B. GENERAL SYNTHESIS REPORT

CONTENT

1. Introduction

1.1. Rationale and Organisation

This report describes the general results of the *JOULE-SENSER* project ("Synergies between European and national strategies for energy RTD", jos3-ct95-0005). This project was a follow-up to the *JOULE-PANEL* project, which reviewed national Energy R&D management in five European countries.[1] The *PANEL* project recommended a full review for all European Member States, and was the starting point for the *SENSER* project.

The objective of the project was:

> "*... to provide a full review and comparison of energy RTD strategies in all the countries of the EU, and to analyse the synergies between the national and EU-level RTD programmes...*"

This was to be reached by:

> "... [assembling] *a data and information base, and from this developing key indicators to advise EU policy-makers on the* [four topics listed below]..."

For practical reasons, the work was divided into four *topic areas*, each relating to a specific aspect of the national management of non-nuclear Energy RTD. These were:

- Evaluation and Monitoring of RTD;
- Technology Characterisation and Foresight;
- Analysis of Factors Driving Energy Markets;
- Targets for EU Intervention.

The SENSER project was carried out by members of the E^{n}R-network, i.e. national energy agencies (which in many countries also have an environmental mission). The countries involved covered all European Member States with the exception of Luxembourg, but including Norway.

The **project organisation** was as follows. A *project co-ordinator* (NOVEM, Netherlands) was responsible for the overall co-ordination of the project. Four *topic area leaders*, forming the 'core team' of the SENSER project, were responsible for designing the work to be performed under each topic mentioned above, and the analysis of the results. These topic leaders were, respectively ADEME (FR), NOVEM (NL), ETSU (UK), and ENEA (IT). Finally, *national teams* were responsible for establishing country reports, generating national information on the four topic areas.

For each of the topics an instructions report was prepared (May 1996). This document was discussed in a meeting and, with slight revisions, formed the basis for national teams to write their country reports (Draft : August 1996, final versions January 1997). On the basis of the country reports, the topic leaders prepared the topic reports. The results of the topic areas were discussed in meetings with the Commission (July 1997), and with the national teams (November 1997). Finally, the conclusions common to the four topics were drawn together by the core team in the present general synthesis report (December 1997). A first draft of this report has been reviewed by the national teams, a second draft by European experts. The overall reporting structure is given in Figure 1.

[1] See Marsh et al., (1996), EC JOULE Panel (JOU2-CT93-0265). The five European countries were Italy, the Netherlands, France, UK, Germany.

