Evaluation and Impact Assessment of the European Non Nuclear Energy RTD Programme

Development and implementation of a methodology for evaluation and impact assessment of the energy programme of the Fifth and Sixth Framework Programme of the European community for RTD activities

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Contact name and address for this study:
Paul Simmonds
Technopolis Ltd.
3 Pavilion Buildings, Brighton BN1 1EE, UK
Email: paul.simmonds@technopolis-group.com
Tel: +44 1273 204320

European Policy Evaluation Consortium (EPEC)
Brussels contact address: 25 rue de la Sablonnière – B-1000 Brussels
Tel: +32 2 275 0100 Fax: +32 2 275 0109
E-mail: contact@epec.info URL: www.epec.info

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# Content

1. Summary of results and key issues 1

   1.1 Context and challenges of NNE research activities 1
   1.2 Non nuclear energy research activities in the Fifth and Sixth Framework Programmes 2
   1.3 Scientific and technological achievements 3
   1.4 Policy impacts 5
   1.5 Economic and social impacts 7

2. Introduction 9

3. Context and challenges of NNE research activities 11

   3.1 Overall context 11
      3.1.1 Past and present priorities framing NNE research 11
      3.1.2 The new European strategy for energy technology: the SET-Plan 12
   3.2 Most important scientific and technical challenges by area 13
      3.2.1 Solar energy 13
      3.2.2 Wind energy 14
      3.2.3 Energy from biomass 14
      3.2.4 Other sources of renewable energy 15
      3.2.5 Clean Fossil fuels and CCS 15
      3.2.6 Energy Storage and distribution 16
      3.2.7 Socio-Economic research 16
      3.2.8 Hydrogen and fuel cells 17
   3.3 Cross area analysis 17

4. Non nuclear energy research activities in the fifth and sixth framework programmes 21

   4.1 Objectives of European NNE Research Programmes: FP5 and FP6 21
      4.1.1 Overall objectives of EU NNE research 21
      4.1.2 FP5 21
      4.1.3 FP6 22
   4.2 FP 5 and FP6 NNE research budgets 22
      4.2.1 Evolution of FP budgets 22
      4.2.2 Comparison of EC and member states NNE research budgets 24
      4.2.3 Budgets per area 25
      4.2.4 Determinants of NNE budgets by area and underlying logic 28
   4.3 Structure and composition of EC-led NNE research activities 30
      4.3.1 Participation, participants and projects 30
      4.3.2 Type of participants 31
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3.3 Projects funding profiles</td>
<td>33</td>
</tr>
<tr>
<td>4.3.4 Geographical distribution of participation</td>
<td>34</td>
</tr>
<tr>
<td>5. Scientific achievements</td>
<td>38</td>
</tr>
<tr>
<td>5.1 Outputs and results of FP5 and FP6 NNE projects</td>
<td>38</td>
</tr>
<tr>
<td>5.1.1 Outputs and results at programme level</td>
<td>38</td>
</tr>
<tr>
<td>5.1.2 Outputs and results by area</td>
<td>40</td>
</tr>
<tr>
<td>5.2 Codes, standards and other infratechnologies</td>
<td>46</td>
</tr>
<tr>
<td>5.3 Transnational cooperation in FP5 and FP6 NNE projects</td>
<td>48</td>
</tr>
<tr>
<td>5.3.1 Transnational cooperation within EU</td>
<td>48</td>
</tr>
<tr>
<td>5.3.2 Transnational cooperation beyond EU</td>
<td>51</td>
</tr>
<tr>
<td>5.4 The effectiveness of large FP6 instruments</td>
<td>54</td>
</tr>
<tr>
<td>5.4.1 The assessment of large projects in the survey</td>
<td>54</td>
</tr>
<tr>
<td>5.4.2 The pros and cons of large projects in interviews</td>
<td>55</td>
</tr>
<tr>
<td>6. Policy impacts</td>
<td>60</td>
</tr>
<tr>
<td>6.1 The effect of FP5 and FP6 NNE projects on the coordination of national research policies</td>
<td>60</td>
</tr>
<tr>
<td>6.1.1 Energy ERA-NETs and other coordination actions</td>
<td>60</td>
</tr>
<tr>
<td>6.1.2 The coordination of national research policies according to countries</td>
<td>62</td>
</tr>
<tr>
<td>6.1.3 The coordination of national research policies according to areas</td>
<td>64</td>
</tr>
<tr>
<td>6.1.4 The effects on research funding (additionality of funding)</td>
<td>64</td>
</tr>
<tr>
<td>6.2 The effect of FP5 and FP6 NNE projects on other policies</td>
<td>65</td>
</tr>
<tr>
<td>6.2.1 Main generic results</td>
<td>66</td>
</tr>
<tr>
<td>6.2.2 Main results per area</td>
<td>66</td>
</tr>
<tr>
<td>7. Economic, environmental and social impacts</td>
<td>72</td>
</tr>
<tr>
<td>7.1 Economic impacts: overall picture</td>
<td>72</td>
</tr>
<tr>
<td>7.2 Economic impacts per area</td>
<td>73</td>
</tr>
<tr>
<td>7.2.1 Economic impacts in the solar area</td>
<td>73</td>
</tr>
<tr>
<td>7.2.2 Economic impacts in the wind area</td>
<td>76</td>
</tr>
<tr>
<td>7.2.3 Economic impacts in the biomass area</td>
<td>76</td>
</tr>
<tr>
<td>7.2.4 Economic impacts in the area of other energy sources</td>
<td>77</td>
</tr>
<tr>
<td>7.2.5 Economic impacts in the storage and distribution area</td>
<td>77</td>
</tr>
<tr>
<td>7.2.6 Economic outputs and effects in the Hydrogen and fuel cells area</td>
<td>78</td>
</tr>
<tr>
<td>7.2.7 Economic impacts in the socio-economic area</td>
<td>78</td>
</tr>
<tr>
<td>7.3 Environmental impacts</td>
<td>79</td>
</tr>
<tr>
<td>7.3.1 Overall environmental impacts</td>
<td>79</td>
</tr>
<tr>
<td>7.3.2 Environmental impacts by area</td>
<td>80</td>
</tr>
</tbody>
</table>
7.4 Social impacts

8. Recommendations

Annexe A  Glossary

Annexe B  Bibliography

Annexe C  Methodology of the evaluation

  C.1. Scope and levels of the evaluation

  C.2. Methodological tools

Annexe D  Interview guidelines - Project coordinators

Annexe E  Interview guidelines – EC officers

Annexe F  Interview guidelines - Stakeholders

Annexe G  Share of EC funding by country, programme and area

Table of exhibits

<table>
<thead>
<tr>
<th>Exhibit</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhibit 1</td>
<td>Realisations, targets and expectations for EU renewable energy use</td>
<td>12</td>
</tr>
<tr>
<td>Exhibit 2</td>
<td>Lessons learned from context and challenges of NNE research activities</td>
<td>18</td>
</tr>
<tr>
<td>Exhibit 3</td>
<td>Synthesis of main results per area – context and challenges</td>
<td>19</td>
</tr>
<tr>
<td>Exhibit 4</td>
<td>Synthesis of main results per area – context and challenges (continued)</td>
<td>20</td>
</tr>
<tr>
<td>Exhibit 5</td>
<td>Total R&amp;D expenditure by thematic priority, FP4-FP7 (in M€)</td>
<td>23</td>
</tr>
<tr>
<td>Exhibit 6</td>
<td>Share of NNE R&amp;D FP4-FP7 (in %)</td>
<td>24</td>
</tr>
<tr>
<td>Exhibit 7</td>
<td>Total NNE R&amp;D expenditure in EU27, 1998-2007 (in M€)</td>
<td>25</td>
</tr>
<tr>
<td>Exhibit 8</td>
<td>FP5 and FP6 DG RTD budget by area (M€)</td>
<td>26</td>
</tr>
<tr>
<td>Exhibit 9</td>
<td>Evolution of FP5 and FP6 DG RTD budget by area (M€ and %)</td>
<td>27</td>
</tr>
<tr>
<td>Exhibit 10</td>
<td>Participants and average budget per participants by research area in FP5 and FP6</td>
<td>27</td>
</tr>
<tr>
<td>Exhibit 11</td>
<td>Share of EC contribution in total eligible costs, FP5 and FP6, by area</td>
<td>28</td>
</tr>
<tr>
<td>Exhibit 12</td>
<td>Budgets for each research area related to technology maturity and potential</td>
<td>29</td>
</tr>
<tr>
<td>Exhibit 13</td>
<td>Lessons learned from the analysis of FP5 and FP6 NNE budgets</td>
<td>30</td>
</tr>
<tr>
<td>Exhibit 14</td>
<td>Participation per research area in FP5 and FP6 NNE research</td>
<td>31</td>
</tr>
<tr>
<td>Exhibit 15</td>
<td>Distribution of number of participations by type of participant in FP5 and FP6</td>
<td>31</td>
</tr>
<tr>
<td>Exhibit 16</td>
<td>Distribution of number of participations by type of participant in FP5 and FP6, by area</td>
<td>32</td>
</tr>
</tbody>
</table>
Exhibit 17: Funding profiles in FP5 instruments, in m€ and # of projects ........................................... 33
Exhibit 18: Funding profiles in FP6 instruments .................................................................................. 34
Exhibit 19: Share of EC funding according to instruments, per area, FP6, in % ................................. 34
Exhibit 20: Collaboration between countries in FP5 projects .......................................................... 35
Exhibit 21: Collaboration between countries in FP6 projects .......................................................... 36
Exhibit 22 Country ranking and % of EC funding, FP and FP6 ......................................................... 36
Exhibit 23 Lessons learned from the analysis of the structure of partnerships ................................. 37
Exhibit 24: Outputs produced by the individual or their organisation ............................................. 39
Exhibit 25: Impacts of FP projects on the researchers ..................................................................... 40
Exhibit 26 The Wavedragon project (FP5) ....................................................................................... 43
Exhibit 27 Lessons learned from the scientific achievements assessment ........................................ 46
Exhibit 28 Infratechnology outputs produced in FP5 and FP6 NNE projects ........................................ 46
Exhibit 29 The case of CIS/CIGS PV technology ............................................................................ 50
Exhibit 30 The case of the Carbon Dioxide Knowledge Sharing Network (CO2NET) ....................... 51
Exhibit 31 Believed extent of benefit to the ICPC partner(s) ............................................................ 52
Exhibit 32 Lessons learned from the analysis of transnational partnerships in FP5 and FP6 NNE research activities .......................................................... 54
Exhibit 33 Lessons learned from the analysis of large instruments ................................................. 57
Exhibit 34 Synthesis of main results per area – scientific achievements ........................................... 58
Exhibit 35 Synthesis of main results per area – scientific achievements (continued) ...................... 59
Exhibit 36 ERA-NETs in the energy field ............................................................................................ 61
Exhibit 37 The IRED cluster in the energy storage area ..................................................................... 62
Exhibit 38 Effect on projects of using resources other than EU funding ........................................... 65
Exhibit 39 Lessons learned from the policy impacts assessment ..................................................... 68
Exhibit 41 Synthesis of main results per area – policy impacts ....................................................... 70
Exhibit 42 Synthesis of main results per area – policy impacts ....................................................... 71
Exhibit 40: Outputs and impacts produced in FP NNE projects ...................................................... 72
Exhibit 41: Impact of the project on the respondent’s organisation .................................................. 73
Exhibit 42 Development and commercialisation of CIS/CIGS thin film solar cells in Europe ....... 75
Exhibit 43 Lessons learned from the economic impacts assessment ............................................... 79
Exhibit 44 Impact of the project on energy and the environment ..................................................... 80
Exhibit 45 Lessons learned from the environmental impacts assessment ........................................ 81
Exhibit 46 Lessons learned from the social impacts assessment .................................................... 82
Exhibit 47 Breakdown of the number of projects by area, FP5 and FP6 ........................................... 93
Exhibit 48  Online survey response rates ................................................................. 95
Exhibit 49  Online survey response rates ................................................................. 95
Exhibit 50  Country ranking and % of EC funding, by area ....................................... 103
Exhibit 51  Country ranking and % of EC funding, by area (continued) .................... 104
1. Summary of results and key issues

1.1 Context and challenges of NNE research activities

This report presents the results of the evaluation of the EU energy research supported through FP5 and FP6. It details the achievements of EU non-nuclear energy (NNE) research in light of the objectives defined in the EU energy / climate change and competitiveness policies. The results are expected to inform the Commission regarding ways to improve the added value of future support for energy research in a context of increasing energy challenges.

Main results regarding NNE research challenges:

- Progress in most areas was relatively slow over the period. The main challenges at the start of FP5, end of FP5 and end of FP6 remained the same in most areas. The dynamics of NNE areas is very specific: in most cases, it requires a mix of very fundamental research (basic understanding of processes such as conversion, degradation of performance at material structure level) and a lot of learning by doing and experimentation. The complexity of the problems at stake (due for instance to the systemic nature of several technologies such as biomass or smart grids, the need to consider well-to-wheel pathways in fuel cells, the differences of processes at stake according to the scale-up in batteries, the problem of durability in fuel cells, batteries, marine energy technologies, etc.) make most of the areas rather empirical and poorly suited to a major breakthrough.

- Areas are very heterogeneous with regards to their stage of development. At the start of FP5, some areas were (and still are for the most part) at a very early stage (e.g. marine technology, carbon capture and storage (CCS)), while others were further advanced with major demonstrators or even-first generation products in the market (e.g. fuel cells, biomass), others were growing rapidly (wind, solar) while others (e.g. battery, hydropower) confronted rather mature markets. However, all areas, even the mature ones, confronted important technological opportunities or challenges: advanced battery technologies had to be scaled-up for new applications (EV or HEVs, stationary), which requires significant basic research as well as tests and demonstration; hydropower faced end of life questions as well as maintenance and renewal issues; further improvements in price-performance were needed for photovoltaics to be cost-competitive; new generations of biomass conversion techniques had to be developed and proven.

- Challenges were and still are in all areas primarily of scientific and technological nature. Policy, economic and social challenges were more limited at this stage of development. They related to regulation and standards issues, acceptability and the development of new business models and concepts for innovative energy systems.

Main results regarding the relevance of FP5 and FP6 objectives:

- The objectives of FP5 and FP6 were in line with the main challenges identified (cost, efficiency, durability, ...). They were also very similar between FP5 and FP6 since the challenges of most NNE technologies were relatively stable over time. Objectives evolved in the certain areas, those that experienced more rapid progress: in solar for instance, FP5 focused on technology transfer and scale-up of production; FP6 was closer to the market. In contrast, in fuel cells where the main bottlenecks remained, the objectives of FP5 were largely retained for FP6.

- Several areas such as Hydrogen and fuel cells, biomass and solar energy benefited from the presence of dedicated Technology Platforms, which helped to brief the Commission Services on relevant research opportunities. This information were provided through direct contacts and through documents such as strategic research agendas (SRA).
Main results regarding the **span and focus of FP5 and FP6 research activities:**

- The span of NNE FP programmes is wide and allows activities to adapt to the specific challenges in each area, from fundamental research to applied research and demonstration.

- Although the objectives were similar, the way activities were organised and implemented was dramatically different in FP5 and FP6. In all areas, FP5 was characterised by a diversity of rather small and focused projects, while the bulk of the EC contribution in FP6 was dedicated to large projects with an overall system perspective (essentially integrated projects (IPs)). It is clear for instance in the biomass area that, in FP6, the whole value chain was addressed in each of these large projects, whereas FP5 projects were dealing with one issue at a time.

1.2 Non nuclear energy research activities in the Fifth and Sixth Framework Programmes

An in-depth analysis of the DG RTD project database was carried out for all areas. Also in each area, an analysis of available project portfolios (catalogues of projects,...) was performed in order to get the whole picture of the area (in some areas such as Hydrogen and fuel cells, DG Research led activities represent less than half of total EC contribution to these technologies).

Main results regarding the **EC financial contribution to NNE areas:**

- In FP5, the energy-research budget was around €1 billion. The budget for FP6 was around 30% lower at €701m. DG RTD reduced its expenditure levels between the programmes,

- Desk research suggests this reduced budget lead to an even sharper fall at the European level, with FP energy-related research slipping back from as much as 25% of all EU spend to about 10% (depending on areas), as FP funding decisions were met by increasing member state investment. Notwithstanding this shifting balance of investment, it seems clear that the increased importance of RTD for EU energy systems as stated in policy documents was not translated into increased budget for energy RTD.

- The average size of projects, as well as the average budget for each participant, increased significantly from FP5 to FP6.

- The distribution of funding across thematic areas changed between FP5 and FP6. The budget of Hydrogen and fuel cells was increased markedly, while several other areas were allocated substantially lower levels of funding, specifically clean fossil fuel and CCS (which in this specific case traduces a focus on CCS only), wind, socio-economic research (accounting for a redistribution of socio-economic research into other areas for a better integration) and energy storage. This re-balancing reflected judgements as to the degree of technology maturity (the need for public support) and the differences in the anticipated scale of socio-economic impacts. In general, embryonic technologies with high potential are well funded and more mature technologies are supported to a more modest extent.

- Solar and wind experienced budget cuts between FP5 and FP6 although important technological challenges remained to be tackled. Moreover, some budget choices (large budget for biomass) seem difficult to justify. While the “maturity test” is a legitimate and familiar rationale for choosing amongst investment options, and especially against the backdrop of a diminishing overall budget, a more careful analysis might have produced a less dramatic change in funding levels. Especially, it might have been relevant to consider the different generations of technology within a given area: some new generations can still be very exploratory, and therefore call for support, although a market has already emerged for older generations. The consideration of this evolutionary nature of technological change might have smoothened budget cuts which have in some cases jeopardised existing research networks.

Main results regarding **project composition:**

- Industry participation, as a share of all participation, was 42% in FP5 and 31% in FP6. There are several inter-linked factors that appear to have caused this fall off in interest amongst the business community: the increase in the size and complexity of projects in FP6 reduced the attractiveness of coordinating projects (setting agendas, shaping flow of benefits); it also
meant enterprises had fewer project opportunities to consider and the larger consortia were likely to include direct competitors. Lastly, in the energy area specifically, the reduction in budgets reduced the prospects for success, which was a further disincentive.

1.3 Scientific and technological achievements

The results of FP5 and FP6 NNE research projects were analysed through an online survey and in-depth interviews. The survey was sent to 2,869 project participants, of which 462 provided answers (16% response rate, representing 64% of all FP5 and FP6 projects). Further to the survey, around 240 interviews were carried out with FP participants and coordinators, area experts, Commission staff and member state policy makers.

Main results regarding scientific outputs and results:

- The vast majority of projects produced multiple outputs from across the spectrum of output types, including: contributions to conferences, seminars and other events; new or improved tools, methods or techniques; publications in refereed journals or books; other publications; newly qualified personnel (MSc, PhD, etc.) and new or improved models and simulations.

- The volume of key outputs was substantial, however at around 7 refereed articles per million Euros, research ‘productivity’ is not especially strong when compared with equivalent metrics for selected national energy-research programmes (e.g. EPSRC in the UK: 28; VIB in Flanders: 11; LTIs in the Netherlands; 10).

- FP5 respondents report c. 20-30% more of most types of output, in proportionate terms, which underlines the fact that project teams continue to produce project-related outputs – from events to papers to tools – several years beyond the conclusion of the programme.

- The level of scientific output differed across the eight thematic areas. According to the survey, the level of outputs produced in solar energy projects was far above the all-NNE average. The lowest level was found in the Hydrogen and FC area. The interviews suggest these differences are structural, i.e. not related to the EU RTD programme or changes from FP5 to FP6. For instance, the market take-off in PV has raised interest from companies, which has invigorated research and eased technology transfer; in contrast, in the fuel cell area, market developments are very limited and research progress fell a long way short of what was anticipated at the start of the programme.

- Interesting results in several areas were related to the strong efforts in ‘infra-technologies’ (metrology, test procedures, standard data sets, etc), which were evident both in dedicated projects and within the relevant work-packages of large projects. This was apparent in areas such as solar, Hydrogen and fuel cells, CCS and battery, where benchmarking alternatives is crucial to progress and where new test methodologies and data streams can greatly improve technology assessment.

- It is difficult to precisely identify the success and failure factors. One important parameter without any doubt is the nature of the technology itself (complex and still immature in the FC area for instance).

- The continuity in public support to research from one FP to another can be crucial. For instance in the solar energy area the continuity of effort on CIS/CIGS technologies has allowed the same network of participants to be supported since FP4. Continuity of funding has also allowed knowledge and network continuation even when national budgets were cut in the past (as in solar energy or CHP in Germany). In the fuel cell area, the continuous effort since FP4 on some SOFC technology explains the good results obtained in these projects, however this continuity is not clear from the start and not conditioned to the achievement of milestones. In absence of such rules established at the start of the research, the advantages of continuity are to a certain degree lost.
Main results regarding the relevance of instruments:

- Participants and stakeholders stated that the new instruments introduced for FP6 had both good points and bad, although the balance of opinion tended towards the view that the grand scale of the Integrated Projects was often problematic. The large size of IPs was reported to be a major limitation on project coherence by interviewees across almost all thematic areas. The level of cooperation and the benefits of cross-fertilisation amongst partners was said to be superior in projects with a limited number of partners:
  - Biomass: some participants in large projects claimed they were only “satellite partners”, as opposed to “core partners”, and were disappointed they had not been involved enough in the project. Industry partners were reluctant to participate in large applied research projects that included their competitors.
  - Solar: interviewees were rather positive about large projects: there were for instance 4 IPs in PV, each having – in a given sub-area – the objective to bring together all relevant partners of the value chain, combining all pieces of relevant knowledge accumulated in the past 10 years. These 4 IPs have covered the whole PV landscape, addressing the main research topics of PV. However in most cases, the strict division of labour have restricted the level of cooperation between groups of partners.
  - In the FC area, several interviewees voiced their disappointment in large FP6 projects as opposed to the smaller and more focused FP5 projects.
  - In the storage energy area, it was documented that large FP6 instruments have generated more “contacts” than real cooperation.

- These results were echoed in the workshops. It was claimed that large projects are often little more than an amalgam of smaller projects pursuing separate issues with limited overlap or cross-fertilisation. As a result, the new instruments offer little additional benefit – as regards integration and coordination of knowledge – in comparison with the preceding regime. It was considered to be an administrative innovation principally, reducing project numbers and transferring aspects of the administrative workload to the projects themselves.

- IPs also have positive qualities. Certain classes of RTD activity, usually downstream, related to test and demonstration, have costs that far exceed what a single member state might be willing or able to fund. That was the case of the Hot Dry Rock project in geothermal energy, the cost of which was over €50m (co-financed by the EC with France and Germany).

- Large projects also allowed the parallel development and demonstration of different alternative options (exploration activities) in a common environment (methods of test, target performance and specifications) developed directly in the project or in associated projects. This ensures that the common methods and protocols developed will be highly relevant to the purpose and used by all partners.

Main results regarding the support to science-industry relationships:

- The gathering together of public and private researchers and engineers was at the core of the added value for all projects investigated. New and rejuvenated public-private sector partnerships were reported to be important FP-specific outcomes by most interviewees.

- However, in some large projects this logic might be pushed too far. In the Hydrogen and FC area, tensions were reported between the research community and the industry partners in an IP. This large project aimed to integrate all activities in a single project, from basic research to demonstration. The different timeframes and motives (dissemination of information vs. competitiveness) proved difficult to reconcile.

Main results regarding the transnational cooperation and durability of EU networks:

- The main impact of NNE FP projects on the participants’ organisations was the enhancement of cooperation with partners in other EU countries. This was very clear in the survey results and in interviews at area level:
Solar: the opportunity to cooperate with EU partners is seen as the main added value of FP projects, as no country control the whole value chain of PV. FP projects combine specific competencies spread in different countries and can also allow access to specific testing grounds (e.g. German leaders team-up with Spain for CSP).

In the other renewable energy areas, the impact of FP projects was important despite the limited budget, since the key competencies are scarce and distributed unevenly throughout the EU. Transnational cooperation is reducing fragmentation and catalysing more consequential work by extended virtual teams.

There was consensus regarding the added value of FP for transnational cooperation, which amongst other things, was considered to be vital to gathering together the spectrum of complementary expertise, which only very rarely exists in a single member state. Some projects on embryonic technologies (e.g. Wave Energy network in FP5, followed by Ocean Energy coordinated action in FP6) have had a great role in the development of a research community.

Integration efforts are not entirely successful at producing wider spillovers, either in the guise of transnational networks that persist beyond and outside Framework or the cross-fertilisation amongst projects within the energy portfolio:

As regard the durability of FP project networks, despite some success stories (e.g. set-up of bilateral or multilateral partnerships between former project partners in the solar energy area), the most frequent follow-up of projects is the submission of another proposal in a subsequent call.

The coordination and exchanges between projects are limited. There is no mechanism to encourage these relationships beyond project boundaries. The existence of such relationships depends to a great extent on individual initiatives (from project coordinators, Commission staff,...)

Main results regarding the participation of ICPCs and third countries

International Cooperation Partner Country (ICPC) partners were commonly included, with bidders responding positively to the signals from the Commission. The majority of respondents indicated that their motivation was principally financial, seeking to improve their chances of success in securing a project award, however most also stated that they had positive experiences from the relationship. Most partnerships were grounded in pre-existing relationships however the measure did deepen that connectedness and in that sense can be seen as a valuable work-in-progress. Participants were satisfied with their ICPC partner(s) contributions and financial costs were low, which reflects a relatively light level of engagement of non-EU partners with most projects. In that sense, the potential added value of ICPC partners has yet to be grasped fully.

While these global alliances proceeded smoothly for the majority, there were frictions in some cases. In highly competitive areas such as solar energy and fuel cells, industry partners were reluctant to include partners from competing countries (such as China for instance) or reluctant to present results when already in.

1.4 Policy impacts

Main results regarding the coordination of national research policies

The coordination between national policies and EC research is very different according to areas and, especially, countries.

In the UK and Germany, researchers reported that they were invited by national agencies to try to secure funding from the FP first and then come back to national funding agencies should they not succeed. The motive to bid in to Framework is in part a shortage of national funding for research, at least in certain areas. The scarcity or abundance of relevant national research
funds and their coincidence with international funds, was also found to influence persons in charge of national and international programmes alike.

- Coordination of EU and MS research programmes was most evident in the CCS area where the EC has played a large role in setting the agenda as well as implementing it in the first stages. Also, in energy storage, evaluators found examples where EC-led research had paved the way for the launch and direction of national research, especially in new member states.

- The FPs articulation of energy research needs and its signalling of priorities were reported to have improved MS programme focus and structures, and even budgets, in several cases. As a result, several member states’ national programmes were said to have attracted much greater interest from national researchers. This was the case in Finland and France for instance (related to, depending on countries, a less heavy process, a higher success rate, the smaller size of projects). Moreover, several initiatives in countries like France and Germany intend to open up national programmes, which will begin to complement FP support for transnational cooperation, although FP will be the principal European ‘transnational’ programme, in terms of both the amount of funding available and the diversity of partners (nationality, types of organisation).

- The EC effort in one area can also provide legitimacy for Member states to invest in parallel in order to derive benefits from the EC contribution. That was for instance the case of the Hydrogen and FC area where international interest in the fuel cell JTI convinced French policy makers that it was right to continue with a national programme in this area (H-PAC, successor to PAN-H). This public re-commitment was made at a time when the interest of French industry had waned, and, more generally most countries (including the US) had diminished their efforts. In certain cases therefore, the stability of the EC funding, as well as a certain gap in the following of international trends due to the time needed to negotiate and design a programme, can mitigate the crowding out of an area.

- In other areas, European networks, roadmaps and coordination activities have been developed, some of which have had a large impact on peoples’ cooperation patterns, and internationalised the research agenda. This was confirmed in the workshop on the socioeconomics of NNE: technology roadmaps are a good instrument on which to build European programmes, according to the workshop participants. Roadmaps are written with input from all relevant parties in Europe and hence reflect the interest of the researchers and industry across Europe. Some national roadmaps use European roadmaps such as the Fuel cell or the PV roadmaps.

FP energy research has made direct contributions to the other policy realms (i.e. besides research and innovation policies) in just a small number of cases. For instance, the NILE project, in the Biomass area, instituted a regular debate with the EU Parliament’s Environment Committee, which was well regarded and provided politicians with a rather flexible and user-friendly route into finding out more about technology issues and the opportunities they present for helping to tackle major environmental issues. It also facilitated frank debate around the pluses and minuses of biomass. The DEEP project, in the energy storage area, took a more formal route to the provision of data relevant to the policy arena, and its international mapping and benchmarking of regulatory regimes (and constraints affecting the technology) was instrumental in the set up of a new coordination institution; the European network of transmission operators. In the social science and policy-related research area, support for the evolution of energy models, and the provision of additional data sets, has informed the measures and targets set by the Commission in several European directives.

For the most part, researchers and policy makers report rather indirect benefits in the guise of insight and understanding realised through the participation in events or the reading of policy briefings. However, while the mode of impact is clear, from the cases where insight has arisen, a majority of policy respondents had only very general awareness of the existence of the FP energy programme and little or no knowledge of the project portfolio and its policy-relevant work. Commission officials tended to be more aware of the programme than were their counterparts in the member states, however they had no greater command of project activities and results.
Few projects, through the formation of relevant networks, have created the conditions for stakeholders to gather and lobby on policy (for instance, for feed-in tariffs on geothermal energy in France).

