+	+		
Ireland	+							
Italy	s		s	s	+	+		
Netherlands	-	s				+	s	
Norway			+	s		-		
Portugal					+	+		
Spain					s			
Sweden	+ +	+	s	s				
Switzerland	s	s	s	s	s	s	-	+
United Kingdom			--					

Source: IEA RTD Database; Technopolis' analyses

The following sections briefly describe some NNE-RTD expenditures in different countries, organised by increase in expenditure, by stable patterns, by a decrease overall, or by selected areas.

Several countries increased (selected) NNE-RTD expenditures …

Italy had a strong increase in spending on selected areas, first in power and storage technologies in 2000, followed by a rise in expenditure on solar energy RTD.
Finland, after a peak in 1998 in conservation, decreased until 2001, had renewed uptake in 2002, supported by growth in other technology/research.
France experienced a continuous increase in NNE-RTD budgets since 1998, in conservation, other technology/research and conservation.
Sweden experienced an important increase in overall budgets since the end of the 1990s, especially due to increases for conservation RTD, and increase in biomass while other areas remained relatively stable.

[11] ++ strong increase, + increase, S stable, - decrease, -- strong decrease. Hydro is not significant and therefore left out of the table.

Hungary, starting from close to zero in the mid 1990s, since 2000 experienced a strong increase in biomass and in solar, and to a lesser extent in fossil fuels. The overall budget for this country is low but today exceeding that of Portugal.
Ireland (for which data are not available before 2001) saw an increase in conservation RTD in 2003.

…others showed a stable pattern…

Austria overall had a stable pattern of NNE-RTD expenditures.
Italy, since 1993, has had a stable overall pattern (with relative shifts as discussed above).
The **Netherlands**, apart from some marginal fluctuations, shows a stable pattern with only recently a slight dip in conservation RTD.
Norway showed a rapid decrease of NNE-RTD in the beginning of the 1990s and since then overall is relatively stable with the exception of a peak in 1999, after which a decrease in fossil fuel research should be noted, the slope of which only since 2003 seems to change direction.
Portuguese NNE-RTD showed a very steep decline between 1990 and 1994 when expenditures were divided by nearly a factor of 10. Expenditures are stable, but at a low level since mid 1990s, with a concentration on solar in 2002 and fossil fuels in 2003.
Switzerland shows a great overall stability during the whole period.
Sweden and **France** showed a strong growth in NNE-RTD expenditures since the end of the 1990s, but within this rise, absolute budgets for 'other' and for 'power & storage technologies' RTD remained stable.

… others decreased, selectively or across the board

Belgium has recently shown a decline in conservation RTD and to a lesser extent in power& storage technologies, which represented the country's most important NNE-RTD budgets.
The **Netherlands** has seen a decline in conservation and 'other'.
Denmark has decreased its NNE-RTD budgets mainly in solar, and to a lesser extent in conservation, with wind and 'other' remaining the most important areas.
France which shows a quite stable budget overall shows a slight but steady decrease of fossil fuel RTD over the whole period concerned, this nevertheless being still the country's most important NNE-RTD area.
Germany shows a peak overall in 2001, followed by a decrease mainly due to decreases in solar energy RTD and RTD on power and storage technologies.
Portuguese NNE-RTD showed a very steep decline early on, between 1990 and 1994.
Spain showed a continuous decrease since the early 1990s, especially in conservation (which exceptionally peaked in 1991), and 'other' (continuous decrease).
The **UK** showed a steady decrease in NNE-RTD expenditures since 1990 with a plateau from 1997 to 2000 and a further decrease after that period.

Implementation structures for NNE-RTD

Based upon the 33 country studies, the different countries' policy mixes were analysed, covering actors, institutional settings, priorities and priority setting processes, and instruments. Several countries have a very complete panorama of policy instruments in the area of energy RTD, and have set up dedicated institutional structures to manage them. Others have only weakly developed policy mixes, and there are still a few (all to be found among the new Member States) without any explicit NNE-RTD policy at all.
The aggregated results of the analysis are given in an annexe. These are the principal observations and suggestions.

Four ways to implement NNE-RTD policies

In order to create the European Research Area it is important to know which organisation(s) in each country is or are responsible for the implementation of NNE-RTD programmes and policies, since these bodies normally also have the responsibilities, the power and the funds to initiate international co-operation in this area.

From an institutional perspective, there are four main ways of organising the implementation of NNE-RTD policies. These are:

- a dedicated energy agency which often also includes environment; in one case such an agency is shared between different countries: the Baltic Energy Agency, shared by the three Baltic states plus Poland
- a technology agency which manages energy RTD programmes
- the responsibility of the relevant ministry
- the main national research organisation of a country in the area, which acts de facto as an agency (and is also often the one delegated to represent a country in European NNE-RTD fora).

Figure 5 shows the distribution of ERA countries over the different types. The table in the figure distinguishes between the main responsibility of each organisation, that is, energy-dedicated, or RTD-dedicated.

Figure 5 – Institutional anchorage of NNE-RTD policy responsibility[12]

		Agency	Ministry	National Research Organisation
Main responsibility of the institution	Energy	DK: DEA F: Ademe EE, LV, LT, PL: Baltic Energy Agency NL: Novem & Senter DE: Projektträger Jülich IE: SEI SE: STEM	IS: Ministry of Industry, Orkustofnun BE: Regional ministries IL: Ministry of Infrastructure CH: Swiss Federal Office of Energy	EL: CRES NO: IFE ES: CIEMAT PT: INETI IT: ENEA
	RTD	AT: FFF FI: TEKES	AT: BMVIT UK: DTI EL: Science and Technology Ministry	

Moreover, several new Member States and accession countries[13] have an energy agency that does not fund NNE-RTD. The countries not listed in the table have not attributed an explicit institutional responsibility for NNE-RTD at all.[14]

[12] Some countries appear more than once for institutional reasons (shared responsibilities).
[13] Czech Republic, Hungary, Slovak Republic, Slovenia, Romania.
[14] i.e. Bulgaria, Cyprus, Liechtenstein, Luxembourg, Malta, Turkey.

The figure looks fairly simple. However, it should not be forgotten that behind it hides a myriad of national structures and trajectories (Figure 6 shows the example of Germany) which show that today there are many different ways of organising and managing NNE-RTD within the national research landscape.

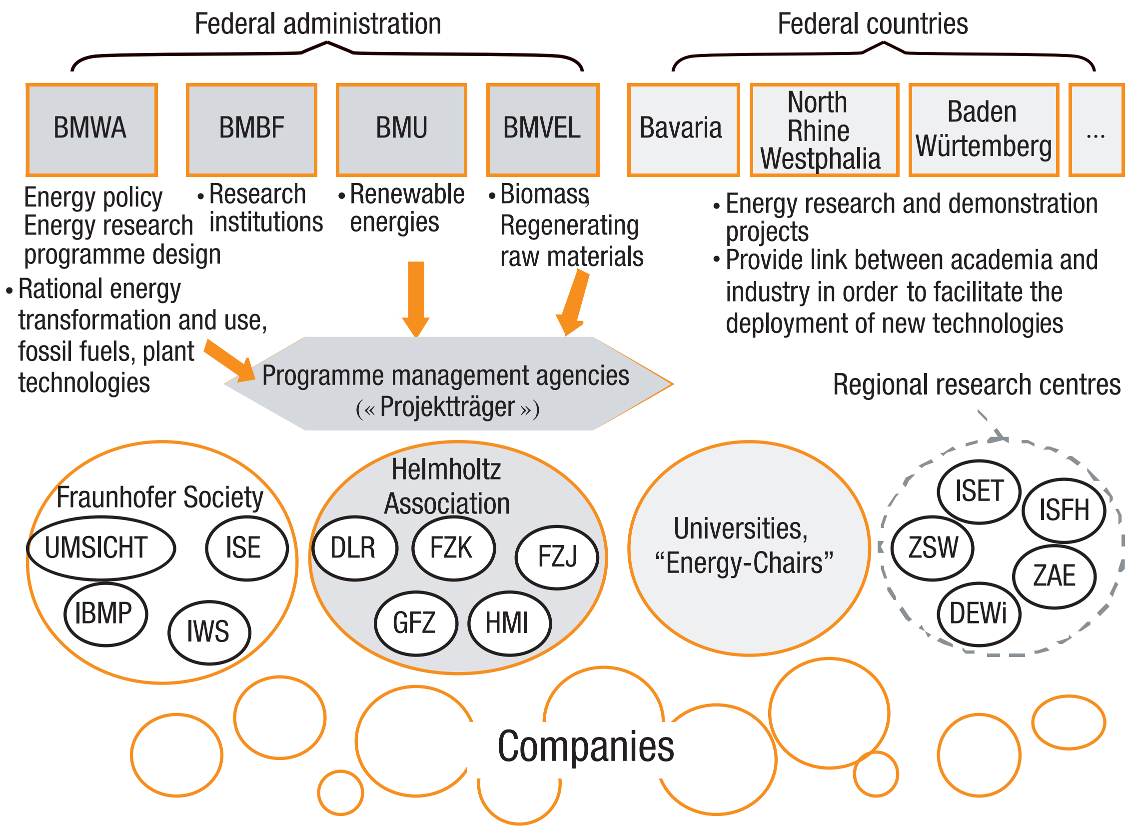
The following other examples can be cited to illustrate this point.

- France has very few research agencies, and non-nuclear energy is an exception as one of the few areas for which a dedicated agency, formerly, agencies, has existed since the first oil crisis. Other programmatic funding (for instance for ICT, health) is either implemented directly through the relevant ministries, with research projects being selected through a labelling procedure involving national experts (networks for research and innovation),[15] or they are implemented directly through research institutes. So the implementation structure for NNE-RTD is for other European countries quite normal, but for France it is atypical
- In Sweden, Denmark and the Netherlands, the agency model, on the other hand, is widespread and this includes energy research. The respective energy agencies have an important role in policy proposition and formulation, and in the implementation of the NNE-RTD, covering the whole spectrum from long-term research to demonstration. Responsibility for energy research in Sweden is spread over four different agencies with STEM being the most important. In Denmark it is concentrated in the Danish Energy Agency and in the Netherlands in Novem. The latter merged in the beginning of 2004 with the technology agency Senter into a new agency SenterNovem for innovation, energy, climate, and the natural and living environments
- Finland follows again another model since the national energy research programmes are managed by the national technology agency TEKES, which is responsible for the implementation of technology programmes in all areas, amongst which is non-nuclear energy RTD
- The UK follows another model for the implementation of RTD programmes. The Department of Trade and Industry is responsible for policy formulation but externalises the management and implementation of its programmes to, mostly private, partners on the basis of three-year renewable contracts. Hence the energy programme is currently managed by a private company[16] on behalf of the DTI
- The German model of projektträgers (programme carriers) is in some way similar to the UK model since programme implementation is contracted out to external partners on the basis of renewable contracts. However these partners are public organisations: in the case of energy it is Forschunszentrum Jülich. Forschungzentrum Jülich is in turn part of a network of research organisations involved with energy research collaborating through the Helmholtz Association.

However, the implementation structures as described above only show the tip of the iceberg, as exemplified by the representation of the German NNE-RTD structure given in Figure 6.

[15] It is expected however that from 2005 there will be an agency which manages incentive RTD funding in France.
[16] Future Energy Solutions, a part of AEA Technology, the formerly public ETSU.

Figure 6 – Apparent simplicity hides a complex reality: main actors in Non-Nuclear Energy research, the example of Germany



Source: Technopolis

The country studies describe all national NNE-RTD governance structures in much detail.

Dedicated NNE research programmes

For the aim of the construction of an ERA in NNE-RTD, it is relevant to know whether or not countries have explicit NNE-RTD programmes. The presence of such programmes will partly determine the extent to which co-operation can be established and national countries' RTD be better coordinated. Differences in priority setting processes are linked to the extent to which the NNE-RTD policies are structured through RTD programmes.

There appears to be a sharp distinction between, on the one hand, the EU-15 Member States plus (most) Associated States, and, on the other hand, the new Member States. According to the results of the country studies, twelve countries of the thirty-three did not have a dedicated NNE-RTD programme in one form or another by the end of 2003. These are the ten new Member States, plus two other, very small, countries[17].

RTD programmes, by definition, involve objectives, have a budget and cover a well-defined period after which, normally, the programme is evaluated, and continued or terminated. The budget is normally reserved for the whole programme period, even if the government budget process can have an annual periodicity. The Scandinavian countries follow the first option: multi-annual programmes. Their NNE-RTD is managed by the relevant national agencies, through multi-annual research programmes. This is also the case in the Netherlands and the UK.[18] In the big European countries, France and Germany, important NNE-RTD programmes exist and do, on

[17] Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Liechtenstein, Luxembourg, Malta, Poland, Slovak Republic, Latvia, Lithuania.

paper, last for several years. In practice however they appear to have been more influenced by annual budget fluctuations than in the countries previously mentioned, especially over the past two to three years when overall budgets for RTD decreased.

In some cases, the national Research Council has dedicated programmes aimed at the promotion of NNE-RTD. This is the case in Austria,[19] Denmark, Finland, France,[20] Norway, Spain and Turkey. All these countries have explicit NNE components in their more basic technological research programmes managed through the national Research Council or the national equivalent. In Spain, the energy programme is a sector within the overall national research programme (PROFIT programme).

The contents of RTD programmes

Apart from the IEA data which allowed analysis of NNE-RTD expenditures and their trends, the individual country reports prepared for the present study described the areas in which there are NNE-RTD programmes in the different countries, and the relative importance of these. This has allowed us to construct Figure 7 which shows, for all the different ERA countries, the relative importance of programmes in the different NNE-RTD areas.

The figure is a qualitative-quantitative construction and reflects which theme programmes exist and where current priorities lie, including the most recent ones, i.e. for 2004. It is partly built on the IEA data shown earlier. However, this information has first been complemented by information from the country reports. Secondly, during the validation workshop participants provided comments on the contents of the table, aiming to make it more up-to-date.

The figure should be read line-by-line, to give relative priorities per country. It gives a static picture and does not account for the stock of technology in each individual country. It is not meant to be used to compare between countries, quantitatively, the information column by column. During the workshop it was suggested, however, that in order for ERA countries to know each other's priorities, it is of lesser relevance to know absolute values than to know relative values. From that viewpoint, the column may also be read vertically, in order to understand in which country this or that subject is a priority or not.

It is important to use the table as a tool rather than as absolute reality, especially since in NNE-RTD this reality changes very rapidly. Apart from finding the most common denominators in terms of priorities, the figure can also serve the following two purposes:

- to identify smaller numbers of countries with similar high priorities, which would for instance lie outside the FP
- to identify larger numbers of countries with similar low priorities, but which through co-operation could constitute critical mass.

In both cases there may be good reasons to start multilateral co-operation, especially in a case where the Framework Programme would concentrate on a small number of major projects.

[18] In the UK, programme management is externalised to a private bureau through public calls for tender, in three-year programmes. This is the only case we have encountered of management of a public programme performed by private companies. For the UK's Department of Trade and Industry it is general practice to externalise its programmes in this way.

[19] In Austria, this Council has a strong advisory role but does not implement the programmes itself.

[20] i.e. in the case of CNRS (Centre national de recherche scientifique), even if this is not a pure research council.

Figure 7 – Thematic overview of national NNE-RTD programmes and their relative internal importance (i.e. within each country)[21, 22, 23]

ERA Country	Conservation (RUE; EE)			Biomass (fuel, wood, waste)			Power & storage		Solar		Fossil fuels			Wind	Geothermal
	I	R	T	F	Wo	Wa	FC/ H_2	Oth	Th	PV	O	C	G		
Austria	+++			+++			++	++							
Belgium	++						+	+		++					
Bulgaria				+				+		+				+	
Cyprus									+	+				+	
Czech Rep.				+	+	+						+			
Denmark							++			+				+++	
Estonia											+				
Finland	+++			++			++			+				+	
France	+	+	++	+			++	++		++	+++	+			+
Germany	+	++	++	++			+++	++		+++		+		++	+
Greece					+					+				++	
Hungary				+						+		+			
Iceland							++	++							+++
Ireland	+++			+				++						+	
Israel		++						++	+++	+					
Italy	+	+					+++	+++	+++	++					
Latvia				+	+	+									
Lithuania	+														
Netherlands	+++	+++	++							++	+		+	++	
Norway					+	+					+++		++		
Poland				+											
Portugal												++		+	
Slovenia		+	+	+			+	+							
Spain				+			+			+				+	
Sweden	+	+		++	++	++	+	++	+	+				+	
Switzerland		++	++		+		+++	+++	++	+++	++		+		+
Turkey					+	+				++		+		+	
UK							++			++					
FP6	+	+	+	+			+	+		+				+	+

Source: IEA data; individual country reports; comments following from validation workshop

This table is a significant result of the study. It shows easily the relative priorities that exist in the different ERA countries, the ERA centres of gravity and commonalities, as well as the themes where less countries are active.

Two themes come up very strongly: PV, and power and storage technologies. Within the latter, fuel cells in particular have gained importance since the second half of the 1990s, often through

[21] Carbon sequestration, being an emerging priority, is not in the figure. Note also that it was not explicitly represented in the IEA figures up to now (but may be in the future).

[22] Liechtenstein, Luxembourg, Malta, Romania and Slovakia are not represented in the figure.

[23] **Legend:** +++ very important priority and/or programmes within a country, ++ important, + average, no symbol means no explicit priority or absent theme. I = Industrial, R = Residential and commercial, T= transport; F=Fuel, Wo=Wood, Wa= Waste; FC/H_2=Fuel Cells and Hydrogen, Oth=Other; Th=Thermo-electric/dynamic solar, PV=Photovoltaïc solar; O=Oil, C=Coal, G=Gas

national programmes, and more recently in conjunction with national 'hydrogen strategies'[24]. It is not surprising that two out of the three present ETPs[25] relate to these two subjects (the third being on biomass).

Even if they enjoy great attention in many countries, PV and fuel cell research are not at the same level. Photovoltaic research concerns research quite close to the market. Fuel cell research, on the contrary, is very closely associated to the issue of the hydrogen society and targets a much longer-term horizon[26]. PV is envisioned as a means to generate the electricity needed to produce hydrogen (among other options for the production of electricity from renewable energy).

A third major theme that has the interest of many countries is conservation in industry, the residential sector and or transport (but especially the first two). Biomass research is also important for many countries, even though the emphasis (from annual crops, perennial crops of waste) differs between countries. There are close links with natural endowments of countries (presence of forests) and potentially with agricultural policies as well.

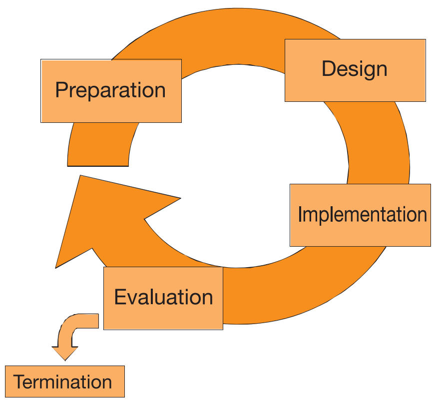
Other NNE-RTD themes are far less systematically present and fossil fuel related research in particular is really important in two countries only: France and Norway.[27] However, even if they are in absolute terms far less important at a European level, several more themes, less strongly present, may very well constitute major opportunities within ERA for individual groups of countries and therefore be a good reasons to set up bi- or multilateral projects and programmes. This would follow the example of the Franco-German Hot Dry Rock project in Soultz (which is not purely bilateral since it is also co-funded by the European Commission).