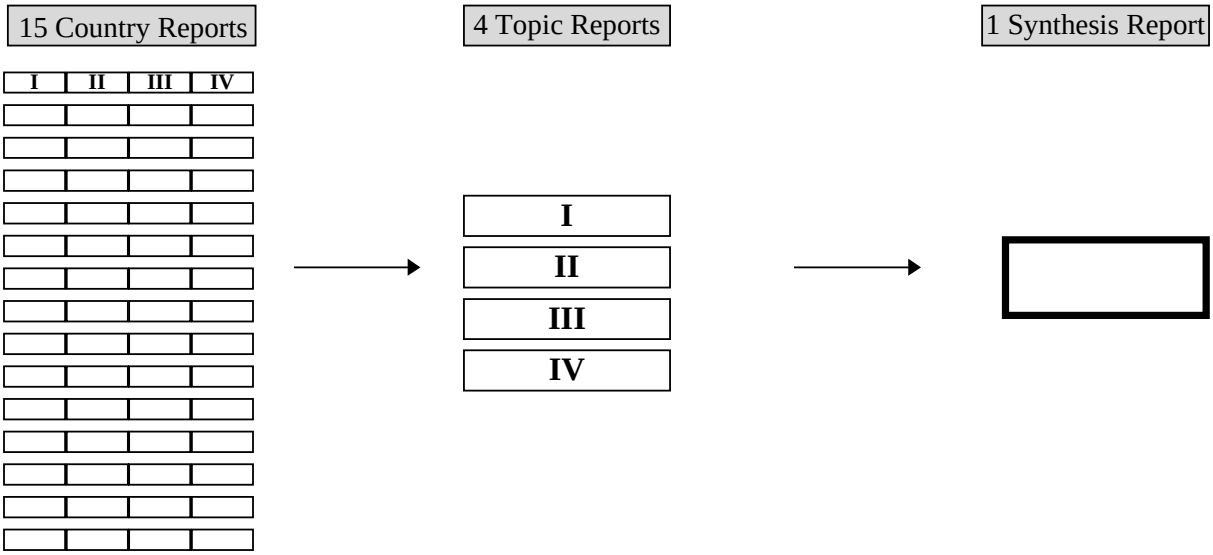

Figure 1. Reporting structure of the SENSER project

This report provides an overview of the findings of the SENSER project. Short summaries on each of the four topic reports are given, and overlapping issues and general conclusions are discussed. The present report addresses the Commission and the European level.

1.2. Management of national Energy RTD in Europe

Government support for Energy RTD is one of several instruments for energy policy in the Member States of the European Union (EU). The Union aims to foster technological innovation, as a response to potential problems with respect to security of supply, environmental impact, economic stability and other considerations. The majority of Member States in the EU are involved in energy research programmes, up to a total of ECU 1.7 billion in 1994. In addition, the EC committed ECU 333 million to energy research in that year.
The main technology areas of energy research are: Nuclear Energy (fission and fusion), Fossil Energy Conversion, Renewable Energy and Rational Use of Energy in Industry, Built Environment and Transport.

All Member States, in one way or another, establish processes by which they define their research priorities, and develop research programmes. In fact, despite the chosen division of the project into four topic areas, the national reports clearly show that in reality the different elements are strongly intertwined, and that strategic decision-making in energy RTD is the result of a **gradual process of construction** in which different elements intervene. Based on the results of the SENSER project, this process can be shown schematically as follows (fig. 2):

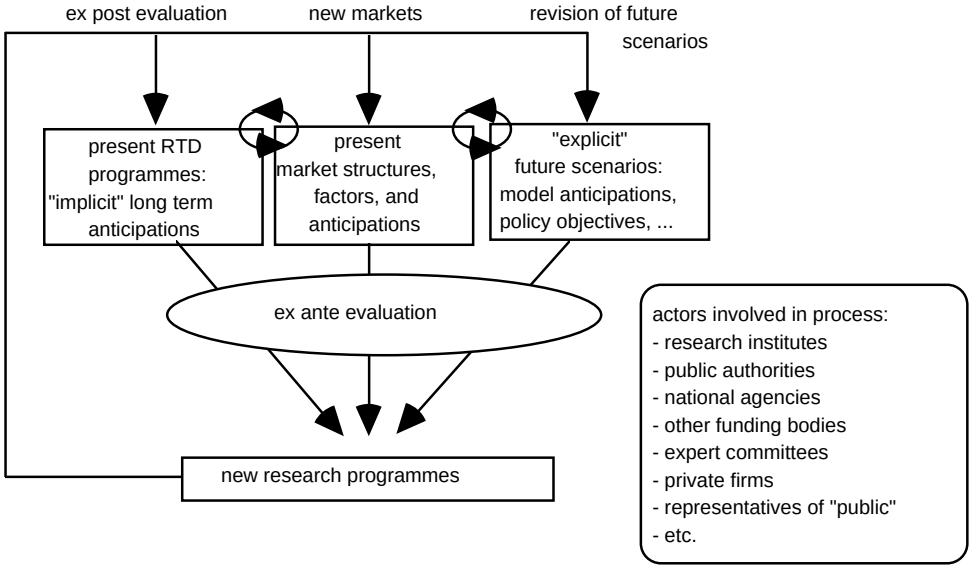

Figure 2. A general representation of European energy RTD priority setting processes

The figure shows that the process of defining new research programmes – in itself basically political – is guided by three main groups of *precursors*:

1. policy objectives – e.g. on reduction of CO_2 emission levels – and expectations on future developments and promising technologies which have been created through foresight exercises;
2. assessment of existing market structures and market factors affecting energy RTD;
3. evaluation of existing research activities.

In addition to national RTD activities, the European Commission (EC) also supports energy research programmes and projects. In the absence of a European energy policy mandate, the objective of the EC interventions is to strengthen the Community policies. For this, the European programmes are developed on the basis of principles of complementarity and subsidiarity, improving co-ordination and synergy between European and national energy RTD strategies, and contributing directly to the core achievements of the EC programmes.