1.5 Economic and social impacts

In all areas, the principal economic impacts are contingent upon the realisation of important scientific and technological objectives and as most of the areas remain a work-in-progress, it might be 10-20 years before the two FPs fulfil their economic potential.

The likelihood of economic impact will also depend to a great extent on industry engagement. In empirical areas such as several NNE areas (e.g. fuel cells), the presence of users to inform on relevant specifications and test the technology is crucial.

Again, the results varied according to areas. For instance:

- In the solar energy area, the survey showed impressive impacts on competitiveness, far above all-NNE areas average. This was backed by several examples of direct economic impacts identified through interviews. FP5 projects started in 1998 are now starting to have commercial spin-offs (which demonstrate that 10 years are needed for first economic impacts). Also, the demonstration of 3 different CSP technologies increased visibility of this sub-area area, and attracted industry interest.

- In the biomass area, leading companies participated in projects in order to keep in touch with developments in state of the art research, although this somewhat at-arms-length relationship to projects and wariness around disclosing technology and market experiences, caused some frustration amongst research partners.

- In the fuel cell area, some industry participants stated that FP projects were proving especially useful for firms that were relatively new to the field, whereby projects were helping to equalise technological capabilities and beginning to close the gap between leaders and followers.

In the meantime, individual participants are realising commercial benefits as a result of the supported projects. The most common commercial outcomes are successful demonstration of novel technologies and the creation of new products and services. The number of patents/million Euro FP spend is comparable with results from other evaluations. New jobs are the main reported impact. Interviews suggest that these are to a large extent related to employment on follow-up research projects, although a minority relate to new products and services. Spin-offs and licenses are reported by 7% of all projects, which is high for a research support programme.

1.6 Recommendations

Only the headlines of recommendations are provided in this summary. The full argumentation of recommendations is provided in the final chapter.

Recommendation 1 The budget dedicated to NNE research should be increased in order to be aligned with the size of clean energy challenges

Recommendation 2 The number and concentration of resources on large instruments should be reduced

Recommendation 3 The EC should set a clearer and more transparent decision process to support its budgetary trade-offs and decisions among areas
Recommendation 4  The Commission should dedicate more resources to the management and, especially, monitoring of projects

Recommendation 5  The coordination of related projects that fall under different thematics should be improved

Recommendation 6  The Continuity of efforts on specific projects should be based on milestones and fulfilment of clear and realistic targets

Recommendation 7  A study into practices of programme and project management in the US and Japan should be launched by the EC

Recommendation 8  DG research should implement and systematise dedicated support actions at area level
2. Introduction

This document is the draft final report of the “Evaluation and Impact Assessment of the European Non Nuclear Energy RTD Programme” (hereafter referred to as “the evaluation”).

The evaluation aims to analyse the outputs, results and impacts of the energy RTD programme in relation to the objectives defined in the EU energy / climate change and competitiveness policies. The results of this evaluation are meant to inform the Commission regarding ways to improve the relevance, effectiveness, efficiency and impact of these activities in a context of increasing energy challenges.

The evaluation was performed for all NNE RTD projects funded by DG RTD under FP5 and FP6. NNE RTD projects funded by DG TREN are not included\(^1\). The work of 563 projects (respectively, 444 and 119 for FP5 and FP6) were included in the portfolio of projects covered by this evaluation.

The evaluation is structured along 8 specific areas that cover the whole spectrum of NNE R&D activities supported by DG Research:

1. Solar energy (including passive solar energy, photovoltaic and solar thermal)
2. Wind energy
3. Energy from biomass
4. Other sources of renewable energy (including geothermal, hydropower, ocean energy)
5. Clean fossil fuels and CO\(_2\) storage and capture
6. Energy storage and distribution (including batteries and grid)
7. Socio-economic and policy related projects
8. Hydrogen and fuel cells

Five complementary methods have been used\(^2\):

- Desk research and challenge analyses
- Analysis of FP5 and FP6 NNE RTD project databases and Social network analysis.
- On-line survey to FP5 and FP6 NNE project participants
- Field interviews
- Thematic workshops

This report starts with an overview of the evaluation, with a strong emphasis on the main challenges research activities in the area of Non Nuclear Energy were facing at the time of FP5 and FP6 (Chapter 3). We then describe the research activities that were performed in terms of both budgets and structure, with an exploration of underlying rationales and objectives (Chapter 4). The next chapters examine the scientific outputs and results, the policy impacts and the economic impacts (respectively chapters 5, 6, 7).

The remaining chapters successively present the results of the evaluation as regard the scientific and technological impacts (Chapter 5), the policy impacts (Chapter 6) and the economic, social and environmental impacts (Chapters 7).

\(^1\) A separate evaluation was carried out specifically for activities supported by DG TREN under FP5: “Ex Post Evaluation of the NNE Programme Supported by DG TREN under FP5”, Ecotec, 2007.

\(^2\) The methodology is presented in more details in Annexe C.
Where there are clear differences between FP5 and FP6 this is explicitly stated and analysed. Results are presented at overall programme level and, when significant differences are identified, area level.

The recommendations will be added to the final version of the report, further to discussion during the final workshop.
3. Context and challenges of NNE research activities

3.1 Overall context

3.1.1 Past and present priorities framing NNE research

Energy has always been an important policy issue for the EU, dating back from the 1952 Coal and Steel Treaty and the 1957 Euratom Treaty, with focus on continuous and cheap energy supply.

In the 1995 White paper “An energy policy for the EU”\(^3\), the triple aims of competitiveness, security of supplies and protection of the environment (as a consequence of the “Fifth Environmental Action Plan-Towards Sustainability”\(^4\)) are explicitly mentioned. Technology is seen as both having an important effect on competitiveness as well as contributing to other energy policy goals, “in particular security of supply, by improving access to indigenous energy resources, including renewable energies, by helping to improve the fuel mix and by achieving higher energy efficiency and further energy savings.” Public support for RTD is seen as essential.

The White paper ‘Energy for the future: Renewable sources of Energy’ from 1997\(^5\) focuses entirely on the possibilities of renewable energy sources and the necessity to use these possibilities in order to ‘facilitate member States achieving the objective of 15% greenhouse gas emissions reductions target for industrialised countries in the year 2010 from the 1990 level’ (related to the December 1997 Kyoto protocol). It had the ambition to double the contribution of renewable sources of energy to the EU inland energy consumption by 2010 to 12% (which was seen as an ambitious but realistic objective). Growth of use of renewable energy was especially expected in the area of biomass, wind, hydropower and solar thermal collectors. Smaller contributions were expected from geothermal sources, photovoltaics and other energy sources. There was seen to be ‘still great scope for Research, Technological Development and Demonstration to improve technologies, reduce cost and gain user experience in demonstration projects...’. “The 5\(^{th}\) Framework Programme should offer the possibility to finance the necessary RTD efforts in this area”.

In 2001, the ‘Directive on the promotion of electricity from renewable energy sources in the internal electricity market’\(^6\) was accepted, giving legal support to the promotion of renewable energy sources for electricity supply and setting a target of 21% electricity from renewables for the EU25 by 2010. In the following years a number of directives providing legal instruments to promote renewable energy and energy efficiency were adopted.

The role of RTD was not mentioned very explicitly in these Directives, but it was acknowledged by an increase in budget for energy RTD in FP6 of M€890 in the thematic priority ‘Sustainable Energy Systems (in relative terms however, the NNE budget diminished to 5.0% of total FP6 research).

From 2006 (after the success of ‘An inconvenient Truth’) the high-level political attention for climate change (and therefore renewable energy) increased sharply and in 2007 the Commission Communication ‘An energy policy for Europe’\(^7\) was published. In this communication the


\(^4\) COM(92)93, Fifth Environmental Action Plan- “Towards Sustainability”

\(^5\) COM(97) 599 final: White Paper: Energy for the future - renewable sources of energy

\(^6\) Directive 2001/77/EC

\(^7\) COM(2007) 1, Brussels, 10.1.2007
Commission states that the renewable energy targets for 2010 will not be met (10% instead of 12%) because of high costs and the lack of a coherent policy throughout the EU.

In order to change the situation the Commission presented an 'energy and climate change package' including a Strategic Energy Review focusing on both external and internal aspects of EU energy policy. The package contains proposals for specific targets on:

- Renewable energy (20% by 2020)
- Biofuels (10% in transport by 2020)
- Greenhouse gas emissions reduction (20% by 2020)

A Roadmap is included in the package, making provision for each Member State to adopt mandatory targets and action plans in line with its potential. These action plans must include specific measures and objectives for the three following sectors: electricity, biofuels and heating and cooling. This flexible approach will leave Member States enough room for manoeuvre.

3.1.2 The new European strategy for energy technology: the SET-Plan

Technology is seen as vital to reach these goals and a specific 'European Strategic Energy Technologies plan (SET-plan)' was published later in 2007\(^8\). In this SET-plan heavy underinvestment for the development of energy technologies (since the 1980s) is observed and the efforts outside Europe are considered stronger. In the Technology Map\(^9\), accompanying the SET plan, actual as well as potential data for 2020 and 2030 (baseline scenario and maximum potential) for various renewable energy options are given (Exhibit 1).

Exhibit 1: Realisations, targets and expectations for EU renewable energy use

<table>
<thead>
<tr>
<th></th>
<th>1995(^a)</th>
<th>2010 target(^b)</th>
<th>2006(^c)</th>
<th>Potential 2020</th>
<th>Potential 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wind</strong></td>
<td>2.5 GWe</td>
<td>40 GWe</td>
<td>50 GWe</td>
<td>120-180 GWe</td>
<td>148-300 GWe</td>
</tr>
<tr>
<td><strong>Hydro</strong></td>
<td>92 GWe</td>
<td>105 GWe</td>
<td>106 GWe</td>
<td>114.5-126 GWe</td>
<td>115-131 GWe</td>
</tr>
<tr>
<td><strong>PV</strong></td>
<td>0.03 GWp</td>
<td>3 GWp</td>
<td>3.4 GWp</td>
<td>12-125 GWP</td>
<td>22-665 GWP</td>
</tr>
<tr>
<td><strong>Biomass</strong></td>
<td>44.8 Mtoe</td>
<td>135 Mtoe</td>
<td>3.9 Mtoe biofuels (2005) ?</td>
<td>10-25 Mtoe biofuels</td>
<td>25-40 Mtoe biofuels</td>
</tr>
<tr>
<td><strong>Geothermal</strong></td>
<td>0.5 GWe+1.3 GWth</td>
<td>1 GWe+9GWth</td>
<td>1 GWe+9GWth</td>
<td>1-6 GWe+40 GWh</td>
<td>1.3-8 GWe+70 GWth</td>
</tr>
<tr>
<td><strong>LT Solar</strong></td>
<td>6.5 mln m²</td>
<td>100 mln m²</td>
<td>13 GWth</td>
<td>52-320 GWth</td>
<td>135-700 GWth</td>
</tr>
<tr>
<td><strong>Others:</strong></td>
<td>-</td>
<td>1 GWe</td>
<td>-</td>
<td>0-1.8 GWe</td>
<td>0-4.6 GWe(^d)</td>
</tr>
<tr>
<td>CSP</td>
<td></td>
<td></td>
<td></td>
<td>2 MWe</td>
<td>0.9-10 GWe</td>
</tr>
<tr>
<td>Wave</td>
<td></td>
<td></td>
<td></td>
<td>1.7-16 GWe</td>
<td></td>
</tr>
</tbody>
</table>

Source: various EC publications

Although no overall targets for energy from biomass are stated there is a Bio-energy Europe Initiative announced with focus on ‘next generation’ biofuels within the context of an overall bio-energy use strategy. For transportation fuels, there is a tenfold increase foreseen between 2005 and 2030. Furthermore, a large effect should be expected from biomass in CHP (Combined heat and Power generation).

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\(^8\) COM(2007) 723, Brussels, 22.1.2007
\(^9\) SEC(2007) 1510, Brussels 22.11.2007, SET-Plan: Technology map, for EU27
\(^a\) COM(97) 599, for EU15
\(^b\) ibid.
\(^c\) ibid.
\(^d\) excluding possible imports from Northern African countries, max. 55 TWh, 216 TWh resp.
As well as targets for energy from sustainable sources, attention is also given in the SET-Plan for other parts of the energy supply and demand chain that have also been themes in FP5 and FP6: ZEPP (Zero Emission Power Plants, with focus on CCS), smart grids, and Hydrogen/fuel cells. The environmental effects of research in the storage and distribution area are also limited. Research in these last two areas is not directly aimed at reducing environmental impact, but rather trying to develop technologies and knowledge that can fulfill framework conditions in a transition from a fossil fuel economy to a renewable based economy.

3.2 Most important scientific and technical challenges by area

The scientific and technical challenges are directly related to these challenges. In the following paragraphs, the main technical challenges are given per area.

3.2.1 Solar energy

3.2.1.1 Solar PV

During the FP5-FP6 period, the main technological challenges for solar PV were to reduce production costs and increase the efficiency of cells and modules. (Multi)crystalline silicon solar cells are dominating and have the largest market share, but other technologies are being developed as well and offer promising alternatives for niche-markets or to reduce production costs. For both crystalline and thin film solar cells the same technological challenges apply:

- Shifting the practical efficiency towards the theoretic maximal efficiency.
- Minimising the cost of the solar cells (€/Wp).
- Lowering the cost, and increasing the efficiency and lifetime of system components that are used to install the modules, to transport and store the energy etc.
- Increasing the lifetime of a PV-module and the convenience of PV for end-users.

In general these main challenges (increase practical efficiency while reducing production costs; indicated by decreasing cost per power (€/Wp)) have remained the same for FP5, FP6, and FP7, although the relative focus was on the challenges at the top of the list, rather than on the challenges lower down the list.

3.2.1.2 Solar thermal

The field of Solar Thermal energy should be split up in two separate domains: low and medium temperature ST and high temperature ST.

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Low and medium temperature ST are rather low-tech technologies that produce heat with a temperature lower than 220°C that is used directly or stored and used later. At the start of FP5 there was already a large capacity of these low-tech solar heat production units. Technical challenges relate to:

- Integrating the solar heat receiver systems into other systems for domestic and industrial use, such as heating, cooling, air conditioning, desalination of water, etc.
- Increasing the efficiency of the solar heat receivers, while improving the life time and robustness of the system.

High temperature ST consists of technologies that use heat with temperatures above the 220°C for electricity production. To achieve high temperatures, lenses and mirrors are used to focus indent sunlight of a large area to a device that produces the heat. At the start of FP5 no dominant design existed. Today, still no dominant design has emerged, however, a roadmap is been developed in FP6 to compare the technological alternatives. Although CSP is amongst the cheapest renewable energy sources, it needs to shift the efficiency of the subsystems and the system as a whole to the highest level, while minimising the cost of the systems. The challenges are to a large extent related to engineering and demonstration to increase the scale of CSP power plants. The main scientific challenges are related to energy storage as this defines to a large extent the success of CSP.

3.2.2 Wind energy

In the late 1990s, there were already commercial wind turbines for good wind locations. However, in order to increase the potential, cost reduction was necessary as well as a reduction in uncertainty with respect to energy delivery, minimisation of environmental impacts and enabling of large-scale use. At the beginning of FP5, main challenges related to the interaction of wind power with the grid and the location of wind turbines in complex terrain. At the start of FP6, off-shore wind energy became realistic, and the main mid to long term challenges related to forecasting power performance, standardisation, grid interaction and storage techniques (reduction in uncertainty of delivery), aerodynamics and aero elasticity, identification of new locations, especially offshore and social acceptability (noise, aesthetic integration, ...).

3.2.3 Energy from biomass

The biomass energy area covers a very wide spectrum of options, from the biomass feedstock (agriculture, municipal, forestry, industry waste, crops, sewage sludge, animal manure,...) to the end-use product (electricity, fuel, heat,...). Along this chain, several combinations and conversion processes are available. This variety of feedstock available and the variety of products makes it difficult to narrow down the choices and pathways. There is no clear-cut distinction between FP5 and FP6 challenges, but where FP5 focused more on technological issues and individual processes (e.g. reduction of the cost of production and transportation of feedstock resources, increasing energy efficiency of thermal conversion, fuel mixes, biogas production, liquid biofuel processes), FP6 focused on the development of cost effective integrated approaches: from biomass collection to fuel production and uses, which take sustainable biomass procurement and market opportunities into account.

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3.2.4 Other sources of renewable energy

Marine energy’s main technological barriers have to do with designing marine energy devices robust enough to withstand the excessive forces and loads experienced while operating in the rough oceanic environment. Demonstration projects are necessary to resolve these issues. The emphasis of marine energy technology development during FP5 and FP6 has been on transition from the model stage to testing in real oceanic conditions to moving towards correctly operating designs at a competitive price.

Challenges for technological development in geothermal energy can be divided in challenges experienced in the reservoir exploration and drilling phase, and reservoir exploitation phase. Challenges in exploration of the reservoir and drilling of wells have to do with developing technology to better determine the location and assess the structure and quality of reservoirs; development of drilling technology and instruments and tools able to withstand high temperatures; and geothermal fluid handling. Challenges related to reservoir exploitation depend on whether exploitation is for direct use (heat pumps) or electricity production. For geothermal heat pumps the technology is rather mature, but there has been a need for incremental progress concerning the performance and costs of the systems. In general the technology for geothermal electricity production by means of conventional and binary systems is quite mature with the need for incremental development to make the system more efficient. New and more radical developments can be found in the area of ‘Enhanced Geothermal Systems’ (EGS), which is not yet producing at an economically competitive rate.

Hydropower is a mature technology and is now facing a loss of expertise in research institutes and universities, which is a problem considering the great deal of electricity it provides and the growing risk of decay of plants built long ago. In addition, some incremental steps to increase the efficiency can be taken and more research is needed to investigate integration of the plants with other renewables when using hydropower as a grid stabiliser. Specific scientific challenges for small hydropower have to do with the development of multipurpose plants and the need for cheaper and simpler automatic monitoring and operating systems.

3.2.5 Clean Fossil fuels and CCS

Prior to FP5, the growing realisation that Europe is dependent on a few – partly unreliable – countries in terms of oil and gas supply as well as diminishing oil and gas reserves led to the need to develop better technologies. The main challenge was to use reserves more efficiently by improving exploitation.

In FP5, a change of paradigm can be observed. The growing consciousness of the danger of CO2 for the atmosphere as well as the political discussions surrounding the run-up to the Kyoto protocol resulted in an increasingly critical view of fossil fuels as an energy base for Europe. Therefore, the emphasis was shifting from the classical exploration and production side to the environmentally sound exploitation as well as the reduction of greenhouse gases. Therefore, the main scientific and technological challenge at the time of FP5 were to improve existing clean fossil fuels technologies in order to increase the efficiency of fossil fuels, and in particular coal, and to minimise the amount of resources to be used per unit of energy produced, make them more environmentally friendly through more efficient energy conversion processes or cycles, including combustion efficiency. The challenge was to decrease the global and local environmental impact, while reducing the cost, of the generation of electricity and/or heat on a large scale, for new and retrofitted plant, based on solid, gaseous or liquid fuels - fossil, biomass or waste and mixtures thereof.

At the time of FP6, another paradigm shift could be observed. Increasing environmental pressures and growing scepticism regarding fossil fuels, which around 2002 were considered as backward, environmentally damaging and dirty by large parts of the public, resulted in heightened efforts in order to achieve what became known as ‘zero emission fossil fuels’. Thus, rather than reducing CO2, the goal now became virtually eliminating greenhouse gases at the end of the fossil fuel process. As a result research efforts in Europe centred on ‘Carbon Capture and Storage’ (CCS).
CCS was seen by many – including the power generation industry – as a last chance by coming up with a ‘raison d’être’ which was both technologically feasible and environmentally sound. However, at the end of FP6 the main technological challenges in the CCS area, both at the time of FP6 and to date, are:

- Purification of CO₂ after capture
- Explore safe and cost-efficient storage options for CO₂
- Reduce risks associated with CO₂ transport
- Increase the commercial viability of CCS
- Further increase plant efficiency through advanced technologies

3.2.6 Energy Storage and distribution

At the outset of FP5 the level of European research in the area of energy storage was no longer top class as the substantial efforts in battery development for electric vehicles in the 1980’s had been terminated by the major European technology providers due to the lack of perspective and success with electric vehicles. The principal problem for energy distribution was how to handle the integration of the electricity grids and the problems associated with embedded renewables and other local generation into weak grids that the liberalisation of energy markets gives rise to. The type of scientific advances most needed were demonstration projects on fuel cells in the range up to 200 kW. There was also a need for technological innovations in the electric grid infrastructure. The challenge seemed to lie in fine-tuning existing technologies rather than to look for or expect quantum leaps.

At the outset of FP6, research needs were identified on the following major areas of energy storage technologies:

- On critical technologies to achieve improved performance, durability and cost reductions for components such as electrochemical cells, modules and complete batteries, super-capacitors, fuel cell stacks, and flywheels.
- On innovative energy storage technologies for grid-connected applications by developing new concepts for energy storage technologies and by exploiting the synergies with transport applications.
- On benchmark technologies and promotion of cost-effective implementation.

3.2.7 Socio-Economic research

The scientific challenges in this area can be split into two groups, segmented by the primary purpose of this proposed research.

In the first case, socio-economic research is cast in the role of support to European-level technological innovation in the energy field. Here the research challenges relate to the definition of research agendas and technology trajectories (to increase the prospects for more positive outcomes) and to the socio-economic aspects of novel / emerging energy technologies, from questions to do with consumer behaviour to the identification and valuation of risks to the costing of wider implementation.

In the second case, we have medium to long term applied research through which to support the evolution of European energy policy including new conceptual models, with which to better characterise energy systems and responses to differing policy scenarios; New data sets / time series, with which to strengthen existing energy models; New operational tools, with which to compare the costs and benefits of competing energy technologies and systems (options appraisal) and new knowledge about the impacts and cost-effectiveness of given policy interventions.
3.2.8 Hydrogen and fuel cells

During the period of FP5 and FP6, the alleged promises made by Hydrogen and fuel cell technologies have tremendously increased: these technologies were seen by many as the potential solution for cleaner, more efficient and more politically secure energy. The resulting economic opportunities – the third driving factor of NNE research – are huge: the market potential of both the Hydrogen infrastructure and the FC systems is unprecedented as they can serve a wide variety of applications, from stationary, transport to consumer electronics. At the start of FP6, the expectations were especially optimistic, and the interest even within the policy arena and population became very high, especially for transport application.

However, the challenges were also huge and, despite progress, the major technological bottlenecks of cost and reliability have remained during FP5 and FP6. Cost reduction was and is still a major challenge, although in the 10 years preceding FP5, the cost had been cut by a factor of 10. Reliability and durability became a larger challenge as more systems were tested under real conditions. Multiple demonstrations revealed limitations in durability of technologies that had previously shown encouraging results in labs.

Regulatory challenges are also high: the different activities (Hydrogen production, transport, service stocking,..) are regulated by national legislations that are very disparate throughout Europe. This caused major difficulties for vehicle or stationary FC demonstrations and of course market deployment. The need was to first identify the different regulations and licensing and then to try to gather major stakeholders in a common effort to foster harmonisation.

These challenges were primary to research activities before FP5 and remained basically the same at the end of FP6. One of the main developments relates to expectations, which have become much less positive than at the turn of the century. Most of the stakeholders are now inclined to believe that progress will be from incremental innovations and applications/demonstrations of the early markets, mainly stationary.

It is worthwhile noting that fuel cells are currently being commercialised or at least demonstrated in an increasing numbers of early applications, mainly stationary applications (back-up systems,...) or niche vehicles (fork-lifts,...).

3.3 Cross area analysis

The investigation of challenges and progress in each area have highlighted some important results to be borne in mind before considering the contribution of EC led research to the improvements.

NNE technologies face major challenges that require a mix of sometimes very fundamental research (e.g. basic understanding of processes such as conversion, degradation of performance at material structure level) and a lot of learning by doing and experimentation. Even the most mature areas call for significant basic research, for instance to develop the next generation in parallel to the deployment of early technologies. Although batteries were developed more than a hundred years ago, the scale of new battery technologies for new applications (EV or HEVs, stationary) requires significant basic research as well as tests and demonstration. Likewise, hydropower plants, which have been in use for decades, will soon face the end of life of many plants with maintenance and renewal issues, calling for research to update and maintain competences. Further reductions in cost are needed in photovoltaics in order to become cost-competitive; new generations of biomass conversion techniques have to be developed and proven.

However, most of the areas are empirical and poorly suited to major breakthroughs based on these research activities. Progress is incremental and follows several generations or successive “layers” of research-development-demonstration trajectories. This empirical nature of energy technologies is due to complexity of the problems at stake. To name just a few: several areas involve systemic technologies, such as biomass or smart grids; several technologies cannot be considered in isolation from the complete well-to-wheel pathways (fuel cells, biomass) or life cycle analysis; the fundamental processes at stake can be different according to the stage of scale-up of the
technology (batteries); the impossibility to accurately replicate the conditions of real use (fuel cells and batteries for transport applications, marine energy technologies, etc.).

In the end, considering how the challenges have evolved during the period of FP5 and FP6, it appears that progresses in most areas have been relatively slow. The main challenges at the start of FP5, end of FP5 and end of FP6 remain the same in most areas. When progress was recorded, it was hardly sufficient to allow a significant step forward in terms of technology deployment and market take-off.

Areas are very heterogeneous with regards to their stage of development. Some areas are still at embryonic stage (marine technology, CSS), others have first generation products in early market niches or real-world tests (fuel cells, biomass), or even a growing (wind, solar) or mature (battery, hydropower) market.

Exhibit 2 Lessons learned from context and challenges of NNE research activities

- Although NNE research has been supported from the very start of the FP, FP5 and FP6 activities were carried out under unprecedented demand for efficient, secure and clean energy
- The time scale of development of energy technologies is beyond the time frame of one single FP. In most areas progress is visible over around 10 years, i.e. the time frame of both programmes
- NNE technologies face major challenges that require a mix of very fundamental research and a lot of learning by doing and experimentation
- Areas are at very different stage of development from very embryonic to very mature. However, even the most mature ones have important opportunities
- Challenges in all areas are primarily of a scientific and technological nature. Policy, economic and social challenges are more limited at this stage of development. They relate to regulation and standards issues, acceptability and the development of new business models and concepts for innovative energy systems.
- Progress in most areas has been relatively slow over the period covered by the evaluation. The challenges have remained the same in most areas.
### Exhibit 3  Synthesis of main results per area – context and challenges

<table>
<thead>
<tr>
<th>Relevance of objectives Difference FP5/FP6</th>
<th>Solar energy</th>
<th>Biomass</th>
<th>Other renewables</th>
<th>H2 and Fuel cell</th>
</tr>
</thead>
</table>
| **Clear focus on same relevant challenges in FP5 and FP6:** | •No differences in challenges between FP5 and FP6  
•Project address the main challenges, covering the whole chain from feedstock to end-use products | •A limited number of projects, three different technologies (geothermal, marine, hydropower), cannot address all relevant barriers.  
•Hydropower discontinued because considered as mature although strong importance of the domain (growing risks of decay of aging plants, loss of knowledge and competencies on this technology) | •At the start of FP5 and FP6, same scientific challenges: cost, durability. All projects directly addressing these challenges  
•Political challenges: harmonisation of regulations related to H2, currently hinder demonstration activities and market deployment  
•In FP6, strong expectations generated by optimistic announcements (fuel cells cars especially) |

| Span and focus of FP5 and FP6 activities | •FP5 strong focus on transfer of technology from lab to industry and scale-up of production. FP6 closer to market  
•FP5: many small and focused projects. FP6 larger projects with overall system perspective | •FP5 and FP6 EC-led research activities  
•In FP6, whole value chain included in each project, where as FP5 projects were dealing with one issue at a time  
•More socio-economic research in FP6 | •FP5 and FP6: same focus on cost-effectiveness of technologies  
•FP6 more emphasis on market access  
•Very small budget | •In FP5, given the uncertainties, funding of research on a wide number of key technologies across research, development and demonstration  
•In FP6a bit more focused, some options (reformer in particular) have been abandoned  
•More strategic approach to FC research in FP6. Interaction with HFP Platform for first calls |
### Exhibit 4  Synthesis of main results per area – context and challenges (continued)

<table>
<thead>
<tr>
<th></th>
<th>Energy storage</th>
<th>Wind</th>
<th>CSS</th>
<th>Socio-economic and policy related research theme</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relevance of objectives</strong></td>
<td>Distribution research has political relevance since it is related to liberalisation</td>
<td>FP5 and FP6: Strong consensus that, although most of the product and component development should take place on the industry’s side, there was still a need for basic research to be carried out outside the companies. Main challenges related to the interaction of wind power with the grid and the location of wind turbines in complex terrain.</td>
<td>Fully in line with Kyoto protocol and further European commitment</td>
<td>Dual strategy, with (i) all thematic areas being invited to embed socio-economic elements within what was predominantly technological development; and (ii) a separate SEPR theme which focused on new models, tools and communication activities</td>
</tr>
<tr>
<td><strong>Difference FP5/FP6</strong></td>
<td>The research topics were not that different between FP5 and FP6 – but the way people work together was. FP6 involves only one project on batteries, compared to more than 20 projects in FP5. The FP6 project, however, is bigger in size</td>
<td>31 projects in FP5, 1 IP in FP6. Slump in budget. FP6 large project focus on very large turbines, which is in theory relevant with the European Added value.</td>
<td>Support to clean FF in FP5, especially coal, then more focus on CSS. In FP6, only CSS, real paradigm shift, strong thematic focusing</td>
<td>Both FP5 and 6 SEPR areas were designed to strengthen an integrated and coherent approach to energy research through:</td>
</tr>
<tr>
<td><strong>Span and focus of FP5 and FP6 activities</strong></td>
<td></td>
<td>31 projects in FP5, 1 IP in FP6. Slump in budget. FP6 large project focus on very large turbines, which is in theory relevant with the European Added value.</td>
<td>Support to clean FF in FP5, especially coal, then more focus on CSS. In FP6, only CSS, real paradigm shift, strong thematic focusing</td>
<td>Both FP5 and 6 SEPR areas were designed to strengthen an integrated and coherent approach to energy research through:</td>
</tr>
<tr>
<td></td>
<td>Distribution research has political relevance since it is related to liberalisation</td>
<td></td>
<td>CSS</td>
<td>Socio-economic and policy related research theme</td>
</tr>
<tr>
<td><strong>Difference FP5/FP6</strong></td>
<td>The research topics were not that different between FP5 and FP6 – but the way people work together was. FP6 involves only one project on batteries, compared to more than 20 projects in FP5. The FP6 project, however, is bigger in size</td>
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<td></td>
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<td></td>
<td>Distribution research has political relevance since it is related to liberalisation</td>
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<td>Fully in line with Kyoto protocol and further European commitment</td>
<td>Dual strategy, with (i) all thematic areas being invited to embed socio-economic elements within what was predominantly technological development; and (ii) a separate SEPR theme which focused on new models, tools and communication activities</td>
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</tr>
<tr>
<td><strong>Span and focus of FP5 and FP6 activities</strong></td>
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</tr>
</tbody>
</table>

**EPEC – Evaluation and Impact Assessment of the European NNE RTD Programme**

**Final report**

20
4. Non nuclear energy research activities in the fifth and sixth framework programmes

4.1 Objectives of European NNE Research Programmes: FP5 and FP6

4.1.1 Overall objectives of EU NNE research

The overall objectives of EU NNE research can be split into two connected groups of objectives; the “thematic” and “transversal” objectives.