Finally, wind energy and biomass (especially for fuels) are typically a theme on which many countries work in terms of research, but which, with some exceptions, seems overall not to be regarded as a high priority. As indicated above, this may also be a good reason to build critical mass.

NNE-RTD management tools become increasingly adopted

The policy cycle is a concept that has been developed out of the science of analysing policy and is based on an understanding that a distinction can be made between the different phases in the policy-making process (Figure 8).

Figure 8 – The policy cycle



[24] e.g. Germany (with Deutsche Wasserstoff Verband) starting in 2001 but most other countries only in 2004, cf. France (Pan-H inter-ministerial initiative), the UK (hydrogen strategy), Denmark (national hydrogen strategy) in 2004, etc.
[25] European Technology Platforms, see p59.
[26] The IEA has recently published a very detailed compilation of fuel cell research policies in IEA countries.
[27] And given the endowment of these two countries, dealt with from quite different angles.

The following paragraphs discuss in particular the issues of **priority setting**, which cuts across both the preparation and design phases of the policy cycle, and the issue of **evaluation**. The actors responsible for implementation of the policies have been discussed before.

Of course, policy development is not a linear process, neatly and predictably following a sequence of steps. Policy-making is ambiguous and layered and not a single, uniform, transferable process. As such, the policy cycle should not be read as a staged and ordered process but an active and iterative process. The policy cycle model does, however, outline the key components to be considered in developing policy.

Priority setting is closely linked to the existence of NNE-RTD programmes yet its organisation varies greatly between countries

Priority setting is organised in very different ways. The way in which it is organised is closely tied in with the NNE-RTD infrastructure as discussed, and especially with the question of whether a national agency and one or several NNE-RTD programmes exist.

The country studies make it possible to distinguish between highly structured, moderately structured and weakly structured priority setting processes. In order to judge between these three attributes, the following sub-steps of the policy cycle were taken into account:

- issue identification
- past/future policy analysis
- definition of policy instruments
- consultation of stakeholders
- coordination (between relevant government departments and agencies)
- decision-taking after weighing options.

If all these elements were clearly identifiable within a country's national NNE-RTD priority setting process it was said to be highly structured. If they were only partially present or identifiable it was characterised as moderately structured. A priority setting process was characterised as being weak (in several cases meaning absent) if those elements could not be identified.

The overall goal of energy policies in the short term is to achieve the Kyoto targets. However, no instances could be identified where Kyoto targets were directly linked to the NNE-RTD that was, finally, funded. Even though foresight exercises exist (especially in modelling) to indicate the promises of different energy technologies, these generally do not lead straight to a choice for the set of energy technologies to promote through NNE-RTD.

Figure 9 shows that the level of institutionalisation and formalisation of priority setting processes is linked to the extent to which the NNE-RTD policies are structured through RTD programmes and when national agencies exist that are responsible for implementing these. Programmes, by definition, involve objectives, a budget and cover a limited time span. The budget, normally, is reserved for the whole programme period, even if government budgeting can have an annual periodicity. This is precisely the case in the Scandinavian counties, who have their NNE-RTD run through the relevant national agencies, through multi-annual research programmes. This also involves a periodical priority setting, when it has to be decided whether new programmes are to be created, existing programmes continued or terminated (see the next section on evaluation).

Figure 9 – Structuring of NNE-RTD priority setting in ERA countries

Structuring	Country	Remarks
High	Austria	Strong and explicit priority setting process
	Denmark	Strong programmatic & cyclic structure; strong agency
	Finland	Strong programmatic & cyclic structure; strong role for agency: all research is performed through technology programmes, run by TEKES (60 million programme stable over past five years); systematic and structured planning process (market studies, international benchmarking, identification of relevant national actors, discussion groups)
	Iceland	Energy is one out of four major national policy objectives (2001); priorities much linked to natural resources; Orkustofnun (national energy authority) establishes five year plan; priority setting increasingly formalised
	Ireland	Alternative Energy Requirement (AER) programme (1995). Energy Technology Foresight Panel 1998. Green Paper on Sustainable Energy (1999), defining national priorities. National Development Plan 2000-2006 (2000). National Climate Change Strategy (2000). Sustainable Energy Act (2002) establishing the SEI. Public consultation on wind energy
	Netherlands	Strong policy initiated by Ministry of Economic Affairs, carried out by intermediary organisation (national agency SenterNovem). Several strands: energy research strategy EOS; transition management, several NNE-RTD incentive research programmes
	Norway	RCN (national research council) has process for long-term energy R&D planning, but not for the petroleum sector where government has strong role (cf OG21 plan)
	Sweden	Strong and explicit, resulting in the Energy Act (1997) and STEM's strategy (the Energy Policy Programme) that distinguishes between a short-term and a long-range energy RTD programme
	Switzerland	The CORE (Federal Energy Research Commission) elaborates an Energy Master Plan every four years through consultation process involving mainly private and public (research) institutions
Moderate	Belgium	Regional devolvement; weakly co-ordinated
	France	No overall integrated priority setting involving all actors. National agency has priorities and NNE-RTD programme (approx €55 million annually); CNRS has NTE programme (€1.5 million of incentive funding); foresight exercise (2002) between ADEME, CNRS, CEA and IFP; currently severe budget cuts do not allow priorities to be followed up
	Germany	At national level, the priority given to NNE research is based on an assessment of energy research in 1999 by the *Wissenschaftsrat*. Priority-setting process at federal policy level is marked by rather frequent mutations of responsibilities in energy research after the creation of new government. At regional level, policy setting is more oriented towards industry and applied research than at national level. The priority setting process varies from one *Land* to another.
	Greece	Low internal coordination. Very much aligned with EU / strong EU dependence in financial terms. Recently Greek Foresight exercise has started
	Portugal	No specific NNE-RTD policy; energy is transversal theme
	Romania	There is a policy process, involving external consultations, that has led to the MENER energy research programme which contains around 30% of NNE-RTD
	Slovenia	Explicit process: renewable energy sector reinforcement is long-term goal of government
	Spain	At national level, NNE-RTD part of broader basic research programme

	United Kingdom	House of Commons would find sums invested in energy research insufficient and lacking focus. Technologies are developed but incentives lacking for the private sector to take them forward.
Weak	Bulgaria	No explicit energy policy
	Cyprus	Emerging
	Czech Republic	Emerging
	Estonia	Emerging
	Hungary	Overall strategy formulation is missing. However NNE-RTD actors are small in number, and networked. In RTD priorities, alignment with EU programmes; also inspired by energy obligations (increased renewables)
	Israel	Israel has no targeted NNE-RTD budget (technology funding is non-oriented, bottom-up).
	Italy	Weakly coordinated; bottom-up; energy one of the eight major RTD priorities (but less than 5% of total RTD expenditures); ENEA has rolling three-year plan
	Latvia	Lack of national priority-setting process
	Liechtenstein	n.a.
	Lithuania	No specific NNE-RTD policy
	Luxembourg	No specific NNE-RTD policy
	Malta	No specific NNE-RTD policy
	Poland	Emerging
	Slovak Republic	Emerging
	Turkey	Characterised by an erratic pattern of government spending on NNE-RTD until the end of the 1990s; in 2001 however work on an ‘Energy Technologies R&D Programme and Action Plan’ was started at the request of the Supreme Council for Science and Technology

There is no explicit synchronisation today between national research programmes or policies between countries: every country seems to follow its own pace. There is, especially for the new Member States and for smaller countries, a close alignment of national priorities on the priorities of the Framework Programmes in order to create a higher leverage effect for funding. Given the importance of NNE-RTD under the Framework Programme (see page 57) in bigger countries there is de facto a thematic alignment on the European programmes, since these programmes provide incentive funding whereas, often, national funding accounts for salaries only, and as shown earlier, “Brussels” today represents 20 % of total funding of ERA countries in the area of NNE-RTD (Figure 3). At national level, the same research groups participate in both the European projects and projects funded through the national agencies’ programmes. Also, the increased involvement of foreign experts in, especially, ex post evaluations of programmes may lead to increased synchronisation. Finally, countries are, increasingly, investigating where other countries’ priorities lie. (Informal) networks between national programme managers are important for such information exchanges.

More recently, and again more due to initiatives of the European Commission than to bottom-up initiatives of Member States per se, there is a growing interest in each others’ priorities and priority setting processes, especially because of the ERA-NETs which are bringing countries’ administrations closer together. This is discussed in a separate section (see p59).

Industry involvement in NNE-RTD

Different possible types of industry involvement

Although it was not the aim to make a separate study of industrial NNE-RTD, it has been studied whether and how the private sector, or more generally, companies, are involved in public NNE-RTD policies. In some countries, such as Denmark, industry involvement is quite clear, explicit and relatively important. In other countries, and often depending on the NNE area at stake, industry involvement mainly takes place through the project selection process and through the participation of companies in the public NNE-RTD programmes. In many countries private sector involvement is low.

Private sector involvement is in theory not limited to one single phase in the policy cycle only. Through research and literature reviews[28] on the subject, one can identify the following types of private sector involvement in the different stages (see Figure 10).

Figure 10 – Content and type of private sector involvement by stage of policy development

Stage in policy cycle	Main issues at stake in the decision process	Examples of type of interactions
Preparation	Identification of the need for policy Determination of high-level priorities (themes, sectors, etc.) Actors' enlistment Definition of the role of actors Design of the structure of interaction, incentives, policy instruments	High-level expert consultative panels for national research priority Advisory committee to policy decision-making Collective elaboration of roadmaps, 'visions' or strategic plans Prospective inquiry (national, regional, research organisations & institutes)
Design	Design and choice of instruments/ means Determination of lower-level priorities (technologies, projects, etc.) Allocation of resources	Multilateral or bilateral hearings of private stakeholders Consensus building workshops Consultation of potential industry beneficiaries of measures Consultative group with potential participants to a research programme Specific funding mechanisms (public-private cost-sharing) Various structures of coordination
Implementation	Operational implementation Sound management practices Project evaluation and selection	Mixed public/private steering committee of a public research programme
Evaluation	Interim reviews and ex post evaluation; monitoring of progress Revision of initial decisions	Industry experts involvement in evaluation of public research programmes

This analysis by stage of research policy development is useful to exhaustively scan the whole process of research policy decision-making from the early instigation stage to the implementation and, eventually, revision stage. In reality, research policy is most often far from completely and unambiguously determined before it starts. Decisions are not confined to the mere instigation and design stage. Important, strategic, decisions are taken during implementation and revision according to what is often a trial and error process and in other cases more formalised (through interim reviews and evaluations).

[28] Also including studies other than the present one.

Form and structures of public private-interactions in policy decision-making are deeply embedded in the underlying institutional contexts. These include formal government and industry structures (administrative and political bridges between the public and private sectors, role of industry associations, size of the public sector for instance) to more informal determinants (strength and tradition of government intervention, cultural context regarding state-business relationships, social networks). More than a deliberate choice, these determinants are the product of history and, as a consequence, are specific to a country or group of countries, and, within countries, specific to the technology or NNE-RTD area.

Selected examples of industry involvement in NNE-RTD

For example, in **Denmark**, industry is involved in the NNE-RTD priority setting process in three ways:

- industrial parties take part in strategy development on energy R&D in the areas of PV, fuel cells, wind energy. They are represented in the Advisory Committee for Energy Research and are in general widely involved in consultations with the national Energy Authority
- the two Public Service Obligation (PSO) programmes are designed and implemented by the Danish (private) utilities (after approval by the Energy Agency), and carried out by industry
- industry is involved in proposing R&D proposals (Implementation phase) and, as an evaluator, in their selection (in parallel to proposal evaluators from academia).

In **France** in the field of renewable energies (i.e. non-nuclear, non-fossil), RTD priority setting, with funding being relatively marginal up to date, as compared to nuclear, has been traditionally performed in close co-operation with the few industrial partners in each area (mainly SMEs, such as Photowatt in PV, now one of Europe's main PV cell producers). For fossil fuels, the nexus in research is the French Petroleum Research Institute (IFP) which apart from having private status, works closely with the relevant industry in all stages of NNE-RTD planning. Finally, in the field of fuel cells (PACo) and in transport, research networks (not programmes but labelling procedures) exist which involve industrial partners in the design phase, but especially the project proposal and selection phase. More generally, industry representatives are involved in national energy foresight/scenario exercises (not only related to RTD).

In **Finland**, national funding programmes for energy research are designed and implemented by the national energy agency TEKES. Industry is consulted during the definition of the programme priorities, and in the project selection phase.

In **Germany**, industrial involvement is mainly realised through the involvement of industrial partners in publicly funded research projects. Another example that can be cited is the Kompetenznetze (www.kompetenznetze.de) , an initiative launched by the federal ministry for research to promote the establishment of regional networking and clustering in different areas of research. Apart from specific cross-cutting areas (nanotechnology, biotechnology, materials science), of especial interest for the present report are the four "competence nets" dealing with power engineering, i.e. EnergieRegion Nürnberg, the Fuel Cell Initiative Baden-Württemberg (BZI), the Fuel Cell Network Nordrhein-Westfalen and ReFuelNet[29].

In **Ireland**, industry is involved in many different ways, in, especially, the preparation phase, and in the implementation phase. With nine out of 12 members, industry is also represented on the Board of Enterprise Ireland (the main funding agency), however much less in the R&D

[29] See the country report and http://www.kompetenznetze.de/navi/en/kompetenznetze.html.

subsidies approval committee. Concerning the preparation phase of NNE-RTD policy, there has been an Irish foresight exercise in which energy had an important place, and in which industry was involved. Sustainable Energy Ireland, which grew out of the Irish Energy Agency in 2002, implements industry-oriented sustainable energy research programmes in different areas. It has co-ordinated/is co-ordinating several research/technology roadmapping exercises (on ocean energy, on biomass, on CHP) where a consensus view is sought with the relevant industrial partners on the research that has to be performed on different strands of NNE-RTD.

Although in the **Netherlands** industry is estimated to have a high share in the overall funding of NNE-RTD, it is not strongly involved in priority setting processes. The high share is mainly accounted for by the WBSO, a tax credit for research, which is entirely a bottom-up mechanism. Moreover, the lion's share of private NNE-RTD funding is in energy efficiency research, and this phenomenon is attributed to the existence of the sectoral agreements between the Dutch government and different industrial sectors to reduce greenhouse gas emissions. Industrial stakeholders have been consulted however in the current two strands of Dutch energy RTD policy, i.e. the EOS Energy Research Strategy and the policy of transition management toward a sustainable society.

In **Norway**, an interesting difference can be seen between the two parts of NNE-RTD (i.e. fossil against renewables). Whereas energy RTD is handled within RCN (the national research council) based on some general political guidance, in the petroleum sector, the government has taken a much more active role. The ministry's ambition is to develop a national technology strategy for the petroleum sector together with industry. Through the establishment of Oil and Gas 21 (OG 21) this dialogue has led to a number of priorities and joint programmes. The R&D parts are normally managed by RCN, but based on much more direct priorities in the rest of energy R&D. The experiences from this sector are an interesting example of joint action between the government and the industry, and how government, more than in most sectors, has realised the potential of R&D for long-term policies.

In **Spain**, the success of the wind energy and photovoltaic renewable energy sectors in that country have depended a lot on the interplay between targeted R&D programmes on the one hand and market instruments on the other.

As concerns industry involvement, a typical feature of **Sweden** is the existence of industry associations/foundations. Industry associations commission important parts of the R&D portfolio, using core funding from STEM (the national energy agency) plus industrial contributions. These associations do not themselves perform research, but contract projects to universities, institutes and (in some cases) their members.

In the **UK** it is noteworthy that the Engineering and Physical Sciences Research Council supports energy research projects which have a high industrial relevance by having half of the members on the Council representing industry. This Research Council has recently been criticised for exactly this by the House of Commons: it would let energy research be too much influenced by (short-term) industry interests.

Explicit private sector involvement in one of the four phases cited in Figure 10 is often linked to whether countries do or not have already a moderately or highly structured priority setting process in place (see p43). In most new EU Member States therefore, the private sector is generally *weakly* involved.

Dedicated NNE-RTD measures oriented towards SMEs do not exist

No specific SME-oriented measures aimed at promoting NNE-RTD were identified whereas at the same time SME involvement is viewed in many countries as important for the NNE sector,[30] traditionally and in the future. Whereas in many of the countries SME innovation programmes and agencies exist, these are generic in nature (e.g. soft loan schemes) and have a bottom-up character, i.e. innovative projects are funded regardless of their precise area. Having SMEs present in research consortia is very often a plus within national RTD programmes, if not a requirement. However this requirement is not specific to NNE-RTD. This is an important finding since most of the NNE sectors consist to a large extent of SMEs.

The situation differs if the entire private sector is considered. In some countries such as Sweden and the UK, there exist dedicated NNE or even NNE-RTD dedicated measures for the private sector. In other countries (Denmark, for instance), the private sector is very closely involved in defining the priorities and the contents of new research programmes, which may lead to an increased industrial involvement in research.

Market-creating regulations, or covenants with industry on reduction targets, as in the Netherlands, may help to boost NNE-RTD indirectly. However, our overview here is incomplete as this issue lies beyond the scope of our study.

There are no Eureka clusters in the area of NNE-RTD. This is understandable, since such clusters normally require industries with a certain critical mass, industrial companies of a certain size, and, especially, a common interest in developing major industries on European level[31]. These three elements seem to have been absent in the past in the area of NNE-RTD. Today, however, some areas within NNE-RTD may be reconsidered in this perspective: hydrogen, PV, wind energy or even the energy application of cross-cutting technologies.

Conclusion

In summary, the two most privileged parts of the policy cycle where private sector stakeholders are involved appear to be the preparation stage and the implementation stage.

- During the preparation stage private sector representatives are involved mostly through dedicated foresight, consultation or other strategic planning exercises. This is the case in all countries where the priority-setting process is moderately to highly structured (see p 43).
- Private sector involvement is also sometimes identified in the design stage of programmes and policies. However, the design stage is generally much more in the hands of the national agencies.
- Where there are one or several national NNE-RTD programmes, the private sector is normally also involved, together with representatives from the research world, in the committees that evaluate and select the project proposals to be funded within such programmes.
- Finally, the private sector is generally only weakly involved in the (ex-post or intermediate) evaluation of NNE-RTD programmes. If so, then they are mostly foreign experts (see p 51).

In several countries industry is a real driving force in NNE-RTD (Denmark, Germany, the Netherlands for some themes / and under specific conditions [respectively wind, regional, agreements]). However in many countries (France, Spain, new member states) research on NNE-RTD is driven by government initiatives and programmes. For the construction of the ERA this means that a greater overall effort should be made to involve industry where appropriate,

[30] In particular renewables.

[31] Which is typically the case for software (ITEA) and semi-conductors (MEDEA+).

especially with a view to the Barcelona objective. This could be done, for instance, through the creation of dedicated 'roadmaps' at national or multilateral level, which would have clear links to the European level.

Recent national and international NNE-RTD related roadmaps

During the course of 2004 while this study was being carried out, several cases of national roadmaps or other NNE-RTD related strategic initiatives involving industry reached maturity. Current examples of such national technology roadmapping mainly relate to fuel cells and hydrogen and can be found in France (Pan-H), the Netherlands (PV roadmap; and more generally the EOS Strategy), Germany (on fuel cells, and on PV also). One multilateral example could be identified: the Nordic H_2 Energy Foresight[32]. Other multilateral roadmaps identified, such as the European Concentrated Solar Thermal Roadmap (ECOSTAR), are co-funded through the Framework Programme.