1.3. Structure of the report

Following this introduction, section 2 discusses the main results of each of the four individual topics. Section 3 discusses main conclusions. These revolve around co-ordination issues relating to, in order, the following fields of interest:

- overall developments of budgets for energy RTD;
- balances between long-term and short-term energy RTD;
- balances between nuclear and non-nuclear RTD;
- complementarity between EU and national research topics;
- integration of research and market implementation strategies;
- methodological support for energy RTD strategy-making and the relationships between evaluation, and technology characterisation and foresight.

The last section of the report summarises the conclusions and recommends opportunities for improving the co-ordination between national and European energy research strategies.

2. Overview of results per topic

2.1. Topic 1. Evaluation Practices In Non-Nuclear Energy RTD

Topic 1 aimed to investigate whether, why and how evaluation of non-nuclear energy RTD is performed in European Member States, with the objective of deriving lessons for the development of indicators and evaluation methodology on a European level.

Major findings of Topic 1 are:

- a great variety exists with regard to (1) the experience Member States have with evaluation of NNE RTD, (2) the policy and political levels at which it is carried out, and (3) the criteria, concepts, and methods used in evaluation;
- justification of public expenses and assessment of goal fulfilment are the main initiators of an (ex post) evaluation exercise. However, evaluation goes beyond the verification of initial objectives only. The use made of evaluation results is usually *strategic*, as they serve to set new priorities and redefine research programmes;
- *within* countries some standardisation of evaluation practices can be observed. Although different from one country to another, 'good practices,' guidelines and methodological approaches exist in several Member States. These merit circulation across Europe;
- the issues addressed by NNE-RTD evaluation are, in decreasing order of appearance in national reports:
    1. scientific and technical quality
    2. programme operation
    3. market opportunities
    4. collaborations
    5. users
    6. energy issues
    7. relation with other sectoral policies

The first four issues are addressed by all countries, and the first two by far the most frequently. The last three are only addressed to a marginal extent in evaluations. The relationship with European policies or research programmes is not explicitly mentioned as being an issue addressed by national NNE-RTD evaluations;

- with very few exceptions, evaluation of NNE-RTD mainly relies on peer review and expert committees. Standardised evaluation instruments are seldom used.
- the types of parties which carry out evaluations are diverse. *Ex ante* evaluation is mostly performed by public authorities and government, by managing agencies, sometimes by independent expert panels but rarely by consultancies only; it is often performed by especially established ad hoc working groups involving several of the above. *Ex post* evaluation is usually conducted by expert panels, sometimes by consultancies or the managing agency. Monitoring, finally, is mostly performed by the managing agency or public authority involved in the programme evaluated.

The **main lessons** derived from the findings of Topic 1 are:

- comparing EC with national practices leads to the conclusion that the European Commission is relatively active in evaluation of energy RTD. Given its length of experience, frequency, scope and scale, the Commission in fact finds itself at the forefront of non-nuclear energy RTD evaluation, together with countries such as Finland, France, Norway and the UK – the other countries analysed having started much later with the systematic evaluation of their energy RTD;
- the assessment of scientific and technical quality, as well as programme management, does not seem to lead to any particular problems;
- instead, given the small number of countries providing answers with regard to this subject, and taking into account the conclusions of the recent Five-Year Assessment of non-nuclear energy programmes, *the assessment of socio-economic benefits of research* remains an issue which could become a more important dimension to be treated in the support of the RTD strategies activity.

2.2. Topic 2. Technology Characterisation and Foresight

Topic 2 aimed to collect descriptions of methods of technology characterisation and forecasting (TC&F) in EU member countries, and to review their strengths and weaknesses.