The general thematic objectives are, in short, to reduce greenhouse gases and pollutant emissions, increase the security of energy supplies, improve energy efficiency and increase the use of renewable energy, as well as enhance the competitiveness of European industry and improving quality of life both within the EU and globally. Despite the different formulations that can be found, the underlying issues are the same: environment concerns related to climate change, the energy security imperative and economic considerations.

The transversal objectives, although here adapted to NNE, can be derived in a similar manner in all FP thematic priorities:

- To support EU policies in energy and sustainable development, through focused and targeted energy research in the Framework Programme.
- To contribute to improve the efficiency of Member States’ research, through the establishment of a European Research Area in energy.
- To prepare for the future, building both upon the experience of the past and upon the anticipation of emerging issues.

These two groups of objectives have remained valid for both FP5 and FP6. The evolution has been in the intensity of the underlying imperative, which has translated into greater emphasis on sustainable energy systems, more targeted research and better coordination of Member States NNE research programmes and policies.

4.1.2 FP5

The strategic goal of the Energy Research Programmes in FP5 was to develop sustainable energy systems and services for Europe and contribute to more sustainability worldwide, leading to increased security and diversity of supply, the provision of high-quality, low-cost energy services, improved industrial competitiveness and reduced environmental impact. A budget of 1,042 M€ was available, distributed over two key actions and some ‘R&D activities of a generic nature’:

- Key action: ‘Cleaner energy systems, including renewables’ (479 M€, under the responsibility of DG RTD, for: Large-scale generation of electricity and/or heat with reduced CO2 emissions from coal, biomass or other fuels, including CHP; Development and demonstration of renewable energy sources, in particular biomass, wind and solar technologies, and of fuel cells;

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18 Cordis website: http://cordis.europa.eu/sustdev/energy/energy.htm
19 As stated in Poireau M., Energy research strategy in the energy sector, Conference on the Future of Energy in Enlarged Europe, Perspectives for R&D Co-operation, Warsaw, 7-8 October 2004
Integration of new and renewable energy sources into energy systems; Cost effective environmental abatement technologies for power production).

- Key action: ‘Economic and efficient energy for a competitive Europe’ (547 M€ under the responsibility of DG TREN, for Technologies for the rational and efficient end use of energy; Technologies for the transmission and distribution of energy; Technologies for the storage of energy on both macro and micro scale; More efficient exploration, extraction and production technologies for hydrocarbons; Improving the efficiency of new and renewable energy sources; The elaboration of scenarios on supply and demand technologies in economy/environment/energy systems and their interaction, and the analysis of the cost effectiveness and efficiency of all energy sources).

- R&D activities of a generic nature (16 M€ to develop and apply tools for assessing and monitoring the socio-economic aspects of energy technologies, systems and services using a ‘technology assessment’ approach at the project level and a ‘global systems analysis’ approach at a much more general level).

4.1.3 FP6

The strategic objectives of FP6 in the NNE area addressed the reduction of greenhouse gases and pollutant emissions, the security of energy supply, the increased use of renewable energy as well as to achieve an enhanced competitiveness of European industry. There were two parts to NNE RTD in FP6:

- Research activities having an impact in the short and medium term (265 M€). These activities were managed by DG TREN in order to bring innovative and cost competitive technological solutions to the market as quickly as possible through demonstration. The areas covered: Clean energy, in particular renewable energy sources and their integration in the energy system, including storage, distribution and use; Energy savings and energy efficiency, including the use of renewable raw materials and Alternative motor fuels.

- Research activities having an impact in the medium and longer term (436 M€). DG RTD led this action with a view to developing new and renewable energy sources, and new carriers. The goal was to foster further reduction in greenhouse gas emissions beyond the deadline of 2010. Research topics were structured as follows: Fuel cells including their applications; New technologies for energy carriers/transport and storage, in particular Hydrogen; New and advanced concepts in renewable energy technologies and Capture and sequestration of CO2, associated with cleaner fossil fuel plants.

4.2 FP 5 and FP6 NNE research budgets

4.2.1 Evolution of FP budgets

The importance of energy research was reflected in the budgets at European level since the founding Treaties (European Coal and Steel Community, European Atomic Energy Community-Euratom and European Economic Community)\textsuperscript{22}. In addition to the attention given to Nuclear energy, energy research has been on the agenda since FP1 and there was a specific programme for non-nuclear energy research in FP2 (Joule programme, 1989-1992, budget 122 M€)\textsuperscript{23}. In FP3, demonstration projects were added (Thermie-programme) and the total budget for NNE activities


\textsuperscript{22} European union energy research, Rossetti Divaldalbero D., Poireau M., et al., Revue Générale de l’Énergie, 576, 2007

\textsuperscript{23} Programme information CORDIS
increased to 567 M€ (1991-1994). In FP4 (1994-1998), the budget was nearly doubled to 1076 M€, and measures to improve market application (SAVE (for improving energy efficiency)), ALTENER (promotion of renewable energy sources) as well as international cooperation (INCO) were implemented.

The budget of the Fifth Framework Programme amounts to 13,700 M€. 1,042 M€ has been allocated to non-nuclear energy projects (7.6% of FP5-budget), of which 480 M€ (46%) came from DG RTD24. The amount of NNE research in FP5 diminished in comparison to FP4, despite the above mentioned policy intentions in the White paper ‘Energy for the future: Renewable sources of Energy’ from 1997. There was however a shift from fossil fuel (and energy saving) RTD, towards RTD in the area of renewable energy (from 45% in FP4 to 75-80% for the DG RTD financed activities in FP5, including Hydrogen and fuel cells.

The Sixth Framework Programme had a total budget of 19,000 M€. 701 M€ were dedicated to non-nuclear energy (436 M€ of which from DG RTD). This represents a serious reduction compared to FP5 both in absolute and relative terms. This trend does not reflect the high ambitions of the 1997 Kyoto Protocol and the 2001 ‘Directive on the promotion of electricity from renewable energy sources in the internal electricity market’. The FP6 research was however almost completely focused on climate neutral energy supply (renewables and CCS).

In FP7, there is a special sub-programme ‘Energy’ within the “Cooperation” programme. The EU Member States and the European Parliament have earmarked a total of 2,350 M€ for funding this theme over the duration of FP7 (now 7 years, compared to 5 years in previous FPs), out of a total budget of 32,413 M€ for the “Cooperation” programme (Exhibit 2).

Exhibit 5: Total R&D expenditure by thematic priority, FP4-FP7 (in M€)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td>358</td>
<td>890</td>
<td>2,255</td>
<td>6,050</td>
</tr>
<tr>
<td>Food</td>
<td>646.5</td>
<td>779</td>
<td>713</td>
<td>1,935</td>
</tr>
<tr>
<td>IST</td>
<td>3,604</td>
<td>3,120</td>
<td>3,745</td>
<td>9,110</td>
</tr>
<tr>
<td>Nanotech</td>
<td>1,906</td>
<td>731</td>
<td>1,479</td>
<td>3,500</td>
</tr>
<tr>
<td>Energy</td>
<td>1,030</td>
<td>1,026</td>
<td>810</td>
<td>2,300</td>
</tr>
<tr>
<td>Environment</td>
<td>566.5</td>
<td>895</td>
<td>773</td>
<td>1,800</td>
</tr>
<tr>
<td>Surface transports</td>
<td>256</td>
<td>691</td>
<td>733</td>
<td>2,000</td>
</tr>
<tr>
<td>Aeronautics</td>
<td>700</td>
<td>924</td>
<td>2,100</td>
<td></td>
</tr>
<tr>
<td>Socio economics</td>
<td>112</td>
<td>165</td>
<td>225</td>
<td>610</td>
</tr>
<tr>
<td>Space</td>
<td>0</td>
<td>237</td>
<td>1,430</td>
<td></td>
</tr>
<tr>
<td>Security</td>
<td>0</td>
<td></td>
<td>1,350</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8,479</td>
<td>8,988</td>
<td>11,894</td>
<td>32,185</td>
</tr>
</tbody>
</table>

Source: European Commission

Despite becoming a policy priority of increasing importance in recent years, the share of NNE research in total the FP research budget has significantly decreased, from 11.4% in FP5 to 6.8% in FP6 (Exhibit 6).

24 Nuclear energy R&D is funded and performed under the Euratom Framework Programme. As a matter of comparison, the EURATOM FP5 and FP6 had a budget of respectively 1,260 million Euro and 1,230 million Euro.
Exhibit 6: Share of NNE R&D FP4-FP7 (in %)

Source: European Commission

4.2.2 Comparison of EC and member states NNE research budgets

Exhibit 7 shows the IEA-estimates of expenditure for public energy research\(^{25}\). On the FP themes, from 1998 to 2007, total expenditure on NNE increased from 350-400 M€ in 1998 and 1999 to almost 1000 M€ in 2007, with continuous attention given to energy efficiency (200-300 M€) and fossil fuels (<100 M€/year until 2002, after 2002 200 M€/year) for these years. During FP5 and FP6, on average 100-125 M€/year was spent on the 8 NNE themes.

The relative importance of EC supported research in the NNE area therefore decreased over the years relative to overall EU effort (from approximately 25% to approximately 15% to 10% according to areas). FP was therefore an important, but not dominant part of financing for NNE research in Europe.

\(^{25}\) IEA statistics are incomplete for many countries and not all data are completely reliable, but the larger the expenditure in a country the more complete and reliable the data. Therefore the absolute figures that are given are rough estimates, but trends are quite reliable.
4.2.3 Budgets per area

In general, EC dedicates about 40% of its NNE research budget to renewables and 55% to other technologies and, finally, 5% to cross-cutting and coordination activities\textsuperscript{26}.

Exhibit 8 shows the distribution of the European Commission DG RTD contribution over the research areas in FP5 and FP6.

\textsuperscript{26} The State and Prospects of European Energy Research Comparison of Commission, Member and Non-Member States’ R&D Portfolios, EUR 22397, 2006.
Solar energy, biomass, clean fossil fuels (including CCS) and Hydrogen and fuel cells are the largest areas in both FP5 and FP6; energy storage is of intermediate size and the other three areas (wind, other sources, socio-economic research) are relatively small. The area Hydrogen and fuel cells alone accounts for 24% of DG RTD resources dedicated to NNE.

Significant changes are apparent in FP5 and FP6 budgets: the EC has reduced funding for clean fossil fuel research in FP6 (witnessing in fact a strong focus on CCS research to the detriment of other clean fossil fuel technologies), the contribution to research in Hydrogen & fuel cells was increased (+48%), as was the research budget for other sources of energy (+71%, however remaining a limited budget in absolute terms). Research budgets for solar energy (-9%) and especially wind energy (-43%) have gone through severe cuts. Research dedicated to the Socio economic research area also decreased significantly. However, priority in FP6 was given to the greater integration of socio-economic research into each of the areas to which it relates. A significant – although unknown – share of projects in the socio-economic area are therefore accounted for in each of the other areas. For instance, in the FC and Hydrogen area, about 9% of the area FP6 budget was dedicated to “pathways and socio-economic analysis”, which is almost as much as the total FP6 budget for the dedicated area Socio economic research.

27 Some projects could not be assigned to a research domain and were removed from the evaluation sample (esp. in FP5, e.g. projects on enhanced oil and gas production from (nearly) depleted fields.
Exhibit 9: Evolution of FP5 and FP6 DG RTD budget by area (M€ and %)

The data presented above in Exhibit 9 only accounts for the DG RTD budget dedicated to NNE research. It does not include DG TREN FP5 and FP6 budget. Moreover, several NNE technologies are transversal to multiple sectors from which they draw materials and components. For instance, in the Hydrogen and fuel cell area, although DG Research was the main contributor, its contribution under the Energy thematic area represented only about 58% of the total EC contribution to this area. DG TREN came second to support short to medium term research, with 18% of the total contribution. Other thematic areas of FP6, especially Transports (including aeronautics) and New material products, represented about 20% of the total EC contribution to Hydrogen and fuel cells. In total, the FP5 and FP6 budget dedicated to Hydrogen and fuel cell research amounted respectively to €145m and €300m (as compared to €70m and €104m respectively within the scope of this evaluation).

It should be noticed that the average budget per participants has significantly increased from FP5 to FP6 in all areas but “other sources of renewables” (Exhibit 10). This average budget greatly varied according to areas, from 346,824€ in wind (where only one project was funded) to 97,227€ in the socio-economic area.

Exhibit 10: Participants and average budget per participants by research area in FP5 and FP6

<table>
<thead>
<tr>
<th></th>
<th># Participants</th>
<th>Average budget per participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FP5</td>
<td>FP6</td>
</tr>
<tr>
<td>Solar</td>
<td>625</td>
<td>127</td>
</tr>
<tr>
<td>Wind</td>
<td>222</td>
<td>14</td>
</tr>
<tr>
<td>Biomass</td>
<td>522</td>
<td>289</td>
</tr>
<tr>
<td>Other sources</td>
<td>80</td>
<td>161</td>
</tr>
<tr>
<td>Clean Fossil &amp; CCS</td>
<td>745</td>
<td>317</td>
</tr>
<tr>
<td>Storage &amp; distribution</td>
<td>455</td>
<td>226</td>
</tr>
<tr>
<td>Socio economic research</td>
<td>399</td>
<td>127</td>
</tr>
<tr>
<td>H2 &amp; fuel cells</td>
<td>486</td>
<td>512</td>
</tr>
<tr>
<td>Total</td>
<td>3534</td>
<td>1935</td>
</tr>
</tbody>
</table>

*Source*: European Commission

The share of EC contribution in total eligible costs has also experienced a noticeable increase from FP5 to FP6 (Exhibit 11). In average this share of EC contribution if about 60% of total eligible costs, except in “other sources of renewables” in which it is about 30%.

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28 Some projects could not be assigned to a research domain and where removed from the evaluation sample (esp. in FP5, e.g. projects on enhanced oil and gas production from (nearly) depleted fields
Exhibit 11  Share of EC contribution in total eligible costs, FP5 and FP6, by area

<table>
<thead>
<tr>
<th>Area</th>
<th>Total EC funding (in m€)</th>
<th>Total eligible costs (in m€)</th>
<th>Share of EC contrib.</th>
<th>Total EC funding (in m€)</th>
<th>Total eligible costs (in m€)</th>
<th>Share of EC contrib.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>83.8</td>
<td>154.7</td>
<td>54%</td>
<td>76.1</td>
<td>131.8</td>
<td>58%</td>
</tr>
<tr>
<td>Wind</td>
<td>25.5</td>
<td>45.6</td>
<td>56%</td>
<td>14.6</td>
<td>22.6</td>
<td>64%</td>
</tr>
<tr>
<td>Biomass</td>
<td>64.0</td>
<td>111.4</td>
<td>57%</td>
<td>84.0</td>
<td>132.7</td>
<td>63%</td>
</tr>
<tr>
<td>Other sources</td>
<td>13.3</td>
<td>36.9</td>
<td>36%</td>
<td>22.7</td>
<td>69.4</td>
<td>33%</td>
</tr>
<tr>
<td>Clean Fossil &amp; CCS</td>
<td>99.9</td>
<td>178.6</td>
<td>56%</td>
<td>69.5</td>
<td>130.7</td>
<td>53%</td>
</tr>
<tr>
<td>Storage &amp; distribution</td>
<td>65.9</td>
<td>126.2</td>
<td>52%</td>
<td>51.3</td>
<td>85.2</td>
<td>60%</td>
</tr>
<tr>
<td>Socio economic research</td>
<td>21.0</td>
<td>33.8</td>
<td>62%</td>
<td>12.1</td>
<td>17.9</td>
<td>68%</td>
</tr>
<tr>
<td>H2 &amp; fuel cells</td>
<td>70.3</td>
<td>128.8</td>
<td>55%</td>
<td>104.1</td>
<td>188.5</td>
<td>55%</td>
</tr>
<tr>
<td>Total</td>
<td>443.7</td>
<td>815.9</td>
<td>54%</td>
<td>434.4</td>
<td>778.7</td>
<td>56%</td>
</tr>
</tbody>
</table>

Source: European Commission

4.2.4 Determinants of NNE budgets by area and underlying logic

It is unclear how the division of the total FP budget was made between the various research domains. Interviews with EC officers tend to show that the maturity of technology, the existence of a market for this technology, and their anticipated progress (both CO2 reduction potential as well as industrial potential) played an important role in determining the respective research budgets of areas.

The Exhibit 12 tends to confirm this statement. In general embryonic technologies with high potential are well funded and more mature technologies are supported to a more modest extent. However, the existence of a market for early generations (e.g. solar, wind) or a mature market for traditional technologies (e.g. batteries, hydropower) pushes toward budget decrease. An exception is biomass where, although the technology maturity of early generations is fairly high and market for early applications and niches exist, the support is high (and increased between FP5 and FP6).

To a great extent, the trends of EC contribution to different areas between FP5 and FP6 has followed that of leading European and third countries. For instance, the decrease in budgets for energy storage can be explained by a diminished battery research: at this time fuel cells were considered a more realistic alternative, and research in that area increased.
Two issues can be highlighted at this stage:

- The rationale for budget cuts and raises remain unclear and should be made more transparent. The rationales provided by EC officers appeared more as an excuse to cut budgets in a context of decreasing overall funding than real decisions based on an assessment of strategic opportunities.

- The rationales regarding the maturity of the technology and existence of early markets can in some instances be misleading. As claimed earlier, NNE technologies evolve by successive generations of technology. Hence, the deployment of the first generations of technologies does not exclude the need for basic research, focusing on next generation and longer term options. In most cases, the potential for CO2 reduction and increased energy efficiency of the first “mature” generations are low. Moreover, in the NNE domain in particular, as early markets are often not well established on a solid and profitable business model, it is doubtful that the revenues raised on the deployment of the first generations of technologies will be sufficient for companies to invest massively in the next generations, where technical feasibility and increased market potential are still uncertain.
Exhibit 13  Lessons learned from the analysis of FP5 and FP6 NNE budgets

- At a general level, EU NNE research aims to respond to environment concerns related to climate change, the energy security imperative and economic considerations. The objectives have remained similar in FP5 and FP6.
- The increased importance of sustainable energy for energy policy was reflected in increased relative importance of renewable energy sources and CO2 low fossil fuels in the energy research portfolio (of DG RTD) compared to fossil fuel research.
- The budget for NNE research in FP6 diminished in both relative and absolute terms in comparison to FP5 and FP4, despite the policy intentions (White paper on energy for the future, Directives on renewables, Kyoto protocol,...).
- The relative importance of EC supported research in the NNE area decreased over the years, relative to overall EU effort (from approximately 25% to approximately 15% to 10% according to areas).
- Significant changes are apparent in FP5 and FP6 budgets: the EC has reduced funding for clean fossil fuel (-30 %), solar energy (-9 %), and especially wind energy (-43 %), while the contribution to research in Hydrogen & fuel cells was increased (+48%).
- It is unclear how the division of the total FP budget was made between the various research domains. Apparent determinants are: maturity of technology, existence of a market for the technology and anticipated progress.
- The rationale for budget cuts and raises remain unclear and should be made more transparent. The rationales provided by EC officers appeared more as an excuse to cut budgets in a context of decreasing overall funding than real decisions based on an assessment of strategic opportunities.
- The rationales regarding the maturity of the technology and existence of early markets can in some instances be misleading. It should not be used to cut budgets in a context of overall reduced funding.
- The scope of the evaluation does not cover the whole range of EC efforts dedicated to NNE research. Beside DG TREN budgets, there are also projects funded under other FP thematic programmes (transports, etc). Other budgets can be found in Marie Curie actions, ERA-Nets that do not fall under the scope of this evaluation.

4.3 Structure and composition of EC-led NNE research activities

4.3.1 Participation, participants and projects

In FP5, the 444 NNE (DG RTD) research projects were implemented by roughly 2,273 distinct legal entities, which together represented the 3,534 funded participations. In FP6, the 119 projects included 1,276 legal entities for 1,935 funded participations. Hence, the number of participations and the estimated number of participants fell by about 45% in FP6 in comparison with FP5 figures. This dramatic change is due to the introduction of new instruments, Integrated Projects and NoEs (discussed later in this section).

Exhibit 14 draws a comparison between number of participations and number of participants in FP5 and FP6 for each of the research areas. The average number of participations by project has at least doubled in all areas, reflecting the larger size of projects in FP6. This average is rather homogenous across areas, between 13 (solar) to 21 (socio economics) participations by project, the wind area aside (in FP6, there was only one project in this area, with 42 participations).
More than 80% of participants are involved in one area only, 10% in two areas and 10% in more than two areas (mainly multi-thematic national research centres such as CNRS or Fraunhofer). However, available data does not allow for deeper analysis, as the exact participating entity (laboratory, team) within these large national research centres is not available.

### 4.3.2 Type of participants

The composition of consortia has also significantly changed between FP5 and FP6 (Exhibit 15). There was a marked increase in research centres participations from FP5 (31%) to FP6 (39%). However, participations from industry decreased more notably from 42% to 31%. This slump of industry participation is less pronounced in value (i.e. in terms of EC contribution they received), although still significant: going from 36% to 28%.

The decrease in industry participation can be observed in almost all research areas (Exhibit 16). The greatest reductions were in Other sources of renewables and clean fossil fuel.
Interviews conducted in this evaluation, supported by evidence drawn from national studies in Sweden, Ireland and the Netherlands, show that industry participants have had difficulties with the increasing project complexity and administrative requirements between FP5 and FP6 (and therefore have a lower tendency to participate as project coordinator), the size and span of projects, which required that they team up with competitors, as well as the low rate of success in tenders (leading to decreasing input). This crucial issue will be dealt with later in the report.
4.3.3 Projects funding profiles

As noted above, the introduction of new instruments in FP6 have had a tremendous impact on research activities. Not only were the IPs and NoEs aimed at combining the critical mass of activities and resources needed to achieve ambitious, clearly defined scientific and technological objectives (IPs) and strengthen excellence on a research topic (NoEs), they were also expected to improve the coordination of activities within the extended scope of the project, which was assumed to be easier to achieve within a given large project, than across several more modest projects as was the case in prior FPs, including FP5. Finally, in compliance with FP6 overall objectives, these IPs and NoEs were also aimed at structuring the ERA, overall and in each particular (sub-)area. The extent to which these distinct effects were actually achieved is considered in the chapter on scientific achievements.

Exhibit 17 and Exhibit 18 confirm that the average project size in terms of budget and number of participants increased from FP5 to FP6 to a large extent because of the introduction of the new large instruments. In average, IPs included >25 participants, the largest one having 66 participants. However, the more traditional projects increased in size as well.

In FP5, total eligible costs of shared-cost actions were covered up to 50% by EC funding, and EC funding covers over 75% of the cost of the other FP5 instruments (Exhibit 17). Similarly Exhibit 18 reveals that in FP6, EC funding represents over 50% of total eligible costs of Integrated Projects (IP) and Specific Targeted Research Projects (STREP), as well as over 72% of eligible costs of the other FP6 instruments.

Exhibit 17: Funding profiles in FP5 instruments, in m€ and # of projects

<table>
<thead>
<tr>
<th></th>
<th>Average Funding (in m€)</th>
<th>Maximum Funding (in m€)</th>
<th>Average Consortium</th>
<th>Maximum Consortium</th>
<th>Total EC funding (in m€)</th>
<th>Total eligible costs (in m€)</th>
<th>Number of projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared-cost actions</td>
<td>1,18</td>
<td>9,47</td>
<td>7,2</td>
<td>41</td>
<td>453,18</td>
<td>849,94</td>
<td>384</td>
</tr>
<tr>
<td>Support to networks</td>
<td>0,96</td>
<td>2,07</td>
<td>29,2</td>
<td>57</td>
<td>16,32</td>
<td>20,07</td>
<td>17</td>
</tr>
<tr>
<td>Accompanying measures</td>
<td>0,26</td>
<td>1,80</td>
<td>4,7</td>
<td>18</td>
<td>12,18</td>
<td>16,19</td>
<td>47</td>
</tr>
<tr>
<td>Fellowships</td>
<td>0,13</td>
<td>0,24</td>
<td>1,0</td>
<td>1</td>
<td>2,92</td>
<td>2,92</td>
<td>23</td>
</tr>
<tr>
<td>Coordination actions</td>
<td>0,26</td>
<td>0,26</td>
<td>17,0</td>
<td>17</td>
<td>0,26</td>
<td>0,33</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>484,86</strong></td>
<td><strong>889,45</strong></td>
<td></td>
<td></td>
<td><strong>472</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Technopolis analysis based on EC database
Exhibit 18: Funding profiles in FP6 instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Average Funding</th>
<th>Maximum Funding</th>
<th>Average Consortium</th>
<th>Maximum consortium</th>
<th>Total EC funding</th>
<th>Total eligible costs</th>
<th>Number of projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Projects (IP)</td>
<td>8,28</td>
<td>16,00</td>
<td>25.8</td>
<td>66</td>
<td>264,99</td>
<td>472,99</td>
<td>32</td>
</tr>
<tr>
<td>Specific targeted research projects (STREP)</td>
<td>2,09</td>
<td>5,00</td>
<td>11.3</td>
<td>31</td>
<td>116,77</td>
<td>236,93</td>
<td>56</td>
</tr>
<tr>
<td>Networks of excellence (NOE)</td>
<td>5,86</td>
<td>8,00</td>
<td>14.8</td>
<td>26</td>
<td>29,30</td>
<td>49,43</td>
<td>5</td>
</tr>
<tr>
<td>Coordination actions (CA)</td>
<td>1,13</td>
<td>2,30</td>
<td>20.1</td>
<td>47</td>
<td>17,02</td>
<td>19,90</td>
<td>15</td>
</tr>
<tr>
<td>Specific support actions (SSA)</td>
<td>0,57</td>
<td>2,38</td>
<td>7.1</td>
<td>16</td>
<td>6,28</td>
<td>8,46</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>434,36</strong></td>
<td><strong>778,71</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>119</strong></td>
</tr>
</tbody>
</table>

Source: Technopolis analysis based on EC database

The weight of the different instruments varies according to area (Exhibit 19). IPs received the bulk of funding in all areas, especially in socio-economics and CCS and Hydrogen and fuel cells (above 80% of EC contribution in each of these three areas). They represent only about 20% to 40% of the number of projects in each area, due to their large size.