Evaluation practice

One-third of ERA countries have very weakly developed evaluation practice

Based on analysis of the country reports, Figure 11 gives an overview of the development of evaluation practice in NNE-RTD in the different ERA countries. The (relatively minimal) requirement to score in the 'Strong' column is that there should be a systematic evaluation of NNE-RTD programmes, at least at their end. There is typically a link between the development of priority setting and evaluation practice in the countries in which evaluation is strongly developed.

For the two countries in the 'moderate' column (i.e. Germany and France), evaluation is organised in a more ad hoc fashion (but clear instances of evaluation are present). For these two countries evaluations often also remain internal and unpublished. For the countries in which evaluation is weakly developed (right column) no formal obligation, nor a clear practice of evaluation in NNE-RTD, could be identified.

Figure 11 – Development of evaluation practice in NNE-RTD

Strong	Moderate	Weak	
Austria	France	Belgium	Liechtenstein
Denmark	Germany	Bulgaria	Lithuania
Finland		Cyprus	Luxembourg
Ireland		Czech Republic	Malta
Netherlands		Estonia	Poland
Norway		Greece	Portugal
Sweden		Hungary	Romania
Switzerland		Iceland	Slovak Republic
United Kingdom		Israel	Slovenia
		Italy	Spain
		Latvia	Turkey

Hence the table shows a clear difference between, on the one hand, the countries in the north of Europe, and the countries in southern, central and eastern Europe – with the geographically 'middle' countries, in the middle: Germany and France. Whereas for the northern and middle European countries in recent years evaluation of NNE-RTD has been sharpened (in comparison

32 see http://www.h2foresight.info/

to the results of the PSI and SENSER projects) this does not seem to have been the case for southern, central and eastern Europe.

The Scandinavian countries quite systematically involve foreign experts in the final/ex post evaluations of their NNE-RTD programmes and (more generally) have evaluations managed often by foreign consultants. This practice is less visible in the other countries studied although the use of foreign experts in the evaluation of national research programmes is also increasing in France.

National NNE-RTD evaluation practice mostly developed in the north of Europe

This section analyses some evaluation practices in NNE-RTD more in detail, shows some results and draws lessons in general and for ERA in particular. This draws upon the country reports and in some cases on additional material. It discusses, depending on the case, evaluation procedures & processes, evaluation outcomes, or both.

As described earlier in this report[33], **Finland**'s RTD governance system is characterised by the organisation of technology research in technology research programmes managed by the national technology agency TEKES. The agency's technology programmes are systematically evaluated at the end of the programme and mostly also at mid-term. Programme evaluation reports are publicly available. The aim of each evaluation is to provide insights in the effectiveness and relevance of the programmes and to produce information to support the strategic development of programme activities and the activities of TEKES in general. The impact analysis unit in TEKES uses external experts to carry out the evaluation of technology programmes in order to obtain a varied and independent view on the effectiveness of its programmes. The evaluation provides information and understanding on the dynamics of research and development practice and the factors contributing to its success or failure. The last overarching evaluation of TEKES' energy RTD programmes took place at the end of the 1990s[34]. This did not refer to international co-operation and recommendations were focused on the internal improvement of the programmes and their effectiveness (through definition of verifiable objectives and monitoring impact).

In 2003, at a more general level TEKES performed an assessment concerning the conditions that influence the impact of technology policy and programmes on climate change.[35] This showed that many of the factors that influence uptake of renewable energy go beyond mere support for RTD only and are dependent on the existence of buying obligations, public procurement, public opinion and the existence (completeness) of the value chain for the technology.

In **France**, incentive RTD programmes in the field of energy are normally evaluated at the end of their term, and sometimes while ongoing. Hence, in the area of NNE-RTD the national transport programme PREDIT and the fuel cell programme (PACo) were evaluated in 2002 and 2003 respectively. Evaluation reports are not published widely but communicated to stakeholders directly involved, especially those within administration.

With a view of the impact on RTD of liberalisation and internationalisation of energy markets, ADEME, the French national energy agency, 2001 performed a meta-evaluation of its NNE-RTD over the period 1985-95. Over the 11 years covered by this period, the agency financially

[33] See p36 and especially p39
[34] cf Review of Tekes Energy Technology Programmes 1993-1998.
[35] See Jari Hiltunen (ed), "Climate change – Impacts of technology policy and programmes", TEKES 2003.

contributed (mainly through shared-cost funding) to non-nuclear energy R&D for a total of €250 million[36]. ADEME's action could be characterised following three intervention modes, which:

- focus on the development and maturing of specific technologies and their associated techno-economic networks (especially used for renewable energy technologies)
- focus on energy problems within specific sectors (often related to energy efficiency
- are less often adopted but especially successful in the field of heat exchangers, which concerned the construction and the support to research platforms providing research services, tests and normalisation services to industrial companies.

Following the evaluations, the agency's impact over the period was considered to be great in photovoltaics, fluidised bed combustion, heat exchangers, super-insulating materials for buildings, and the development of the European label for energy consumption of household appliances.

Two main recommendations of the evaluation were to integrate NNE-RTD strategies in a broader strategy taking into account markets and users, as well as problems of normalisation and regulation; as well as within a broader strategic vision regarding energy. It was also recommended to make international benchmarking a more integral part of the development of NNE-RTD strategy.

Recently, the energy area, and in particular the area of NNE, received a new impulse in France crystallising in the New Energy Technologies report (op cit). This strategic report, followed up in 2004 by a hydrogen strategy, was supported by a series of evaluations, not of programmes but of technologies / research areas, which for the purpose of the exercise were systematically assessed with the help of a multicriteria analysis, against their strategic objectives (contribution to decrease of greenhouse effect / French competitiveness / energy independence / equilibrium supply/demand / development) and the feasibility of development (future perspectives / current state of industrial development / social acceptance). For each of the technology areas ways of development were sketched, and the question asked whether France should lead, co-lead or not invest.

In **Germany**, evaluation of the effectiveness of national NNE-RTD programmes is seen as an ongoing process and an important tool for decision-making in the ministry (of economics) responsible for NNE-RTD. Evaluations are, however, confidential, and no published evaluation reports on energy research are available. Programme evaluations are most often realised internally, sometimes with the support of external consultants and experts.

At regional level NNE-RTD is oriented more towards industry and applied research than at national level. The priority setting process varies from one *Land* to the other, but evaluation procedures are used, as it was for instance the case in North Rhine-Westphalia, where the photovoltaic programme was evaluated after 10 years in order to prepare a new orientation, or in Bavaria, which evaluated the research funding in hydrogen energy. In Baden Würtemberg, strategic evaluation or foresight projects could not be identified. Priority setting is partly supported through communication platforms, organised either by the research alliances and networks themselves, or by the ministry, as for instance in the framework of a conference on the future of energy supply.

In mid October 2003, a new orientation for energy research was announced by the governing board of the Helmholtz Association, an organisation grouping together Germany's main research

[36] 1.64 billion francs.

organisations in the NNE-RTD area. The new orientation is based on a radical reorganisation of the governance structure of the Helmholtz Association, based on the programmatic-strategic evaluation of programme proposals prepared jointly by the participating Helmholtz centres in the different domains by international and national high-level experts. The integration of international experts can be regarded as recognition of the importance of the international orientation of the centres. The evaluators were expected to comment on the strategic orientation and scientific quality of the programmes and centres, and give recommendations for their development.

Sweden has a long tradition of external evaluation by specialist consultants and (mostly foreign) experts. Evaluation reports are, as in Finland, public. In such a perspective, the long-range energy programme was recently evaluated. The main conclusions were:

- a transparent strategy to link and prioritise detailed activities with high-level objectives was missing
- there are problems of fragmentation and over-focus on traditional Swedish PhD-based research, both in the funding and in the institutions in which much of the research is done, whereas activities need to be related not only to their potential energy system benefits but to the supply chains and contextual factors in Sweden that will be necessary in using knowledge to help change reality
- the mission of STEM (the Swedish energy agency) would need to be reinvigorated, more explicitly connecting R&D to other policies and framework conditions
- new and innovative instruments are needed to tackle policy for change in a liberalising world, some of which will involve private sector actors more heavily
- it was recommended that the programme should focus on using knowledge that can be implemented in areas where Sweden has, or can realistically be expected to build, comparative advantages.

The evaluation report states that this strategy should take account of international changes – such as the Sixth Framework Programme – and the need to build critical mass in places. [...] Some of the critical masses of competence needed may best be built in international collaboration.

The **Swiss** Federal Office of Energy started carrying out evaluations in the 1990s, and within the scope of its Energy 2000 programme it arranged for a total of 60 evaluations. This tradition is to remain an integral part of SwissEnergy (the successor to Energy 2000), with a modified organisational structure. Evaluation of energy research programmes has a legal basis in the Energy Act, which came into effect in 1998 and obliges the Federal Council to periodically examine implemented measures, publish the results of its studies and report to Parliament.

The aim of evaluation of NNE-RTD programmes is to draw attention to weak points and include recommendations concerning ways in which measures in the area of energy policy can be improved. This means that in Switzerland evaluation is viewed as both a control mechanism and a learning tool. At the same time, evaluation should provide an assessment of the impacts of energy-policy actions and thus create transparency for the general public, Parliament and the Federal Council.

In the **United Kingdom**, the Department of Trade and Industry (DTI) has a well-established system of evaluation where activities to be evaluated are identified annually. Most of the evaluation work is conducted by external contractors, although the department does have some dedicated evaluation staff.

The DTI's evaluation programme is co-ordinated by the Strategy Unit's Performance and Evaluation Team. The team helps ensure that robust evidence is gathered to measure the effects of the department's activities. This evidence is fed to the DTI Performance Committee which overseas performance measurement in the department and to senior administrators to inform future strategy.

Evaluations in the areas related to NNE-RTD commissioned by the DTI over the past five years concern:

- the Environmental Technology Best Practice Programme (1999)
- offshore geology
- the OSO[37] Offshore Supplies and Service Company Assistance for Research programme
- the OSO Support for Innovation in the Oil and Gas Industry
- the evaluation of the Link Programme on Hydrocarbon Reservoirs
- new and renewable energy under NFFO and the Supporting Programme[38].

Until 2003, evaluation in the UK DTI was organised following 'ROAME'[39] statements, but in 2003 this was replaced by a system governed by a management-by-objectives[40]. Each objective is monitored four times a year and the results reported to the Executive Board of the DTI. These results are measured against the top target for the DTI (productivity and competitiveness for the UK).[41] The Objective Delivery Group for each objective makes a prioritisation of resources as determined by the success of activities as measured by these criteria[42]. The objectives are translated into different products to be delivered. In this new system, three of the new objectives for DTI relate to NNE-RTD[43] (and a fourth to nuclear energy), although RTD as such is not mentioned.

Conclusion

The development of evaluation practice is varied and heterogeneous. Some general practices are emerging which can be considered to be good:

- regular intermediate and *ex-post* evaluation
- better design of programmes (ex-*ante* evaluation)
- involvement of experts from other European countries in especially *ex-post* evaluation.

In the evaluation reports analysed in the framework of the current study, two follow recurrent recommendations[44]:

- NNE-RTD should be integrated into broader policies in order to improve the uptake of its results
- national NNE-RTD should take better account of the international and especially European dimension.

[37] Offshore Supplies Office.
[38] NFFO is the "Non-Fossil Fuels Obligation". The latter is not a real research programme.
[39] Rationale, Objectives, Appraisal criteria, Monitoring, Evaluation.
[40] See http://www.dti.gov.uk/energy/egstrategy.shtml
[41] One should recall that there is no specific department for science or for research in the UK but an Office of Science and Technology falling under the DTI.
[42] Similar procedures have been put into place during 2004 in France through the 'Loi Organique des Loi des Finances'.
[43] Namely DTI Objective 4: 'ensure the continuity and security of energy supply at affordable prices through competitive markets, whilst minimising environmental impacts and delivering social objectives'; DTI Objective 11: 'promote sustainability, through the delivery of the low carbon aims of the Energy White Paper and improving the contribution of business to sustainable development'; DTI Objective 13: 'safe, economic, efficient and effective management of energy […]'.
[44] Also given by the Socio-economic impact analysis of energy research projects report by an Independent Expert Panel for the European Commission, report EUR 19464 (see p69).

Conclusions

All ERA countries have NNE-RTD activities, to a greater or lesser extent, and in varying ratios with regard to the total energy research budget and as part of the total research budget.

There are four major groups of NNE-RTD investors:

- The ‘heavy investors’ of Italy, Germany and the Netherlands spending the equivalent of over $140 million per annum
- The ‘upper medium investors’ of France, Switzerland, Sweden which in 2003 spent just over $100 million per annum
- The ‘medium investors’ of Finland, Norway, UK, Spain, Austria and Denmark which in 2003 spent between $20 and 80 million per annum
- The ‘low investors’ spending $10 million or lower.

Three major classes of motivation have been identified for supporting NNE-RTD:

- support to national energy and/or energy technology endowment and support to national industrial sectors
- energy independence and security issues, which have become increasingly urgent given current oil prices, and for all countries involved in ERA
- longer-term RTD policies, especially relating to the hydrogen society and more generally the contribution of energy RTD to policies of sustainable development (most developed in the Netherlands with the transition concept).

Visions against which NNE-RTD is justified relate in particular to greenhouse gases and their devastating effects on the economy and society.

Analysis of NNE-RTD expenditures over time shows that trends vary greatly between countries, especially with regard to:

- NNE-RTD expenditure per se
- the overall evolution of NNE-RTD expenditures: some drop, some rise, others show an erratic pattern, some are stable
- a great variation over time in priorities for each country
- a great variation in priorities and their evolution between the different countries.

Currently, shared priorities between ERA countries are generally power and storage technologies, in particular fuel cells, and photovoltaic solar. To a lesser extent there is an interest in biomass and conservation. Other NNE-RTD priority themes are shared by a limited number of countries only.

From an institutional perspective, there are four major ways of organising the implementation of NNE-RTD policies. These are:

- through a dedicated energy agency which often also includes environment, sometimes shared between different countries
- through a technology agency which manages energy RTD programmes
- directly falling under responsibility of the relevant ministry
- through the main national research organisation of a country in the area, which acts de facto as an agency (and is also often the one that is delegated to represent a country in European NNE-RTD fora).

With regard to the presence of dedicated NNE-RTD programmes, there appears to be a sharp distinction between, on the one hand, the EU-15 Member States plus (most) Associated States, and, on the other hand, the new Member States. One-third of the 33 countries studied did not have a dedicated NNE-RTD programme by the end of 2003 – these are the ten new Member States, plus two other small countries.

Concerning private sector involvement, the most privileged parts of the policy cycle where private sector stakeholders are involved appear to be the preparation stage and the implementation stage. No specific SME-oriented measures aimed at promoting NNE-RTD could be identified whereas at the same time SME involvement is viewed in many countries as important for the NNE sector, traditionally and in the future. SME-oriented measures are generic in nature (soft loan schemes, tax incentives, etc.) and not linked specifically to NNE-RTD.

The development of evaluation practice is varied and heterogeneous. There are some good practices emerging, originating mostly in the administrations in northern Europe and trickling down to the southern and eastern parts.

Lessons from co-operation attempts

A long-standing tradition through the FP and IEA

The idea for a study aimed at gathering information on national NNE-RTD to support international co-operation did not wait for the ERA concept to be born. A first attempt to construct a pan-European database on NNE-RTD information was made by the former DG XII as early as the end of the 1980s[45], and this idea was later worked out through two JOULE projects, SENSER and PSI respectively[46].

This testifies that NNE-RTD has a long-standing tradition in international co-operation, especially through two important policy mechanisms, one European and the other OECD-related.

- The **European Framework Programme for RTD**. This has from the outset paid attention to energy research and in particular non-nuclear energy and sustainable (i.e. non fossil) sources of energy provision. Many European technologies, standards and items such as the energy consumption label, have been developed with the help of the European Framework Programme, which on the most relevant NNE subjects has brought the important European actors together[47] and has been a major force in streamlining national NNE-RTD priorities between European countries[48].
- The **International Energy Agency** is playing a major coordinating role especially through the so-called Implementing Agreements, which focus on research, technology development and diffusion, to which countries can participate on a voluntary basis. An overview of currently running IEA Implementing Agreements and their participation is given in Annexe D.

In the area of NNE-RTD, ERA collaboration is already greatly structured and well developed, especially centred around the European Framework Programme. Multilateral co-operation other than through the Framework Programme or the IEA Implementing Agreements is rare, and, by the start of this study, the only substantial exception was the Nordic Energy Research programme of the Nordic Research Council[49]. There seems to be room for improvement for the development of ERA in NNE-RTD, especially for co-operation that would go beyond the mere Framework Programme (cf analysis of results presented in Figure 7).

However, interviews show that it is not easy to draw people's minds away from the Framework Programme and reflect about alternatives or complementary actions. This is not surprising given the historical weight of the Framework Programme. By the end of the 1990s the European Commission contributed far more than 25% of the total public funding for non-nuclear energy

[45] P. Larédo, P. Mauguin, D. Vinck, 1988, Base Européenne d'information réciproque sur les programme de R3D énergétique, Brussels: DG XII.

[46] SENSER PSI, were carried out by a consortium involving all EU-15 Member States' energy agencies and aimed at exchanging on research priorities and priority setting mechanisms.

[47] As early as the 1980s, see: M. Callon, et al., 1989, *Evaluation des programmes publics de recherche. Le cas du programme non-nucléaire communautaire*, Presses Universitaires Namur, which reflects the work done for the evaluation panel led by Mr Bondi in 1988, to evaluate the European Commission's R&D programme in the field of non-nuclear energy 1985-88.

[48] The non-nuclear energy RTD budget has been subject to substantial fluctuations, from €830 million in FP1, to €120 million in FP2, €260 million in FP3, to more than €1 billion in FP4 and FP5, but these variations are very much flattened if demonstration energy RTD, only included in FP4 and FP5, are considered in the period from 1984 to 1994, i.e. corresponding to the time-schedule of the first three FPs.

[49] However, the NNE-RTD area is moving fast and during the same period over which the present study was carried out, several new initiatives saw the light, either within the framework of the FP (especially, ERA-NETs) or outside.

RTD in Europe (EU-15)[50] and still today the EC provides by far the largest single budget for non-nuclear RTD in Europe. Our interviewees found it quite counterintuitive to discuss the European Research Area without first referring to the Framework Programme. **It is an important finding of this study that the persons responsible for NNE-RTD in the ERA countries regarded it as unnatural – not to say quite difficult – to view European multilateral research in another perspective than that of the Framework Programmes**[51].

There is little co-operation outside the European Framework Programme

Existing initiatives, albeit scarce ones, show that there is more to international co-operation in NNE-RTD than the Framework Programme only. These will be briefly discussed below.

Multilateral co-operation programmes

Before the present study started, the only relevant multilateral non-FP co-operation existing was the Nordic Energy Research Programme. However in parallel to the present study several other initiatives saw the light, sometimes in the framework of the European Technology Platforms. These initiatives will be discussed in turn.

Nordic Energy Research

The only example of a multilateral, regional co-operation agreement with a common budget, financed by the different national governments, is the so-called Nordic Energy Research (NEFP)[52]. NEFP is a Nordic institution under the Nordic Council of Ministers and is funded by the Nordic governments. The Nordic Energy Research Programme was established in 1986 and was set up as a Nordic institution in 1999. The Nordic Energy Research board is composed of Denmark, Finland, Iceland, Norway and Sweden. In 2002, Nordic Energy Research revenues reached the total amount of circa €3.91 million[53].