Major findings of Topic 2 are:

- with regard to Technology Characterisation, Modelling and Foresight activities, different levels of analysis can be distinguished (national, sectors, energy services, technologies, etc.). In most cases little interaction between activities on the various levels has been observed;
- models and foresight studies are often carried out to support the development of more general energy and environmental policies, and are not prime movers in high-level energy RTD priority setting, which is basically a political process. The main role of TC&F methodologies is to organise and facilitate expert debates;
- at the national/regional level a selection of methodologies is broadly used, including activities with models such as EFOM, MARKAL, etc., whereas at the level of sectors, services and technologies, a much larger variety of (less standardised) methods is applied;
- the 'average' TC&F method combines formal and analytical methods with expert consulting. The precise form of specific applications varies strongly, depending on local circumstances and scope or level concerned;
- the perspective and scope of TC&F activities has changed. Nowadays, environmental issues and economic and market opportunities (both EU and World) are the most important objectives, whereas the impact of concerns with regard to security of supply has decreased;
- expert judgements are often used; subjectivity and lack of transparency are regarded as problems by Member States;
- in most countries no national integral approach for data collection or technology characterisation exists; this is especially relevant for the foresight of future cost and future market potential of technologies;
- characterisation of technologies and the establishment and maintenance of data(bases) require substantial efforts and are time consuming. Only a few countries are able to allocate sufficient time and money for these activities to derive reliable sets of data. Little (international) exchange of technology data is observed.

The **main lessons** derived from the findings of Topic 2 are:

- given the widespread application of modelling and forecasting methodologies for energy and environment policy development, there is a strong need to improve the methods and approaches for technology characterisation and data collection for Member States and thus, dissemination is important. Special attention should be paid to the transparency of the methods used and the consistency of the data sets derived. International information exchange and co-operation could be helpful;
- there is no 'ideal' methodology for energy RTD priority setting. Good practices consist of various combinations of analytical and consulting methods;
- experiences show that technology characterisation, modelling and forecast techniques can be designed to support the process of energy RTD strategy development, but are rarely specifically used for this. These methods could be used to generate input, amongst other things, for RTD strategy debates and may contribute to the transparency of the decision-making process. Therefore existing TC&F practices should be better adapted to respond to the specific needs of political decision-making;
- activities concerning the impact of energy technologies and systems usually do not interact with activities at the other levels. The improvement of these interactions may well result in a better insight into the possible impacts of various technology developments on the complex energy system;
- much experience exists with regard to energy R&D priority setting in various Member States. These experiences should be used to improve the co-ordination between EU and national energy RTD strategies, through workshops and common analyses (ex ante and ex post).

2.3. Topic 3. The Effect of Market Factors on Energy RTD

Topic 3 studied the market factors affecting the direction, scope and scale of R&D expenditure by national governments, industry and academia, based on a review of the national reports. It was found that the main drivers of R&D, common to many sectors and many countries, were:

- privatisation and liberalisation programmes, leading to a dramatic decrease in overall R&D funding by both governments and the private sector, and a very marked decline in long-term R&D for most of the countries. The decline in long-term R&D is partly due to the transfer of energy technology responsibility from government to the private sector, coupled with industry's preference for incremental improvements to existing technologies rather than radical new technologies (e.g. supercritical steam cycle plant is preferred to coal gasification);
- environmental concerns, particularly global warming, but also those related to local health problems have a particular impact on the transport sector. These concerns drive R&D in a wide range of topics: abatement technologies, cleaner combustion technologies and fuels, energy efficiency and renewable energy technologies. Private industry generally only invests in such technologies when driven to do so by regulation, or when governments act to provide market support for certain technologies;
- security of supply and world fuel prices. Although security of supply has receded as an issue for many EU countries, it is still important for those with limited indigenous fuel reserves, and it is likely to re-emerge as a concern in the medium to long term as EU reserves of fossil fuel are depleted and reliance on imports from politically unstable areas increases;
- the globalisation of the world economy, the growth of international trade in energy, and the emergence of large multinational companies as key players, together with the recognition of large potential markets for energy technologies in developing countries.

The **main lessons** derived from the findings of Topic 3 are:

- the most striking conclusion from this study has been the dramatic decline of both national and private sector RTD associated with liberalisation and privatisation programmes. Alternative arrangements for the support of long-term R&D will be necessary to ensure the development of new technologies to meet the future needs of Europe, and the EU can play a key role in this;
- there is a need for strengthened support for R&D to address environmental problems of energy supply, and to maintain a secure, diversified base for the EU's energy sources;
- there is an urgent need for enhanced technology transfer to developing countries in view of the globalisation both of the world economy and environmental problems. The Kyoto conference on Climate Change has confirmed this need;
- conflicts and synergies between R&D drivers can be addressed by a coherent EU-level energy RTD strategy. For example, investment in R&D in renewable energy technologies can achieve several objectives simultaneously: reduction of environmental impact; enhanced security of supply and exploitation of global markets. Similarly, the conflict between the drivers of privatisation and liberalisation (leading to price reductions) and the need for improved energy efficiency to address environmental concern can be addressed by a strong EU-level RTD programme on energy efficiency.