Exhibit 19: Share of EC funding according to instruments, per area, FP6, in %

<table>
<thead>
<tr>
<th>Instrument</th>
<th>CA</th>
<th>IP</th>
<th>NOE</th>
<th>SSA</th>
<th>STP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>5.1</td>
<td>70.3</td>
<td>0.0</td>
<td>0.0</td>
<td>24.7</td>
</tr>
<tr>
<td>Wind</td>
<td>0.0</td>
<td>100.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Biomass</td>
<td>1.9</td>
<td>75.1</td>
<td>4.7</td>
<td>0.1</td>
<td>18.3</td>
</tr>
<tr>
<td>Other sources</td>
<td>50.7</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>49.3</td>
</tr>
<tr>
<td>Clean Fossil &amp; CCS</td>
<td>0.2</td>
<td>84.9</td>
<td>5.1</td>
<td>0.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Storage &amp; distribution</td>
<td>6.6</td>
<td>63.3</td>
<td>9.0</td>
<td>5.1</td>
<td>16.0</td>
</tr>
<tr>
<td>Socio economic</td>
<td>6.3</td>
<td>88.5</td>
<td>0.0</td>
<td>0.0</td>
<td>5.3</td>
</tr>
<tr>
<td>Hydrogen &amp; fuel cells</td>
<td>1.0</td>
<td>80.8</td>
<td>7.4</td>
<td>0.9</td>
<td>9.9</td>
</tr>
</tbody>
</table>

Source: Technopolis analysis based on EC database

4.3.4 Geographical distribution of participation

In FP5, 87% of participations came from the EU15, with participations from New Member States and Associated States, each almost reaching 6%. In FP6, EU15 participation dropped to 76%. With New member States and Associated States both participating at almost 9%, with ICPCs (International Cooperation Partners Countries) accounting for 4.5%, while Third countries and the JRC participate for less than 1%.

Exhibit 20 and Exhibit 21 displays collaboration patterns between countries in FP5 and in FP6 projects. A comparison between the two figures shows:

- In FP5, Germany, France, Spain, Italy and Denmark composed the core group. New member states and ICPC were weakly represented and the distance between them indicates they were not involved in the same projects.
• In FP6, France and Germany notably increased their positions in the energy theme and participation of new member states increased significantly. The number of countries involved in FP6 increased overall, in particular the number of ICPC. China increased its collaborations, mainly with EU15 countries.

• New member states mainly collaborated with other new member states both in FP5 and FP6; nevertheless one can observe increasing collaboration with other EU countries and the remarkable level of collaboration of Poland placed among the key collaborating countries in FP6.

• Other countries such as the United States or Canada (that do not benefit from EU funding but can participate in FP projects) collaborated mainly with EU15 countries during FP5 and also collaborated with each other in FP6 projects.

Exhibit 20: Collaboration between countries in FP5 projects

Source: Technopolis analysis based on EC data
The structure of country leadership as measured by the share of EC contribution has remained rather stable overall. Germany and France have ranked first and second in FP5 and FP6, with 22% and 12% respectively of funding in both programmes. The UK has taken over from the Netherlands in third place. Poland is ranked first for the New member states in FP5 and FP6, and its share, although still modest (1,6% of FP6 EC funding) has doubled from FP5 to FP6. For ICPCs/third countries, China ranks second in FP6, although it was barely present in FP5.

Exhibit 22  
Country ranking and % of EC funding, FP and FP6

<table>
<thead>
<tr>
<th>Country ranking</th>
<th>%</th>
<th>Country ranking</th>
<th>%</th>
<th>Country ranking</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU 15 or associated states</td>
<td></td>
<td>New member states</td>
<td></td>
<td>ICPC</td>
<td></td>
</tr>
<tr>
<td>FP5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-DE</td>
<td>22,12%</td>
<td>1-PL</td>
<td>0,90%</td>
<td>1-UA</td>
<td>0,02%</td>
</tr>
<tr>
<td>2-FR</td>
<td>12,12%</td>
<td>2-HU</td>
<td>0,30%</td>
<td>2-EG</td>
<td>0,01%</td>
</tr>
<tr>
<td>3-UK</td>
<td>10,99%</td>
<td>3-SI</td>
<td>0,30%</td>
<td>3-TN</td>
<td>0,01%</td>
</tr>
<tr>
<td>FP6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-DE</td>
<td>22,83%</td>
<td>1-PL</td>
<td>1,60%</td>
<td>1-RU</td>
<td>0,60%</td>
</tr>
<tr>
<td>2-FR</td>
<td>11,77%</td>
<td>2-CZ</td>
<td>0,40%</td>
<td>2-CN</td>
<td>0,60%</td>
</tr>
<tr>
<td>3-NL</td>
<td>11,06%</td>
<td>3-HU</td>
<td>0,40%</td>
<td>3-ZA</td>
<td>0,10%</td>
</tr>
</tbody>
</table>

Source: Technopolis analysis based on EC data
Germany, France, UK and the Netherlands are among the three leaders in each area in FP5 and FP6 (see Annexe C). They are joined or replaced by other countries according to national comparative advantages such as Solar in Spain and Wind in Denmark. The structure of leadership remained stable from FP5 to FP6, at least two of the leading countries in FP5 were also among the three leaders in FP6, in all areas.

The concentration is high since the three leading countries account for 45% of EC contribution in both FP5 and FP6. In certain areas, this share is even higher, as in energy storage in FP5 (58%), other sources of renewables in FP5 (68%) and wind in FP6 (66%).

**Exhibit 23 Lessons learned from the analysis of the structure of partnerships**

- The average number of participations by project has at least doubled in all areas, reflecting the larger size of projects in FP6
- There was a strong increase in research centre participations from FP5 (31%) to FP6 (39%). The decrease in industry participation can be observed in almost all research areas
- IPs have received the bulk of funding in all areas, especially in socio-economics and CCS and Hydrogen and fuel cells (above 80% of EC contribution in each of these three areas)
- The share of participation of EU15 countries dropped from 87% in FP5 to 76% in FP6, while the share of New Member States and Associated States increased to about 6% each. In FP6, the EU15 participation dropped to 76%
- The structure of country leadership as measured by the share of EC contribution has remained stable overall. Germany, France, UK and the Netherlands are among the three leaders in each area in FP5 and FP6
5. Scientific achievements

5.1 Outputs and results of FP5 and FP6 NNE projects

5.1.1 Outputs and results at programme level

Numerous scientific and technological outputs were found in all projects in various forms, including contributions to conferences, seminars and other events; new or improved tools, methods or techniques; publications in refereed journals or books; other publications; newly qualified personnel (MSc, PhD, etc.) and new or improved models and simulations. This result was backed by evidence in the survey and interviews.

Exhibit 24 shows the results from the survey regarding outputs. The most commonly reported outputs were ‘conferences, seminars and other events’, new or improved tools, methods or techniques and different types of publications (whether in refereed journals or not). Although this is true for most areas, there are strong differences in the share of people actually reporting such results. For example in solar energy 97% of respondents report ‘conferences, seminars and other events’ as a direct result of their project, as compared to 73% of respondents in the clean fossil fuel and CCS area.

FP5 respondents report c. 20-30% more of most outputs, in proportionate terms. In particular, publications in refereed journals (85% to 74%) and new or improved demonstrators, prototypes or pilots (65% to 52%) stand out as much more frequently occurring in FP5. This difference can be attributed to the timeframes: outputs can take quite some time to be produced also, most publications and patents are produced at the end of the projects, if not after the projects. However, the interviews conducted provide alternative explanations:

- The participants in large projects, which as it was shown earlier account for the bulk of resources allocated to NNE research in FP6, appeared to be not well informed about the outputs and results of their projects. Their visibility is reduced to their immediate project environment (i.e. the work package or even task in which they are involved). Even the coordinators interviewed were sometimes not aware of all the developments in their projects. In STREPS, the partners in a given projects seemed much closer involved and proved to be more aware of what was produced even by other partners, not only after the project end but also during the project.
- The size of the projects have in some cases hindered the project effectiveness, as it was claimed by several interviewees and survey respondents in open comments. This issue is discussed more in-depth later in this section.

The scientific excellence and quality of these outputs cannot be assessed in this evaluation. Such assessment would require a peer review.

The specificities of each area are provided in a dedicated section.
Exhibit 24: Outputs produced by the individual or their organisation

<table>
<thead>
<tr>
<th>Outputs</th>
<th>Produced</th>
<th>Not produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conferences, seminars and other events</td>
<td>88%</td>
<td>12%</td>
</tr>
<tr>
<td>New or improved tools, methods or techniques</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>Other publications</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>Publications in refereed journals or books</td>
<td>77%</td>
<td>23%</td>
</tr>
<tr>
<td>Newly qualified personnel (e.g. MSc, PhD, etc)</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>New or improved models and simulations</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>New R&amp;D strategy</td>
<td>63%</td>
<td>37%</td>
</tr>
<tr>
<td>New or improved processes</td>
<td>56%</td>
<td>44%</td>
</tr>
<tr>
<td>New or improved demonstrators, prototypes, pilots</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>New jobs</td>
<td>46%</td>
<td>54%</td>
</tr>
<tr>
<td>New or improved products</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>New or improved services</td>
<td>42%</td>
<td>58%</td>
</tr>
<tr>
<td>Software or codes</td>
<td>31%</td>
<td>69%</td>
</tr>
<tr>
<td>New or improved norms or standards</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>Patent applications</td>
<td>24%</td>
<td>76%</td>
</tr>
<tr>
<td>Copyrights</td>
<td>20%</td>
<td>80%</td>
</tr>
<tr>
<td>Spin-off companies</td>
<td>7%</td>
<td>93%</td>
</tr>
<tr>
<td>Licenses sold</td>
<td>7%</td>
<td>93%</td>
</tr>
<tr>
<td>Other outputs</td>
<td>30%</td>
<td>70%</td>
</tr>
</tbody>
</table>

Source: Technopolis survey

Note: n varies between 384 and 424

Based on survey results, it has been possible to calculate the average number of each output produced by the respondents, as well as an estimate of the programmes total output\(^{31}\). On average, participants declared 2.7 conferences and other events, and 2.1 publications in refereed journals. For each MC research, 7 publications in refereed journals are estimated. This is not high compared to some national programmes (e.g. ESPRC in the UK: 28; VIB in Flanders: 11; LTIs in the Netherlands: 10).\(^ {32}\)

The estimated average number of outputs per participant (based on responses) has fallen slightly overall from FP5 to FP6, but the difference remains minimal for most outputs. Noticeable differences are in publications again (2.5 in FP5 against 2.0 in FP6) newly qualified personnel (2.0 in FP5 against 1.5 in FP6), as well as demonstrators and prototypes (1.6 in FP5 against 1.0 in FP6). There also appears to have been little change between Framework Programmes in the relative incidence of different outputs, with the most common outputs in FP5 continuing to dominate in FP6 NNE projects.

The most important scientific impact on the individual researcher is enhanced knowledge. 99% of all respondents report this effect (of which 52% report a high impact). Other important impacts are enhanced skills, new or enhanced links to EU contacts, enhanced reputation and image, and access to complementary expertise (see Exhibit 25).

\(^{31}\) For those respondents reporting a particular output having been produced, they were further asked to estimate the number in each case. Respondents could select from 1, 2, 3, 4 and 5+. In the few cases where 5+ was selected, a count of 5 was used as a conservative estimate in following calculations. The majority were able to provide an estimate.

\(^{32}\) Evaluation of STW (The Netherlands), 2006; Evaluation of LTI programme The Netherlands, 2006; Evaluation of VIB (Flanders), 2006; which also include benchmarks with a number of other international programmes and institutes.
In addition to effects on the individual researcher, effects on the researchers organisation were also questioned in this survey: Enhanced cooperation with partners in EU countries (71%) and enhanced reputation and image (66%) stand out, with over two-thirds of respondents sighting their project as having had either a medium or large impact in these two areas. Overall, one-third of respondents (35%) believed that the impacts of the project on them as an individual had been greater than expected. This compares favourably to the 10% who believed that the impacts had been less than expected.

An independent assessment of the FP research scientific quality (e.g. bibliometric analysis, peer review) was not a part of this evaluation. The participants themselves in general state that FP research produced scientific outputs of high quality.

5.1.2 Outputs and results by area

The profile of outputs is more differentiated at the area level. However, all themes with the exception of socio-economic research have recorded significant numbers of all types of output.

Solar energy records significantly higher than average outputs across almost all types of benefit:
- Wind research was ‘top’ for the production of new tools, models, software, patents and licenses
- Solar research was particularly strong on events, newly qualified people and new jobs
- Biomass research was strong on events, publications and new jobs
- Clean fuels research was strongest on improved processes, models and codes

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33 Interview results
• Energy storage and Hydrogen broadly track the average
• Socio-economic research is strong on new models, publications and events, but respondents reported below average commercial outputs within this theme.
• In Hydrogen and FC, only 29% of respondents declare that outputs were greater than expected. More generally, respondents in this area report the lowest levels of outputs and results.

A closer look at the survey results and a cross analysis of interviews allow for finer area level assessment of outputs at area level.

5.1.2.1 Solar energy

There is little doubt that solar energy is one of the areas where the most significant results were achieved.

In the survey, reported outputs by project participants were far above the all-NNE areas average. For instance, 94% of the respondents in the area claimed that the projects resulted in new or improved tools, methods or techniques, while the all-area average is “only” 83%. This difference translates into important gaps in the number of outputs produced. According to this estimation, the area alone contributed to the organisation of over 3000 events.

The interviews have shown that the main challenges related to efficiency and production costs have been addressed and achieved. Examples are 14.4% efficiency for a poly Si cell in the FP6 Athlet project (state of the art was 9% at the start of the project, target for 2010 is 15%), a 19% cell efficiency for inline deposition of CIS thin film cells (in the Larcis project) and the rapid thermal processing that was developed in the Flash project and that decreased production costs by 10%. In the CSP-area the PS10 project (FP5) resulted in an 11 MW central receiver system near Seville in Spain. With this project, it was demonstrated that that high temperature ST power plants can work.

Some projects did not achieve their ‘industrial’ goals, but developed relevant knowledge. For example, for amorphous Si the state-of-the-art at the beginning of the project was 9%. The aim was to reach 14%, but this goal was too ambitious, according to one of the main research partners interviewed, and could not be achieved. However, the project is not considered to be a failure by partners, as crucial knowledge was gained about the different layers of the cell a-Si cell and how to optimize these layers.

Together with the efforts in national programmes, the FP projects contributed to the improvement of the European competitive position in the area of solar research. At around the start of FP5 ten years ago, the US was generally considered to be way ahead in the field of triple-junction GaAs solar cells and Japan was ahead in thin solar cells. European research (and related manufacturing) organisations can now compete at world-class level.

5.1.2.2 Wind energy

The survey also recorded higher than average outputs across almost all types of benefit for Wind energy projects, although the gap is less than in solar energy. The most significant scientific output is the production of new or improved tools, methods and techniques (mentioned by 94% of respondents), while conferences and events are lower than in several areas (mentioned by 88% of respondents).

Although the main challenges in the area of wind energy now are in the same fields as they were at the beginning of FP5, progress has been steady. New models were developed for windflow along the blades; more knowledge was obtained on aerodynamic stability; new, improved, models were developed for wind forecasting; etc. As a result it has been possible to shift focus from research on 3-5 MW turbines to 8-10 MW turbines.
FP budgets have also been important to maintain national expertise in countries with a limited focus on wind energy (e.g. Greece and Sweden).

5.1.2.3 Biomass

The level of results reported by respondents in the area is slightly above the average for most scientific outputs.

FPs have clearly contributed to the overall scientific progress in biomass energy in the last 10 years. It is however not possible to precisely link project findings and results to the overall scientific progress. Projects in FP5 and FP6 have permitted scientific progress in several technical domains such as the improvement in combustion (use of low fuel qualities at the same time as an increase in the electric efficiency), improvement in fuel flexibility, improvement in gasification and gas cleaning. At the end of FP6, several questions remain for the feedstock production (lignocellulosic feedstocks, fuel crops production) and conversion pathways (slagging and fouling are still a problem; liquid biofuel production must be embedded in an infrastructure).

Most research is application oriented (e.g. in FP5 2/3d of the projects were focusing on conversion processes) and the next phase should be demonstration. Fundamentally new (breakthrough) technologies were not developed.

5.1.2.4 Other sources of renewable energy

As it was shown earlier, the area of other renewable energy sources is very small area in terms of both number of projects and funding compared to the other areas. It is also quite diverse since it incorporates marine energy, geothermal energy and hydropower which diverge greatly in terms of research needs and sector barriers.

The contribution of European money into the projects was relatively low compared to EC contributions to projects in other NNE areas. It will therefore not come as a surprise that impact is limited and more of an incidental nature. As in most other areas, the progress towards cost-reduction objectives have been limited: marine energy and Enhanced Geothermal Systems are beyond the acceptable cost.

In the survey, the level of outputs reported is lower than the average. Still it should be noted that 52% of respondents declared that outputs from their projects were greater than expected. This is the highest level of all areas (33% in average). This conjunction of a relatively low level of output while still higher than expected by individual participants might indicate sub-areas that are still not very structured and do not yet receive much attention. The level of expectations was low, which allowed for pleasant surprises.

More precise results are observed at sub-area level. The positive results are limited to marine and geothermal energy research projects. Impacts from hydropower projects have been especially low.

In marine energy, the main technological barriers have to do with designing marine energy devices robust enough to withstand the excessive forces and loads experienced while operating in the rough oceanic environment. Results are more in the technological domain than in the ‘high science’ domain, and the main impact is enhanced knowledge (e.g. the Wavedragon, see below).
The Wavedragon project (the Wavedragon is a floating, slack-moored energy converter – a device designed to convert energy from waves into electricity which is loosely secured to the sea bottom) was successful in the sense that the outcome of the project in FP5 led to a greater understanding of how a floating barge behaves in different sea conditions. Knowledge gained from both projects has contributed to applications for other technologies as well as integration of wind and wave energy, which would otherwise be based on assumptions rather than on empirical evidence. It has led to former Wavedragon partners to be involved in efforts to set up standards (IEA), and writing a position paper for the IPCC. Research done in the Wavedragon project has allowed for scaling up of the device, which plays a major role in reducing costs. In addition, a lot was learned about going from tank setting to real sea environment testing. This knowledge is now being used in consulting for other firms operating in marine energy during their testing phases. A prototype of the Wavedragon was installed in 2003 off the coast of Denmark and plans are to start a project in Portugal in 2009.

Exchange between initiatives is an important effect of FP: The six projects in geothermal energy financed by DG RTD also led to more practical knowledge about the use of geothermal energy.

Hydropower research in FP has been so small (2 projects in FP5 (of which no information is available) and one in FP6) that only very limited effects can be identified. The (university) knowledge in this area in Europe might become sub-critical, although a Swedish national programme (Swedish companies are leading in the world in this area) has recently started to (re)build more fundamental knowledge in this domain.

5.1.2.5 Clean Fossil fuels and CO2 Capture and Storage

The survey shows that the percentage of projects resulting in a direct output was slightly higher than average for most categories. It is worthwhile noticing that the two categories that are more widely reported by respondents are “New or improved tools, methods or techniques” and “New or improved models and simulations”. This clearly indicates that infratechnologies are especially important in this area and that projects were successful in developing such elements. For example, in the field of circulating fluidised bed combustion systems the CFB-Combustors project has provided important data and has confirmed the accuracy of simulated models. The results help operators to run their plants more effectively and encourage manufacturers to design and build larger units to compete with more traditional power-generation technologies.

The main research activities under FP5 related to improving existing clean fossil fuels technologies. Projects contributed to an increase in the efficiency of fossil fuel combustion and a decrease in emissions. Knowledge was developed on e.g. new materials (making more efficient higher temperature cycles possible), new processes (e.g. fluidised bed combustion), corrosion mechanisms (making diversified feedstock, e.g. biomass, possible) and turbine technology.

In the second half of FP5, the emphasis was increasingly on Carbon Capture and Storage. Under FP6, the focus was exclusively on CCS. Under both FP5 and FP6, considerable progress has been made in terms of scientific and technological development. Significant development has been achieved in the area of capture technologies. Post-combustion capture can now be considered technologically mature, and oxyfuel combustion is in the demonstration phase.

There is little doubt that the European Commission has played a significant role in pushing CCS across Europe. Apart from the early adopters Norway and the Netherlands, few countries had national CCS funding programmes at the beginning of FP6. During FP6, many countries like Germany, France and Spain set up their own programmes. As a result EU researchers are leading the field in this area.

5.1.2.6 Energy Storage and distribution

A large proportion (about 40%) of FP5 research projects in the area of energy storage and distribution focused on batteries. More than half of the projects focusing on batteries were
coordinated by industry. About one third of the FP5 projects concerned issues affecting infrastructure (including ICT), microgrids and distributed generation. Some five or six projects can be classified as concerning energy storage on a more general level, and a few projects cover issues such as electric vehicles and transport.

In FP6, interest has decidedly turned to infrastructure (including ICT), microgrids and distributed generation. With the exception of two or three, all FP6 projects deal with these issues. It has been noted before that the relative importance of industry has decreased in FP6 projects in this area in general, counted as number of participations. This does not hold true for projects concerning infrastructure (including ICT), microgrids and distributed generation. FP6 involves only one project on batteries.

In battery research there have been no great breakthroughs, but rather a situation where existing competences have improved through collaboration. The research has focused on systems and testing, hence more applied science. The arrival of nanotechnologies over the last few years has opened up a new field of research, and development is now rapidly proceeding in that field. Superlions (micro batteries in electronic systems) constitute another example of developments in the area.

The technical necessity for refurbishing existing and constructing new generation facilities in the EU member states led to two innovation strategies: the development of large renewable energy generation systems such as e.g. large wind parks on the one hand, and the development of distributed generation facilities on the other. Both these objectives have received a lot of attention, and substantial progress can be reported in both fields. Many technological innovations and demonstration programmes have been successfully completed. E.g. the DG Facts project showed that it is possible to influence reflective power control and to deliver more power with reactive power control within the limits of voltage. And since research on utilities is on average 0.2-0.3 % of turnover, European cooperation brings significant benefits.

5.1.2.7 Socio-Economic research

The socio-economic projects within FP5 can be clustered into three different types of activity:

- Data collection and model development
- The development of methodologies, tools and guidelines for assessment and implementation projects
- Training, networking and seminars to disseminate or share information

In the area of data collection and model development, the DAT-GEM-E3 project provides a useful example of the type of outputs produced. It involved the geographical extension of the GEM-E3 General Equilibrium Model Database and this was the main output from the project. The database includes economic data such as national accounts data, input-output tables, trade flow information and R&D data on innovation, plus energy/environment data on energy balances, emission coefficients, emission transport and transformation parameters and damages of major pollutants linked to energy use. As an example of the development of methodologies, tools and guidelines, the Baselines for Accession States in Europe (BASE) project delivered a methodology for preparing and assessing project proposals, and could be used by relevant government agencies and ministries in assessing and agreeing new project proposals. The DIEM project provides an example of a project that focuses on dissemination/training/networking activities.

The largest FP6 project in the field of socio-economic and policy related research, both in terms of funding and the number of participants, was the New Energy Externalities Development for Sustainability (NEEDS). The project is based on the results and methodology of the former ExternE project, funded during FP5. The follow-up project aimed to refine the methodology and the figures provided by ExternE and extend the geographical coverage of the former project. The most important output and results for the project included databases, software tools including web based tools, modelling platforms and a large number of publications from methodological reports through technical papers to publications on the project results.
5.1.2.8 Hydrogen and fuel cells

In this area, despite significant effort and some major achievements, several projects have failed to reach their objectives.

The survey results confirm the above statement. The production of outputs in the area was less frequent than in the whole NNE thematic area. This was true for most types of outputs and results: new or improved models and simulations, new R&D strategy, new or improved products, new or improved demonstrators, prototypes or pilots, new jobs, new or improved services, copyrights, patents and licenses sold. Even publications, for which very good results are reported across all areas, only about 60% of the respondents in the area declared they have produced a publication in journals, refereed or not. This is the lowest level of all areas (the average is 77% for all areas). This also holds true for the estimation of the number of outputs produced: publication level again appears as especially low in the area as compared to other areas (1.6 per respondents in this area compared to 2.1 for all areas). More generally, the average number of outputs declared by respondents as a result of their project is below the all-areas average for all types of outputs.

Interviews have allowed a deeper exploration of these below-average results: In most projects, the level of ambition was high, reflecting the very expectations put on fuel cell technology at the start of FP5 and especially FP6. This level of ambition required outstanding achievements to be realised in order to fulfill these expectations. That was particularly the case in FP6 large projects funded through IPs, which objectives spanned from basic research on new materials and components to the test and demonstration of these new elements. The complexity of the systems and the uncertainty over the different options did not allow these large projects to achieve the full “cycle” of achievements, from research to demonstration.

These mitigated results should not of course hide several significant successes in certain projects. For instance, in the field of SOFC, significant achievements were observed: the project REAL SOFC\textsuperscript{34}, which tackled the problem of degradation of planar SOFC succeeded in designing two subsequent generations of technology. In the end, two systems were tested during more than 10,000 hours, which exceeded project targets (but was still inferior to a number of stationary application targets). Another project, PIP-SOFC\textsuperscript{35} aimed at developing and testing a 10 kW SOFC stack in a pressurised system environment, with integral internal reforming from natural gas. The project satisfied its objectives and the technology is still being developed, benefiting from significant investment from the main industry partner, RRFCS. A 10 kW stack was demonstrated and reached its targets in 2006. Building on the results of PIP-SOFC, RRFCS has successfully tested an 80 kW pressurised system and is still dedicated to the development of 1MW system. The PIP-SOFC was described as providing a go/no go test.

However, even the successes show that the development of new FC technology is slow and incremental. It calls for focusing on specific issues and trying to achieve progress in certain dimensions, while “freezing” other parameters. In the aforementioned REAL SOFC project, the materials used were not superior to state of the art materials as regards most performance criteria. The efforts in this project were focused on the processing of the materials in order to improve the stack durability. Similarly PIP-SOFC was a focused project with a limited number of partners who had previous experience of cooperating together.

One striking feature of FP5 and, especially FP6 projects lies in their ability to run and coordinate parallel development and test activities of different alternative materials or design. This is of utmost importance in conditions of high technological uncertainty, where different potential options coexist. The size of the project, measured both in terms of funding and number of complementary competencies gathered, allowed different options to be developed simultaneously and benchmarked under common test procedures.

\textsuperscript{34} Realising Reliable, Durable, Energy Efficient and Cost Effective SOFC Systems, FP6

\textsuperscript{35} Pressurization of IP-SOFC Technology for Second Generation Hybrid Application, SOFC
Exhibit 27  Lessons learned from the scientific achievements assessment

- High quality and numerous scientific and technological outputs were found in all projects in various forms
- The most commonly reported outputs were ‘conferences, seminars and other events’, new or improved tools, methods or techniques, different types of publications (whether in refereed journals or not)
- FP5 respondents report c. 20-30% more of most outputs, in proportionate terms: this reflects not only the different (shorter) timeframe in FP6 but also the reduced visibility of outputs and results in FP6 large instruments
- On average, participants declared 2.7 conferences and other events, and 2.1 publications in refereed journals. For each M€ research, 7 publications in refereed journals are estimated. This is not high compared to some national programmes
- The profile of outputs is more differentiated according to area. Solar energy is one of the areas where the most significant results were achieved. Survey results show below average in H2 and fuel cells area: high ambitions were not fulfilled

5.2 Codes, standards and other infratechnologies

Important efforts were put into this area on infratechnologies, i.e. the varied set of technical tools that perform a wide range of measurement, test, integration, and other support functions.

In the survey 83% of respondents in average claimed that they have benefited from new or improved tools, methods or techniques in their projects. 67% of respondents mentioned New or improved models and simulations as a direct result of the project they participated in (82% in the Wind area). These activities are clearly pre-normalisation activities, as shown by the very little number of projects that resulted in norms or standards.

Exhibit 28  Infratechnology outputs produced in FP5 and FP6 NNE projects

<table>
<thead>
<tr>
<th>Outputs Produced</th>
<th>Biomass</th>
<th>Clean fossil fuels</th>
<th>Energy storage</th>
<th>Hydrogen and fuel cells</th>
<th>Other sources</th>
<th>Socio-economic</th>
<th>Solar Energy</th>
<th>Wind</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>New or improved tools, methods or techniques</td>
<td>85%</td>
<td>86%</td>
<td>76%</td>
<td>82%</td>
<td>77%</td>
<td>72%</td>
<td>94%</td>
<td>94%</td>
<td>83%</td>
</tr>
<tr>
<td>New or improved models and simulations</td>
<td>67%</td>
<td>79%</td>
<td>53%</td>
<td>50%</td>
<td>68%</td>
<td>75%</td>
<td>71%</td>
<td>82%</td>
<td>67%</td>
</tr>
<tr>
<td>New or improved demonstrators, prototypes or pilots</td>
<td>58%</td>
<td>59%</td>
<td>55%</td>
<td>43%</td>
<td>65%</td>
<td>19%</td>
<td>73%</td>
<td>87%</td>
<td>55%</td>
</tr>
<tr>
<td>Software or codes</td>
<td>18%</td>
<td>34%</td>
<td>34%</td>
<td>27%</td>
<td>39%</td>
<td>33%</td>
<td>29%</td>
<td>94%</td>
<td>31%</td>
</tr>
<tr>
<td>New or improved norms or standards</td>
<td>28%</td>
<td>33%</td>
<td>31%</td>
<td>23%</td>
<td>22%</td>
<td>12%</td>
<td>17%</td>
<td>33%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Source: Technopolis survey

Two types of projects should be distinguished: projects that included some activities that aim at developing test and measurement methods, and projects that were specifically dedicated to these activities, usually providing their results to a set of other FP projects for more effective and harmonised tests.

Specific results were found in socio-economics, and also in Hydrogen and fuel cells (see Exhibit 28) and CSS.
In CSS for instance, some of the projects have contributed to the development of standards, especially with regard to storage criteria. Among others, these are:

- **Site selection criteria:** Some projects like the Geocapacity actually produced the first set of technical criteria for the selection of a proper storage site. The criteria include features like location, depth, reservoir and seal properties, well completions and abandonment quality, size and geometry of storage, injectivity and strength requirements. The criteria are related to anticipated volumes/pressure/quality of CO2 to be stored.