Nordic Energy Research is based on the vision that “the Nordic countries have ambitious political goals for development of the energy markets, including goals for renewable and environmentally friendly energy sources/carriers and sustainable consumption”[54]. The objective is thus to achieve the development of industry and research within Nordic countries.

The action plan for 2003-2006 gives several directions:

- goal-oriented research (projects) with focus on results and their use
- increasing linking to and co-operation with industry and public authorities
- support for authority processes that require specialist insight into energy-related issues
- further development of knowledge and networks developed in previous periods
- increased co-operation with national R&D players
- increased co-operation with research programmes in the EU and IEA
- increased flexibility.

[50] PSI Final Report, p.14.
[51] This may have changed during the course of the study since several ERA-NETs have been set up over the same period.
[52] www.nefp.info
[53] Annual Report 2002.
[54] Presentation of Nordic Energy Research on the website.

Three core areas have been defined in the plan:
- climatic themes
- Nordic electricity co-operation
- regional co-operation.

The 2003-2006 project period will focus on five thematic areas:
- integration of the energy market
- renewable energy sources
- energy efficiency
- the hydrogen society
- consequences of climate change on energy supplies.

The funding of projects relies on calls for proposal, open to all research institutions as well as trade and industry. The first one was implemented in the winter of 2002[55].

Nordic energy co-operation now also involves the Baltic region, i.e. the Baltic countries (Estonia, Latvia and Lithuania) and north-west Russia. One of its objectives is to create a Nordic Platform for a greater European and international co-operation.

Many multilateral initiatives were only begun recently
However, many initiatives begun in the period before the present study were to be implemented from 2004. In particular, the following important initiatives should be mentioned.

The **European Academy for Wind Energy** (EAWE) is a collaboration on wind energy R&D by research institutes and universities in four countries: Germany, Denmark, Greece and the Netherlands. The Academy was founded to formulate and execute joint R&D projects and to coordinate high quality scientific research and education on wind energy at a European level. The initiating partners are:
- Denmark, RISØ, DHI, universities of Copenhagen (DTU) and Aalborg (AAU)
- Germany, ISET, University of Kassel
- Greece, CRES, universities of Athens (NTUA) and Patras
- The Netherlands, ECN, Delft University of Technology (DUWind).

Also, during the course of the present study three ERA-NETs in the energy area were selected (for bioenergy, hydrogen and fuel cells, PV), and a platform (not as yet an ETP since these do not formally exist as instrument) on hydrogen and fuel cells (HFP) as well as PV-TRAC, a high-level advisory council on PV (which is has produced a roadmap and is currently considering a platform)[56].

Apart from these initiatives, in 2001 the various European renewable energy associations created an umbrella organisation, the European Renewable Energy Council (EREC). This associates the five industrial organisations in the fields of photovoltaics (EPIA – European Photovoltaics Industry Association), small hydropower (ESHA – European Small Hydropower Association), solar thermal

[55] 70 applicants responded and applications reached a total amount of circa €70 million for four years. An in-depth evaluation process was then implemented in all five countries in accordance with a set of criteria concerning relevance, Nordic profile, finances, objectives and implementation plans.
[56] See http://europa.eu.int/comm/research/energy/nn/nn_rt/nn_rt_pv/article_1265_en.htm

(ESTIF – European Solar Thermal Industry Federation), biomass (EUBIA – European Biomass Industry Association) and wind energy (EWEA – European Wind Energy Association), plus the EUREC Agency that in itself already is an umbrella organisation of the European Renewable Energy Research Centres. The EREC therewith covers most of the European renewable energy industry and hence may in the future be an interesting vehicle, or at least a partner, in the construction of ERA in the area of NNE-RTD.

In other words, the construction of an ERA in NNE-RTD after a period of low activity now seems to be experiencing rapid change in a period of great excitement. Whereas by the beginning of 2004 there were no relevant multilateral initiatives apart from the Nordic energy research programme, by the end of 2004, many new pan-European NNE-RTD-oriented activities were up and running.

No movement as yet towards opening up national NNE-RTD programmes

Although international co-operation appears to increase, there are as yet **no concrete examples** of opening up of national programmes other than the ones already cited in the current version of the report (i.e. inviting foreign experts to sit on the selection panels). The barriers are positioned on two levels and are not related to NNE-RTD specifically:

- There is the problem of the accountability of the politician toward taxpayers. In countries like the UK legal barriers exist which prevent foreign teams from receiving subsidies from a national programme and thereby from fully participating in a national programme.
- There are implementation issues relating to the fact that administrations are organised differently. No examples for NNE-RTD were found (since such initiatives do not exist, but the experience of the Finnish-French PROACT programme in software technologies testifies to the problems that can arise when two Member States' administrations try to co-operate in research[57].

Increasing participation of foreign experts in project selection (relevance) and programme evaluation (effectiveness)

Referring to the structure of the policy cycle in four stages (see Figure 8, p.42), the results of the study show that, in general, foreign experts have not been much involved to this date, although this is changing. Foreign experts, if involved, generally appear to intervene at two specific stages in the policy cycle:

- in the selection of projects within programmes. This is an increasing practice in smaller countries, where the pool of national experts is thought to be too small to contain independent experts (e.g. Belgium, Scandinavian countries).
- in the external evaluation of programmes, for the same reason, but increasingly also triggered by European integration in RTD. Here there is no difference in practice between smaller and bigger countries and there is an increasing tendency to involve foreigners in final or ex-post evaluations of RTD programmes.

Although, again, no instances of this were found in the study linked to the area of NNE-RTD, in the future a 'collegiate' meta-evaluation between national authorities may be possible. Examples have been encountered in environment and in development aid showing the political viability of this idea.

[57] See Academy of Finland & Tekes, 2003, Assessment of the PROACT programme for 2002.

Working internationally on NNE-RTD programmes – identifying natural partners

The study, as well as broader experience, shows that, even before ERAs existed, the most natural partners for international co-operation at programme level were those who manage these programmes at national level, that is, the national agencies which have a NNE-RTD responsibility (the first two columns of the table in Figure 5). The ERA-NETs that were approved (in parallel with the present study) also involve this type of actors. However, in the absence of a national agency, another (public or private) body can only participate in ERA-NETs if it is managing a national programme on behalf of the government. According to the workshops held for the present study, this has frustrated full participation of countries such as Italy, Portugal and Spain who do not have agencies explicitly in charge of managing NNE-RTD programmes and so far have often relied on their national institutes to represent government in international fora related to NNE-RTD (whether EC or IEA). In other types of international co-operation at the level of national governments and agencies, it may be difficult to identify a natural partner in another ERA country.

During the course of the present study, ERA-NETs existing in sub-fields (PV, fuel cells) were established and were approved by the EC. The two first workshops[58] showed that there is also a clear need for a better coordination of initiatives at the level of national NNE-RTD policies and hence between policy-makers. In our view, such an initiative should take into account the variety of implementation structures in existence in the different ERA countries, and not let the absence of some types of actor be an excuse for excluding countries. On the other hand, this is also a clear message to countries who may want to better clarify the national situation for a foreign partner by a clearer definition of responsibilities for NNE-RTD, if, of course, they were aiming at participating in such international networks at policy level.

Conclusions

There is a long-standing tradition of international co-operation in NNE-RTD through the European Framework programmes and through the IEA, especially the IEA Implementing Agreements. The study shows that people find it difficult to imagine other types of co-operation which would bypass these two forms. There are only a few examples of multilateral co-operations which do so (especially through the Nordic Research Council).

During the course of the study several initiatives in international co-operation in NNE-RTD saw the day, especially in the area of fuel cells, PV and biomass, through the establishment of networks and platforms.

No participation in each other’s national programmes could be identified.

A need for better coordination of national policy initiatives in NNE-RTD was expressed by participants in the workshops held for this study.

[58] The introductory, generic, workshop and the one concerning NNE-RTD policy mixes.

The integration of new Member States in the NNE ERA

Given their particular features, one cannot ignore the new Member States, especially the former Soviet countries. While generally having a well-trained population of researchers, most of these countries are characterised by very low (NNE) RTD budgets and the absence of explicit (NNE) RTD policies and responsibilities, and where improvements to their national energy systems are likely to be more efficient with regard to, for instance, Kyoto objectives, than in former EU-15 countries, where return on energy investment decreases with increasing energy investments.

By its focus on a specific group of countries only, this chapter has a different focus from the previous ones. However, the subject should be dealt with in the light of recent discussions on cohesion and excellence. NNE-RTD seems to be a good case for reflecting upon cohesion and excellence simultaneously, since the integration of the energy system is one of utmost importance for the new Member States, especially the Central and Eastern European countries still confronted with the heritage of highly polluting and CO_2-intensive energy systems, and with the problem of integrating their research systems which were drastically reduced in size during the 1990s. Since, on the other hand, the research population in these countries is generally highly qualified, there is a risk of ‘brain drain’ from these countries to other European countries or other continents.

Little co-operation between new Member States

Being geographically close does not mean that eastern and central European countries necessarily work together. The western orientation of (NNE) RTD collaboration within the New Member States was apparent, to a greater or lesser degree, for all countries analysed. Some examples:

- In Poland it appears that east-west co-operation is by far the greatest tendency and that co-operation with neighbouring new Member States is only slowly emerging. A major reason is that Eastern European countries all experience similar financial problems and cannot be expected to help each other financially. A second reason is that they have comparable technical backgrounds
- The three Baltic republics have a strong drive towards international co-operation, and this is oriented to countries now belonging to the EU, eg Estonia towards Finland and Latvia towards Sweden. Surprisingly little remains of contacts and co-operative activity with Russian actors. The western orientation goes beyond Europe and includes co-operation with the US even if EU activities are the most intensive and do not leave much capacity to develop other relations. It should be noted besides that the Baltic countries have their own energy agency
- The Czech Republic only has some co-operative contacts in NNE-RTD within Visegrad countries[59] with Slovakia, with which it was a single country (Czechoslovakia) until 1993.

New Central and Eastern European Member States share many features

No two new Member States really resemble each other in their energy endowments and their eventual energy RTD assets. Some are net importing and some are net exporting countries, some countries use nuclear energy and other do not; the patterns of use of different fossil fuels, and different degrees of foreign direct investment in energy supply are very different from country to country.

[59] Hungary, Slovakia, Czech Republic and Poland.

Although they are quite different with regard to their energy endowment, many of the central and eastern European new Member States have commonalities, concerning

- the change in political systems
- a corresponding, often drastic, downsizing of the research system
- the particularities of the liberalisation of the energy market in this context
- the process of accession to the European Union, implying a negotiation process that covers the energy system and environmental targets.

The new Member States are individual nations with big differences, particularly in energy resources, but commonalities rather than differences dominate the energy policy debates at present. These are due to their history as part of the Soviet Union, the recent independence and total reorientation of policies, international contacts etc. This massive reorientation also, to a large extent, explains why these countries have not devoted much time and energy to the issue of energy RTD policy. This issue may get increasing attention in the years to come, implying that any initiative to assist in developing a long-term strategy for energy RTD will be welcome, if not necessary. It was therefore particularly striking to learn that on the level of NNE-RTD, virtually no collaborations exist between these countries, and that all oriented towards western partnerships.

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Figure 12 – Characteristics of Former Soviet Union EU Accession Countries (ranked by RTD intensity)

Country	GERD on GDP	Explicit Energy Policy	Explicit NNE-RTD	Barriers to co-operation cited	Import level	Main Energy Dependence 1	Main Energy Dependence 2	Sustainable Sources in Energy Supply	Main SES Source	NNE-RTD Themes	NNE-RTD Priority setting process
Slovenia	1.71%	Yes	Yes	None cited	High (coal, oil, natural gas)	Oil	Coal & nuclear	11.00%	Hydro & renewables	Eco-buildings; PV; geothermal; storage; fuel cells & H_2; integration of RES & distribution; clean urban transport & biofuels; gas power generation	Strong and explicit: renewable energy sector reinforcement is long term goal of government
Czech Republic	1.35%	Emerging	Emerging	None cited		Coal	Nuclear	Marginal	Marginal	None specific	Weakly coordinated; bottom-up;
Hungary	1.00%	Yes	Emerging	Lack of strategy at Hungarian national level; absence of clear policy on national level. Low industrial participation	High (oil)	Oil	Gas	Marginal	Marginal	Biomass, wind, waste incineration, geothermal	Overall strategy formulation is missing. However NNE-RTD actors are small in number, and networked. In RTD priorities, alignment with EU programmes; also inspired by energy obligations (increased renewables)

Country	GERD on GDP	Explicit Energy Policy	Explicit NNE-RTD	Barriers to co-operation cited	Import level	Main Energy Dependence 1	Main Energy Dependence 2	Sustainable Sources in Energy Supply	Main SES Source	NNE-RTD Themes	NNE-RTD Priority setting process
Estonia	0.75%	Emerging; increase use of RES by 2/3 in 2010; decrease in importance of oil shale	Emerging; apart from oil shale, in line with EU RTD priorities	Lack of: national financial resource for RTD, of scientific personnel (age structure), innovation capacity, and national strategy	High (coal, oil, natural gas)	Oil shale	Oil shale	Marginal	Marginal	Oil shale; recent upsurge of research in different renewable areas; fuel cells; H_2 technology; peat (country specific); district heating (country specific)	Starting
Lithuania	0.64%	Yes (National Energy Strategy)	Yes	None cited	High (Oil, Gas)	Nuclear	Gas	Marginal	Hydro; conventional thermal	NA	General RTD policy
Poland	0.60%	Emerging (white paper 1997 on renewable energy), “soft obligations”	No	Absence of national priority setting process. Harmonisation of administrative rules making Polish participation easier.	Average	Coal		2.50%	biomass (wood, straw)	Coal; PV	No

Country	GERD on GDP	Explicit Energy Policy	Explicit NNE-RTD	Barriers to co-operation cited	Import level	Main Energy Dependence 1	Main Energy Dependence 2	Sustainable Sources in Energy Supply	Main SES Source	NNE-RTD Themes	NNE-RTD Priority setting process
Slovak Republic	0.59%	Yes (preparation for the EU energy market)	Emerging	Lack of equipment; lack of national co-funding; country specific issues not taken into account; lack of 'pro-active' representatives at European level	High (oil, coal, gas)	Gas	Coal & nuclear	2.80%	Hydro	Unidentified	Emerging
Latvia	0.50%	Yes	No	Researcher population went from over 31,000 in 1989 to 4300 today.	Very high (oil, gas)	Wood & peat	Gas	No	None	Except for peat, in line with the EU FP priorities	Lack of national priority setting process

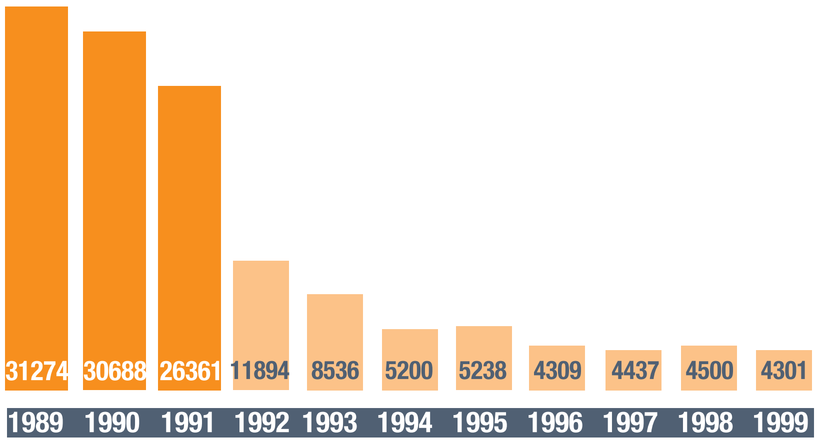
Very low NNE research budgets and a strong reduction in research personnel

Per capita GDP is low in most of the new Member States, and research budgets are also low (below 1 % of GDP for all countries, except for Slovenia and the Czech Republic). Energy research and non-nuclear energy research expenditures are therefore very low.

The move towards larger integrated projects (IPs) in the European Framework Programme makes it almost impossible for new Member States to take a leading role in European projects. In several cases, the budget for a single integrated project may be far higher than the annual budget of all NNE-related research institutes of a national university.[60] Statistics show that the new instruments have discouraged participation of new Member States in the Framework Programme[61] and their integration in the ERA through other mechanisms than the FP is therefore a particular challenge.

Another problem of the research systems in transition is the sharp reduction in research personnel since 1989. The Latvian example is the most drastic of all countries that were analysed, as the proportion of research personnel in total population was relatively high under the old regime.

Figure 13 – R&D personnel, Latvia, 1989-1999



Source: Ministry of Education and Science, http://www.izm.gov.lv/en/default.htm

A general problem is the weak position of companies in international R&D co-operation. On the one hand they are too small, on the other hand they are partly in foreign ownership since privatisation, and the international companies do not allocate research resources to the new Member States. As a consequence, in new Member States the participants in European projects often come from universities, research institutes and Academies of Science.

[60] Research institutes' budgets far lower than in western countries are also encountered elsewhere, like in Estonia, where the Tallinn Technical University is responsible for most of the energy research, and does energy research at a volume of about €1 million (including projects with the business sector).

[61] Cf Marimon Report – we do not have specific statistics for NNE-RTD.

Priority setting and opportunities for ERA in NNE

Interviews with experts and policy representatives in the accession countries concur in the analysis that the priority setting process and evaluation in NNE-RTD in these countries is weak.

- In Slovenia, for instance, a priority setting process should have led to a ranking of priorities from 0 to 5 (with 5 being the highest rank), with the result of 10 research themes all marked with importance 5.
- For the Polish study "a point of convergence of various interviews with Polish experts is that there is neither a clear set of priorities for NNE-RTD nor any clear priority-setting process in Poland", leading to an important need for priorities coming from the EU programmes.
- The studies of Lithuania, Estonia and Latvia mention that "with a weak base of national energy research and limited capacity in terms of both personnel and funding, there is a strong need for defining some priority areas. […] If the Commission could facilitate this process through co-operation or parallel processes in a number of countries, this could be beneficial to all."
- In Hungary, a national technology foresight exercise has been undertaken in recent years. However, energy is considered as part of the environment sector, and the results cannot be directly translated into priorities in the field of NNE-RTD. A representative of the Hungarian Ministry of Research, in charge of NNE-RTD programmes, states that "the main weakness is the missing general research strategy. The staff is very limited for strategy building."

Obligations derived from the negotiation of accession concern the energy system in the first instance, and are translated in energy laws, passed in most cases in 1999-2001. Besides other things, these obligations always concern the increase of renewables and the improvement of the emission balance, orientations that may be further translated into research programmes.

The counterpart of the "need for priorities coming from the European Union" and the weakness of domestic priority setting can be seen in the difficulty of accession countries in imposing their technical priorities in European programme design. Poland, for instance, faces a strong dependence on coal, a technology not covered in European research programmes, therefore "EU and Polish energy priorities do not combine so easily"[62].

Moreover, interviews with representatives of national R&D financing institutions in the Czech Republic and in Hungary indicate that, due to the need for technological adaptation and catching up in the energy system, both on the production and the user side, R&D projects are often very close to application and demonstration, which does not necessarily correspond to the European claim of scientific excellence. However, it has to be underlined that in most countries we encountered the assurance that within the research system, mainly in universities and the Academies of Science, excellent researchers are already well integrated in European co-operative research networks.