2.4. Topic 4. National RTD Activities and Scope for EU Intervention

Topic 4 aimed to provide a comprehensive database of national RTD programmes for European countries, in order to assist more efficient targeting of resources for EU-level programmes using the principle of subsidiarity. The work performed under Topic 4 consisted of the collection and synthesis of information on national energy RTD effort (both public and private) through the organisations participating in the project. Next, this information has been put into perspective with data from existing statistical databases (EUROSTAT and IEA surveys on energy R&D budgets).

Major findings of Topic 4 are:

- total government expenditures for energy R&D by the 15 EU countries (plus Norway) in the period 1983-93 show a considerable decline, both in current and constant money, whereas overall government R&D budgets have grown over the same period;
- this trend seems to be connected with: the downsizing of the nuclear fission programmes after 1984 and the Chernobyl accident; the oil price collapse in 1985-86 and the persistence of relatively low prices in the oil market; policies of government budget containment carried out by all EU countries; the Europe-wide trend towards privatisation of state-owned utilities and oil/gas/coal industries and, finally, attainment of maturity by a number of energy technologies and the lack of new technological breakthroughs in the energy field;
- EU governments funding of total energy R&D in 1994-96, after a long fall, may have reached a plateau. Public funding in real terms for non-nuclear (NNE) technologies is decreasing or stable;

- currently, the shares of nuclear (NE, including fission & fusion) and NNE R&D over total EU governments' budgets are around 58-60% for NE and 42-40% for NNE. Of the total EU government budgets for NE, about 28% goes to fusion research;
- presently, government budgets for NNE R&D allocate 41-45% of resources to *Rational Use of Energy (RUE)* , 33-38% to *Renewables* and about 20% to *Fossil Fuels.* Therefore national governments pay a lot more attention to energy supply technologies, which obtain 68-70% of total resources for non-nuclear energy R&D, rather than to energy end-use technologies (30-32%);
- wide differences exist concerning the areas of greater interest at the national level depending on climatic conditions, resource endowment, industrial base and national comparative advantage;
- governments are increasingly oriented towards short-term research, but maintain a role both in some long-term, high-risk activities and in areas where a specific national interest has emerged;
- government funding is becoming the only source of financing for some technologies that either have not reached a commercial stage, represent only niche markets, or are being pushed out of the market. Continued funding is politically justified by energy security or employment reasons;
- within European Commission energy R&D budgets, the funding for nuclear energy (fission + fusion + radio-active waste and decommissioning) is by far the most important. Funding for fusion is about 66% of all nuclear energy technologies;
- currently, EC funding for renewables and RUE is increasing, while funding for R&D on fossil fuel technologies is falling. Very few resources are devoted to general, cross-cutting technologies. Hence in EC budgets the relative preference for energy supply technologies is even stronger than in national budgets;
- EC funding plays a crucial role in the national R&D programmes of Spain, Portugal and Greece;
- private R&D seems to be particularly strong in the oil and gas industry and in power generation, but the focus has shifted towards shorter-term research. The interest for renewables appears to be weak. Research efforts are concentrated on incremental improvements in the performance of plants, processes and products in terms of costs and emissions reduction or efficiency gains;
- the wave of privatisation in the energy industry is causing RTD budgets to fall in the privatised companies but data on overall private budgets are insufficient to determine whether this is a long- or short-term trend.