- **Geological capacity assessment standards:** A number of assessments of geological storage capacities of different countries, areas and regions have been developed.

- **GIS-based inventory and mapping:** The basic methodology for GIS-based inventory & mapping of carbon dioxide emissions and geological storage location was developed in the GESTCO project. Also, in the Geocapacity project, this method has been developed and applied in a more overall manner, such that large coverage European mapping can be achieved.

- **The DSS Economic Evaluation Method (a decision-support software tool) has already set the standards for the evaluation of site-source scenario economics. The DSS is arguably the most advanced such system of its kind in existence today and will be a standard setting tool in the future, with improved user facilities.**

In the **Hydrogen and fuel cells area,** many projects, especially large FP6 ones, put significant efforts into tests and measurements. For instance, AUTOBRANE set up an innovative structure in which the OEMs (the car manufacturers) gathered in the steering committee provided the test procedure and performance targets to the developer and research communities working on material and component development. This was considered an important achievement since university researchers do not often interact with industry on commercial car requirements. Their relationships remained limited to labs and prototypes. Also the NESSHY project (Hydrogen solid storage) also opted for an integrated approach, dealing with issues such as development of new materials but also new analytical and characterisation tools, modelling and measurement techniques, production processes and methods. A distinction was made between horizontal (different infratechnologies) and vertical (different materials) activities. The parallel effort on these two lines of activities was important for allowing the effective and harmonised test of different solutions by different partners (22 partners from 10 countries).

Some projects were specifically dedicated to developing such infratechnologies. That was the case of two subsequent projects, FCTESTNET (FP5) and FCTESQA (FP6). FCTESTNET was the first step, striving to inventory test procedures and protocols in use and create a network of research and industrial organisations involved in development and testing of FC technologies. FCTESQA was more applied, aimed at validating test procedures identified in FCTESTNET for evaluation of performance, operational characteristics, efficiency, safety and environmental compliance for fuel cell systems. The main advantages of these projects are:

- They allow the coordinated development of infratechnologies for a wide range of activities. FCTESQA addressed infratechnologies from micro-fuel cells to 10 kW systems, from PEMFC, to MCFC and SOFC, for different applications, at different levels (single cell to full-system testing).

- Once acknowledged as a reference in the field, these projects can be a catalyst for large-scale cooperation. Both projects interacted with several other FP5 and FP6 projects, diffusing their results so they are used on a larger part of the technological landscape. FCTESQA was used as a vehicle for discussing and debating on test procedures with IPHE (common progress meetings were held with US and Japanese IPHE partners) and also several INCO countries. The project representatives were also invited to present their activities by the body in charge of these issues in Japan. Currently, some project procedures are being tested by Korean partners.

- These projects also acted as a clearing-house to store and disseminate relevant information on these issues.
The added value of these two projects was said to be very important, for a moderate cost. It has improved the coherence and harmonisation of test procedures. Prior to this project there was a number of different procedures used by different partners, which did not allow benchmarking of the results achieved. Even the vocabulary used to define elements was different, to such an extent the project had to produce a glossary that is now widely used. One procedure produced within the project is currently under review by IEC TC 105, the International Electrotechnical Commission group whose aim is to prepare international standards regarding fuel cell technologies for all type of applications. FCTESQA also allowed synergies with US and Japanese partners, which are very active in this field.

In the **biomass area**, the TAR protocol\(^{36}\) and Tar measurement standard\(^{37}\) projects and the BIONORM project\(^{38}\) in FP5 aimed at developing norms and standards.

In the **Wind area**, the STABCON consortium produced guidelines on how to better design wind turbines for more stability. These guidelines can be implemented in the standards for wind turbines. Another example is in the biomass area where the development of life cycle analysis in FP projects was also a way to inform the policy arena.

### 5.3 Transnational cooperation in FP5 and FP6 NNE projects

It is clear in all types of investigations that the main added value of the Framework Programme lies in transnational cooperation. The projects carried out under FP5 and FP6 generated and supported partnerships that are larger in terms of both number of partners and geographical scope, relative to any other type of available cooperative research programme.

#### 5.3.1 Transnational cooperation within EU

In the survey, responses regarding the impacts on the individual respondents and on its organisation were completely consistent: new or enhanced links to EU contacts (89% declared large or medium impact on individual respondent) and enhanced EU cooperation (71% declared large or medium impact on its organisation) were among the two most cited types of impact. The patterns of responses show little differences between the different areas.

When asked to list other significant impacts of the project on them as individuals, several impacts related to the transnational dimension of projects were provided (see verbatim below).

**VERBATIM (SURVEY)**

- “Better knowledge of others European countries and interesting and fruitful contacts”
- “Being in contact with most relevant research groups within Europe, networking.”
- “Awareness of a European research community being formed”
- “Enhanced geothermal knowledge and common work with EU partners”
- “Exposure to companies, which normally do not participate to research projects”
- “Good relation to the colleagues from the partner entities”
- “New contact to industry and university”

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\(^{37}\) Standardisation of a Guideline for the measurement of tars in biomass producer gases (Tar Measurement Standard)

\(^{38}\) Pre-Normative Work On Sampling And Testing Of Solid Biofuels For The Development Of Quality Management (BIONORM)
This added value of NNE projects is directly related to the composition of the consortia. The projects brought together both new and pre-existing partnerships, supporting the geographical extension of collaboration (EU and beyond) and providing opportunities for new cooperation. This holds true especially for FP6 large instruments, regardless of the intensity of the cooperation\textsuperscript{39}. In the survey, 96\% of respondents were in a project consortium with at least one partner that they did not previously know, while at the other end of the scale, 91\% of respondents reported that they were in a project consortium with at least one organisation that was already one of its traditional partners. When asked about the extent to which the project had provided opportunities for enhanced cooperation with each of these groups of partners, respondents claim that regardless of prior cooperation, the projects led to enhanced cooperation (either to a small or large extent) in the majority of cases.

The strongest evidence might be found in the controversial question: almost all project participants (92\%) who agreed that, in absence of FP funding, the project would have been set up using other resources, claimed the project would have comprised fewer partners.

A few limitations should be noted:

- Regarding the durability of networks, despite some success stories (set-up of bilateral or multilateral partnerships between former project partners in solar energy), the most frequent follow-up to projects is the submission of another proposal in a subsequent call.
- The coordination and exchanges between projects are limited. There is no mechanism to encourage these relationships beyond project boundaries. The existence of such relationships depends to a great extent on individual initiatives (from project coordinators, Commission staff,...)

\textit{VERBATIM (INTERVIEW)}

- EU research has an impact on networking. At some point, I knew more European researchers than national researchers, which is very positive.
- Without FP research, there would be far less cooperation so research would be less efficient. FP gives real incentive to research organisations to sit together and collaborate on research projects.

The possibility to cooperate with European research partners is also seen by most interview partners as the main added value of European funded research. This holds true across all areas. Examples drawn from a few areas include:

- In Solar energy, all interview partners stressed the importance of international collaboration between research partners, but also between research and industry partners. National funding programmes are often not designed to engage in international collaboration so the European Commission fills this gap. The opportunity to cooperate with foreign (research) partners is seen by most interview partners as the main added value of European funded research.

Some research institutes interviewed for this study have established new contacts with industry partners in other European countries that still exist after the project ended. Without European funding these relationships would never have been established. For examples the German Fraunhofer ISI has developed a long-term cooperation with UK based BP.

All partners interviewed indicated that European cooperation is necessary because not all knowledge is available at the national level. By collaborating with the best researchers of Europe the speed of technology development in Europe is increased. Especially for new and...

\textsuperscript{39} In the survey, the average number of project partners was 8 in FP5 and 20 in FP6.
emerging concepts for (thin-film) pv, which requires many different technologies and different disciplines, European collaboration provides added value and reduces time-to-market. For example, Germany has a strong knowledge base in the field of solar energy, but even in Germany not all knowledge is available, and German (research) partners are looking to cooperate with research partners from France, Italy, The Netherlands or Sweden as well.

Exhibit 29  The case of CIS/CIGS PV technology

The added value of European collaboration is clearly illustrated by the development of CIS/CIGS technology in Europe. From FP4 a strong European network is built of research institutes and universities from Germany, Sweden, France, and Switzerland who have been working together for almost two decades to develop CIS/CIGS technology and make it ready for industrial application. Since 2006 these efforts have paid off and a number of companies are now commercially producing solar systems based on this technology. All partners interviewed claim that European funded research has played an important role in bringing the partners together and sustaining this network for such a long period of time. And because of that, technology development is increased and has resulted in a shorter time to market. (In 2006 the first company commercially producing pv systems using CIS-technology was located in Europe (Germany)). Also straightforward practical reasons make European cooperation valuable. Especially in the field of CSP, a test facility with a high level of sunlight is needed. For German researchers, the cooperation with Spanish partners is very valuable, because this gives easy access to test facilities in Spain (such as Seville, Alméra etc.).

• In technologies related to other sources of renewable energy, although the amounts of projects and funding were limited, the contribution to the strengthening of ERAs for the various sub areas belonging to this area has been relatively large. The areas are very small in terms of people and organisations involved in research, but also very international, fragmented, and characterised by high mobility. The projects have contributed greatly to collaboration between relevant parties and network enhancement. Not only cooperative projects but also Coordinated Actions have played a major role in this impact. They are found to be important instruments in development of embryonic technologies. They bring international experts and others with a strong interest in progression in a certain field together to exchange knowledge, build networks and develop shared vision for the direction of future developments.

• In CCS technologies, from the very beginning of this technology, the Commission recognised the need for pulling together knowledge obtained in the various CCS projects across Europe in order to avoid duplication of effort and to accelerate research. Under FP5, CO2Net was set up for this purpose (see below). As a result of these efforts, at the end of FP6, a substantial network of CCS actors has been built up, and collaboration has intensified. Under FP6, project CO2GeoNet was engaged in enabling the fast and safe deployment of EU projects on CO2 geological storage for the abatement of CO2 emissions. For FP7, a network is being planned for providing insight into the results of the demonstration projects, and to share these results among European players. This network is currently in the construction phase. Also, some Member States have specific networking projects, e.g. the CO2CLUB in France, the Carbon Capture and Storage Association (CCSA) in the UK and the PSECO2 project in Spain. Although there is no new knowledge developed within these projects, they contribute to the sharing of knowledge and to the build-up of a CCS community.
CO2NET was set up under FP5. The main driver was the fact that there were many CCS projects funded by the EC, but they were not coordinated. The network, coordinated by Statoil, aimed at bringing together the different players and initiatives in the field.

The objective of the project was to build up a transnational skill base and reinforce "people capability" in CCS. Two of the most important outcomes of the project were a database on all CCS projects across Europe as well as a database containing centres of excellence on the subject.

Especially, the network had a community building effect. Most projects in FP6 and also some in FP7 actually came out of the network. In addition, the Zero Emissions Platform was spun off from this network. CO2GEONET is a follow-on project that was funded under FP6.

Also, the network helped the Eastern European countries to develop a network on CSS named 'CO2Net East'. This network is still in place and has 100% industry funding.

Major outputs were the seminars and training programmes. The idea was to bring together experts to explain what is being done, what the barriers are and what still needs to be done. The advantage is that the topic is treated from all different aspects – capture, storage, environmental aspects, safety, legislation, linkages with renewable and nuclear energy etc. In the last three years, three seminars have been held in Athens, Lisbon and Warsaw. In Athens, there were 95 people from industry and research.

In addition, a brochure was developed which has been translated into 19 languages and 20,000 copies were distributed across Europe.

- **In socio-economic research**, many interviewees commented on the enhancement and development of new relationships with organisations within the European Union, though a few highlighted new and improved links in neighbouring regions and other parts of the world. The NEEDS project covered a particularly large geographical area in terms of the partners in the project, with 66 different participants from 26 countries. According to participants within this project, the collaboration has been very successful and the widening of the scientific relationships an important by-product of the project. Although there is no continuation of the project yet planned in FP7, there were definite plans amongst some participants to work together with other NEEDS partners, at least in smaller sub-groups, in the future. At the other end of the scale, participants in one of the smallest FP6 socio-economic projects reported that as a result of their involvement in the project they had seen extended cooperation with organisations within the region of focus. Similarly, interviewees who participated in small FP5 projects explained that the projects had only involved relatively local partners from within the EU, but that they had little or no knowledge of these partners before. As a result of the project, they reported that closer relationships had been established, their levels of EU cooperation had been enhanced and their visibility within Europe had improved. This particular participant saw these benefits as some of the most important impacts emerging from participation.

5.3.2 Transnational cooperation beyond EU

International Cooperation Partner Country (ICPC) partners are commonly included to increase proposal success rates and impact on the development of new research collaboration. They are less widespread than other partner types, but increased significantly from FP5 to FP6 (mostly representing new partnerships). The majority of respondents to the survey were satisfied with their ICPC partner(s) - the quality of inputs were positively assessed and financial costs were low. However, in interviews the added value of ICPC partners was less pronounced. Also, investigation reveals that in highly competitive areas such as solar energy and fuel cells, industry partners were reluctant to include partners from competing countries (such as China for instance) or reluctant to present results when already in.

In the survey, the majority of respondents are satisfied with their ICPC partners. The quality of inputs are positively assessed and financial costs are low (see verbatim below, most comments
beside the questions related to the cost effectiveness ratio of inclusion of ICPC). As a result, the majority (90%) of coordinators gave a neutral or positive cost-benefit assessment of their ICPC partners overall. However, while the majority (79%) of participants anticipate new EU partnerships to be long-lasting, this is much less likely for those with ICPC partners (32%).

**VERBATIM (SURVEY)**

- “The overall budget of the project was rather small and the part dedicated to the ICPC partner very limited. However, the results were very positive.”
- “There was no direct EU-funding for the ICPC partners.”
- “I believe the experience and information contributed by ICPC partners to improve the output of the project is commensurate to the costs involved considering the unique experience of each and every ICPC partner that are not available to EU members.”

The results of the survey also suggest widespread benefits, and the majority of respondents believed that their ICPC partners have benefited to a significant extent in several areas (see Exhibit 31)

**Exhibit 31** Believed extent of benefit to the ICPC partner(s)

<table>
<thead>
<tr>
<th>Benefit Area</th>
<th>Not at all</th>
<th>A little</th>
<th>A lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology transfer</td>
<td>15%</td>
<td>35%</td>
<td>50%</td>
</tr>
<tr>
<td>Capacity building</td>
<td>11%</td>
<td>39%</td>
<td>50%</td>
</tr>
<tr>
<td>The emergence of a national community in the research area</td>
<td>6%</td>
<td>41%</td>
<td>53%</td>
</tr>
<tr>
<td>(in the ICPC country)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The strengthening of a national community in the research area</td>
<td>6%</td>
<td>53%</td>
<td>41%</td>
</tr>
<tr>
<td>(in the ICPC country)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Technopolis survey

- In Wind energy, the impact of projects on cooperation with non-EU countries is less significant than average. This may be due to the fact that Europe is home to the majority of leading organisations that are performing research in the field of wind energy. Business in the ICPC countries may be interesting in the long-term but efforts to include them in projects are rather high and the benefit is more on the ICPC side than on the EU side.
- In Solar Energy, Israel is one of the larger contributors in CSP projects. For Israeli interviewees, the European FP's make up a substantial part (30-50%) of their research budgets, especially during FP6. For the research groups, the FP investment makes up about one third to a half of the research funds of these research groups. Apart from the advantage of
receiving funds, the non-EU partners see a guiding effect of the FP’s. The projects allow partners to cooperate and to get to know new potential partners. According to the interviewees this makes the total development in the longer run more cost effective: several bilateral and multilateral projects were set up with European partners, after the finish of the projects – which would not have been the case without the FP’s.

- In a more policy-driven area like CCS, international cooperation and coordination are however of prime importance. In this field the European Commission is a member of the Carbon Sequestration Leadership Forum (CSLF), a Ministerial-level international climate change initiative that is focused on the development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage. In addition, the EC is studying and monitoring the injection and sequestration of the CO2 at the Weyburn oil field (Saskatchewan, Canada) as an integral part of a long-term IEA-facilitated project. With this project, the EC has established links to one of the first and most important demonstration projects in the area of CCS outside of Europe. This project has enhanced knowledge and understanding of the application of carbon dioxide in enhanced oil recovery (EOR) and its sequestration in oil fields as well as improved understanding of the long-term integrity, safety, performance, and cost implications of storage in this manner. Useful data has been generated that sheds light on the hydrochemical, hydrogeological and geochemical parameters relevant to the Weyburn oilfield, and how these change when CO2 is injected. Furthermore, the Commission is also reaching out to China. Within the project Coach, the idea was to create a strong and durable cooperation between Europe and China to respond to the fast growing energy demand of China. The background of this project is the Memorandum of Understanding, which has been signed with the Chinese Ministry of Science and Technology on how to combat climate change at the beginning of 2006. While the results in terms of enhanced oil recovery in the Shandung province were very limited, the project was more successful in the area of polygeneration.

However, collaboration with partners outside Europe may however be difficult because of competition. As mentioned earlier, the gathering of EU competitors in a common project might already be a crucial problem in some cases. The non-EU origin makes this problem even more acute as the competition is stronger. This problem was especially pronounced in high tech areas such as PV and fuel cells:

- In the field of PV technologies, many interview partners expressed their concern in involving too many non-European partners in the Framework Programme. At the moment European solar cell manufactures are able to compete with Chinese manufactures because they can deliver better quality and performance due to high levels of technical competence. If e.g. Chinese partners (but the same holds true for US, Japanese or others) are involved in European projects they get access to European technology and improve their competitive position. This will have a negative effect on the European PV industry.

- In the Hydrogen and FC area, the relationships with third countries is also a very sensitive issue given the level of competition between European stakeholders and especially between the US and Japanese ones. In particular, industry participants seemed reluctant to engage in projects where their non-EU competitors were present. They clearly stated that in project workshops where representatives of Japan, US, China or Russia were present they purposively delivered only generic information. It was clear from the interviews that in several cases the European Commission was important in, providing advice and sometimes pushing in favour of these international endeavours... In this area, some projects were especially aiming at supporting interactions with non-EU partners, while still allowing for a distance between these partners and the core EU partners. This was the case of the project CARISMA, which aimed at serving as a platform for communication and exchange between the AUTOBRANE community and counterpart groups in particular non-EU countries. The EU project partners were very satisfied by the interactions generated within this project. The interactions with ICPC appear fruitful in the area of infratechnologies (test procedures, and methods, specific national OEMs’ requirements) as well as policy issues. Some institutions already exist to support these global interactions on Hydrogen and FC, such as the International Partnership for the Hydrogen Economy (IPHE). Several FP6 projects had relationships this international institution (IPHE-
GENIE, HYWAYS-IPHE, FCTESTQA, HySIC, SYSAF, WETO-Hydrogen...). This allows the research project, and more generally the related communities of researchers, to bridge their latest results into the process of international harmonisation. However, more institutional types of relationships require longer term, more permanent, platforms for interaction. The duration of a given project is not always compatible with the dynamics of international cooperation. In that sense, other types of institutional bridges – not financed through projects although in direct relationship with the projects – between the framework programmes and international counterparts should be developed.

Another limitation of transnational cooperation within FP projects was emphasised in several interviews, as well as in the second workshop: in some cases, the project composition appears disconnected from partners’ needs in terms of competencies and access to required resources. It responds to the political objective of European cohesion that requires that partners that have not (yet) an advanced knowledge position in certain areas be included in the project. This can result in “cosmetic partnerships” that can cause disruption in the project dynamics. A few interviewees in the fuel cell area claimed that participating in FP projects is more an advantage for laggards in order to catch up or keep on track, as they can learn from their partners, than for leaders to preserve their lead time... At least two companies did confirm that their participation in FP5 or FP6 Hydrogen and FC projects allowed them not to become leaders in the field, but at least to catch up with the European competition in certain areas.

Exhibit 32 Lessons learned from the analysis of transnational partnerships in FP5 and FP6 NNE research activities

- The assessment of the contribution of ICPCs to the projects were assessed more positively (good quality of research for very low cost) in the report than in interviews
- Motives for cooperation are to be found in access to experimental ground, competencies (Israel and CSP), bridge with international organisations (IPHE and DOE in fuel cells), access to lighthouse demonstration project (Weyburn oil field in CCS)
- However collaboration with partners outside Europe may face problems due to fierce competition (PV, FC)
- A few cosmetic partnerships were identified. In these projects, the partnership composition appears disconnected from partners’ needs in terms of competencies: this can cause disruption in the project dynamics

5.4 The effectiveness of large FP6 instruments

As mentioned in the description of activities, the main difference between FP5 and FP6 was not in objectives but in instruments to fulfil these objectives. FP5 activities were carried out through numerous cooperative projects of modest size. These activities– not only in the NNE domain – were criticised for being too dispersed and for their lack of underlying vision in comparison to the allegedly more integrated approach in Japan and the US. In order to add focus and benefit from the expected advantage of critical mass and strategic orientation, large instruments were introduced and were awarded the bulk of resources in FP6.

5.4.1 The assessment of large projects in the survey

The survey results here are mixed: only 54% of respondents declared that the introduction of large instruments has allowed for achieving critical mass and 63% that it has improved multidisciplinary working or increased cooperation and coordination in their research area. Although the changes were seen to have both positive and negative impacts by different respondents in each of the areas, the balance of opinion in each case is towards positive. The net balance (i.e. the proportion of respondents saying ‘positive’ minus the proportion saying ‘negative’) is highest in relation to improving multidisciplinary working (54%) and increasing cooperation and coordination in the research area (51%). The effect of the instrument on the willingness of the respondent’s
organisation to participate received the lowest results. It is worthwhile noting that the respondents for FP5 projects are extremely negative about FP6 large instruments.

Although one can find positive and negative appreciation in comments, the number of comments related to this issue is striking. Nine comments related to the positive impacts of the increased size of projects and the opportunity to work with more diverse or numerous partners within a project.

_VERBATIM (survey)_

- The added value of integrated results obtained jointly by a critical mass of European and multidisciplinary partners (industry, academics, technical centre, professional, institutions)
- An IP makes it possible to cover all aspects of a topic (broad consortium + content). The project duration makes it possible to come to real results. It allows for strategic partnerships

However reported negative impacts were even more numerous. They focused largely on four main areas:

- Nine comments related to the negative impacts caused by the apparent exclusion of, or lack of encouragement for, participation by small or less developed research groups.
- Four comments related to the negative impacts of the increased size of projects, for example "too large consortium requested" or "projects are too large and unmanageable".
- Four comments related to the negative impacts of an increased administrative and bureaucratic burden involved.

Respondents were asked to give any recommendations they had for changes to the scope or focus of the NNE component of future Framework Programmes. 18 out of 71 related directly to the size of projects, recommending smaller projects with fewer partners. 18 others comments called for greater focus of projects either on application and demonstration or on fundamental research, rather than spanning along the whole spectrum.

_VERBATIM (survey)_

- Favour smaller projects (lower number of partners) with well identified scientific and technical targets, then pursue with the demonstration/pilot parts with an extended partnership.
- Number of participants should be limited to max 10; each participant should have a very clear added value to the overall project. In large projects, juxtaposition of unlinked activities should be avoided. There should be clear and strong linkages between different workpackages and partners to achieve real multidisciplinarity through true cooperation.
- less focus on very ambitious projects, take better care of their real success chances
- « This kind of large projects should be prohibited, as they do not produce anything really worthwhile. The projects need to focus on fewer issues, and have larger budgets»
- Set up projects with less partners. Big projects loose momentum
- Reducing the size of consortium will allow a better coordination
- The very large IPs do not allow for enough research topics to be financed.

5.4.2 The pros and cons of large projects in interviews

When asked about the factors influencing the ability of the project to deliver the project, participants support this mixed view on large instruments, with a clear negative balance. The large size of IP projects in FP6 was said to be a major limitation by several interviewees across almost all areas:

Beside the administrative burden, the main problems associated with large projects are (i) the weak level of cooperation (ii) the gathering of competitors in the same project (iii) the span of the project.
(i) The level of cooperation is claimed to be superior in projects with a limited number of partners. This result was confirmed during the workshop held on best practice for dissemination and exploitation of results. It was claimed that large projects resemble more a composition of several smaller projects and include many separate issues that have no overlap. As a consequence large projects hardly result in integration of knowledge.

- Biomass: Some participants in large projects claimed they were only “satellite partners”, as opposed to “core partners”, and regret they were not involved enough in the project.
- Solar: some interviewees were rather positive about large projects: there were for instance 4 IPs in PV, each having - in a given sub-area - the objective to bring together all relevant partners of the value chain, combining all pieces of relevant knowledge accumulated in the past 10 years. These 4 IPs have covered the whole PV landscape, addressing the main research topics of PV. However, in most cases, the strict division of labour has restricted the level of cooperation between groups of partners.
- In the Hydrogen and fuel cell area, several interviewees, especially those who experienced both FP5 and FP6 projects, explained their disappointment in large FP6 projects as opposed to the smaller and more focused FP5 projects. In another large FP6 project, participants from a car company found that outside developments were going faster than those performed inside the project. The rigidity of the project was perceived as a major problem since the partners had to stick to objectives that were no longer relevant.
- In the Energy storage area, it was documented that large FP6 instruments have generated more “contacts” than real cooperation.

(ii) The integration of most relevant players in a given sub-area automatically requires that competitors team up on issues that are very strategic to them. As it was claimed by one participant at one of the workshops, “the competitive environment is the main barrier to dissemination”. It was also claimed that when the companies bring to the project similar competencies (as opposed to complementary competencies), it has proved in the past especially difficult to define the share of each industry partner in the results. Should the large project involve test and demonstration activities, companies are even more reluctant as sharing pre-competitive products or materials make them run the risk of knowledge spill-overs and leakages to competitors.

- Solar: The European Commission was encouraging the European thin film community to combine efforts and form a European consortium. However, as all three technologies were very different from each other it turned to be difficult to find a common topic that was relevant for all partners involved in the consortium. As a result cooperation was limited, especially at the start of the project, and hardly any new relationships were formed. It took time before the project could solve this issue and produce results.
- Biomass: The industry partners were increasingly reluctant to participate in large projects that included their competitors as the project gets closer from applied research.

(iii) The ambition of certain large IPs to integrate the whole spectrum of activities from basic research to test and demonstration also demonstrated its limits.

- In the Hydrogen and fuel cell area, the Autobrane project aimed at developing and demonstrating a membrane electrode assembly (MEA) adapted to higher temperature demands and lower humidification conditions. The project experienced significant problems of communication between the researchers in the most science-based work packages, which aimed at developing new fuel cell materials, and the car companies that aimed at shorter term results for early integration of the fuel cell on-board vehicles. In the end the type of activities were implemented with different timeframes and with little interaction, as priorities were too different.

However under certain conditions, large projects can also have positive results. Some activities, usually rather downstream, related to test and demonstration, have costs that exceed what small projects can afford in volume and timeframe. That was the case of the Hot Dry Rock project in geothermal energy, which cost over €50m (co-financed by the EC with France and Germany).
One striking feature of FP5 and, especially, FP6 projects is their ability to organise parallel research, development and test activities of different alternative options (materials, design, ...). This is of utmost importance in conditions of high technological uncertainty, where different potential options coexist. The size of the project, measured both in terms of funding and number of complementary competencies gathered, allowed different options to be developed simultaneously and benchmarked under common test procedures and against agreed-upon performance targets.

- Solar: The 4 IPs cover the whole PV landscape and address the main research topics of PV
- Clean fossil fuel and CCS: Also some exploration of different options in projects such as CACHET on precombustion capture, 4 promising technologies, most of them pushed to the stage of test and demonstration
- The Hydrogen and FC area, which at this stage still comprises several options of “unknown merit” regarding the Hydrogen production, storage as well as the fuel cell system, offer several examples of such coordinated exploration of the technological landscape:
  - NESSHY developed and tested four different solid storing materials in different workpackages (reversible on-board storage technologies based on porous solids and metal hydrides, regenerative off-board storage technologies based on chemical hydrides). This project included 22 contractors from 12 European countries and the USA.
  - LARGE-SOFC aimed at investigating and producing components and sub-systems for high temperature fuel cell systems. It had two main development strands: one dealt with pressurized SOFC (follow-up of IP-SOFC, see supra) the other with atmospheric SOFC units.
  - The project HYMOSSES aimed at developing advance storage materials, focused on two different technologies, respectively based on nanocarbon tubes and metal hydrides. One of the project results was to show the low potential of nanocarbon tubes since this technology ultimately did not meet the requirements.