Opportunities and challenges for an NNE-RTD ERA

The previous sections show that from several points of view, most of the new Member States, especially the former Soviet countries, deserve special attention when it comes to integration and synergies within the NNE-RTD ERA.

- The generally well-trained research work force but weakly developed national RTD and RTD infrastructure hint at opportunities, if not the necessity, for mobility, especially (but not only) to

[62] Country report Poland.

other European countries where human resources are scarce. Both European and bilateral[63] mobility programmes for researchers exist but the latter aspect especially should be further developed. This should include young researchers going out to other European countries and visiting researchers and professors to the new Member States

- FP6 and its new instruments have generally resulted in lower participation from new Member States. Apart from measures that will probably be taken by the European Commission following the Marimon report, this may also be an opportunity to set up multilateral co-operation initiatives outside the Framework Programme
- It may be interesting for new Member States to seek countries with complementary assets, or with advanced technologies that could help them update their research and technology levels. This seems especially important in the area of fossil fuels, where relative CO_2 gains are expected to be higher than for the EU25 as a whole.

In line with the above points the immediate need of most new Member States lies currently much more with innovation and technology transfer than with participating in more fundamental research programmes. The challenge for the new Member States, to create synergies in NNE-RTD in Europe, is to follow a diversified strategy including increased mobility of researchers to and from the rest of Europe, partnering with other European countries on more basic research where the new Member State has a clear need and the other state has something to offer, and establishing innovation or technology transfer programmes in specific areas, to be accompanied with competence building, training programmes and local development.

[63] The French 'Programmes d'actions intégrées', for instance, supports bilateral exchanges between researchers. This programme, which is a set of bilateral agreements with other countries, covers all Europe as well as countries outside the European continent. A recent external evaluation commissioned by the French Ministry of Foreign Affairs shows that this programme is highly effective and much appreciated by partner countries, and has lasting effects on collaboration between researchers/research groups.

Conclusions and recommendations

Variable levels and trends in funding

IEA figures allow us to estimate[64] that all ERA countries (excluding the EC) together spend around €1 billion per annum on NNE-RTD (public funding). The European Commission budget (Framework Programme) for NNE-RTD is about one-fifth of this sum. The European Framework Programme therefore represents the biggest single budget for NNE-RTD in Europe. According to IEA statistics, Japan spends about the same as the sum of all ERA countries' NNE-RTD expenditures, whereas USA expenditures on NNE-RTD would at least be twice as much.

While the sum of ERA country budgets has decreased over the past ten years, the EC budget has increased. Therefore, overall, no significant decrease in public funding of NNE-RTD can be observed.

Within the ERA, four groups of NNE-RTD investors can be distinguished:

- the ***heavy investors*** of Italy, Germany and the Netherlands spending the equivalent of over $140 million per annum over the past ten years
- the ***upper medium investors*** of France, Switzerland and Sweden which in 2003 spent just over $100 million per annum, with overall budgets being on the rise over the past five years
- the ***medium investors*** of Finland, Norway, UK, Spain, Austria and Denmark which in 2003 spent between $20 and 80 million per annum
- the ***low investors*** (all other countries) spending $10 million and below.

This picture changes considerably if NNE-RTD investments on GDP are considered. In that case Finland, Sweden, Norway, Switzerland and the Netherlands rank first, followed by Italy, Austria and Denmark. Big absolute spenders such as Germany and France have a relative spend in the order of magnitude of countries like Ireland, Spain and Greece.

Visions against which NNE-RTD is justified relate, in particular, to greenhouse gases and their devastating effects on the economy and society. NNE-RTD is further motivated by three closely interrelated aims, i.e. the support to national energy and/or energy technology endowment and support to national industrial sectors; by energy independence and security issues; by longer-term RTD policies, especially relating to the hydrogen society and more generally the contribution of energy RTD to policies of sustainable development.

A great variety in research priorities with an emerging concentration on fuel cells and PV

The presence of dedicated NNE-RTD programmes is variable. There is a sharp distinction between, on the one hand, the EU-15 Member States plus (most) associated states, and, on the other hand, the new Member States. One third of the 33 ERA countries did not have any form of dedicated NNE-RTD programme (i.e. either relating to individual aspects or overarching) by the end of 2003: these are the ten new Member States, plus two other, small, countries.

Even though a great thematic variety exists, generally shared priorities between ERA countries are currently emerging. These are power and storage technologies, in particular fuel cells, and photovoltaic solar. To a lesser extent there is an interest in biomass and conservation. Other NNE-RTD priority themes are shared by a limited number of countries only.

[64] The reader should recall that IEA figures are given in US dollars, not in euros.

Different implementation structures and policy mixes

Countries generally implement NNE-RTD in four distinctive ways:

- through a dedicated energy agency often also covering environmental issues
- through a technology agency which manages energy RTD programmes
- directly falling under the responsibility of the relevant ministry
- through the main national research organisation of a country in the area, which acts de facto as an agency.

No natural evolutions within countries, from one setting to another, have been observed. For most countries the system of governance of NNE-RTD has been very much in a steady state over the past ten years. In many ERA countries, however, the governance of the RTDI system as a whole is currently under revision. This may impact the way in which NNE-RTD is organised in the future (e.g. mergers of agencies).

Concerning private sector involvement, the most privileged parts of the policy cycle where private stakeholders are involved are the programme preparation stage and the programme implementation stage. No specific SME-oriented measures aimed at promoting NNE-RTD could be identified whereas at the same time SME involvement is viewed in many countries as crucial for the NNE sector, both traditionally and in the future. SME-oriented measures are generic in nature (soft loan schemes, tax incentives etc) and not linked specifically to NNE-RTD.

The development of evaluation practice is varied and heterogeneous. There are some good practices emerging, originating mostly in the administrations in the north of Europe and trickling down to the southern and eastern countries.

Weak international co-operation outside the Framework Programme, other EC initiatives and the IEA

With the exception of the Nordic Energy Research programme, there is no systematic or consistent multilateral co-operation in RTD outside the regular EU programmes or the IEA Implementing Agreements. In 2004 however, several technology platforms were prepared, in the field of hydrogen and fuel cells, for PV and for biomass. A European Wind Academy, linking institutes in four different European countries, has recently been set up.

Through its successive non-nuclear energy research programmes (NNE, JOULE, ENERGIE), the European Framework Programme has been the major driver of multilateral research co-operation in NNE in Europe. As a consequence, national policy-makers appear to find it very hard to think beyond the Framework Programme when asked to think about multilateral co-operation. The different ERA countries should be made aware that NNE-RTD bi- or multilateral co-operation outside the sole Framework Programme should become an increasing part of national policy mixes and that such co-operation within ERA should be sought much more actively.

Barriers to the further completion of an ERA in NNE-RTD

The following barriers for further development of ERA could be identified and should be removed:

- National priority setting does not explicitly take into account the priorities of other countries. Hence priorities are not explicitly shared between countries, and only loosely coordinated through the Framework Programme or (often informal) networks. Common priority setting only recently has started to gain an increased interest through initiatives such as the ERA-NETs and ETPs. Shared thematic RTD priorities (which may be complementary) are thought to be the most important reason to work together; differences in the structure of the national policy mix or in national research infrastructures are found not to be a barrier to international co-operation

Recommendation: Today co-operation is initiated in an ad hoc and bottom-up fashion. Since shared RTD priorities are seen as the main reason to co-operate, benchmarking of national NNE-RTD priorities and programmes across European countries should be performed much more regularly and systematically. To this end, IEA data and country studies should be optimised and better exploited.

- Apart from some smaller countries more dependent on the Framework Programme, there is no synchronisation of the priority-setting process with EU programmes or with each other. In order to be able to integrate evolution and priorities in other countries, priority-setting processes should be more aligned between countries

Recommendation: Priority-setting processes in Europe are today largely decoupled. Eventual alignment takes place informally and in an ad hoc manner. In order to create more coherence in priority setting in European NNE-RTD and synergies in the priorities, European countries should evolve more synchronicity in their planning process.

- No dedicated budgets exist as yet for trans-national research. National administrations are only starting to become accustomed, through the ERA-NET concept, to the idea of increased coordination and opening of national programmes, let alone to sharing budgets. National policy instruments, policy processes and priorities remain very national, and foreign participation is most of the time impossible. Even bilateral programmes are carried out ‘with a closed purse’ i.e. national teams are paid by national authorities, as in the case of Eureka. In some countries, legal barriers may prevent foreign participation in national programmes.

Recommendation: Member States should investigate the possibility of reserving budget lines for trans-national, non-FP co-operation. In order for Member States to make this politically attractive, the socio-economic benefits of such trans-national programmes may have to be further investigated.

Recommendation: Countries should eliminate legal eventual barriers to international co-operation and opening up their national programmes to foreign participants.

This notwithstanding, legitimate reasons will continue to exist for countries to promote purely national RTD programmes.

The urgent integration of the new Member States

Finally, during the course of this study, ten new Member States joined the European Union. Given the characteristics of these countries, their integration into the NNE-RTD ERA is of particular importance. Most new Member States have a well-trained researcher population but weakly developed energy policies and often weakly developed or virtually inexistent energy RTD infrastructures. The challenge, for the new Member States to create synergies in NNE-RTD in Europe, is to follow a diversified strategy including mobility of researchers to and from the rest of Europe, partnering with other European countries on more basic research where the new Member State has a clear need and the other state has something to offer, and establishing innovation or technology transfer programmes in specific areas, to be accompanied with competence building, training programmes and local development.

Recommendation: The European Commission and all Member States should develop a coherent and diversified strategy to integrate the new Member States in the ERA for NNE-RTD. This strategy should cover the in- and outgoing mobility of researchers (at all levels), partnering with relevant countries on basic research related to NNE, and the establishment of innovation and technology transfer programmes. This should be accompanied with competence building, (vocational) training programmes and local development. On top of research funding, other types of funds (mobility, structural funds) will be needed to co-finance such NNE-RTD initiatives. Member States' bilateral research mobility programmes, which today are mainly based on scientific disciplines, should be used for the purpose of promoting NNE-RTD.

Where to go from here?

From the current state of affairs, the study points at three ways to go, probably simultaneously.

- First, a joint, top-down coordination from the ERA states and the Commission is recommended. This requires a more strategic approach in which forces are joined together to decide upon the themes that should be pursued at European level, and those that could benefit from multilateral or bilateral co-operation outside the framework programme
- Second, the synergies detected in NNE-RTD themes across countries also hints at the need and possibility for a more bottom-up approach in which two or more countries join forces to launch common calls for proposals. Relevant areas for this are those where a small number of countries are highly involved with a certain type of area: fossil fuel RTD is an example. Inversely, it could also be areas where many countries have a low priority, and create more critical mass. This approach does not exclude the previous one but can be implemented in conjunction with it. There is an increasing experience with such co-operation in other research areas where the need for more European bi- and multilateral co-operation is felt (e.g. information technologies, transport). A mechanism that has proved its validity and is as yet not applied to NNE-RTD would be the Eureka Cluster. Also, IEA Implementing Agreements are a good vehicle for multilateral co-operation in energy RTD and may also contribute to the reinforcement of the ERA
- Third, with a view to the new Member States, but not only to them, much more attention should be given to the mobility of doctoral and especially post-doctoral researchers in the area of NNE-RTD. Today many examples of bi- or multilaterally organised mobility programmes between European countries exist (the French 'Programme d'Actions Intégrées', for instance), but such programmes are organised in a disciplinary fashion. Mobility focusing on NNE-RTD is virtually absent, although recent initiatives such as the European Academy for Wind Energy may constitute a change in this regard.

For all three types of activities to be realised, however, and in order to actively promote such a strategic approach, it is a prerequisite that the ERA countries should be much more systematically, and better, informed about their mutual needs and assets, for instance through an observatory for NNE-RTD and, especially, a better exploitation of the possibilities offered by the IEA in terms of monitoring national NNE-RTD budgets and priorities. Many subsequent initiatives to this end have been taken by the European Commission and the national energy agencies as from 1988, but they did not lead to a lasting structure. With the development of the European Research Area, they may only now find their full justification and its usefulness, not to say necessity, is increasingly felt by Member States.

Annexes

Annexe A – Country study protocol

Overall view

After the approval of our general analytical framework and methodology by the EC in an inception meeting, country studies were conducted comprising the following elements:

- database search (www, CORDIS, national databases, PSI/SENSER information), in order to get a preliminary overview of the NNE-RTD and its organisation in the different countries under scrutiny
- identification of national focal points having a good insight and overview of the organisation of NNE-RTD at national level, as well as of actors and expenditures
- completing a project-internal database with the help of a first-round series of telephone interviews
- results were sent to a selection of interviewees having a sufficient overview for validation of completeness of data and correct emphasis of the information gathered at that stage.
- on that basis, interviews with national focal points were organised in selected countries
- assembling of documentation and further entry points into the national NNE-RTD system
- study of additional documentation
- write country brief.

For the country studies, use was made where relevant of the national contacts identified through the SENSER and PSI projects, and through many other international connections. An initial list produced on that basis was agreed with the European Commission (all interviewee names appear in the individual country reports). Since many countries have to be analysed in a short time period, the overall process will have country studies proceeding in parallel. A well-prepared direct contact with national contact persons, partly by telephone, partly by face-to-face interviews, appeared to be most effective to achieve this.

Interview issues

The main points to be discussed in interviews were

- funding of NNE-RTD
- energy policies and their position within the broader national policy
- broad lines of the organisation of national research and the position of NNE-RTD therein
- organisation of NNE-RTD:
  - ▷ priorities and funding of priorities
  - ▷ major actors, and/or in the setting of priorities
  - ▷ procedures and methods for priority setting, and for monitoring and evaluating NNE-RTD
  - ▷ dissemination of the results of research among policy-makers and other relevant actors.
- international collaboration and possibilities for ERA in NNE-RTD.

Country interview checklists as well as the country study report outline are given on the project web page.

Coping with different sizes and configurations of NNE-RTD

Phase 1 of the study (October-December 2003) was dedicated to the collection and presentation of the information needed for the individual country studies and their synthesis.

Considering the large number of countries to be analysed and the short period in which this was to have been done, a straightforward methodology for the country studies was of utmost importance.

Following work carried out during the inception phase, three levels of detail were to be distinguished for the country studies:

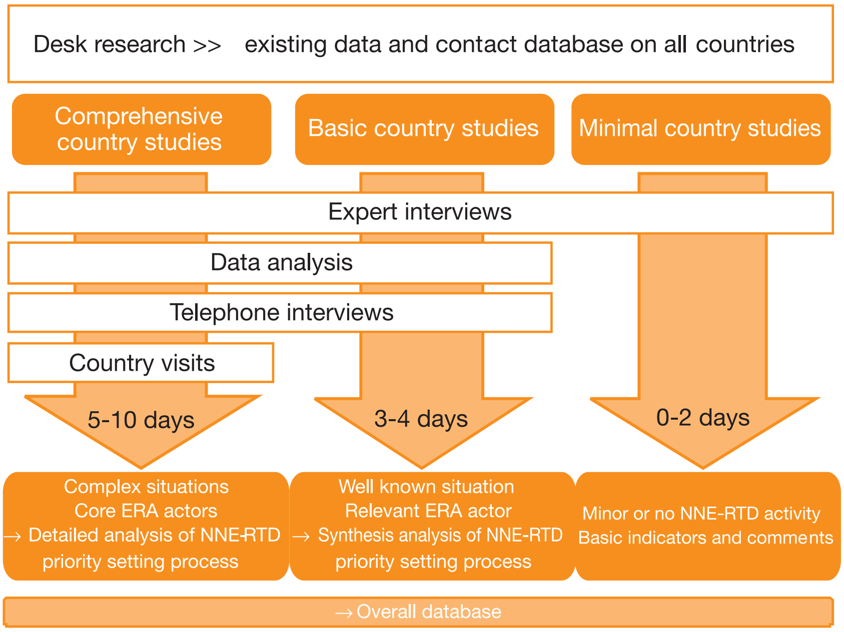
- comprehensive country studies were conducted in countries with a complex distribution of roles (for instance Germany or Belgium) and/or that eventually have important actors for the NNE ERA (for instance France, UK, Poland)
- basic country studies covered countries that are relevant actors in the NNE ERA, but where the situation is already well known or documented
- minimal country studies covered those countries where desk research shows that there is no or very little relevant NNE-RTD activity, beyond the existence of a single research institute (Luxembourg and Liechtenstein with no activity, other countries like Malta, Lithuania, or Iceland with only one research institute, but apparently no explicit national policy in this field).

According to this typology, resources varying between <1 to 10 work-days had been attributed to each country study. The effort needed for each study depends on:

- the complexity of the research policy system. Due for instance to their federalist structure, Germany and Belgium need special attention, as well as France, where important actors are found at different levels (policy-makers, different ministries, ADEME, research organisations and energy providers)
- the information available on aggregated level. This concerns, a priori, all those countries not covered by the PSI project (all eastern European countries, but also the UK where no data exist in the PSI database)
- time required for de visu interviews in order to understand the priority-setting process.

The graph below provides an overview of methods or tools to be applied to each of the types of country studies. Based on pilot desk research undertaken for all countries, countries were attributed to the types.

Figure A-1 – Methods and results for different types of country studies



Minimal case studies relied on desk research (paper documents and Internet), on interviews with experts at international level, having more intimate knowledge regarding the country, and in some cases by telephone interview in order to complete or confirm information assembled so far.

Basic country studies were additionally based on the analysis of available data and on a series of telephone interviews with different actors in the field. No *de visu* interviews are foreseen for these studies, which will nonetheless result in a synthesis analysis of NNE-RTD priority setting processes, apart from the information integrated in the final database.

Finally, the preparation of comprehensive country studies was based on country visits and on *de visu* interviews, with several actors, in order to understand the research system, priorities and the priority-setting process in the field of NNE-RTD as well as the opportunities for complementarity and synergy. Additionally, all other information sources mentioned above were used, like desk research, telephone interviews and data-analysis.

Expectations per country

Following the terms of reference, the study covered the following geographic regions: Scandinavia/the Baltic region, the British Isles, Benelux, Germany, France, Middle and Eastern Europe, Alpine region and the Mediterranean region. Each of these regions will be covered taking into account the respective level and amount of energy RTD activities.

For the purpose of this study, these regions are defined as follows: Scandinavia/Baltic region (Finland, Sweden, Denmark, Norway, Iceland, Lithuania, Latvia, Estonia), British Isles (Republic of Ireland, United Kingdom), Benelux (Netherlands, Belgium, Luxembourg), Middle and Eastern Europe (Poland, Czech Republic, Slovak Republic, Hungary, Romania, Bulgaria), Alpine region (Switzerland, Liechtenstein, Austria, Slovenia), Mediterranean region (Portugal, Spain, Italy, Greece, Malta, Cyprus, Turkey, Israel).

Figure A-2 explains why we have chosen a certain type of study (comprehensive, basic or minimal) for each country.