The **main lessons** derived from the findings of Topic 4 are:

- obtaining data on private sector RTD activities – a goal of this topic – has been possible only in part, due to withholding of information by private industries for commercial reasons. Drawing precise conclusions on private RTD trends is therefore difficult. Furthermore, the classifications used in energy R&D statistics to identify and measure R&D efforts (both public and private) show some intrinsic limitations and do not account for research having important energy implications but which is classified under different headings. There is a need to reconsider classification systems in our statistics to improve information, both at national level and for the EC, concerning the parties involved in energy R&D financing and implementation;
- it cannot be confirmed that the decrease in public R&D budgets for energy represents a negative and worrisome trend *per se*, since sufficient information on the public/private balance and on the energy/non-energy research balance is lacking. The existing trend, however, certainly needs to be further examined and explained. To minimise the risk of negative impacts of this trend on the well-being of future generations, efforts towards rigorous prioritisation in the allocation of available resources could be encouraged. In particular it is felt that synergies in research could be better exploited;
- finally, from the analysis of the specific energy research areas, a need for instruments other than funding alone emerges. Study and design of specific *indirect* measures (e.g. economic, fiscal, regulatory) are required to encourage energy R&D funding and activities by the private sector and to accelerate further adoption of energy-efficient technologies.

3. General conclusions

3.1. SENSER: from 'indicators' to the process of strategic decision-making

The initial objective of the SENSER project was '*to assemble a data and information base, and from this to develop key indicators to advise EU policy makers*,' with regard to the four topic areas 'RTD Evaluation,' 'Technology Characterisation and Foresight,' 'Factors Driving Energy Markets,' and 'Targets for EU Intervention.' This objective has been reached. Through the country reports, relevant data on national energy RTD policies has been gathered and made available in a standardised format. Next, with the establishment of the four topic reports, the main results of which are outlined on the previous pages, a rich information base has been built up on Member States' practices in the strategic management of energy RTD.
In addition, there are lessons to be learned from the SENSER project which go *beyond its initial definition*. The results show that **the work accomplished by the collective efforts of the 15 members of the SENSER team raises highly relevant issues for European level strategic decision-making on energy RTD**. The information gathered and the exchanges made within the SENSER project may therefore contribute **directly** to improved co-ordination between European and Member State energy RTD strategies. This section discusses issues for such co-ordination, and their possible implications.

3.2. A general decrease in overall energy RTD budgets

Overall government and private sector energy RTD budgets are decreasing in most of the Member States. Several reasons have been mentioned for this. The first is the **liberalisation** of energy markets and **privatisation** of energy industries. This development creates pressure on energy companies to reduce costs, and often long-term R&D programmes are viewed as an unnecessary indulgence. Simultaneously, government budgets often decrease as privatisation is associated with a transfer of responsibility for energy technology development from government to industry.
Second, there is a decline in the perceived importance of energy security due to the present regime of low energy prices and increased international trade in energy. It has been observed that security of supply is tending to slip down the agenda for many governments and for the EU. Whilst short-term security of supply is indeed becoming less problematic, long-term security of supply may become less assured as EU fossil fuel resources are depleted. R&D into renewable energy and RUE, driven primarily by environmental concerns, address this issue to a large extent.
Third, there seems to be a progression towards maturity for certain technologies, and an associated switch in focus away from basic R&D towards demonstration and market deployment measures. Nevertheless, one would expect that new technologies would appear to replace the maturing technologies in the development cycle. If society had 'rested on its laurels' after the successful introduction of the wheel, the world today would be a very different place!

3.3. Balances between short-term and long-term research

The decline in budgets mentioned in the previous section have particular impact on how long-term research is funded. Both Topics 3 and 4 observed a decline in funding by national governments and private industry for long-term R&D, whilst at EU level funding remains constant. Already observed by the end of the 1980s, there is no reason to think that this trend will change in the coming years .
The implications of such a division of research labour can be great. Funding 'short-term' research means reinforcing, or at best transforming, existing energy markets, in close co-operation with industries that are more and more internationally oriented. Performing 'long-term' research means that one thinks of going beyond these markets and preparing things currently not, or barely, existing (even though the "day after tomorrow" will not be prepared through research only). For the latter, strong international co-operation is essential, as well as a good overview of national skills. The SENSER project finds that countries show a tendency towards more 'short-term' research, whereas the European Commission's programmes still focus on longer term issues as well. If this trend continues - and put dramatically - the only long-term energy options prepared in Europe will be those currently

co-prepared with the aid of European funding, while Member States will safeguard the institutional settings in which high quality research can be conducted.