Exhibit 33 Lessons learned from the analysis of large instruments

- Large instruments appeared as a ‘hot’ issue in both survey and interviews. Especially in interviews the large size of IP projects in FP6 was said to be a major limitation by several interviewees across almost all areas
- The main problems associated with large projects are:
  1. The administrative burden and rigidity (impossibility to adapt to exterior events in FC)
  2. The weak level of cooperation within the project (existence of “satellite partners” in biomass, more “contacts” than real cooperation in energy storage)
  3. The gathering of competitors in the same project (intra-project competition as a barrier to dissemination, difficulty to share IPs between “similar” partners)
  4. The span of the project (from basic research to demonstration, problems of incompatibility of timeframe and motives)
- The main benefits associated with large projects are:
  1. Some test and demonstration activities have costs that exceed what small project can afford in volume and timeframe (Hot Dry Rock project in geothermal)
  2. Ability of large projects to organise parallel research, development and test activities of different alternative options (materials, design, ...). See solar, FC, CCS
### Exhibit 34  Synthesis of main results per area – scientific achievements

<table>
<thead>
<tr>
<th>Scientific outputs</th>
<th>Solar energy</th>
<th>Biomass</th>
<th>Other renewables</th>
<th>H₂ and Fuel cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High scientific quality, most project objectives met</td>
<td>• In survey, outputs of the area above the all-NNE areas average, especially publications and conferences</td>
<td>• Most projects have met technological objectives or are well underway</td>
<td>• Very ambitious target performance in several projects, especially in IPs</td>
<td></td>
</tr>
<tr>
<td>• In survey, outputs of the area far above the all-NNE areas average</td>
<td>• Some projects did not met their objectives</td>
<td>• Progress towards cost-reduction objectives have been limited</td>
<td>• In survey, outputs of the area below the all-NNE areas average. Moreover, only 26% of respondents declare that outputs were greater than expected (lowest % of all areas)</td>
<td></td>
</tr>
<tr>
<td>• Some projects failed, because goals were too ambitious according to partners</td>
<td>• Survey : only 29% of respondents declare that outputs were greater than expected (highest % of all areas)</td>
<td>• Mitigated results backed by interviews, several projects did not meet objectives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Survey : only 29% of respondents declare that outputs were greater than expected (lowest % of all areas)</td>
<td></td>
<td>• Strong efforts and results in infratechnologies (methods of measurement, procedure of test,...) either in dedicated project or as working package of large projects</td>
<td></td>
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</tr>
</tbody>
</table>

### Relevance of large instruments

<table>
<thead>
<tr>
<th>Solar energy</th>
<th>Biomass</th>
<th>Other renewables</th>
<th>H₂ and Fuel cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 4 IPs in PV, each having - in a given sub-area - the objective to bring together all relevant partners of the value chain, combining all pieces of relevant knowledge</td>
<td>• Some participant in large projects considered themselves as satellite partners, as opposed to core partners, and regret their light involvement in the project</td>
<td>• Example of large project with strong relevance: Hot Dry Rock project, with costs beyond what any given state can afford in volume and timeframe: over €150m (co-financed with France and Germany) Now world leading project on HDR</td>
<td></td>
</tr>
<tr>
<td>• The 4 IPs cover the whole PV landscape, address the main research topics of PV</td>
<td>• Difficulty to coordinate large projects, need training, “professional coordinators”</td>
<td></td>
<td>• Integration of activities from basic research to demonstration in any IP</td>
</tr>
<tr>
<td>• One example of IP in thin film encouraged by EC, but in the end cooperation limited between participants not willing to get aligned on common position</td>
<td>• Reluctance of industry to participate in large projects if presence of competitors and applied research</td>
<td>• Large projects have allowed the parallel development and demonstration of different alternative options (exploration activities) in a common environment (methods of test, target performance)</td>
<td></td>
</tr>
<tr>
<td>• In most cases, strict division of labour have restricted cooperation between groups of partners</td>
<td></td>
<td>• Added value for large demonstration projects (DG TREN)</td>
<td></td>
</tr>
</tbody>
</table>

### Science-industry relationships

<table>
<thead>
<tr>
<th>Solar energy</th>
<th>Biomass</th>
<th>Other renewables</th>
<th>H₂ and Fuel cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Significant impact of FP projects for science-industry relationships in this area stressed by interviewees and backed by survey</td>
<td>• Strong drop in industry participation from FP5 (42%) to FP6 (27%).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Division between development and test working packages can limit close, integrated science-industry cooperation</td>
<td></td>
<td>• Some tensions between research community and industry partners having the impression that development outside the projects are making faster progress</td>
<td></td>
</tr>
<tr>
<td>• Continuity of effort in certain areas, especially CIS/CIGS, same network of participants supported since FP4.</td>
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</tr>
</tbody>
</table>

### Transnational cooperation and durability of EU networks

<table>
<thead>
<tr>
<th>Solar energy</th>
<th>Biomass</th>
<th>Other renewables</th>
<th>H₂ and Fuel cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Opportunity to cooperate with EU partner is seen as the main added value of FP projects, as no country control the whole value chain of PV</td>
<td>• Most frequent follow up of projects is submission of proposal to other FP call</td>
<td>• Important impacts despite limited budget since the competencies are fragmented throughout Europe</td>
<td>• Large consensus among interviewee regarding the added value of FP for transnational cooperation, essential to gather the complementary competencies (not country gather them all)</td>
</tr>
<tr>
<td>• Several examples of relationships that lasted beyond the project duration though set-up of bilateral or multilateral partnerships between former project partners</td>
<td>• Important role of some projects dedicated to develop community on embryonic technologies (e.g. Wave Energy network in FP5, followed by Ocean Energy coordinated action in FP6)</td>
<td>• Great contribution of few projects to enhance networks on each of the three technologies</td>
<td>• A few cooperation between projects, but remain limited</td>
</tr>
<tr>
<td>• FP projects combine specific competencies spread in different countries but also can allow access to specific testing grounds (German leaders team-up with Spain for CSP)</td>
<td></td>
<td></td>
<td>• Continuity of support to SOFC community of research has allowed some successful projects</td>
</tr>
<tr>
<td>Scientific outputs</td>
<td>Energy storage</td>
<td>Wind</td>
<td>CSS</td>
</tr>
<tr>
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<tr>
<td>• In battery research there have been no great breakthroughs, but rather a situation where existing competences have been stronger through collaboration. The research has focused on systems, testing – applied science.</td>
<td>• Most significant scientific output is the production of new or improved tools, methods and techniques</td>
<td>• Substantial scientific achievements. In FP, for instance in fluidised bed boilers technologies, experimental data that allows to confirm and fine tune simulation model. The data have become references, widely used</td>
<td>• Broadly similar pattern to the other technology-based areas (conferences, improved tools and methods and publications dominate)</td>
</tr>
<tr>
<td>• Survey: outputs were greater than expected for the participants themselves rather than for their organisations (33% as compared to 20%).</td>
<td>• Most FP5 projects contributed to the development of several technologies, which were at the top of what was available at a global level</td>
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</tr>
<tr>
<td>Relevance of large instruments</td>
<td>• Large instruments have generated more contacts than real cooperation</td>
<td>• In the FP6 project results are implemented and used continuously. Dissemination is facilitated by the number of project partners</td>
<td>• Relevant for costly large transnational demonstration project, with high visibility. Also some exploration of different options in projects such as CACHET on precombustion capture, 4 promising technologies, most of them pushed to the stage of test and demonstration</td>
</tr>
<tr>
<td>• NoE have polarized research communities according to those who are in the NoE those who are not</td>
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<tr>
<td>Science-industry relationships</td>
<td>• In numbers of participations in the projects, industry is the main participant in both FP5 and FP6. The proportion of industry participants has decreased from 46% in FP5 to about 30% in FP6</td>
<td>• According to some participants, FP5 and FP6 wind energy projects also helped industry and research organisations to cooperate</td>
<td>• Especially in demonstration</td>
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<td></td>
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<tr>
<td>Transnational cooperation and durability of EU networks</td>
<td>• Grid issues are transnational, so transnational research is important</td>
<td>• All projects carried out in the field of wind energy have allowed participating organisations to enhance their cooperation with EU partners. Although researchers usually know most of their partners, projects allow them to strengthen the collaboration and prolong it even after projects are finished.</td>
<td>• EC support in CCS technologies has been essential in the establishment of a community of researcher in CCS technologies. From the very first stage, mapping of projects and competences, then incentives for gathering; Role of catalyst for international cooperation; Some projects have resulted in the development of standards in CSS: especially for storage location criteria. Also, economic evaluation method, such as project GESTCO for site scenario. Might become a standard setter in the future</td>
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EPEC – Evaluation and Impact Assessment of the European NNE RTD Programme

Final report

59
6. Policy impacts

6.1 The effect of FP5 and FP6 NNE projects on the coordination of national research policies

The Coordination of national research policies is one of the pillars of the ERA, which has been made a top priority in FP6. Specific instruments and resources (especially ERA-NETs, Technology Platforms) have been put in place to support it under this programme. In the NNE domain, the concept of ERA was applied and translated into the EERA concept (standing for Energy ERA), emphasising that NNE research was far too fragmented and uncoordinated to cope with the new environmental and security challenges and the increasing S&T global competition.\(^{40}\)

A DG research commissioned study conducted in 2005, made comparison of NNE research related priorities, levels of funding and implementation structures in 33 European countries.\(^{41}\) The resulting picture was one of a very fragmented policy landscape. Only a few areas such as fuel cells and solar PV were common priorities to a significant group of countries. As for means of actions, the countries appeared even more different (existence or not of a dedicated NNE research programme, leading actors, from ministry and agencies to research institutes, etc.) making it difficult to coordinate their support actions even in cases of common interest.

The challenges of the coordination of national research policies with – or through – the EC initiative in the NNE domain are very different according to country and areas.

6.1.1 Energy ERA-NETs and other coordination actions

In order to cope with the challenges, dedicated instruments have been put in place, in particular different types of policy networks in FP5 and ERA-NETs in FP6 (most of the time supported through coordination actions). There were – and still are – a number of ERA-NETs in the area of NNE.

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\(^{40}\) Towards the EERA recommendations by the ERA working group of the Commission’s advisory group on energy (ERAWOG), January 2005

\(^{41}\) Technopolis Group, Non-Nuclear Energy Research in Europe – A comparative study, DG research, 2005
Exhibit 36  ERA-NETs in the energy field

<table>
<thead>
<tr>
<th>ERANET</th>
<th>Domain</th>
<th>Examples of calls and projects</th>
</tr>
</thead>
</table>
| FENCO-ERA   | Zero emission power plants                  | 1 call, 3 contracts:  
• Scrutinizing the impact of CCS communication on the general and local public  
• Analysis of potentials and costs of storage of CO2 in the Utsira aquifer in the North Sea  
• Economic Modelling and Assessment of CCS Implementation in Europe |
| BIOENERGY   | Bioenergy                                   | 4 calls on:  
• Small-scale combustion  
• Gasification  
• Short rotation coppice  
• Clean biomass combustion |
| PV-ERANET   | Photovoltaic                                | Joint Call for Polymol solar cell                                                              |
| INNER       | Innovative, emerging, energy technologies  | 2 calls selecting various research such as “High permeance nanoporous tubular zeolite membranes for efficient separation of CO2 and methanol at demanding conditions”, “Next generation fuel cell materials” |
| HY-CO       | Hydrogen and fuel cells.                    | 4 calls on:  
• Hydrogen storage  
• Fuel cells & Hydrogen storage  
• Deployment Strategies in Hydrogen & Fuel Cells  
• PEMFC - cells, stacks, systems & manufacturing and production technology |

Source: Eranets website

Although this evaluation did not dedicate specific efforts to assess this instrument, interviews carried out in the different areas tend to show that they had only a mitigated effect on cooperation between various public organisations. This result is consistent with the specific evaluation of ERA-NETs.

Exhibit 37  Main results of the FP6 ERA-NETs evaluation regarding ERA-NETs in the field of energy

There were 5 ERA-NETs specific to the field of energy. The Northern countries were more active in the energy ERA-NETs than countries from the south of Europe. The most active Member States in the field were Germany and Austria. Germany coordinated 4 out of the 5 energy ERA-NETs. The main beneficiaries of the joint calls were organisations from Austria, Denmark, Germany, The Netherlands, Sweden and the United Kingdom. Some countries with high participation in the 5 ERA-NETs (France, Spain, and Poland) did not participate in joint call projects.

All fields included, the evaluation concluded that the structuring effect of the FP6 ERA-NETs scheme on the ERA was relatively limited. However, more effects are expected in the future as structuring takes time before it can be apparent. In particular, participation in joint calls had proved to have a positive influence on the structuring effect of the ERA-NET scheme. Significant effect is not expected in the energy field since these ERA-NETs undertook fewer and smaller (in terms of funding) joint calls than other ERA-NETs in other themes. Energy ERA-NETs ranked sixth (out of 8 areas covered in this evaluation) in terms of funding contribution to joint calls.

Beside the structuring effect, the importance of a specific theme in national research programmes increased as a result of ERANETs. This was especially the case in the International Cooperation and Life Sciences ERA-NETs. This effect was "hardly apparent at all in the Energy theme"

Source: Ramboll, Impact Assessment Study of the ERA-NET scheme under the Sixth Framework Programme, DG Research, 2009, EUR 23909 EN

Beside ERA-NETs, other coordination actions that aim at improving the coordination of national research policies were supported. For instance, in the energy storage area, the IRED cluster (see Exhibit 38) has contributed to the recognition in the SET PLAN of Smart grids as a section and the
continuation as one of six new European Industrial Initiatives launched by the European Commission in order to target sectors which working at Community level will add most value.

Exhibit 38  The IRED cluster in the energy storage area

The IRED cluster (the European research cluster on the integration of renewable energies and distributed generation into the European electricity grid) could be considered as something of a best practice case for Coordinated Actions. Integration of Renewable Energy Sources and Distributed Generation into the European Electricity Grid (IRED), FP6 (2004-2007), is a large European Cluster of RTD projects funded by the European Commission and coordinated by the research institute ISET, Germany. The activities of this European research cluster started in 2002 under the initiative and guidance of the European Commission – DG Research with the aim of coordinating the European projects in the fields of RES and DG in a high level steering group. Since 2004 the EC has funded the cluster in the frame of the IRED Coordinated Action, consisting of a variable number of partners over time (by the end of the EU-funded period ten partners from seven EU countries). This Coordinated Action is divided into ten work packages. During this time including representatives of new European projects in the area has expanded the cluster membership.

There are research projects in the cluster, but no research is performed in the IRED as such. Therefore, the projects in the IRED cluster set targets, but the IRED cluster collaboration had no such targets. The cluster was created with the aim of promoting more renewables in the grid through information exchange between the project partners. It focused on “power quality”, and the aim was to coordinate what was happening in the different member states: what is going on, are there any specific type of projects missing, are there unnecessary duplications?

The projects in the cluster learn from each other and profit from input from others. There was from the beginning a strong aim to deliver to the policy level (policy and regulatory roadmaps for DER), and benchmarking was the tool to do it. The aim of IRED was not to do research on better batteries – but to know which technology is the best one in each area. The European Strategic Energy Technology (SET) Plan, which was endorsed by Member States in February 2008 and is expected to accelerate the availability of new energy technologies and create a long term EU framework for energy technology development, also recognises Smart grid as one section (out of seven) and as the continuation of one of the “industrial initiatives”. IRED contributed in this coming about.

The project as such has finished, and has no formal funding any more. But the cluster and networking continues. The cluster participants use the chance to go with project money to meet at cluster meetings, and that is what it now is: a group of project coordinators exchanging experiences. The cluster is now a part of the FP 7 smart grid technology platform. The biannual conference will continue, and it is important is to bring new coordinators and members into the collaboration.

Several projects in FP6 (in FP5 there were smaller examples of the same type of studies), as well as Technology Platforms, have produced roadmaps and strategic research agendas that guide further research in the areas, and that are also meant for (and to some extent used by) policy makers in designing research and innovation programmes. Let’s mention for instance the strategic research agendas in fuel cells, wind, PV,... the “European Hydrogen Energy Roadmap resulting from the HyWays project (which was acknowledged to be widely referred to in the relevant community of actors), the FP5 ERA bioenergy strategy42, CA on Ocean Energy, and a less successful example, the ENGINE research agenda in the area of high temperature energy43.

6.1.2 The coordination of national research policies according to countries

In order to better understand this crucial issue, it is useful to distinguish between the two levels of top-down and bottom-up coordination.

42 ERA Bioenergy strategy -Short-term measures to develop the European Research Area for bioenergy RTD
43 The ENGINE project came up with a research agenda, which was communicated with the Commission. However, since the industry did not take a clear position in whether they would actually commit resources towards EGS technology development, the Commission was not inclined to extend its support.
Top-down coordination consists in the *ex ante* ‘voluntary’ alignment of certain member states and EC programmes, which reduces the fragmentation of European public and private efforts. The presence of policy makers for different countries during the second workshop (dedicated to the coordination of EU NNE policies) provided further insight into the national specificities regarding this type of coordination. One of the prime determinants is the ‘strength’ (funding, visibility, legitimacy, competencies of participants,...) of the national programme. The structure of governance of the national research policy and its link to the European commission are also important:

- Germany for example is a large country and has a large budget for energy R&D which allows funding research across all themes. Its strong budget and the national research capabilities provide the country with a positive influence on the definition of the European Framework Programmes. Also important is the fact that the same policymakers deal with national and international research issue, which makes national and European priorities better aligned (which is for example not the case in France). As a result, there are no strong differences in topics between national German programmes and the Framework Programme. The two programmes have mutual influence.

- The situation is quite different in new member states, where NNE research programmes are much less developed. In Poland for example, in the areas of wind and solar energy - although there is a significant and acknowledged research potential - the industry base is still very weak, which makes it difficult to create a national policy programme in these areas, build an international knowledge position and build up critical mass. Hence, the EU framework programme is a reference for national programmes and guides national policy priorities and funding sources.

- In Latvia, funding for energy research is also limited. There is now a new national programme (2010-2013) in which priorities in research are discussed. One of these priorities is energy and environment (subtopics include energy efficiency, renewables, climate, biodiversity in Baltic seaside). However, the Nordic Energy Research research activities have a stronger impact on this programme since there is a specific focus on needs relevant to Latvia. Also Latvian partners benefit from a requirement in the Nordic Energy Research research activities that each project should have a Baltic partner.

Bottom-up coordination reflects the *ex post* ‘emerging’ allocation of researchers among the respective EC and European programmes, which can improve the synergies between these programmes, but might also generate problems and opportunistic behaviour. Here again, the configurations are diverse according to each country’s position:

- In several countries, e.g. Finland or France, researchers tend to go to national programmes first in order to benefit from better conditions and/or easier procedures and/or greater success rates. The improving structuring and greater funding of national programmes means that some European member states’ national programmes become increasingly attractive to researchers. Moreover, several initiatives in countries like France and Germany intend to open up national programmes. As a result, the Framework Programme is no longer the only vehicle for transnational cooperation. However, it remains by far the largest, in terms of both the amount of funding and geographical and thematic scope.

- There are topics that are no longer funded by the national programmes but that are still covered by EC programmes. For instance, when CHP was no longer a priority for Germany, German partners started to cooperate with Greek partners in this area in FP...

- In the UK, researchers reported that they were invited by national agencies to try to secure funding first from the FP and then from national funding should the first attempt be unsuccessful. The motive here is clearly the shortage of funding for research, at least in certain areas.
Finally, partly as a consequence of longer cooperation in FP (FP3-FP7, as well as FP5 and 6), and on initiatives of the EC, ten leading European Research Institutes have taken up the challenge to found an European Energy Research Alliance (EERA). The EERA aims to strengthen, expand and optimise EU energy research capabilities through the sharing of world-class national facilities in Europe and the joint realisation of pan-EU programmes. This may be a strong vehicle for coordination, but is still in an early stage (and covers only 10 countries).

6.1.3 The coordination of national research policies according to areas

The coordination is also different according to areas:

- In FP5/FP6, CCS is an area where the EC has played a large role in setting the agenda as well as implementing it in the early stages. From the beginning of its CCS research efforts, the Commission recognised the need for pulling together knowledge obtained in the various CCS projects across Europe in order to avoid duplication of effort and to accelerate research. Under FP5, CO2Net was set up for this purpose. Most projects in FP6 and also some in FP7 actually came out of the network. In addition, the Zero Emissions Platform was spun off from this network. At the end of FP6, a substantial network of CCS actors has been built up, and collaboration has intensified. Under FP6, project CO2GeoNet was engaged in enabling the fast and safe deployment of the EU projects on CO2 geological storage for the abatement of CO2 emissions. For FP7, a network is being planned for providing insight into the results of the demonstration projects, and to share these results among European players, that have now also started local projects and networks outside FP.

- In energy storage, evaluators found examples where EC-led research has paved the way for national research, especially in new member states. In other EU member states, FP projects seem not to have contributed directly to better coordination of national research activities within EU. In smaller research areas, the large FP6 projects of the FPs (or clusters of projects in FP5) have had a coordinating effect because they were one of the main vehicles for international cooperation. Examples of this are the PS10 project in CSP, the Wave Energy Network (FP5), the Ocean Energy-CA (in FP6) and the Enhanced Geothermal Innovative Network for Europe (ENGINE, FP6) which is said to have had a very large impact on peoples’ cooperation patterns, and internationalised the research agenda.

- In the fuel cell area, interviews with national research policy makers have provided little evidence of an effect of the FPs on the coordination between member states policies, apart from formal (through the Programme committee, National contact points etc.) and informal flow of information (representatives in the platform was most often involved in the decision making of national Hydrogen and FC programmes). In general, the level of information of national research policy makers regarding what is done and achieved in the FP projects was very low. However, the extent of the EC effort has provided the legitimacy for French policy makers to secure funding for their national programme; recently when the large international attention for the fuel cell JTI convinced French policy makers that is was useful to continue a programme in this area (H-PAC, successor to PAN-H), even though, at that moment, French industry was no longer interested in the topic and, more generally most countries (including the US) have diminished their efforts. In certain cases therefore, the stability of the EC funding, as well as a certain gap in the following of international trends due to the time needed to negotiate and design a programme, can mitigate the crowding out of an area.

6.1.4 The effects on research funding (additionality of funding)

On the basis of the survey conducted in this evaluation, it can be concluded that the research financed was mostly additional research. The majority of respondents in the survey (76%) report

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44 CEA (FR), CIEMAT (ES), CRES (EL), ECN (NL), ENEA (IT), Helmholz Association (DE), LNEG (PT), Risoe DTU (DK), UK ERC (UK), VTT (FI)
that their project was unlikely to have gone ahead at all without FP funding. There is little difference between those participating in FP5 (79%) and FP6 (75%).

Although sample numbers are small, responses do suggest that there may be some differences between the thematic areas in the extent to which projects may have been set up without EU FP funding support. At the extremes, 33% in the biomass theme agreed that the project would have been set up anyway, while in wind (8%) and socio-economic (13%) areas the proportion agreeing was much lower.

Those who claimed that the project would have been set up using other resources also mention that the absence of EC contribution would have translated into fewer partners and reduced objectives. The programme encourages critical mass and is particularly important for increasing the size and scope of projects within it.

Exhibit 39  Effect on projects of using resources other than EU funding

<table>
<thead>
<tr>
<th></th>
<th>(Strongly) Agree</th>
<th>(Strongly) Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>With fewer partners (n=86)</td>
<td>92%</td>
<td>8%</td>
</tr>
<tr>
<td>With reduced objectives (n=85)</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>With reduced funds (n=82)</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>With a longer time scale (n=81)</td>
<td>62%</td>
<td>38%</td>
</tr>
<tr>
<td>Without non-EU partners (n=59)</td>
<td>49%</td>
<td>51%</td>
</tr>
<tr>
<td>'other' (n=10)</td>
<td>20%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Note: due to the small number of respondents, the four options have been combined to form two

A small number of respondents highlighted other types of ‘reductions’ that might have resulted from the loss of EU funding for their project, as follows:

VERBATIM (SURVEY)

- Favour smaller projects (lower number of partners) with well identified scientific and technical targets, then pursue with the demonstration/pilot parts with an extended partnership.
- “Less efficient collaboration”
- “Some individual research needs would have been conducted by partners obtaining resources from internal and alternative funding schemes.”
- “Project would be under-funded”
- “Perhaps as a CCP only project by the members of the international CO2 Capture Project”
- “Major risk of failure”
- “Leadership/funding by one industrial enterprise would create distrust among competitors and limit effectiveness, dissemination of the results and overall impact”
- “It was ahead of its time, other organisations are only now thinking of doing what we did 10 years ago”
- “Continuation of previous work in two separate groups, combination of less funding (even combined), reduced objectives, maybe fewer partners, certainly without synergies between the two groups.”
- “Diversified research”
- “Another future option would have been missed”

6.2 The effect of FP5 and FP6 NNE projects on other policies

Non Nuclear Energy is a policy driven field: research and innovation in this theme supported in order to solve large societal problems. Successes in the field of research also impact on policies
other than research policies: they create knowledge that can be taken into account by policy makers when designing policies, they create options that can play a role in solving the societal problems and can help in creating support in the broader society (through public awareness for instance).

6.2.1 Main generic results

The investigation of policy impacts, drawing especially on interviews with policy makers, has shown results across all areas:

• In all areas, the policy impacts are said to be indirect and conditioned to the realisation of the scientific and technological objectives. The indirect impacts transit through knowledge, which is then disseminated to policy through expertise. However, it is clear from interviews that most policy makers interviewed have a very limited knowledge of FP project activities and results. Also few projects, through the formation of relevant networks, have created the conditions for stakeholders to gather and lobby on policy (for feed-in tariffs for instance on geothermal energy in France).
• Some interesting – though rare – examples can found in certain projects (NILE project, DEEP project).

6.2.2 Main results per area

The area that should be primarily policy driven is the area of socio-economic research. Other areas with stronger direct policy relevance are ‘energy storage and distribution’, ‘fossil fuels and CCS’ and ‘Hydrogen and fuels’.

6.2.2.1 Socio-economic research

In socio-economic research, the new tools and methodologies developed through the research projects are generally held to be relevant to policy interests and most project partners were able to point to some engagement with policy makers and regulators and in a small minority of cases were able to cite specific instances where new techniques, principles and data had been used in a policy setting. None of the projects were able to provide estimates of the nature and extent of the impact of such changed behaviour on policy and on energy systems and environmental performance. There is a series of examples documented where FP5 projects that aimed to develop and refine energy models have shaped EU policy targets on for example the share of electricity derived from renewable sources.

It should be borne in mind that, as mentioned earlier, socio-economic research was not carried out only in the dedicated areas. Especially in FP6, great efforts have been put into the integration of socioeconomic projects into the each area. For instance, in the fuel cell area, 9% of the area funding was put into projects producing pathways, roadmaps and socio-economic analysis.

6.2.2.2 Biomass

In the biomass area, the NILE project is one of the very few projects that had a direct link to the policy arena. The project instituted regular debate with the EU Parliament's Environment Committee, which was well regarded and provided politicians with a rather flexible and user-friendly route into finding out more about technology issues and the opportunities they present for helping to tackle major environmental issues. It also facilitated frank debate around the pluses and minuses of biomass.
6.2.2.3 Energy storage and distribution

In the area of energy storage and distribution, transnational regulatory issues are of importance. The EU DEEP project has had a certain impact on policy, in identifying the regulatory constraints that prevent further distributed energy resources (DER) penetration at different levels and in relation to the business models developed in the project. EU DEEP helped put DER on the map. The project has pointed to the concrete barriers that could be removed, and the principles that need to be discussed by policy makers with stakeholders. This has laid the foundations for new regulatory schemes for DER integration.

Survey results from this area point to moderate impact from the FP5 and FP6 projects in the area of storage and distribution when it comes to development of new environmental legislation or policy. The FP6 RELIANCE project managed to clarify the idea that grids are a trans-national question, which needs a solution involving a trans-national structure at the top. The RELIANCE project was instrumental in bringing about the European Network of Transmission System Operators for Electricity (ENTSO-E), which commenced operation in April 2009, with the aim of ensuring optimal management of the electricity transmission network and to allow trading and supplying electricity across borders in the Community.

The DGFACTS project aimed to solve the set of quality of supply problems arising from the integration of Distributed Generation (DG) into the electric distribution networks. One outcome of the project is that the regulators of Austria, Germany, Switzerland, Italy and the Czech Republic have started to harmonise their rules (the DACH-agreement). Previously bureaucratic hurdles were a main obstacle for the introduction of small generators, but this has now significantly diminished.

The case study on electricity from biomass in Macedonia indicates that the Microgrids and More Microgrids projects may have some impact on national policy. At the same time, another new member state participant claimed that regulation in his country « is not supportive of this type of projects », which means the potential policy impact depends on national circumstances.

6.2.2.4 Clean fossil fuels and CCS

In the area of fossil fuels and CCS, there is little doubt that the European Commission has played a significant role in pushing CCS across Europe. Apart from the early adopters Norway and the Netherlands, few countries had national CCS funding programmes at the beginning of FP6. During FP6, many countries like Germany, France and Spain set up their own programmes.

In FP5, projects were able to heighten attention for the topic as an important enabler to reduce CO2 emissions. High-profile projects like the Sleipner project in Norway which was supported by the EC in both FP4 and FP5 played a prominent role and the awareness engendered by the project gave rise to other storage related projects in Europe. Furthermore, in the project CO2 Net, a CO2 capture and storage strategy was developed as one of the results of the project. The strategy focused on the importance of continued support for CCS and pointed out future areas of activity, which among others include transport, site mapping, issues related to storage, and enhanced oil recovery. In fact, the project team ended up writing the strategic plan for FP6, which the Commission took on board almost entirely. This is one of the few examples of direct impact on policy making.