Figure A-2 – Division of countries according to the degree of detail of the country studies

Country	Type of country study	Comment
Scandinavia / Baltic region		
Finland	Comprehensive	
Sweden	Comprehensive	
Denmark	Comprehensive	
Norway	Comprehensive	
Iceland	Basic	Only one actor identified
Lithuania	Minimal	Research bodies identified, but no apparent NNE-RTD policy
Latvia	Minimal	Research bodies identified, but no apparent NNE-RTD policy
Estonia	Minimal	Research bodies identified, but no apparent NNE-RTD policy
British Isles		
Ireland	Comprehensive	
United Kingdom	Comprehensive	Data to be collected; organisational complexity and much private sector involvement
Benelux		
Netherlands	Comprehensive	
Belgium	Comprehensive	Administrative and organisational complexity
Luxembourg	Minimal	No actor identified
Middle/Eastern Europe		
Poland	Comprehensive	Data to be collected; dynamics of the sector
Czech Republic	Comprehensive	
Slovak Republic	Basic	
Hungary	Comprehensive	International-oriented RTD strategy
Romania	Minimal	Research bodies identified, but no apparent NNE-RTD policy
Bulgaria	Minimal	Research bodies identified, but no apparent NNE-RTD policy
Alpine region		
Switzerland	Comprehensive	Data to be collected, organisational complexity
Liechtenstein	Minimal	No actor identified
Austria	Comprehensive	
Slovenia	Basic	Research bodies identified, but no apparent NNE-RTD policy
Mediterranean Region		
Portugal	Comprehensive	
Spain	Comprehensive	Federalism
Italy	Comprehensive	
Greece	Basic	Available data, organisational simplicity
Malta	Minimal	Research bodies identified, but no apparent NNE-RTD policy
Cyprus	Minimal	Research bodies identified, but no apparent NNE-RTD policy
Turkey	Basic	Data to be collected but organisational simplicity
Israel	Comprehensive	Data to be collected
Other		
France	Comprehensive	Organisational complexity
Germany	Comprehensive	Federalism

Annexe B – Overview of results of country studies

Figure B-1 – Main energy and NNE-RTD characteristics

Country	Import level	Main Energy Dependence 1	Main Energy Dependence 2	Sustainable Sources / Energy Supply	Main SES Source	NNE-RTD Themes (in order of importance)
Iceland	Average (oil)	Geothermal	Oil	70%	Geothermal; hydro	Geothermal; hydro; H_2
Norway	Self-Sufficient	Oil	Hydro	45%	Hydro (large)	Petroleum, hydro, energy systems
Sweden	Average (oil)	Oil & Nuclear	Biofuels, peat	28%	Hydro; biofuels & peat	Forest-based solid fuels; EtOH as transport fuel; conservation; thermal and hydroelectric power generation, transmission and CHP. Energy System Analysis
Austria	High (oil)	Oil	Renewables	25%	Biomass; solar	Biomass & solar; Energy systems for tomorrow; Building for Tomorrow; Factory for Tomorrow
Finland	High (oil, coal, gas)	Nuclear	Oil & wood fuels	25%	Wood fuels; peat	Energy use; Energy production; Bioenergy
France	High (oil)	Nuclear	Oil	20%	Hydro (large)	Renewables [incl PV Solar], H_2 Paths [incl fuel cells], Energy storage; Energy efficiency; Advanced combustion; oil; geothermal (HDR) / CNRS programme: Biomass : enzymatic and micro-biological gasification; Photovoltaic solar energy; Thermal and thermodynamic solar energy; Fuel cells
Turkey	High (oil, gas)	Oil	Coal	14%	Combustible fuels & hydro	Energy efficiency; Renewables (Small hydro, Wind, PV solar); Clean coal
Portugal	High (oil, gas)	Oil	Coal & gas	12%	Hydro (large)	Renewables

Ireland	High (oil, gas)			11%		Conservation (built environment; less in industry and transport); Power and storage (incl CHP); Tidal energy; wind & off-shore wind
Romania	Low	Gas	Oil & coal	11%	Hydro	Energy efficiency; Energy production; Cogeneration; Renewables and fuel cells
Slovenia	High (coal, oil, natural gas)	Oil	Coal & nuclear	11%	Hydro & renewables	Eco-buildings; PV; Geothermal; Storage; Fuel cells & H_2; Integration of RES & distribution; clean urban transport & biofuels; gas power generation
Denmark	Self-sufficient	Oil	Gas	8.6%	Wind; biomass	Renewables, especially with Danish industrial potential (wind, PV, fuel cells, H_2)
Spain	High (coal, oil, natural gas)	Oil	Coal	6.0%	Hydro & renewables	Energy efficiency, Renewables, Energy System Analysis, Fossil Fuels, Conservation, Power and storage technology
Greece	High (oil)	Oil	Lignite	4.7%	Hydro	Wind, biomass, PV
Bulgaria		Coal	Nuclear, Oil, Gas	4.0%	Hydro	Solar, hydro, wind
Cyprus	Very high	Oil		4.0%	Solar (thermal&photo) / highest per capita installed solar collectors	
Italy	High (oil, gas)	Oil	Gas	4.0%	Hydro (large)	
Netherlands	High (oil)	Gas	Oil	3.0%	wind, solar PV, biomass, hydropower	Energy efficiency; Renewables (PV solar, Wind & Biomass)
Israel	High (oil, coal)	Oil	Coal	2.9%	Solar	Oil shale utilisation, energy efficiency in buildings, solar-thermal power generation, PV
Slovak Republic	High (oil, coal, gas)	Gas	Coal & nuclear	2.8%	Hydro	Unidentified

Poland	Average	Coal		2.5%	biomass (wood, straw)	Coal; PV
United Kingdom	Low	Oil	Gas	2.0%	Biofuels and Wind	Bioenergy and offshore energy
Belgium	High (oil)	Oil	Nuclear	1.0%	Marginal	None specific
Czech Republic		Coal	Nuclear	Marginal	Marginal	None specific
Estonia	High (coal, oil, natural gas)	Oil shale	Oil shale	Marginal	Marginal	Oil shale; recent upsurge of research in different renewable areas; fuel cells; H_2 technology; peat (country specific); district heating (country specific)
Germany	Average (oil and gas)	Nuclear	Coal	Marginal	Marginal	Power & storage; Solar; Conservation; Fossil fuels
Hungary	High (oil)	Oil	Gas	Marginal	Marginal	Biomass, wind, waste incineration, geothermal
Latvia	Very high (oil, gas)	Wood & peat	Gas	No	None	Except for peat, in line with the EU FP priorities
Liechten-stein	NA	NA	NA	NA	NA	NA
Lithuania	High (oil, gas)	Nuclear	Gas	Marginal	Hydro; Conventional Thermal	NA
Luxem-bourg	Very high	Oil	Gas	Marginal	Co-generation; Hydro	Biomass, Waste incineration, PV
Malta	Very high	Oil		Marginal		Solar, Energy efficiency
Switzer-land	High (oil, gas)	Oil	Nuclear	13%	Hydro (large)	REU; RES (of which PV solar most important & biomass increasing)

Figure B-1 shows that, first of all, most countries are still very dependent on fossil fuels and/or nuclear energy. For the current Member States this concerns oil and gas mainly, whereas many of the accession and associated countries still have economies based on coal.

A second major characteristic shown by the figure is that many countries, due to their natural resources, have constructed a specific technology endowment: Iceland for geothermal energy, Norway for hydro and petroleum, and France for nuclear, are typical examples.

A third interesting characteristic is that NNE-RTD in the different countries does not always follow the endowment of each individual country with specific sustainable energy sources. Hydro, as a mature technology, is an important natural energy resource, but is generally absent from NNE research programmes in all countries. Generally speaking however, countries perform research on the technologies they promote themselves for their own energy supply, constructing these as technological assets which may be important in ERA. Danish wind turbines are a good example of this, or Iceland's geothermal energy research, leading, more recently, to hydrogen research and fuel cells.

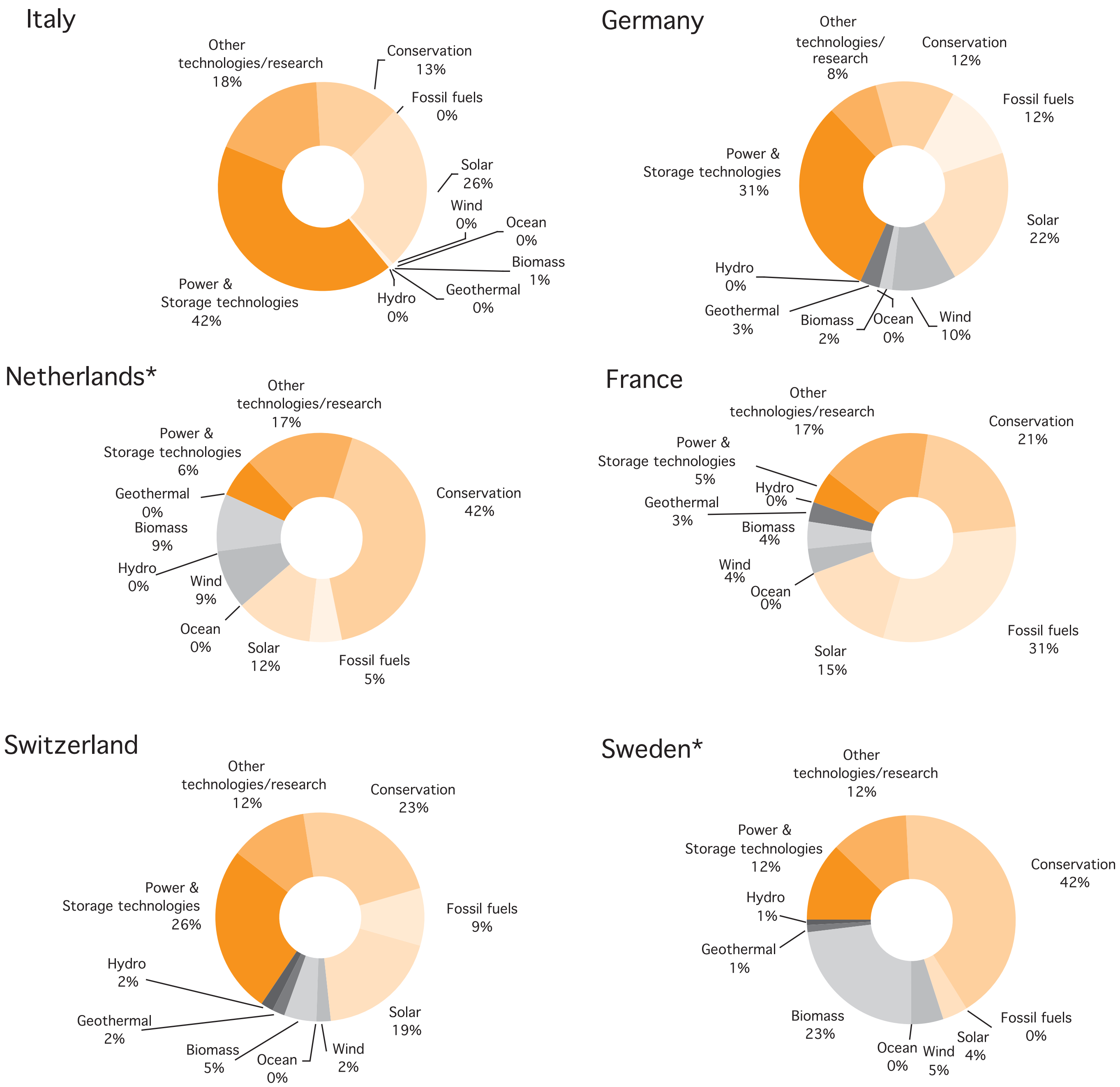
Figure B-2 – Country assets and country needs

Country	Synergies: country assets	Synergies: country needs
Austria	Biomass & solar	Unidentified
Belgium	Unidentified	Unidentified
Denmark	Wind energy RTD	Unidentified
Finland	Major RTD programme on NNE-RTD (€60 million) run by TEKES; energy use is important component (about half); structured and systematic planning and programming process ran by TEKES	For short-term projects: close collaboration between managers of national RTD programmes
France	Fuel cells; PV solar; oil; geothermal (HDR) / nuclear research (CEA strong institute)	Outgoing mobility; complementary assets in hydrogen and FC
Germany	Strong NNE-RTD programme & funding	Coal plant technologies
Greece	Unidentified	Unidentified
Ireland	A quite strong policy process promoting NNE-RTD	Unidentified
Italy	Unidentified	Unidentified
Luxembourg	Unidentified	Lack of adequate RTD infrastructure (only recently starting to be built up)
Netherlands	Major experience with energy efficiency research. Presence of major leading companies and institutes, socio-economic research, energy modelling	Benchmarking; Good practice; disseminate transition ideas to other Member States
Portugal	All domestic energy production (12% of supply) is from SES	Unidentified
Spain	Unidentified	Unidentified
Sweden	Forest based solid fuels; EtOH as transport fuel; conservation; thermal and hydroelectric power generation, transmission and CHP.	Hydrogen, wind, solar power systems, and transport biofuels rated 'below the international average' in a recent survey
United Kingdom	Biofuels & wind; important indigenous resources	Unidentified
Cyprus	Solar as important natural resource	Upgrade NNE-RTD system
Czech Republic	Flash pyrolysis; small-scale combustion plants; anaerobic digestion of agricultural and food residues	NNE-RTD programme (currently not explicitly defined); also see 'needs list' in country report: great demand for RTD on great variety of technologies
Estonia	Oil shale; recent upsurge of research in different renewable areas; fuel cells; H_2 technology; peat (country specific); district heating (country specific)	Fuel cells; H_2 technology defined as priorities; energy policy making; social science research

Country	Synergies: country assets	Synergies: country needs
Hungary	Geothermal (low temperature)	Low industrial participation in research; energy consumption by transport fastest growing sector; energy supply & energy security
Latvia	Unidentified	Social science for policy development in NNE-RTD
Lithuania	Unidentified	• About 90% of primary energy is imported from a single supplier • The early closure of the Ignalina NPP without the required financing • As a result of the slow modernisation of district heating systems, a number of consumers are disconnecting • High dependence on imports of primary energy resources - diversification needed
Malta	Major renewables potential	No exploitation of renewable energy potential (solar; wind). Link RTD and socio-economic research.
Poland	Upgrade of NNE-RTD system	To define the process to set priorities in NNE-RTD and to define priorities. Tackle environmental challenges of coal industry. Technology transfer.
Slovak Republic	Unidentified	Absence of national priorities; Lack of important equipment to carry out NNE-RTD; country specific issues eg related to Soviet era buildings
Slovenia	One of the New Central and Eastern European Member States share many features countries with highest RTD/GDP ratio, and research infrastructure, including in NNE-RTD	Unidentified
Bulgaria	Electrochemical power sources; photovoltaics	Upgrade private sector; Transition to market economy & liberalisation; decrease energy intensity / high CO_2 emissions
Iceland	Geothermal; hydropower	Countries with similar energy profiles/ endowments are few if not inexistent
Liechtenstein	Unidentified	Unidentified
Norway	Petroleum & hydro experience: offshore technologies; industrial production technologies based on gas; CO_2 sequestration, handling and depositing related to natural gas; social sciences for policy making related to petroleum sector, deregulation and climate issues	Improved instruments to involve SMEs on national level; definition of longer term national priority areas for R&D
Romania	Largest producer of crude oil in CEE, and also has gas and coal resources. Largest power sector in south-eastern Europe	Unidentified
Switzerland	High level of industry contribution to NNE-RTD funding (80%)	Unidentified

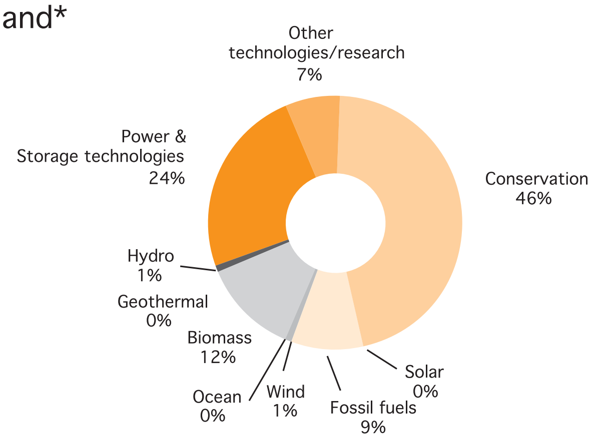
Annexe C – Main energy RTD data

Figure C-1 – Distribution of NNE-R&D budgets in selected ERA countries, according to (2002) technologies