This observation leads to at least four issues for the debate on co-ordination concerning the European Commission and Member States research:

(1) **is the trend the result of a deliberate strategy, on the part of the Member States, or not?**
(2) **if so, is the observed evolution a *desired* one, in particular from the point of view of the Member States for which the observation is especially relevant?**
(3) **if it is desired, what precisely are the long-term energy options which are being prepared for Europe?**
(4) **if it is not desired, can the tide still be turned, and how?**

These questions can only be answered partially by the results of the SENSER project, which typically may provide the kind of information which is necessary to systematically think these questions through.

3.4. Balances between nuclear and non-nuclear energy RTD

A key observation from Topic 3 and 4 was that nuclear energy RTD, however declining in total volume, still holds a dominant position within the European energy RTD portfolio. This has been observed for EC budgets (changing from 81% to 76% in the period 1989-94), as well as for the total overall expenditures in the EU Member States, where the share of nuclear energy RTD ranged between 58% and 60% of total energy RTD in the period 1990-95. This dominance of nuclear energy RTD in the total of EU Member States, energy RTD budgets is not general, but reflects the substantial efforts in this field in a minority of States (in particular France, Germany and Italy).

It is outside the scope of the SENSER project to address issues related to nuclear energy RTD. Nevertheless, it is impossible to neglect the fact that nuclear energy RTD absorbs a large part of EC energy research budgets compared to budgets devoted to RTD on non-nuclear technologies. This dominance may give rise to questions regarding the extent to which actual priorities reflect past and current developments:

1. changing views on the potential contribution of nuclear technologies to the energy situation in the decades to come;
2. ongoing liberalisation and privatisation of energy markets, and the emergence of smaller scale decentralised options for electricity and combined heat and power generation;
3. public concern about nuclear energy, partly related to radioactive waste disposal;
4. a growing number of EU Member States phase out nuclear energy and/or cut back on their nuclear energy R&D activities.

Although it is clearly a political issue, the observed balance of nuclear versus non-nuclear energy RTD shown by the SENSER project is typically an issue for co-ordination between Member States and European level.

3.5. Complementarity in European and national research topics

It has been observed that the programmes of the EU and the national governments are generally complementary. The issues covered by the EU are generally of interest to a reasonable number of Member States, and are in line with EU objectives, whereas topics only of interest to one or two Member States are usually supported mainly by national governments.

However, there is at least one area where the magnitude of research effort does not appear to match the importance of the topic for both EU and national government objectives - this is R&D in RUE in transport. The reason for this could be that the vehicle manufacturing industry, being mature and entirely in the private sector, traditionally carries out its own R&D. Until now, market forces have not acted to encourage industry to manufacture more fuel-efficient cars. This situation can best be amended through appropriate fiscal and regulatory measures, such as higher transport fuel taxes and minimum vehicle efficiency regulations, which should encourage greater consumer demand for efficient vehicles and greater R&D effort by industry. Nevertheless, there is still scope for increased EU or government level R&D into other aspects of RUE in transport, e.g. social and behavioural factors; efficient mass-transit systems; alternative fuels; land-use planning to reduce travel demand.

In both RUE and renewable energy, it has been observed that post-R&D support measures are becoming increasingly important, e.g. grants, subsidies or guaranteed purchase schemes for technology deployment;

regulations; standards; fuel pricing policies etc. These measures can be deployed either by national governments or, in some cases, at EU level. They generally have the effect of encouraging industry to carry out R&D aimed at achieving EU and national government objectives, by creating the right market conditions for 'desirable' technologies to flourish.

3.6. Integration of research and market implementation strategies

The ultimate aim of public funded energy research is to contribute to the (future) sustainability of the energy system. Successful penetrations of new technologies in the market are generally rare phenomena, since the majority of innovations fail in this decisive test of the 'battle for customer acceptance'. To maximise the chance of market successes the majority of Member States are searching for opportunities to combine energy R&D priorities with specific market development measures, to make sure that those technology developments are supported that meet the requirements of existing market structures or expected developments, or to limit specific hurdles that prevent the market penetration desired.
Co-ordination between R&D and market implementation strategies on the EU level and co-ordination between these EU-level activities and the more integrated R&D and market strategies in the Member States should be looked upon to contribute to the improvement of market success of R&D initiatives.