Some of the projects have contributed to the development of standards, especially useful for governments in assessing potential sites for CCS and associated risks. These include site selection criteria (e.g. Geocapacity project), geological capacity assessment standards, GIS-based inventory and mapping; (GESTCO-project) and a DSS Economic Evaluation Method (also firstly developed in the GESTCO project, and it has already set the standards for the evaluation of site-source scenario economics. The DSS has been used for evaluation work for the IEA GHG and it has been recognised that a number of features need to be developed in order to facilitate cost curves to the specifications used by the GHG. In addition, the Geocapacities project managed to enhance facilities for multi-source and multi-sink evaluations as well as making the software much more...
user friendly. The DSS is arguably the most advanced such system of its kind in existence today and will be a standard setting tool also in the future, with improved user facilities).

As explained in the section on challenges, there was virtually no legal and regulatory framework for the commercial exploitation of CCS until very recently. Although it is difficult to attribute growing legislation in the field to particular CCS projects funded under FP6, it is safe to argue that the maturing of CCS technologies led to even greater policy awareness and thereby to a recognition of the need for legislation. In particular, the projects showed that sound legislation is a prerequisite for the commercial exploitation of CCS. Most notably, the European Commission has published a draft Directive (the CCS Directive) to provide a framework for carbon capture and storage (CCS) in the EU, supporting CCS as an emission reduction option. The CCS Directive has been adopted by the Member States in 2008 and is now being transferred into national law.

6.2.2.5 Hydrogen and fuel cells area

In the Hydrogen and fuel cells area, given the low level of maturity of the technology, the policy impacts are indirect and still ‘potential’. The realisation of policy impacts will depend on the actual deployment of these technologies in stationary and transport applications, which is not yet the case.

During interviews, very few, if any, relationships with policy makers were mentioned. The CARISMA project intended to serve as a pool of expertise for European policy related to Hydrogen and FC but no evidence of such activities were found. From a general standpoint, the levels of knowledge and awareness of most member states’ policy makers that were interviewed regarding activities performed and results achieved in FP5 and FP6 projects were low.

6.2.2.6 Other areas

Areas within the NNE programme under FP5 and FP6 that are focusing on developing energy sources (solar, wind, other sources) consist mainly of technology-driven research, focusing on new processes for energy from renewable sources. In these areas, the impact on policy is limited or indirect.

Only rare and project-specific effects could be identified. For instance, the various demonstration oriented projects meet practical problems that can inspire new policies. An example are feed in tariffs in Spain (CSP) and France (geothermal energy) that were raised because demonstration projects proved that the former rates did not adequately support the technologies that were demonstrated (CSP and geothermal needed this type of support).

Exhibit 40 Lessons learned from the policy impacts assessment

<table>
<thead>
<tr>
<th>Effect on coordination of research policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 5 ERA-NETS dedicated to NNE: according to the specific evaluation of ERA-NETS, these ERA-NETS had a limited structuring effect. They have implemented fewer and smaller joint calls than ERA-NETS in other fields</td>
</tr>
<tr>
<td>• Very different effect of FP on national research policies according to countries</td>
</tr>
<tr>
<td>• Top-down coordination: determinants are the weight, scope, and governance of member states policies</td>
</tr>
<tr>
<td>• Bottom-up coordination: determinants are the existence of attractive national alternatives and the need for transnational partners</td>
</tr>
<tr>
<td>• Different effect of FP on national research policies according to areas</td>
</tr>
<tr>
<td>• In CCS the EC has played a large role in setting the agenda.</td>
</tr>
<tr>
<td>• In the fuel cell area, low effect on coordination of research policies, but legitimacy effect to pursue public funding of fuel cells</td>
</tr>
</tbody>
</table>
The survey demonstrated that the research financed was mostly additional research. 76% of respondents report that their project was unlikely to have gone ahead at all without FP funding. And if they had they would have done it with fewer partners.

Effects on other policies (environment, energy)

- The policy impacts are said to be indirect, they transit through knowledge, which is then disseminated to policy through expertise. A few examples of direct impacts (NILE project, DEEP)
### Exhibit 41  Synthesis of main results per area – policy impacts

<table>
<thead>
<tr>
<th>Coordination of national policies</th>
<th>Solar energy</th>
<th>Biomass</th>
<th>Other renewables</th>
<th>H2 and Fuel cell</th>
</tr>
</thead>
</table>
| • FP budget account for a small share of European research. Smaller than R&D budget in Germany alone. However strong leverage effect  
• Continuity of funding has allowed knowledge and network continuation even when national budgets cut back in the past (as in Germany) | • Some research policy makers declare they pay attention to FP in order to avoid duplications | • No clear coordination with national policies  
• Three technologies are of a highly site-specific nature, increasing the importance of national programmes  
• FP plays major role in bringing together multidisciplinary expertise embedded in organisations all over Europe. | • No clear coordination with national policies  
• Level of information of national policy maker regarding activities in FP5, FP6, very limited | • No clear coordination with national policies |
| Other policy impacts | • Technology-driven area, so no direct impacts  
• Most relevant projects for policy impacts: project that aim at roadmapping, creating networks in PV and CSP (in line with Lisbon strategy)  
• Funding of the PV Platform in FP6 and previous network in FP5 that has set the ground for the platform. SRA has provided guidance for FP7 calls and for member states to define priorities  
• Some projects have paved the way for lobbying for market stimulation | • No direct impacts in most cases, apart from NILE project for instance (dinner debate with EU Parliament Environment committee)  
• Some indirect impacts: projects contribute to knowledge that is then disseminated to policy through expertise  
• Some projects directly aims to enhance national research policy coordination: ERA bioenergy strategy project which became a NoE in FP6  
• Funding of the Biofuel Platform in FP6 | • No direct impact in geothermal and marine technology yet,  
• Some indirect impacts: awareness raising through demonstration, e.g. on marine technology  
• Some projects have paved the way for lobbying for higher feed-in tariff in France on geothermal energy | • Policy impacts very indirect and still potential |
Exhibit 42    Synthesis of main results per area – policy impacts

<table>
<thead>
<tr>
<th>Coordination of national policies</th>
<th>Wind</th>
<th>CSS</th>
<th>Socio-economic and policy related research theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy storage</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| • Examples in the area of EC research that have paved the ways for national research, especially in new member states. The interviews provide little evidence that FP projects in Energy Storage and Distribution have contributed to better coordination of national research activities within EU. | • Importance of the Technology Platform for Wind Energy (TPWind) | • In CSS technologies, EC support has extended and increased the investment of pioneer countries Netherlands and Norway.  
• Several large scale demonstration projects are partnerships between the EC and Member states. Role of catalyster of the EC efforts in this area. Implementation of flagship projects.  
• EC thematic networks in FP5 are interacting with the principal CCS national networks  
• Also in gas turbine technologies, the FP5 thematic network has brought together FP4, FP5 and MS projects | • Stakeholder interviews revealed only very limited awareness of the SEPR research activities carried out in FP5 and FP6, which suggests that there is a substantial opportunity for further cross-fertilisation and harmonisation of priorities across EU and MS levels |
| Other policy impacts              |      |     |                                               |
| • Little impact in general  
• One example: EU DEEP project: knowledge provided to policy arena through benchmark. The project was instrumental in the set up of new institution (European network of transmission operators). The project has direct objective to identify and map the regulatory constraints.  
• The IRED cluster have contributed to the recognition in the SET PLAN of Smart grids as a section and the continuation as one of six new European Industrial Initiatives launched by the European Commission in order to target sectors which working at Community level will add most value. |      |     | • 85% of project participants report some positive impact on EU and or member state policy communities  
• MS policy teams were very hard to engage, and the small numbers that did grant interviews acknowledged the relevance of the work but stated they had little awareness of and had made no good use of the FP intelligence or project archive. |
7. Economic, environmental and social impacts

7.1 Economic impacts: overall picture

Often economic impacts are realised quite some time after the R&D project. In this evaluation, projects from FP5 and FP6 were studied, some of which had not finished at the time of evaluation and others had only recently finished. The assessment of effects is therefore only a snapshot of the situation, and effects may increase over time.

In Exhibit 43, outputs produced by the survey respondents or their organisation are given as stated in the survey.

Exhibit 43: Outputs and impacts produced in FP NNE projects

<table>
<thead>
<tr>
<th>Outputs</th>
<th>Produced</th>
<th>Average output production</th>
<th>Average for all participants</th>
<th>Estimated total outputs</th>
<th>Min total outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>New or improved processes</td>
<td>56%</td>
<td>2.2</td>
<td>1.2</td>
<td>3,513</td>
<td>388</td>
</tr>
<tr>
<td>New or improved products</td>
<td>45%</td>
<td>2.0</td>
<td>0.9</td>
<td>2,537</td>
<td>305</td>
</tr>
<tr>
<td>New or improved services</td>
<td>42%</td>
<td>1.8</td>
<td>0.8</td>
<td>2,179</td>
<td>269</td>
</tr>
<tr>
<td>New or improved norms or standards</td>
<td>25%</td>
<td>1.9</td>
<td>0.5</td>
<td>1,340</td>
<td>162</td>
</tr>
<tr>
<td>Software or codes</td>
<td>31%</td>
<td>1.9</td>
<td>0.6</td>
<td>1,669</td>
<td>191</td>
</tr>
<tr>
<td>Copyrights</td>
<td>20%</td>
<td>1.8</td>
<td>0.4</td>
<td>1,039</td>
<td>166</td>
</tr>
<tr>
<td>Patent applications</td>
<td>24%</td>
<td>1.2</td>
<td>0.3</td>
<td>856</td>
<td>131</td>
</tr>
<tr>
<td>New jobs</td>
<td>46%</td>
<td>1.9</td>
<td>0.9</td>
<td>2,578</td>
<td>314</td>
</tr>
<tr>
<td>Spin-off companies</td>
<td>7%</td>
<td>1.6</td>
<td>0.1</td>
<td>338</td>
<td>60</td>
</tr>
<tr>
<td>Licenses sold</td>
<td>7%</td>
<td>1.0</td>
<td>0.1</td>
<td>207</td>
<td>50</td>
</tr>
</tbody>
</table>

Source: Technopolis survey

Note that n varies between 384 and 424

The most common mentioned (economic) outputs are in the group of new or improved processes, products and services. Some 40-55% of all respondents claim (one or more) of these effects. This does not mean that these processes, products or services have been implemented in commercial practice, but it gives a first proxy of possible economic effects in due time.

The number of patents/million Euro research budget is between 0.14 and 0.96 (minimum estimate, maximum estimate respectively). Evaluations of other programmes show a number of patents per M€ research between 0.05 and 0.5, with a strong dependency on sector/science field\[^{45}\]. Even the minimum estimate is therefore in line with results from other evaluations.

New jobs are the main reported impact. Interviews suggest that these are to a large extent related to researcher positions.

\[^{45}\] Evaluation of STW (The Netherlands), 2006; Evaluation of LTI programme The Netherlands, 2006; Evaluation of VIB (Flanders), 2006; which also include benchmarks with a number of other international programmes and institutes
Spin-offs and licenses are reported by 7% of all projects. Even minimum estimates (1.5MC research leads to one spin-off) show a rather large number of spin-offs. Data on the success of spin-offs are not available.

In the case of the majority of the outputs listed, it was more common for FP5 respondents to claim these had been produced than for FP6 respondents. The few areas where FP6 participants have more commonly produced outputs are ‘new jobs’ (suggesting this refers to research jobs), ‘new or improved norms or standards’ and ‘patent applications’.

The resulting impact of NNE projects on participants’ own organisations is impressive, even for commercial outcomes: 10-20% report medium to large impacts on productivity, turnover, market share and / or profitability (Exhibit 44).

Exhibit 44: Impact of the project on the respondent’s organisation

<table>
<thead>
<tr>
<th>Area</th>
<th>Large impact</th>
<th>Medium impact</th>
<th>Small impact</th>
<th>No impact</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced cooperation with partners in EU countries</td>
<td>26%</td>
<td>43%</td>
<td>25%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Enhanced reputation and image</td>
<td>27%</td>
<td>39%</td>
<td>24%</td>
<td>8%</td>
<td>1%</td>
</tr>
<tr>
<td>Opportunity to conduct research in new areas</td>
<td>21%</td>
<td>37%</td>
<td>30%</td>
<td>10%</td>
<td>3%</td>
</tr>
<tr>
<td>Reoriented research strategy</td>
<td>10%</td>
<td>27%</td>
<td>33%</td>
<td>26%</td>
<td>9%</td>
</tr>
<tr>
<td>Development of new business opportunities</td>
<td>10%</td>
<td>25%</td>
<td>31%</td>
<td>24%</td>
<td>11%</td>
</tr>
<tr>
<td>Enhanced competitiveness</td>
<td>13%</td>
<td>27%</td>
<td>23%</td>
<td>25%</td>
<td>12%</td>
</tr>
<tr>
<td>Increased employment</td>
<td>4%</td>
<td>16%</td>
<td>32%</td>
<td>37%</td>
<td>9%</td>
</tr>
<tr>
<td>Enhanced cooperation with partners in non-EU countries</td>
<td>15%</td>
<td>31%</td>
<td>33%</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Reduced technical risks</td>
<td>13%</td>
<td>24%</td>
<td>35%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Enhanced productivity</td>
<td>13%</td>
<td>26%</td>
<td>41%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Access to new markets</td>
<td>13%</td>
<td>21%</td>
<td>40%</td>
<td>21%</td>
<td></td>
</tr>
<tr>
<td>Reoriented commercial strategy</td>
<td>10%</td>
<td>22%</td>
<td>43%</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Reduced commercial risks</td>
<td>9%</td>
<td>21%</td>
<td>46%</td>
<td>21%</td>
<td></td>
</tr>
<tr>
<td>Increased turnover</td>
<td>9%</td>
<td>23%</td>
<td>44%</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>Improved market share</td>
<td>8%</td>
<td>19%</td>
<td>47%</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>Increased profitability</td>
<td>8%</td>
<td>17%</td>
<td>50%</td>
<td>24%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Technopolis survey

Note n varies between 415 and 433

There is a slight increase in the incidence of many areas of impact on the respondents’ organisation from FP5 to FP6, although the most commonly cited benefits are similar between these two groups. Significantly, there appears to be an increase from FP5 to FP6 in the incidence of a range of commercial impacts on the organisation (business opportunities, employment, productivity, etc.).

7.2 Economic impacts per area

The profile of outputs is more differentiated at the thematic level.

7.2.1 Economic impacts in the solar area

Overall the impact of solar energy projects on participants’ own organisations is impressive, even for commercial outcomes: 60% of survey respondents report medium to large impacts on competitiveness and 40% report medium to large impacts on productivity and increased employment. Even 10-15% report medium to large impacts on turnover, market share and / or
profitability. This indicates that EU funded projects in the area of solar energy are relevant for industry and have some level of economic impact as well.

The industrial relevance and economic impact of the EU funded research projects in FP5 and FP6 is also stressed in the interviews with companies and research institutes. We have found a number of examples that show a direct economic impact of European funded research. This can be illustrated by the examples of CIS/CIGS thin film, Crystalline silicon, and in particular the production of metallurgical solar grade silicon and Silicon thin film.  

These cases include three main technology fields for photovoltaics that have received a lot of attention in both FP5 and FP6 and where we have found evidence of technology that is developed in European funded projects and commercialised by industry. Many European projects build upon knowledge developed earlier. For example, most of the basic principles on thin film processing are developed in universities in the eighties. So for thin film a typical time-to-market is 15-20 years. For the projects started in FP5 (1998) we see commercial spin-offs from 2006. So, time to market of (European) funded research is about 10 years.

One has to keep in mind that funding from the EC was only one source of funding, next to national public funding and private investment. Usually these other funds are bigger than those from the EC. For example, the German federal government spent about 40 MEuro per year on R&D in the field of solar energy during the period 1998-2008, compared to approximately 21 Meuro per year EC spend on solar energy for Europe as a whole (budget for solar energy was 76 Meuro in FP6 and 92 Meuro in FP5). Nevertheless, all the interviewees have indicated that EC funding has had a positive and important impact on the development and commercialisation of solar energy technology in Europe, despite the relatively small amount of money that comes from the EC as compared to other funding sources.

Finally, much of the economic spin-off of European research in the field of solar energy takes place in Germany. The case on thin film CIS/CIGS shows that technology developed in Sweden, France and the US is transferred to Germany. The main reason for this is that the German government has invested heavily in PV (and other renewable energy technologies); not only in terms of R&D funding, but more importantly it created a market for PV which has boosted demand and hence the development of the PV industry in Germany. In addition, some German states like Saxony provide attractive (fiscal) incentives for companies who build a production plant for pv. As a result of this, Germany is leading in Europe when it comes to R&D and production of solar cells, and installed capacity. In 2008, more than 74,000 people were employed in the German solar energy industry (of which 57,000 in PV).

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46 These cases are developed in the Solar energy area report.
Since the beginning of the nineties, a number of European research organisations (such as the University of Uppsala, the Swiss Federal Institute of Technology..) have been working on Copper-Indium-Selenide (CIS) and Copper Indium Gallium Diselenide (CIGS) material for thin film solar cell applications.

Research in this area has received significant amounts of funding from national governments and the European Commission in the past decade in order to develop and optimise efficient CIS/CIGS thin film solar cells and make the technology ready for large-scale commercial production.

During the FP4 and FP5 period projects focused on specific components of the cell with a view to demonstrate feasibility of the concept in a laboratory scale for small areas. In addition much research was performed on process technology and production methods. During the FP6 period, the focus was more on transferring promising laboratory results to large-scale industrial production in order to achieve high throughput and quality.

The impact of this continuous research effort in the past 15 years has only recently been visible in terms of economic spin-offs. Wurth Solar was the first company to enter commercial production of CIS modules in 2006 and since then three other companies have opened production facilities for large-scale commercial production of CIS or CIGS thin film solar cells in Europe. All factories are located in Germany because of the attractive market for PV and attractive government schemes in Saxony (solar valley) to set-up a factory there.

Four more or less separate development lines can be identified:

- A line from Stuttgart University in Germany, by way of ZSW to Wurth Solar for commercial application. In 2006 Wurth Solar started with the commercial mass production of CIS solar modules at 15 MW/year and it was the first company that produced thin film CIS solar cells in large volume. Since 2007, the plant runs at full capacity (30 MW/year) and produces about 1000 modules per day. The efficiency of the modules is about 12%. Wurth Solar employed about 210 people in 2008 of which 2/3 worked in production. ZSW research focus is still dedicated to CIS technology over the entire value chain.

- A second line from the Hahn-Meiter Institute in Berlin that demonstrated its (prior developed) technology to manufacture CIS solar cells since 1998 in a European research project (Sulfurell). This resulted in 2001 in the spin-off company Sulfurell Solartechnik GmbH. Development continued within Sulfarcell, with support from HMI, and in 2003 a pilot line was set-up and expanded in 2006 when commercial production started. In 2007 the production capacity was about 1 MW/year. The company now employs 60 people and is planning to build a second production facility.

- In Sweden the Ångström Solar Center at the University of Uppsala has been working on the development of CIGS solar cells since the nineties, with national as well as EU funding. In 2001 a spin-off company was set-up named Solibro AB to commercialise the CIGS technology developed at the institute. Solibro has achieved the production of modules at industrial scale with efficiencies exceeding 11.5%. In 2006 Solibro GmbH was set-up as a joint venture between Solibro AB and Q-Cells. Q-Cells has a 67.5% shareholding in the new company. Solibro GmbH currently has a production capacity of 30 MWp per year and 183 employees in Germany (Bitterfeld-Wolfen, Saxony) and Uppsala. The company is expanding its production capacity in Germany and announced in October 2008 that it will build a new manufacturing plant for CIGS modules in Germany with a production capacity of 90 MWp. This will result in 250 new jobs in the region and a 165 million investment in the new factory. First modules from the new factory are expected before the end of 2009.

- Finally, Shell Solar has played a major role in the development of first-generation CIS technology both in Europe and the US. Shell Solar participated in European funded projects via its partner Saint Gobain from France. In 2007 the company AVANCIS was founded which is joint venture between Shell Solar and Saint Gobain. AVANCIS brings CIS thin-film modules to the market with an efficiency level of 11%. The company opened its first production plant of 20 MW in Torgau Saxony (Germany) in October 2008 and plans to expand its production capacity at this location to 80 MW. AVANCIS has created 85 new highly qualified jobs in the first wave of development at the Torgau production site and a further 45 will be added in 2009, according to the website. In addition 30 R&D employees are employed at the R&D facility in Munich.

To conclude, EC research funding during FP4-FP6 has clearly contributed to the development and commercialisation of CIS/CIGS technology in Europe. At the same time other factors (i.e. RTDI funding from national governments, private investments, etc) also played an important role, but EC funding proved to be important.
7.2.2 Economic impacts in the wind area

Projects carried out in FP5 and FP6 in the field of wind energy have helped to make wind energy more attractive by lowering the cost of wind turbines, through research in the fields of aerodynamics and aeroelasticity, components and materials, etc. and by increasing reliability of wind turbines, through research in the areas of forecasting, control and monitoring, interaction with the grid, etc. However, it is difficult to assess precisely the extent to which FP projects have contributed to these trends. Other direct effects are the direct application of developed tools in various projects e.g. in the ANEMOS where commercial contracts for the wind forecasting model developed were established with companies such as Hydro-Québec (Canada’s largest electric utility) and Nenmco (National Electricity Market Management Company Limited) in Australia. This latter contract led to the implementation of the ANEMOS system in all Australian wind farms.\textsuperscript{48} In the STABCON project, the consortium commercialised the computer tool that was developed during the project to wind turbine manufacturers on the basis of licence contracts. Project partners were also requested to do some consultancy work for companies.

On the social/environmental side, wind energy projects have had an indirect positive effect on the public acceptance of wind turbines, by helping to minimise the drawbacks of wind turbines (vibrations, noise, visual impact). E.g. KNOW-BLADE and STABCON achieved results in the field of elasticity and structural stability of wind turbines and SIROCCO contributed by improving the design of silent rotors by acoustic optimisation.

In FP6, there is only one project in the area of wind energy, which is due to finish in 2010 (UPWIND). It focuses on offshore wind technology. Economic effects are not clear yet, but there is a strong involvement of industry.

7.2.3 Economic impacts in the biomass area

The biomass area participants performed much better in producing economic outputs than the rest of the participants according to the survey, especially spin-off companies and licenses sold occur twice as much in the biomass area than average. However, breakthrough technologies have not been developed.

Several examples of concrete economic outputs were described, most of which come from SME partners. For instance, the FP5 Co-production Biofuel (IBUS) project has acknowledged a success for both the SME that actively contributed to the development of the solution and the utility company (Elsam in Denmark, now part of DONG Energy, the largest utility in Denmark) that took over the results to build a large-scale production of bioethanol from straw demonstration plant. Elsam conducted research on the utilisation of straw for large-scale energy production in the 1990’s. The IBUS project allowed for the development of prototypes and to demonstrate the complete process of the IBUS technology that had been designed by the SME partner. The project ended up in the creation of the INBICON company, which now belongs to DONG Energy. The director of the SME sold its INBICON shares to DONG. The company has decided to invest largely in building a bioethanol demonstration plant in Kalundborg. DONG has the objective to present the operating bioethanol plant in the UN climate summit in December 2009, which will be hosted by Denmark.

Other examples are the AER GAS I (FP5) and II (FP6) projects. The first project was about proving the feasibility of the Absorption Enhanced gasification/Reforming (AER) process. The AER GAS II focused on the development of the process at an industrial level. According to one participant, an investment of a dozen million euros is planned to build a plant in Germany.

The main diffusion channel for the scientific results to the economic arena is first and foremost the participation in projects. Users (mostly industries) are often part of the project from the writing of the proposal stage. Barriers for practical application relate to the very high costs and risks

\textsuperscript{48} See Annex 1 for more information on the ANEMOS project
associated to the building of new plants. Indeed, only a few gasifiers are running to date, and not yet on a commercial scale.

The industry seems to be characterised by small technology developers and large utilities that are conservative from a technology point of view and that often do not see process development as their core business. The price to pay for a new plant is in the dozen million euros range. Industries are not willing or able to take the technological risk for such amounts.

Interviewees from utilities regretted that the EU funding is fragmented and lagging behind other countries (e.g. United States). Apart from the funding issue, legal barriers arise when it comes to implementing biomass solutions in existing plants. Even for co-firing plants, the cheapest and most promising short-term solution to increase the biomass use, the delays in permits delivery by national authorities hinders its development.

### 7.2.4 Economic impacts in the area of other energy sources

The economic impacts of marine energy projects, if any, have been very small. There have been some achievements in the up-scaling of devices, but in general costs remain high, commercial application is not yet achieved and marine energy is still a very risky sector. The modest, but more positive results on enhancement of the organisation’s image, increased employment, opportunities to conduct research in new areas and enhanced cooperation within the EU lead to the belief that marine energy projects have contributed to nudging the sector more towards circumstances that will help them to further develop the sector, which, considering the small amount of projects and funding is probably all that can be expected. It is clear that much more support will be needed to achieve this goal in the end.

In the area of geothermal energy, enhanced competitiveness and reputation were rated as large impacts by nearly a third, and half of the survey respondents, respectively. In addition, reduced technical risks and development of new business opportunities were rated as medium to large impacts by more than half of the respondents. On the other side, impacts on profitability, turnover, and improved market share were relatively small. The rather low economic impacts relate to the small extent to which knowledge from the projects is at present being exploited commercially. In Europe, many locations are suitable for this type of exploitation and further demonstration is now needed. Only after more demonstration and commercial use of the EGS technology, the potential economic impacts will be realised.

### 7.2.5 Economic impacts in the storage and distribution area

The time scale for economic impact in projects concerning energy storage and electricity distribution is typically long-term. It is therefore still too early to expect economic impacts from these projects. Economic results were not the main target: many projects were focusing on solving a problem at system level, not pursuing direct economic interests. However almost one third of those from this area who answered the survey have reported economic outputs, mainly new services and new processes Some 11% of those who answered the survey have filed patent applications (which is low compared to other areas).

Interviews show that there are signs of economic results coming through in several projects:

In the DEEP project, improving business is seen as the next step of the project. Utilities will be able within the next five years to develop offers and have started analysing it in detail now.

**VERBATIM (INTERVIEW)**

- The DEEP project developed a toolbox for the aggregators to model and run a business. Some of the tools we developed are ready for application, we have a clear picture of the required functionalities and targeted costs for others.
In the Alistore project, milestones that will change the battery market can be identified, but require up-scaling and industrial testing. New ideas are now being patented, with the possibility of market introduction within a couple of years, according to one project participant.

One participant in More Microgrids explained that the process they have developed in their part of the project is at present undergoing patent evaluation. By the end of 2009 this scheme should be operational, but total costs of the investment are high (estimated between EUR 6 and 7 million). Cooperation of both policy makers and bankers is thus required, since other sources of funding are difficult to come by.

### 7.2.6 Economic outputs and effects in the Hydrogen and fuel cells area

The economic effects of the participation in FP5 and FP6 Hydrogen and fuel cell research projects fall below the all NNE areas average in the survey. For instance, only 41% (54% for all areas) declare there has been an increase in employment as a result of the project, mostly researchers. When asked about project results, only 34% of Hydrogen and FC respondents (46% for all areas) declare the projects resulted in the creation of new jobs. Productivity gain is also well below the all areas average (34% in the FC area against 44% for all areas).

The presence of companies was put forward by several public researchers as a good practice to increase the likelihood to use and exploitation of the results produced in the project. User companies are especially beneficial to the project through two main roles:

- They develop real world specifications that become project targets or at least guidelines;
- They can test the products more easily and provide effective feedback to the developers and researchers. As one interviewee put it, they provide the “reality check” which is essential in fuel cell technologies given the number of parameters at stake, the heterogeneity of application requirements and the paucity of knowledge on real-world behaviour of fuel cells materials, components and systems.

However, several participants in different projects mentioned that a crucial problem affecting FP5 and especially FP6 projects was the absence of European FC developers since the last one, Nuvera, was sold to a US company. This event was an important hurdle in the AUTOBRANE project, in which Nuvera initially participated. More generally, the failure to secure the participation of a key industry partner can be seen as a failure, as for instance in the GENFC project which lacked a material or component developer.

One of the very few SMEs that succeeded in coordinating a project mentioned that there is also a significant label and leverage effect in doing so. The legitimacy and visibility of the company increased in the FC area, especially with regards to access to national public funding (the coordination or participation in a FP project is a positive criteria in several national calls for proposal). The leverage effect can play a role in industrial relations: another company explained that, although it had not had any activity in FC prior to its participation in a FP5 project, it has since then been approached by and subsequently awarded a contract by a US company to commercialise its stationary FC (UPS application) in exchange of access to its customer base.

### 7.2.7 Economic impacts in the socio-economic area

The stakeholder interviews provided no examples of socio-economic projects having produced directly attributable economic benefits, which was not expected given the programme objectives and primary purpose.

By contrast, although lower than in other areas, the participant survey revealed a broad range of economic impacts attributable at least in part to the FP5 or FP6 project in question. The development of new business opportunities was the most widely reported economic benefit, with more than 50% of all respondents stating that their involvement in the FP project had delivered a gain of some measure to their employer. 40% of respondents stated that the project had led to an improvement in the competitiveness or international standing of their employer and 30% of
respondents stated that the project had led to an improvement in employment. 20% of respondents stated that the project had led to an improvement in one or more of several other classes of benefit, from turnover to profitability. In most cases, the impacts realised were reported to have been small to medium.