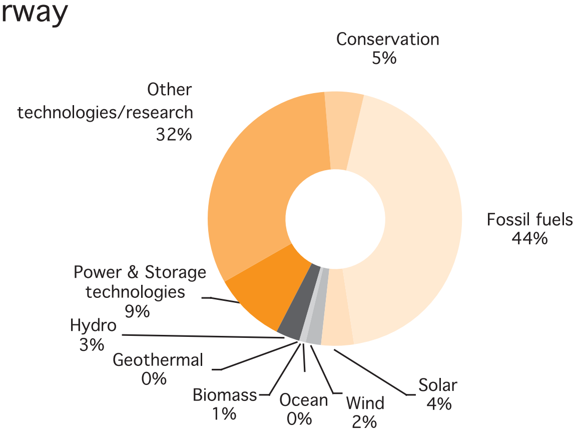


* 2001 data

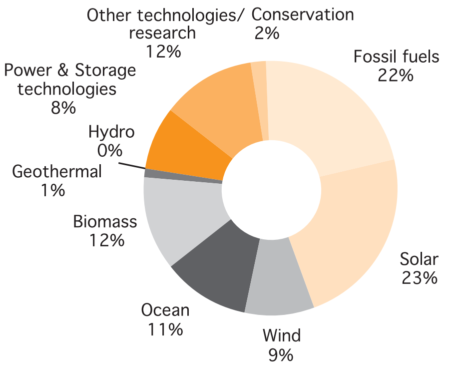
Finland*



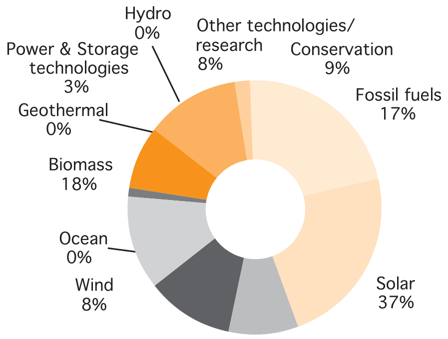
Norway



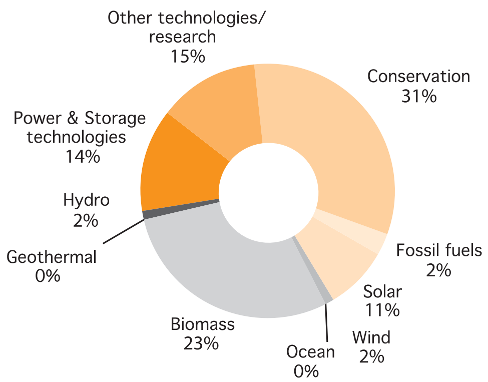
United Kingdom



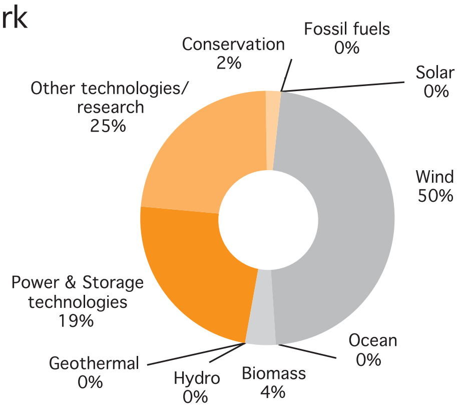
Spain



Austria

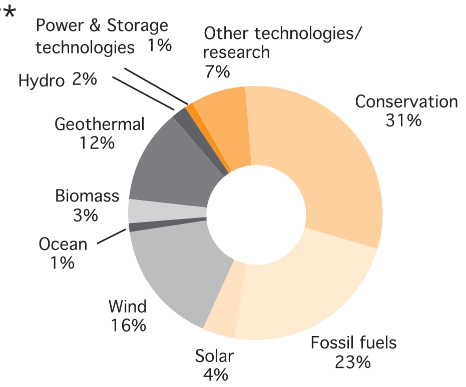


Denmark

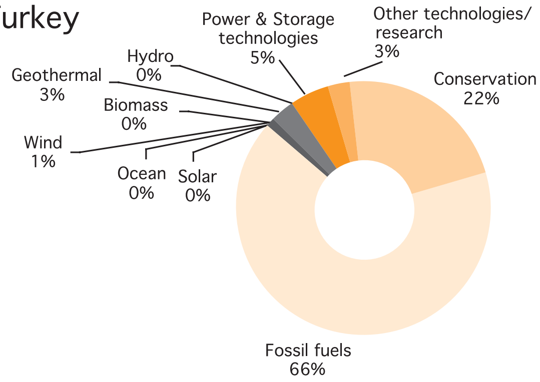


* 2001 data

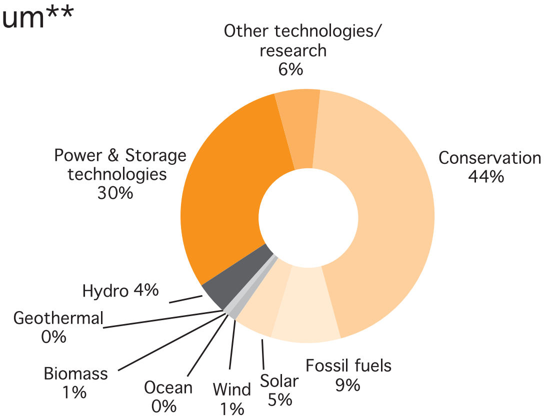
Greece***



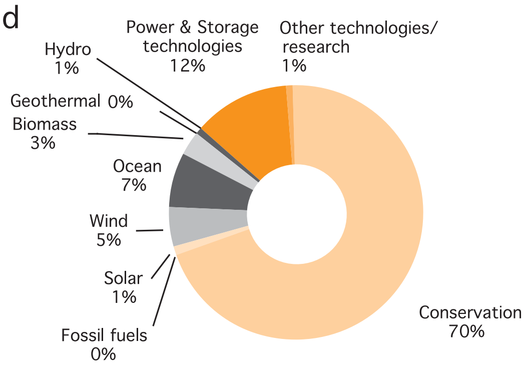
Turkey



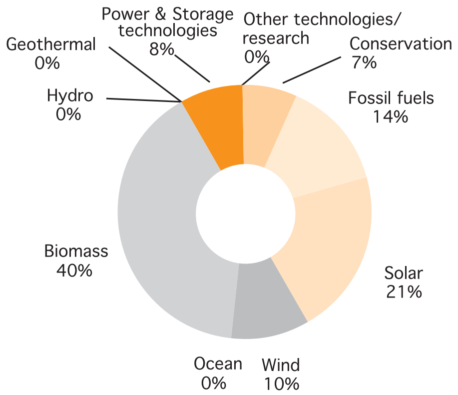
Belgium**



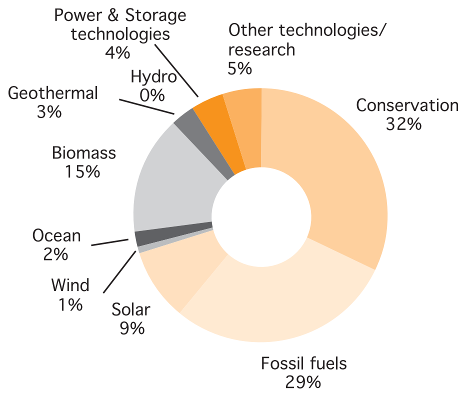
Ireland



Hungary



Portugal

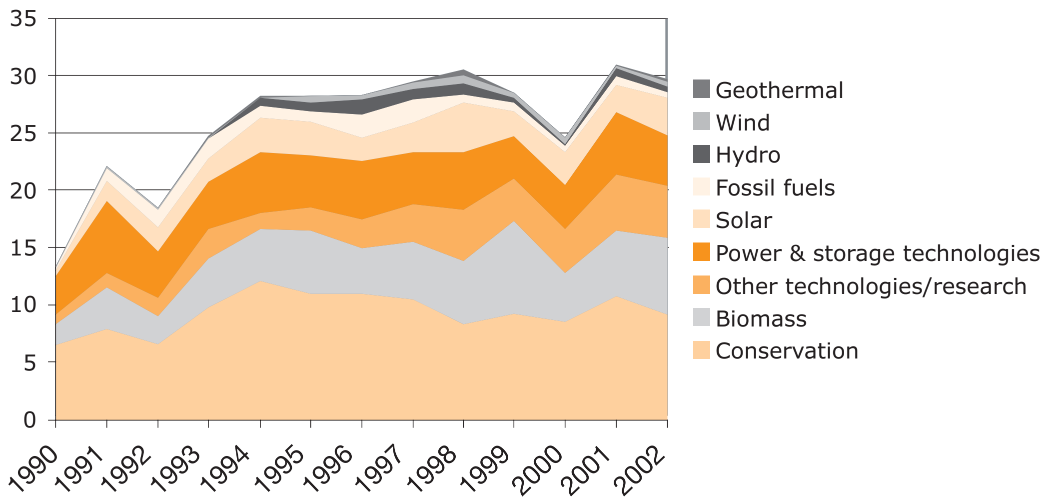


** 1999 data

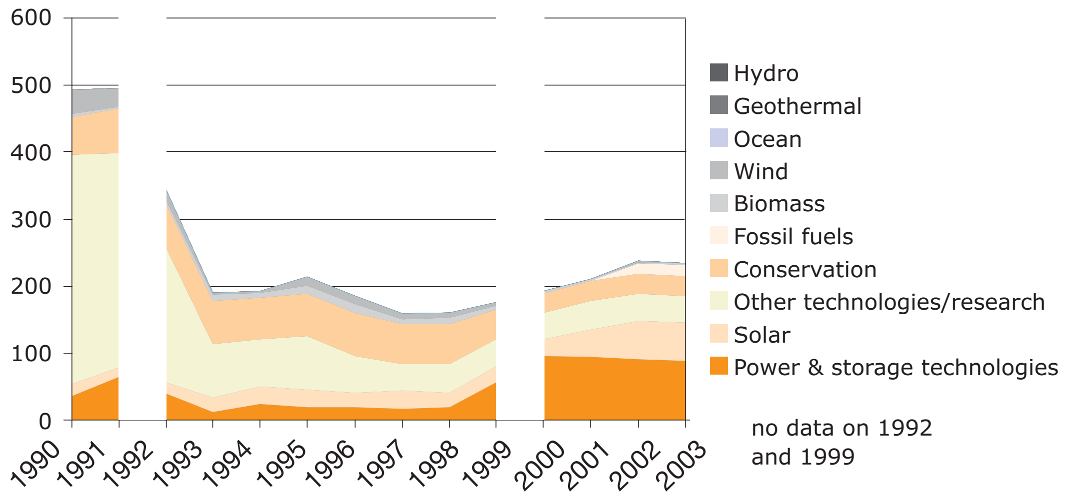
*** 1997 data

Figure C-2 – Evolution of NNE-RTD budgets of selected ERA countries (scales differ; thematic order follows relative sizes)
Evolution and contribution of individual themes (vertical units are arbitrary)