3.7. Methodological support for strategic decision-making: toward a common vocabulary for past and future evolutions

A final important issue emerging from the SENSER project concerns the methodologies to support strategic decision-making. It is clear that the different countries use very different mixtures of a variety of approaches. These approaches are either more 'foresight', or more 'evaluation' oriented. The different types of approaches used, as well as their role in the energy RTD strategy-making process are represented in Figure 2 at the beginning of this report.
Foresight activities frequently make use of a limited number of simulation models that are often developed in international co-operation. Moreover, a large number of approaches are used in the processes of energy RTD strategy development, varying from formalised technology assessment methods to ad hoc, informal consulting activities and expert opinions. **Evaluation** (ex post) mainly relies on expert opinion and especially addresses scientific and technical quality, and programme management and organisation. Finally in most of the countries, monitoring deals with administrative matters only. The systematic assessment of socio-economic benefits is only weakly developed and appears as an issue only in a small number of countries.
It is striking to see that in most countries, no explicit relations exist between Technology Characterisation and Foresight and Evaluation of non-nuclear energy RTD. This is regrettable since both aim at improving the quality of energy RTD strategies and could benefit from mutual learning. It is therefore suggested that more attention be paid to the potential relationships between activities in the field of programme (ex post) monitoring and evaluation, on the one hand, and ex ante evaluation and foresight on the other. These all need to build on accurate assessments of past technological, market and socio-economic developments, and the corresponding future anticipations. There is clearly a need for a common set of references which would allow for the construction of a set of shared expectations toward possible future energy systems and socio-economic images and scenarios.
Therefore, it is proposed to view the different methods and procedures surrounding energy research strategy-making as **different ways of organising different types of information**. Even if they give different types of results, the principal aim of different methods for strategy support is to stimulate exchange and debate on past and future development of energy technologies, viewed in their broader context. The results of the SENSER project and the exchanges which have taken place during its course indicate that strategy-making in the field of energy RTD could benefit from developing a common vocabulary, or maybe even a common culture for assessment of both past and future technological developments.

4. Conclusion: more co-ordination of European energy RTD strategies

Having pointed out the general issues emerging from the four topics in the previous sections, it can be concluded that SENSER has proven that it is able to fulfil **three complementary roles**. First, it is a practical information gathering tool. Second, it has identified main market drivers and has shown that these have to be regularly updated. Third, it can provide the necessary support to political debate on Energy RTD and thus contribute to the co-ordination between Member States and the Community levels.

(1) As a **practical tool** the SENSER project has gathered and summarised a large amount of relevant information on energy RTD in the Member States in a relatively short period of time. A high level of detail could be achieved by using a special project organisation involving representatives of all national energy agencies and the E^{n}R network. SENSER thus constitutes a valuable source of information not only for national and European decision-makers in the area, but also for other bodies which need information on the different aspects of energy RTD management and strategy-making, such as Five-Year Assessment Panels, or the IEA.

(2) As a means of identifying current market drivers, SENSER has fulfilled the role of interface between national developments on the one hand, and the European decision-makers on the other. The observations show that, over the years, policy objectives, market developments and technological promises driving energy RTD activities vary strongly. Two conclusions about the approaches towards energy RTD strategy development can be drawn from this. Firstly, **regular updating** on actual technology and market developments should be carried out, and results should be widely exchanged and discussed with relevant decision-makers at both national and EU levels. Secondly, to prevent 'zigzagging' energy RTD strategies, attention should be paid to the development of robust sets of energy futures, coping with different possible market, policy and technology developments. These scenarios could be used in assessments to identify promising (robust) technologies to focus energy RTD activities.

(3) Finally, the type of work conducted under the SENSER approach can typically provide the technical support needed to shape the political debate on energy RTD issues between Member States, and between Member States and European levels. SENSER results have shown that it becomes increasingly difficult in Europe to account for national non-nuclear energy RTD policies without taking into account what happens in other countries, or at the EU level (the balance between long and short term being probably the most striking example). Both in Member States and in the EU choices are made which increasingly depend on, and influence, each other. The technical support lent by the type of work conducted under JOULE-SENSER is able to draw out the important issues for debate. It can thus contribute in a positive way to the improvement of co-ordination between the national and the EU-level.