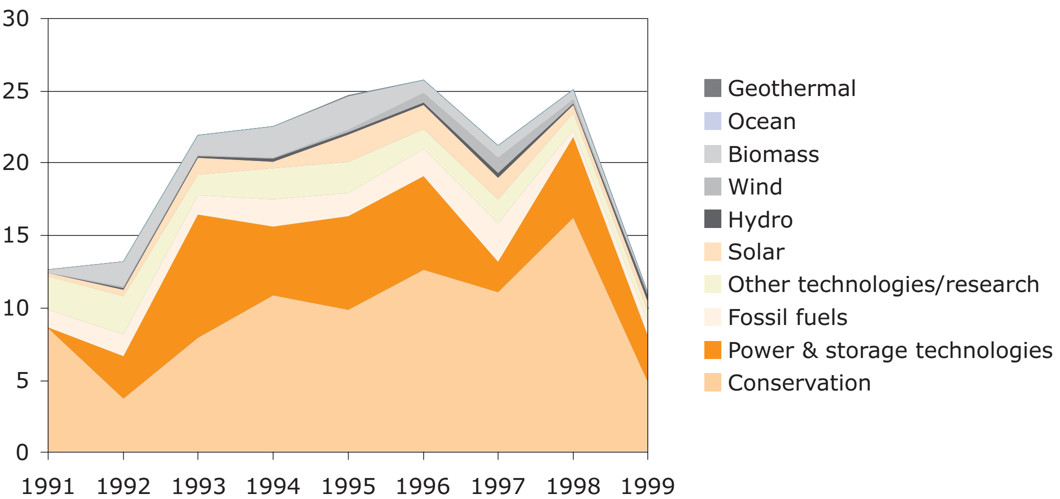
Austria



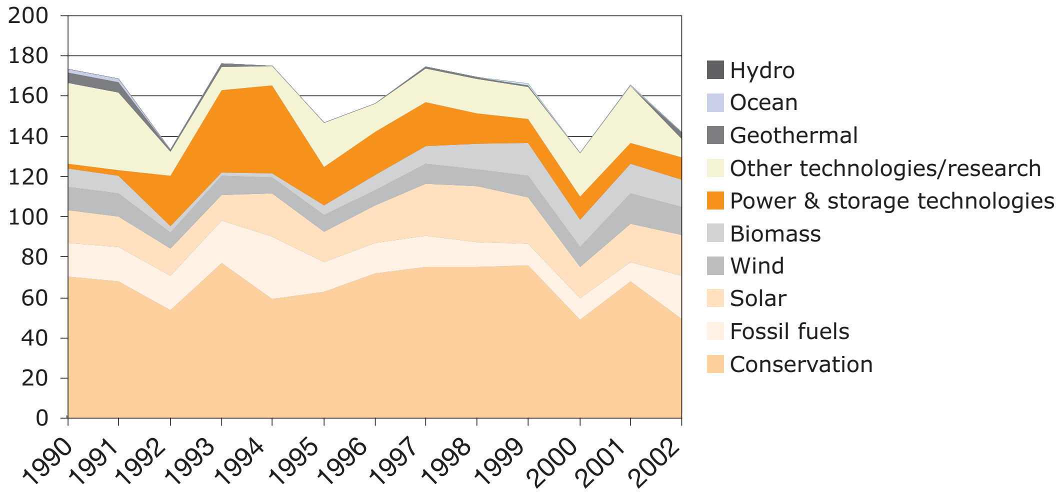
Italy



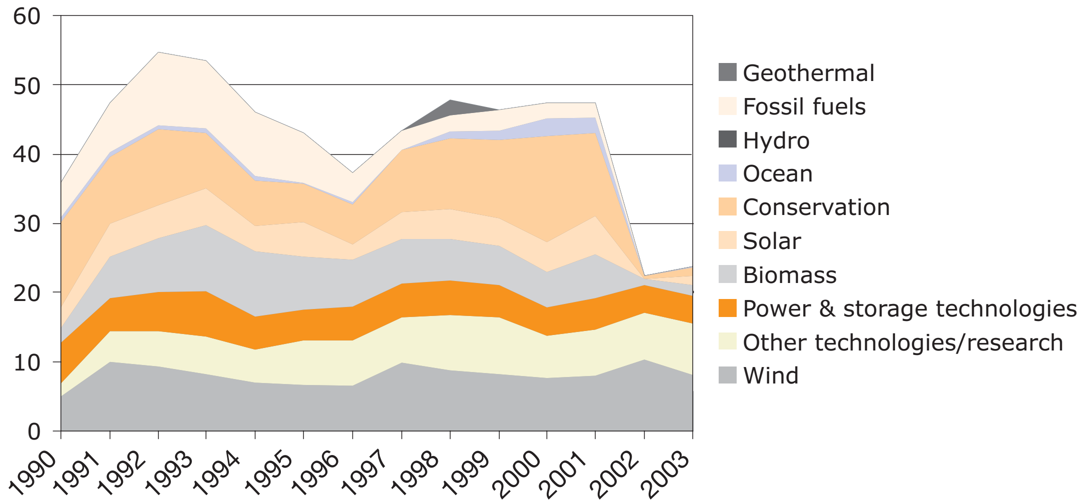
Belgium



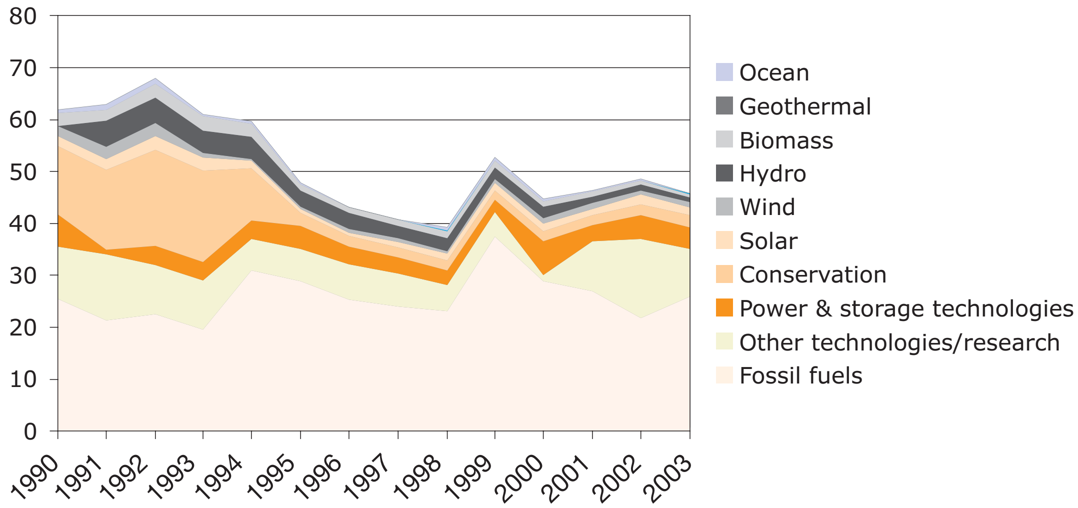
Netherlands



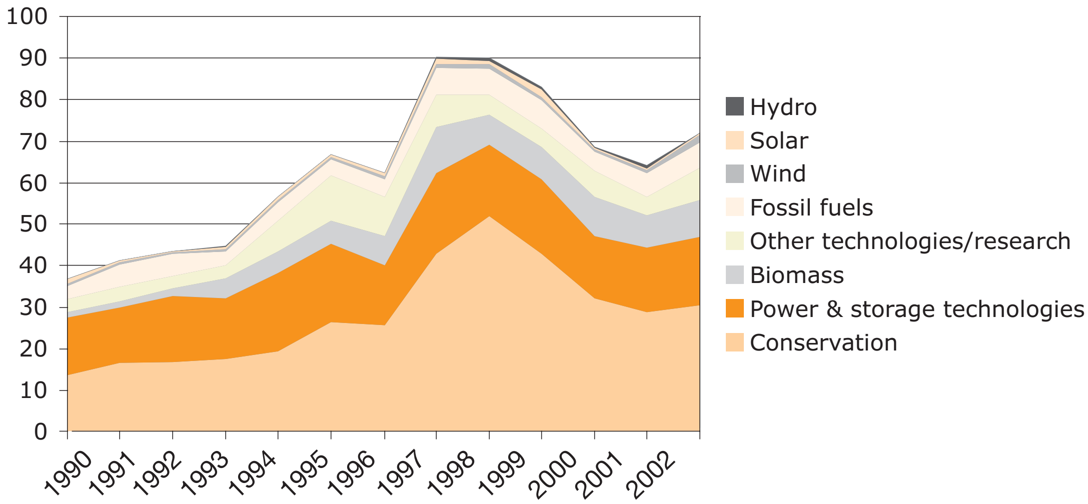
Denmark



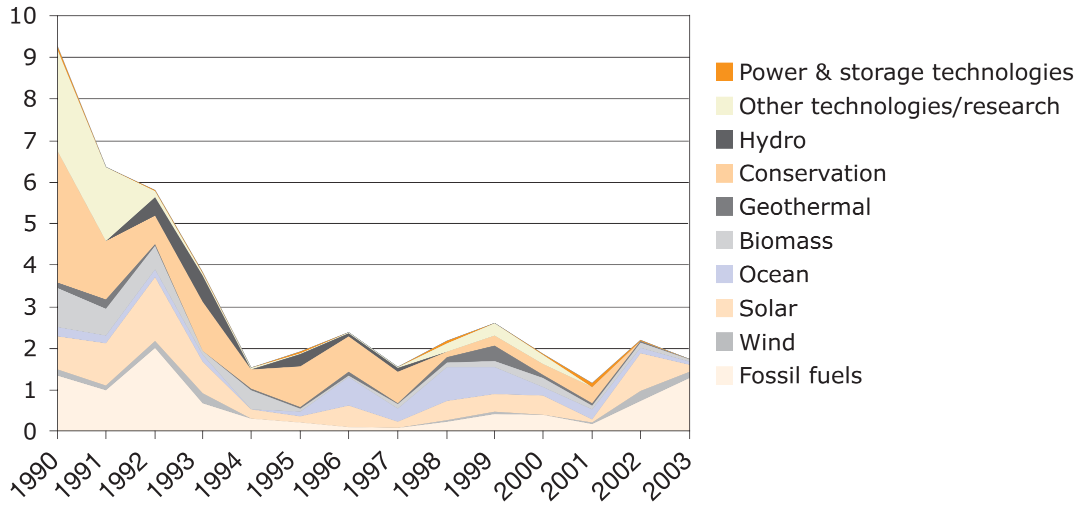
Norway



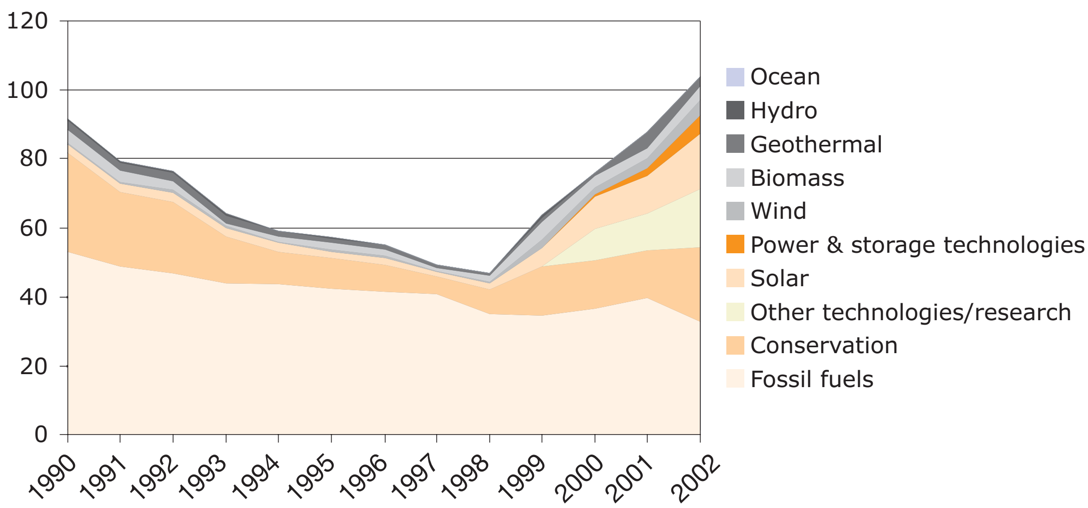
Finland



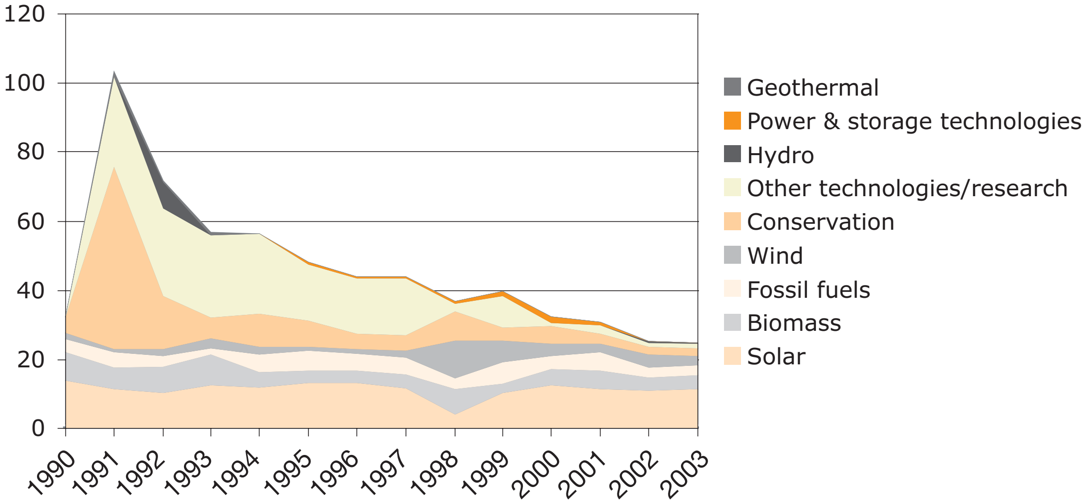
Portugal



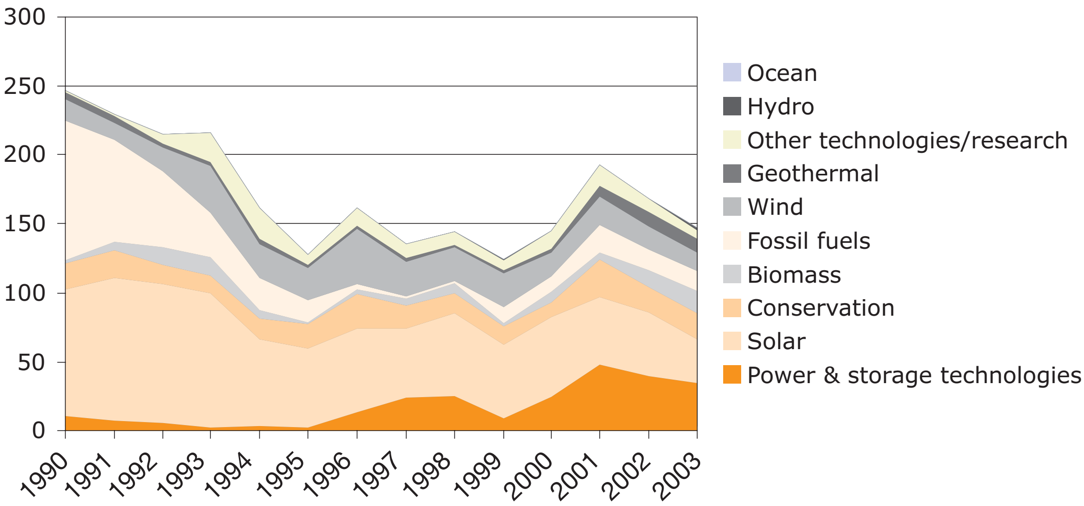
France



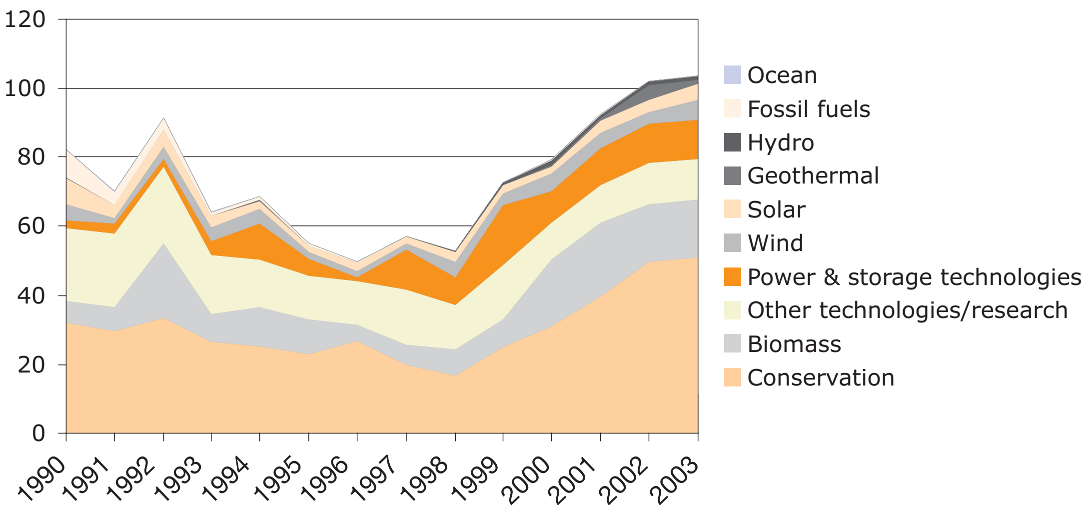
Spain



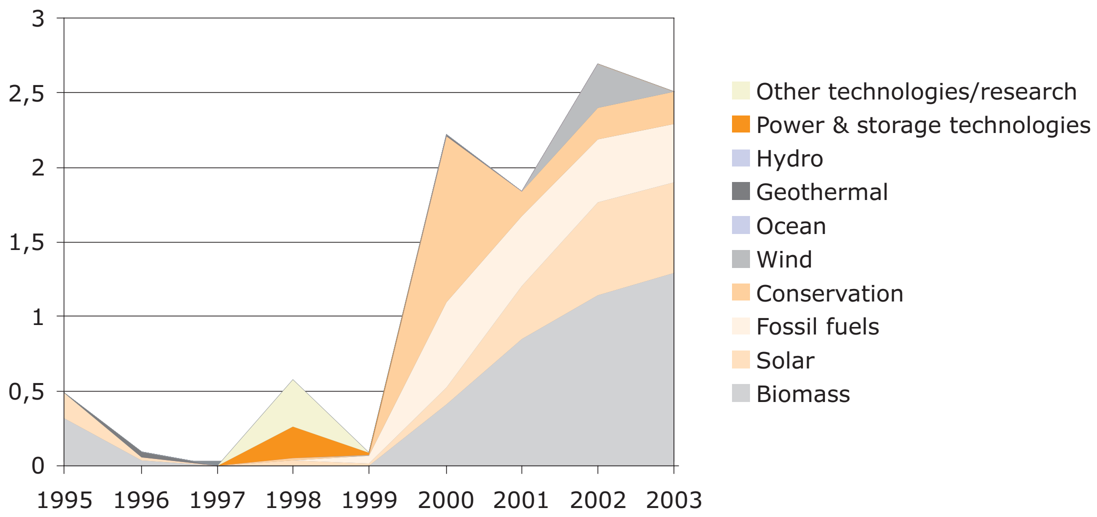
Germany



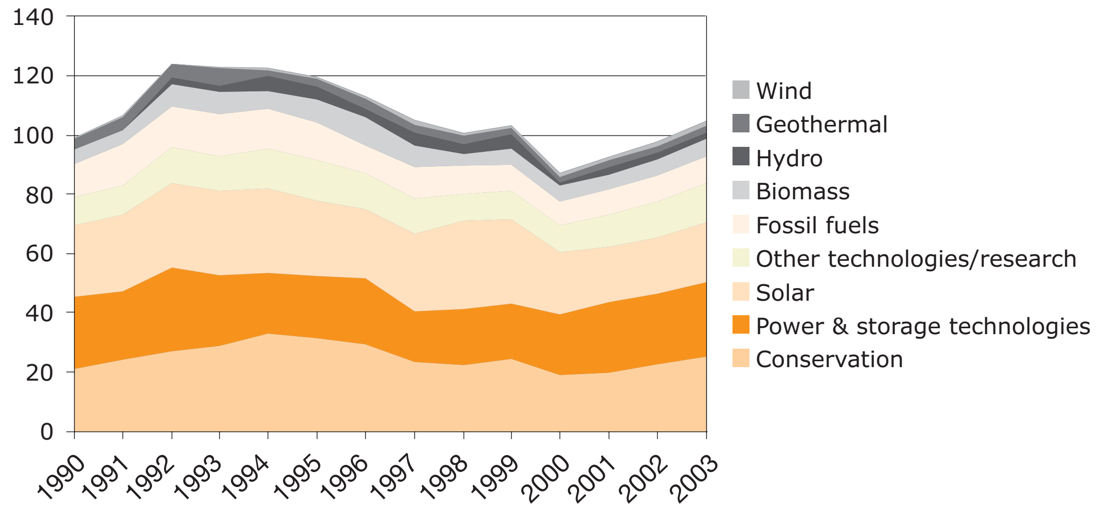
Sweden



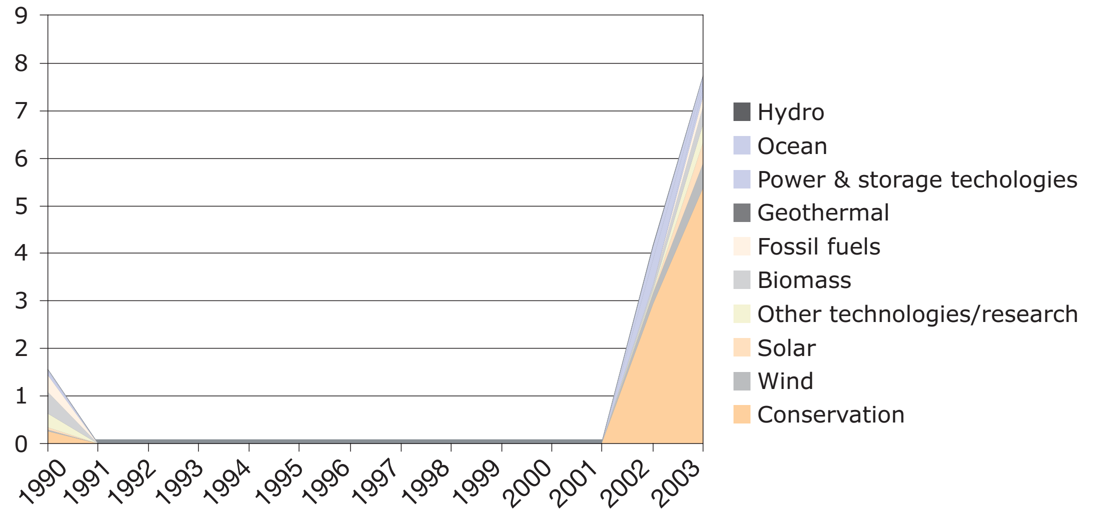
Hungary



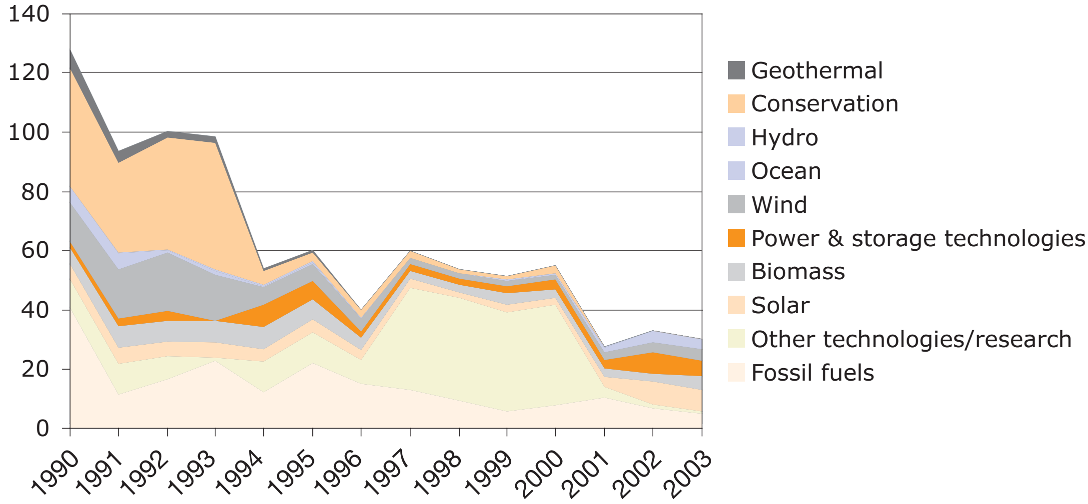
Switzerland



Ireland



UK



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2001
2002
2003
Geothermal
Conservation
Hydro
Ocean
Wind
Power & storage technologies
Biomass
Solar
Other technologies/research
Fossil fuels

Annexe D – IEA Implementing Agreements

Since its creation in 1974, the IEA has provided a structure for international co-operation in energy technology research and development (R&D) and deployment. Its purpose is to bring together experts in specific technologies who wish to address common challenges jointly and share the fruits of their efforts. Within this structure, there are currently some forty active programmes, known as the IEA Implementing Agreements. They are the core of the IEA's International Energy Technology Co-operation Programme, embracing other activities that enable policy-makers and experts from IEA member and non-member countries to share views and experiences on energy technology issues. IEA implementing agreements focus on technologies for fossil fuels, renewable energies, efficient energy end-use and fusion power. An intensive review in 2002 of the legal and management structures underpinning the co-operative activities of these IEA Implementing Agreements resulted in the 'IEA Framework for International Energy Technology Co-operation', providing common rules for participation in Implementing Agreements.

The Implementing Agreement mechanism is flexible and accommodates various forms of energy technology co-operation among participants. It can be applied at every stage in the energy technology cycle, from research, development and demonstration through to validation of technical, environmental and economic performance, and on to final market deployment. Some Implementing Agreements focus solely on information exchange and dissemination.

The idea of creating an Implementing Agreement usually comes from prospective contracting parties, with support from the IEA Secretariat. Before it comes into being, the agreement must be approved by the IEA's governing board.

Figure D-1 – IEA Implementing Agreements in non-nuclear energies, as of 30 April 2003, European countries, US, Japan

IEA Implemeting Agreeents in non-nuclear energies As of 30 April 2003	Fossil Fuels							Renewable Energy Technologies									
	IEA Clean Coal Centre	Clean Coal Science	Enhanced Recovery of Oil	Fluidised Bed Conversion	Greenhouse Gases	Multiphase Flow Sciences	Total	Bio-energy	Geo-thermal	Hydrogen	Hydro-power	Photovoltaic	Solar Heating and Cooling	Solar-PACES	Ocean Energy	Wind	Total
OECD Members Countries																	
Austria	✦		✦	✦			3	✦				✦	✦			✦	4
Belgium					✦		1	✦					✦				2
Czech Republic							0										0
Denmark	✦	✦	✦		✦		4	✦				✦	✦		✦	✦	5
Finland		✦		✦	✦		3	✦			✦	✦	✦			✦	5
France			✦	✦	✦		3	✦			✦	✦	✦	✦			5
Germany		✦					1		✦			✦	✦	✦		✦	5
Greece				✦			1		✦			✦	✦	✦		✦	5
Iceland							0		✦	✦							2
Ireland	✦						1	✦							✦	✦	3
Italy	✦	✦		✦	✦		4	✦	✦	✦	✦	✦	✦			✦	7
Japan	✦	✦	✦	✦	✦		5	✦	✦	✦	✦	✦	✦		✦	✦	8
Netherlands	✦	✦			✦		3	✦		✦		✦	✦			✦	5
Norway			✦	✦	✦	✦	4	✦		✦	✦	✦	✦			✦	6
Poland	✦				✦		2					✦	✦		✦		3
Portugal				✦			1			✦		✦	✦	✦		✦	5
Spain				✦	✦		2	✦		✦	✦	✦	✦			✦	6
Sweden	✦	✦		✦	✦		4	✦	✦	✦		✦	✦	✦		✦	7
Switzerland					✦		1			✦		✦					2
Turkey							0										0
US	✦	✦	✦		✦	✦	5	✦	✦	✦		✦	✦	✦		✦	7
OECD Non-Member Countries (NMCs)																	
Israel							0					✦		✦			2

Energy End-Use Technologies: Transportation					Energy End-Use Technologies: Buildings						Energy End-Use Technologies: Industy						Energy End-Use Technologies: Information				
Advanced Fuel Cells	Adv.Motor Fuels	Hybrid and Electric Vehicles	Adv. Materials for Transportation	Total	Buildings and Community Systems	Demand Side Management	District Heating and Cooling	Energy Storage	Heat Pumping Technologies	Total	Combustion	Heat Transfert and Heat Exchangers	Process Integration	Pulp and paper	Super-Conductivity	Total	EETIC	ETDE	Energy Technology Systems Analysis (ETSAP)	Total	Total in NNE
		✦		1		✦			✦	2						0			✦	1	11
✦	✦	✦	✦	4	✦	✦		✦		3	✦				✦	2		✦	✦	2	14
				0	✦					1						0				0	1
				0	✦	✦	✦	✦	✦	5			✦		✦	2		✦	✦	2	18
✦	✦	✦		3	✦	✦	✦	✦		4	✦		✦	✦	✦	4		✦	✦	2	21
✦	✦	✦		3	✦	✦			✦	3						0	✦	✦		2	16
✦			✦	2	✦		✦	✦	✦	4	✦	✦			✦	3		✦	✦	2	17
				0	✦	✦				2						0			✦	1	9
				0						0						0				0	2
				0						0						0			✦	1	5
✦	✦	✦		3	✦	✦		✦	✦	4	✦				✦	2	✦	✦	✦	3	23
✦	✦	✦	✦	4	✦	✦		✦	✦	4	✦				✦	2	✦	✦	✦	3	26
✦		✦		2	✦	✦	✦		✦	4		✦			✦	2		✦	✦	2	18
✦				1	✦	✦	✦	✦	✦	5	✦	✦		✦	✦	4	✦	✦	✦	3	23
				0	✦					1						0				0	6
				0	✦					1			✦			1				0	8
	✦			1		✦		✦	✦	3						0		✦	✦	2	14
✦	✦	✦	✦	4	✦	✦	✦	✦	✦	5	✦	✦	✦	✦	✦	5	✦	✦	✦	3	28
✦		✦		2	✦				✦	2	✦	✦			✦	3		✦	✦	2	12
				0	✦			✦		2					✦	1			✦	1	4
✦	✦	✦	✦	4	✦	✦	✦	✦	✦	5	✦	✦		✦	✦	4	✦	✦	✦	3	28
				0	✦					1					✦	1				0	4

Annexe E – Glossary

SES	Sustainable Energy System
ERA	European Research Area
NNE	Non-Nuclear Energy
RTD	Research and Technological Development
IEA	International Energy Agency
FP5	Fifth Framework Programme
FP6	Sixth Framework Programme

European Commission

EUR 21614 – Non-Nuclear Energy Research in Europe - A comparative study

Luxembourg: Office for Official Publications of the European Communities

2005 – 101 pp. – 21.0 x 29.7 cm

ISBN 92-894-9369-0

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ISBN 92-894-9369-0
9 789289 493697