Exhibit 46 Lessons learned from the economic impacts assessment

The main results are as follows:

- the principal economic impacts are indirect and contingent upon the realisation of important scientific and technological objective, especially costs and reliability. In several areas, these S&T achievements are still uncertain (as for instance in the fuel cell area).
- it might take 10-20 years and even much more for projects to fulfil their economic potential
- the intensity of economic impact also depend on the involvement of industry, which has decreased from FP5 to FP6 (in terms of share of number of participations)
- the results varied according to areas. In the solar energy area especially, the survey and interviews showed impressive economic impacts (increased competitiveness of incumbents, new spin-offs).
- According to the survey, at individual participants level, the most common commercial outcomes are successful demonstration of novel technologies and the creation of new products and services.
- The number of patents/million Euro FP spend is comparable with results from other evaluations.
- New jobs are the main reported impact. Interviews suggest that these are to a large extent related to employment on follow-up research projects, although a minority relate to new products and services.

7.3 Environmental impacts

7.3.1 Overall environmental impacts

Positive environmental impacts result from the progress made by NNE research projects when widely applied. Progress in application of renewable sources between 1995 and 2006 has been significant: application of solar PV has increased by a factor of more than a hundred; wind energy by a factor twenty; solar thermal and biomass have increased and even hydroelectric power increased with an absolute 16 GWe. This increase in use of renewable energy decreases CO2 emission and (in most cases) also fossil fuel related emissions of NOx and SO2.

However, they are indirect, conditioned to the scientific, economic and policy achievements. Their assessment therefore faces the same challenges: long term time frame and imputation problem.

In the survey, respondents were asked to assess the impact of the project more broadly, on energy and the environment (Exhibit 47). More than half of all respondents reported medium or large impacts for the development of clean energy systems (76%), reduced environmental impacts from energy production/use (60%) and development of renewable energy sources (57%). It should be noted that these impacts are certainly more expected impacts than effective impacts.

Some significant differences exist between the thematic areas. For example, those participating in biomass, solar energy and wind themes most frequently pointed to the development of renewable energy sources as an area of medium or large impact from the project, whereas the development of new environmental legislation/policy was most commonly reported amongst those within the socio-economic and policy related theme. Even so, medium or large impacts on the development of clean energy systems was most commonly cited in most cases.
Exhibit 47  Impact of the project on energy and the environment

<table>
<thead>
<tr>
<th>Impact Area</th>
<th>Large Impact</th>
<th>Medium Impact</th>
<th>Small Impact</th>
<th>No Impact</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of clean energy systems</td>
<td>38%</td>
<td>38%</td>
<td>15%</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Reduced environmental impacts from energy prod.</td>
<td>28%</td>
<td>32%</td>
<td>21%</td>
<td>12%</td>
<td>7%</td>
</tr>
<tr>
<td>Development of renewable energy sources</td>
<td>20%</td>
<td>28%</td>
<td>21%</td>
<td>14%</td>
<td>8%</td>
</tr>
<tr>
<td>Development of markets for sustainable energy</td>
<td>15%</td>
<td>34%</td>
<td>28%</td>
<td>14%</td>
<td>19%</td>
</tr>
<tr>
<td>Reduced costs of sustainable energy technologies</td>
<td>20%</td>
<td>31%</td>
<td>26%</td>
<td>15%</td>
<td>8%</td>
</tr>
<tr>
<td>Increased efficiency of energy production</td>
<td>25%</td>
<td>26%</td>
<td>21%</td>
<td>18%</td>
<td>10%</td>
</tr>
<tr>
<td>Reduced dependence on fossil fuels</td>
<td>23%</td>
<td>25%</td>
<td>24%</td>
<td>19%</td>
<td>9%</td>
</tr>
<tr>
<td>Increased security of energy supply</td>
<td>16%</td>
<td>27%</td>
<td>23%</td>
<td>21%</td>
<td>12%</td>
</tr>
<tr>
<td>Development of new environmental legislation</td>
<td>10%</td>
<td>27%</td>
<td>26%</td>
<td>25%</td>
<td>12%</td>
</tr>
<tr>
<td>Increased efficiency of energy use</td>
<td>18%</td>
<td>16%</td>
<td>20%</td>
<td>28%</td>
<td>17%</td>
</tr>
<tr>
<td>Increased efficiency of energy storage and dist.</td>
<td>12%</td>
<td>14%</td>
<td>20%</td>
<td>34%</td>
<td>19%</td>
</tr>
<tr>
<td>Reduced demand for energy</td>
<td>12%</td>
<td>7%</td>
<td>10%</td>
<td>47%</td>
<td>24%</td>
</tr>
<tr>
<td>Improved techniques for carbon capture and storg.</td>
<td>12%</td>
<td>7%</td>
<td>10%</td>
<td>47%</td>
<td>24%</td>
</tr>
</tbody>
</table>

Source: Technopolis survey

Note: n varies between 21 and 197

In addition to the potential outcomes listed above, respondents were asked to list any other significant impacts of the project on energy and the environment (see verbatim below).

**VERBATIM (SURVEY)**

- Medium impact on the development of new photovoltaic system
- Integrated assessment of EU policies on energy and environment
- Definition of comprehensive strategies for air quality improvement, climate change mitigation, security of energy supply
- Increased efficiency, reduction on fossil fuels, increased use of renewable resources
- Increased definition of key parameters of SOFC entrance into the market
- Enhanced European competitiveness
- Developed carbon capture and storage faster than expected
- Developed spin off projects, networks of excellence -CO2GEONET and ZEP technology platform. CO2NET now specialising in CCS personnel capacity building
- Better analysis of overall European Energy/Environment interactions
- “Energy modelling capability useful for further analyses of EU energy and climate policies”

7.3.2 Environmental impacts by area

As has been stated above in the chapter on economic impacts, the effects of FP outside the research world are indirect and not fully traceable. They are however significant in the area of solar energy
and more limited in the areas of wind energy and biomass (because of the limited impact of FP research on the developments in these areas) and non-existent in the area of hydropower (because this was mainly outside the scope of FP).

In high temperature geothermal energy, ocean energy and CCS, the role of the FPs has been more significant, but most projects are still in the R&D or early demonstration phase. Although possible (future) impacts are large; actual environmental effects are restricted to the demonstration and pilot plants.

With CCS there may also be adverse effects. Greenpeace has pointed out in a recent report that it is very likely that CCS comes too late to successfully reverse climate change. As CCS will not be available before 2030, it will not stop global warming as this would require a reduction of global greenhouse gas emissions starting from 2015. The most important argument made by environmentalists, however, relates to the negative energy balance of CCS. It is estimated that CCS uses between 10% and 40% of the total energy produced in a power station. Thus, the large scale implementation of CCS could reverse the efficiency gains obtained in the last 50 years. Last but not least, not everybody is convinced that the underground storage of CO2 will be safe in the long run.

The environmental effects of research in the storage and distribution area are also limited. Research in this area is not directly aiming to reduce environmental impact, but in trying to develop technologies and knowledge that can fulfil framework conditions in a transition from a fossil fuel economy to a renewable based economy.

In the Hydrogen and fuel cell area, the environmental impacts of projects can only be potential at this stage of the technology development. The potential impacts are tremendous since the technologies could be used in a wide range of applications among the main producers of CO2 and pollution, especially transport and in (depending on national energy mixes) electricity production. Most projects had very ambitious goals in terms of energy efficiency, along with objectives in terms of low emissions and competitive costs. These projects tested innovative concepts for Hydrogen generation (from water splitting, coupled with renewable energy,...), storage or conversion to fulfill these expectations. For example, the series of projects led by RRFCS (MF-SOFC, PIP-SOFC) developed fuel cell/gas turbine hybrid stacks which, if successful in combining these two technologies, could reach efficiency in the range of 60-70%. The project clean energy from biomass aimed at the development of a high-energy efficiency system (55% or even higher if the system can be used for cogeneration) by coupling of biomass steam gasification and a Molten Carbonate Fuel-Cell (MCFC). Also, the FP6 project Biocellus developed an innovative SOFC concept from biomass that involved heating an allothermal gasifier with the exhaust heat of the fuel cell by means of liquid metal heat pipes. This use of wasted heat should allow electrical efficiencies of above 50%, as compared to 30% for typical biomass fuel cells systems.

Exhibit 48 Lessons learned from the environmental impacts assessment

The main results are as follows:

- Positive environmental impacts result from the progress made by NNE research projects when widely applied. Progress in application of renewable sources between 1995 and 2006 has been significant: application of solar PV has increased by a factor of more than a hundred; wind energy by a factor twenty; solar thermal and biomass have increased and even hydroelectric power increased with an absolute 16 GW. This increase in use of renewable energy decreases CO2 emission and (in most cases) also fossil fuel related emissions of NOx and SO2.

- However, they are indirect, conditioned to the scientific, economic and policy achievements. Their assessment therefore faces the same challenges: long term time frame and imputation problem.
7.4 Social impacts

'Social impact' is used here in its broadest sense (from impacts on education and training to awareness raising, legitimacy and social and health impact studies).

An important area that has been realised in a number of projects is the development of training programmes and courses. They are found in most FP6 large instruments’ dissemination packages. Much more than in FP5, these projects almost systematically carry out training and courses in parallel to technical developments: teaching and training with lectures, conferences at universities, visit of plants. In the storage and distribution area for instance, the Alistore project has led to the creation of the new university programme (Erasmus mundus label). The programme is a two-year course on storage and conversion, created jointly by three universities participating in the project (from France, Poland and Spain). In the fuel cell area, the IP REAL-SOFC organised a one week well-appreciated summer school on Manufacturing SOFC « From the laboratory to the industry and into the market place ». However, considering the frequency of these events, the initial momentum seems to have decrease toward the second half of these projects.

Social impacts on society at large includes effects on ‘increased acceptance of renewable energy’. In the area of biomass the increase in socio-economic research in biomass FP projects was a reaction to the growing concern by civil society and policy makers about environmental damages of the biomass deployment. Apart from new technologies with diminished impacts, LCA methodologies have been developed to evaluate the various environmental impacts in order to take away civil concerns. In the wind area, a lot of research attention was aimed at minimising the drawbacks of wind turbines (vibrations, noise, visual impact: e.g. in KNOW-BLADE and STABCON that achieved results in the field of elasticity and structural stability of wind turbines. SIROCCO contributed to improve the design of silent rotors by acoustic optimisation). More indirectly positive results from demonstration projects also led to effective communication on the positive effects and possibilities of renewable energy (e.g. PS-10 in CSP, many popular scientific articles on PV, etc.) there may be more effects of this kind as a result of the FP5 and FP6 research. However, it takes time to assess this sort of outcome, at the same time as it is very difficult to pin down any results or benefits for the end users stemming from one specific project.

Exhibit 49 Lessons learned from the social impacts assessment

The main results are as follows:

* training programmes and courses are found in most FP6 large instruments’ dissemination packages. However, the frequency of these events seem to decrease toward the second half of these projects.

* several socio economic projects undertook investigations of the effect on certain technologies on negative social and environmental effects such as in the biomass area.
### Exhibit 50  Synthesis of main results per area – policy impacts

<table>
<thead>
<tr>
<th>Solar energy</th>
<th>Biomass</th>
<th>Other renewables</th>
<th>H2 and Fuel cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic impacts</td>
<td>• Survey show impressive impacts on competitiveness, far above all-NNE areas average</td>
<td>• Large companies do not expect breakthrough but aim to keep in touch with state of the art research</td>
<td>• Minimal economic impacts (Marine: some achievements in up scaling of devices, but costs remain high and commercial application is not yet achieved; Geothermal: only economic impacts after demonstration which up to now is limited)</td>
</tr>
<tr>
<td></td>
<td>• Several examples of direct economic impacts. FP5 projects started in 1998 start now having commercial spin-offs (10 years for first economic impacts).</td>
<td>• A few success stories such as IBUS project in FP5, has contributed to creation of a company</td>
<td>• Barrier: lack of involvement of industry in up-scaling of technology beyond prototype</td>
</tr>
<tr>
<td></td>
<td>• 5 demonstration of 3 different CSP technologies have increased visibility of this sub-area area and attracted industry</td>
<td>• Barrier: lack of involvement of industry in up-scaling of technology beyond prototype</td>
<td></td>
</tr>
<tr>
<td>Environmental impacts</td>
<td>• Real impact on energy efficiency and green-house gas since PV are on the market</td>
<td>• No impacts since technology are not yet commercialised</td>
<td>• Some technology can have negative environmental impacts, FP6 project do research on impacts (hydro-power, geothermal)</td>
</tr>
<tr>
<td></td>
<td>• Survey: main expected impact: clean energy systems (94%)</td>
<td>• Survey: main expected impact: Development of renewable energy sources (99% of respondents)</td>
<td>• Survey: main expected impact: Development of clean energy systems (100%)</td>
</tr>
</tbody>
</table>

### Exhibit 51  Synthesis of main results per area – policy impacts

<table>
<thead>
<tr>
<th>Energy storage</th>
<th>Wind</th>
<th>CSS</th>
<th>Socio-economic and policy related research theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic impacts</td>
<td>• The time scale for economic impact in projects concerning energy storage and electricity distribution is typically long-term, and many interviewees say it is still too early to expect economic impacts from these projects.</td>
<td>• Economic results of wind energy projects are generally better than average, especially in terms of patent applications, copyrights and licenses sold. The development of new or improved products is mentioned by a majority (66%) of respondents as a result of projects.</td>
<td>• Limited at this stage beyond some participants drawing benefits of certain development. Several technologies elaborated in FP projects are applied by companies but still for pilot unit testing, not yet commercialised.</td>
</tr>
<tr>
<td></td>
<td>• That said, there are some indications of economic result. Almost one third of those from this area who answered the survey have reported new or improved products from their participation. About one third indicate new or improved services, and some report new or improved processes. Three participants have achieved copyrights as a result of taking part in a project and seven project participants have filed patent applications.</td>
<td>• Significant impact on public awareness of CCS technologies</td>
<td>• Stakeholder interviews suggest the embedded socio-economic research (often support for dialogue, market research and communications) had made a critical difference to the success of technical projects, however no one could begin to quantify its contribution</td>
</tr>
<tr>
<td>Environmental impacts</td>
<td>• Survey: main expected impact: clean energy systems (89%)</td>
<td>• Survey: main expected impact: clean energy systems (94%)</td>
<td>• Survey: main expected impact: clean energy systems (94%)</td>
</tr>
</tbody>
</table>

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**EPEC – Evaluation and Impact Assessment of the European NNE RTD Programme**  
**Final report**
8. Recommendations

Recommendation 1  The budget dedicated to NNE research should be increased in order to be aligned with the size of clean energy challenges

The evaluation has demonstrated that FP NNE research is an essential component of European research toward more efficient and cleaner energy. In this thematic, which encompasses such challenging areas, the added value of transnational research that allows the gathering of complementary competencies is obvious and well acknowledged by participants and stakeholders.

However, the relative budget dedicated to NNE research in FP has dramatically decreased since FP4, while during the same period the scope of clean energy challenges and underlying stakes dramatically increased. This decrease is also not consistent with the official policy intentions repeatedly put forward at EU level. The EC contribution has also experienced a significant decrease relatively to EU-27 NNE R&D expenditures. The difference is such that it is not clear at all whether FP research can still pretend to leverage and coordinate member states NNE research budgets; which is essential to reach the order of magnitude of the principal competing countries, particularly the US and Japan in most strategic areas.

Recommendation 2  The number and concentration of resources on large instruments should be reduced

The added value and rationales for large instrument has been very debated in interviews, survey free comments and workshops. Despite some acknowledged successes and clear advantages under certain conditions where seeking economies of scale and scope makes sense (for codes, tests and models, for large infrastructure as in CCS, for exploring a variety of uncertain options in fuel cells and PV...), the assessment is mitigated. Not even mentioning the administrative burden, the relationships between the different participants in different parts and working packages of large projects were often weak. Several problems related to competitive behaviours between participants or different strategies of research and industry have also hindered the effectiveness of these large instruments. As a result, evaluators found little evidences of their expected positive effects in terms of increased cooperation and improved coordination. Several interviews with industry can even support the idea that the increased reluctance to participate was due to, or at least increased by, large instruments.

This limitation of FP6, where the EC concentrated the bulk of its contribution on large instruments, has already been reported in other occasions, from the beginning of FP6 (Marimon report, 2004) to more recent reports (European court of Auditors, 2009). These results and recommendations were taken on-board by the Commission in FP7, in which the very large projects have been suppressed (however, the average size of projects increased even more). However, given the importance this question had in this study, evaluators would like to emphasize some specific issues:

- Decision upon the most adequate size of the project should be based on a proper estimate of what added value is expected: where are economies of scale and scope to be found? What type of critical mass should be achieved? What justify the gathering of a large number of actors in a given project? The aforementioned report of the European court of Auditors explicitly recommended that large instruments should be based on an explicit intervention logic "linking...".

50 ‘Networks of excellence’ and ‘integrated projects’ in community research policy: did they achieve their objectives?, European court of Auditors, 2009
the instruments to realistic objectives”. The evaluation of FP6 NNE research clearly back this recommendation: the type of instruments has been disconnected of the objectives, it became to some extent an end in itself... In sum, large instruments should not be banned from the EC “toolbox”, it is important that the Commission still use this instrument in certain conditions, in so far as it is used with a clear underlying strategy and intervention logic.

• The decision of setting up a large project should be more concerted with the main potential participants, especially the industry. Such gathering of competences cannot be done where competition is fierce, unless a proper governance structure, with clear “organisational walls”, is set up and accepted by participants. Cooperation between competitors cannot just be assumed, it must be prepared with the concerned parties...

• More resources, guidelines and training should be given to the coordinators and working package leaders in order for them not only to manage the budget, deadlines and deliverables, but also to moderate the relationships and exchanges.

Recommendation 3  The EC should set a clearer and more transparent decision process to support its budgetary trade-offs and decisions among areas

From one programme to another the allocation of budget among the different areas can significantly vary, as it was the case between FP5 to FP6. The origin and justification of these differences remain unclear, which open the way to severe criticisms of the programmes, instability and misunderstanding in the research community.

The Commission should therefore clarify the decision process that involve, among the principal influences, programme committees, technology platforms, and Commission internal expertises. For instance, in several areas such as H2 and fuel cells, technology platforms were said to have improved the relevance and focus of research. However, the basic principles of the contribution of these platforms to the EC strategy remains unclear.

Moreover, once the consultation is well advanced, the strategic principles that guide the choices should also be made more explicit, through the publication of a strategic document that set clear overarching orientations. This strategic document, at programme (NNE) level, should guide and found the subsequent work programmes. The results of the consultation and EC internal choices is directly put into the work programmes, which is too operational, related to calls. Such a process does not allow a sound strategy that would guide research activities.

Recommendation 4  The Commission should dedicate more resources to the management and, especially, monitoring of projects

The level of involvement of EC officers in the monitoring of projects is very different according to areas as well as periods. This can be easily explained by the low level of EC human resources relatively to the portfolio of projects and the rapid turnover of officers among areas. According to our information, project officers at the Commission can have between 15 to 20 projects – including in FP6 some very large projects – to manage. This is too heavy to pay proper attention to project progress and results.

EC project officers should be especially instrumental in supporting exploitation and dissemination activities, and coordination of relationships between projects at area level.

Recommendation 5  The coordination of related projects that fall under different thematics should be improved

In certain areas, the portfolio of projects was spread over several thematic priority, some of them being under the responsability of different DGs. Despite some progresses between FP5 and FP6,
the coordination of these projects was still in most cases weak and only done ex post, when the projects were already launched and sometimes well advanced.

Bridges should be built so these projects are thought and monitored in a common framework, well beyond the mere “catalogue approach” that too often currently prevails. Some interesting initiatives have been reported, such as in the H2 and Fuel cell area, where two sessions of “Review days” were organised with presentations of H2 and Fuel cell projects of different Commission origins. Such good practices should be systematised in all areas and made more regular.

**Recommendation 6** The Continuity of efforts on specific projects should be based on milestones and fulfilment of clear and realistic targets

The evaluation has shown that the most visible progresses were identified in sub-areas where the EC has afforded a continuous and focused effort, over several FPs. However, the continuity of funding is problematic as it reduced the funds available for new projects and participants. A more transparent and organised procedure should be set and made explicit regarding the opportunity of continuous financing of successful projects.

Lessons could be drawn to some extent from the DOE project management procedures: projects management should be based on clearer objectives and milestones that would determine the continuation of the EC effort on a given project. Such a process would also make compulsory the setting of clear, realistic and concerted goal performance, which was lacking in several projects.

**Recommendation 7** A study into practices of programme and project management in the US and Japan should be launched by the EC

DG research launched a well-appreciated study into the level of financing of NNE research in member states, EC and third country, by area. However, a complementary study into the governance and management principles that guide programme and projects would be useful. During workshops and interviews, several participants referred to DOE practices for instance (ex ante consultation process, systematic roadmapping directly related to programming, project management though milestones,....).

Although there is no “one best way” to programme and project management, a better knowledge of best practices drawn from third country experience in NNE research would be of great value to the Commission and Member States.

**Recommendation 8** DG research should implement and systematise dedicated support actions at area level

The evaluation has shed light upon the heterogeneity of the different areas within the NNE thematic priority. Areas should be the relevant level for strategic thinking and operational monitoring:

- Dedicated strategic initiatives should be implemented at area level, in order to support the Commission’ choices and research activities in projects: roadmapping, consultations, benchmarking... Such initiatives have been implemented in several projects (coordination actions but also in some cases IPs). However, their status as regards the other projects was not clear and to some extent hindered the participation of other actors and the diffusion of their results to the whole community of actors. The particular status of these projects, especially roadmapping and foresight initiatives, should be made more explicit: they are not just one more project, but an initiative that aim to ease coordination between projects, provide relevant information and, in some cases, support EC programming in the area.

- Dedicated monitoring and dissemination initiatives should be implemented at area level. The aforementioned “Review days” in H2 and fuel cells, drawn from DOE experience, were
Unfortunately not systematised and replicated in other areas. These types of events allow fruitful exchanges of information between projects, allow comparison and benchmarks of different options, improve the dissemination of project results to the relevant community and, finally, increase the “community effect” of EC projects participants in the same area, beyond their project boundaries.
Appendices
## Annexe A  Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCO</td>
<td>Specific International Scientific Cooperation Activities</td>
</tr>
<tr>
<td>NNE</td>
<td>Non nuclear energy</td>
</tr>
<tr>
<td>FP</td>
<td>Framework Programme</td>
</tr>
<tr>
<td>EPEC</td>
<td>European Policy Evaluation Consortium</td>
</tr>
<tr>
<td>ICPC</td>
<td>International Cooperation Partners Countries</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
<tr>
<td>IP</td>
<td>Integrated project</td>
</tr>
<tr>
<td>NoE</td>
<td>Network of Excellence</td>
</tr>
<tr>
<td>CA</td>
<td>Coordination actions</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>DG RTD</td>
<td>Research Directorate-General</td>
</tr>
<tr>
<td>DG TREN</td>
<td>Energy and Transport Directorate-General</td>
</tr>
<tr>
<td>H₂</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>CCS</td>
<td>Carbon capture and storage</td>
</tr>
<tr>
<td>EV</td>
<td>Electric vehicles</td>
</tr>
<tr>
<td>HEVs</td>
<td>Hybrid Electric vehicles</td>
</tr>
<tr>
<td>SRA</td>
<td>Strategic research agendas</td>
</tr>
<tr>
<td>ESPRC</td>
<td>Engineering and Physical Sciences Research Council (UK)</td>
</tr>
<tr>
<td>LTI</td>
<td>Energy research Centre of the Netherlands</td>
</tr>
<tr>
<td>VIB</td>
<td>Flanders Interuniversity Institute for Biotechnology</td>
</tr>
<tr>
<td>PV</td>
<td>Photovoltaics</td>
</tr>
<tr>
<td>CHP</td>
<td>Combined heat and power</td>
</tr>
<tr>
<td>SOFC</td>
<td>Solid oxide fuel cell</td>
</tr>
<tr>
<td>CSP</td>
<td>Concentrated solar power</td>
</tr>
<tr>
<td>JTI</td>
<td>Joint Technology Initiative</td>
</tr>
<tr>
<td>RTD</td>
<td>Research, Technological Development and Demonstration</td>
</tr>
<tr>
<td>ZEPP</td>
<td>Zero Emission Power Plants</td>
</tr>
</tbody>
</table>
Annexe B    Bibliography


Ecotec, 2007, Ex Post Evaluation of the NNE Programme Supported by DGTREN under FP5


ERAWOG, 2005, Towards the EERA recommendations by the ERA working group of the Commission’s advisory group on energy, January.


EU advisory group on Energy, 2008, A vision for Energy R&D on a European scale, recommendation by the EU advisory group on Energy;


European court of Auditors, 2009, ‘Networks of excellence’ and ‘integrated projects’ in community research policy: did they achieve their objectives?.


Annexe C  Methodology of the evaluation

C.1. Scope and levels of the evaluation

This evaluation was performed for all NNE RTD projects funded by DG RTD under FP5 and FP6 programmes. NNE RTD projects funded by DG TREN are not included in the scope of this evaluation\(^{51}\).

Further to interaction with the Commission, 563 projects (444 and 119 for FP5 and FP6 respectively) were included in the portfolio of projects covered by this evaluation.

This evaluation was carried out at two levels, programme level (FP5 and FP6 NNE programmes) and area level respectively.

C.1.1. Investigations and analyses at area level

One of the main challenges of this evaluation lies in the heterogeneity of NNE research topics and technologies. The different sub-areas encompass a wide diversity of objectives and knowledge bases and relate to various communities and sectors.

As such, the evaluation was structured along 8 specific areas that cover the whole spectrum of NNE R&D activities supported by DG Research. For reasons of continuity and comparison, the investigation of both FP5 and FP6 are structured along the same thematic areas:

1. Solar energy (including passive solar energy, photovoltaic and solar thermal)
2. Wind energy
3. Energy from biomass
4. Other sources of renewable energy (including geothermal, hydropower, ocean energy)
5. Clean fossil fuels and CO\(_2\) storage and capture
6. Energy storage and distribution (including batteries and grid)
7. Socio-economic and policy related projects
8. Hydrogen and fuel cells

The breakdown of the number of projects by area is provided in Exhibit 52.

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\(^{51}\) A separate evaluation was carried out specifically for activities supported by DG TREN under FP5: “Ex Post Evaluation of the NNE Programme Supported by DGTREN under FP5”, Ecotec, 2007.
Exhibit 52 Breakdown of the number of projects by area, FP5 and FP6

<table>
<thead>
<tr>
<th>Research area</th>
<th>FP5 projects</th>
<th>FP6 projects</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Solar energy</td>
<td>93</td>
<td>20</td>
<td>113</td>
</tr>
<tr>
<td>2 Wind energy</td>
<td>31</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>3 Biomass</td>
<td>72</td>
<td>19</td>
<td>91</td>
</tr>
<tr>
<td>4 Other sources of renewable energy</td>
<td>11</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>5 Clean fossil fuel CO2 storage</td>
<td>90</td>
<td>19</td>
<td>109</td>
</tr>
<tr>
<td>6 Energy storage &amp; distribution</td>
<td>52</td>
<td>15</td>
<td>67</td>
</tr>
<tr>
<td>7 Socio-economics</td>
<td>50</td>
<td>6</td>
<td>56</td>
</tr>
<tr>
<td>8 Hydrogen &amp; fuel cells</td>
<td>45</td>
<td>29</td>
<td>74</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>444</strong></td>
<td><strong>119</strong></td>
<td><strong>563</strong></td>
</tr>
</tbody>
</table>

Source: EC project database

Each area was under the supervision of a dedicated evaluator. Each area evaluator produced a specific area report, based on the cross-analysis of relevant documentation and internet resources, the survey results split by areas and the interviews within the area.

Area reports were reviewed and commented on by area experts.

C.1.2. Programme level

Once area evaluations were carried out, evaluators grossed up and cross-compared area results in order to assess achievements at the level of the whole FP5 and FP6 programmes. This was essential for two main reasons:

- Although heterogeneous, activities carried out in each area aim to fulfil the same overarching (programme) objectives which are reducing CO2 emissions, increasing energy efficiency, improving energy security,... Based on a review of progress in each area, trade-offs are made between them for the allocation of limited budget resources. An overall analysis, that covers all area taken together, is therefore needed to inform this process. A 2005 DG RTD report on energy research impact assessment recommended that energy research should be part of a structured and comprehensive energy vision. It is one of the evaluation objectives to investigate and address this overall level.

- The programme level analysis also aims to account for the similarities, patterns and differences among areas and relate them to their respective results. Several determinants are transversal to all areas but will differently affect activities in each of them, according to structural characteristics such as maturity of the market, the nature of the knowledge base (science-based, empirical,...), the organisation and governance of the communities of actors (existence of large influential companies such as carmakers in the fuel cell and battery areas,...), the availability and spatial distribution of energy sources and materials (wind, geothermal, ocean, natural gas,...), the existence of large indivisibilities in investment (such as in CCS),... In return, this higher level of analysis provides a better understanding of the determinants of success and failure and allow for fine-tuning of intervention in each area.

The overall analysis at programme level is provided in this draft final report. In each of the main sections, an overview of results are given in each area.

C.2. Methodological tools

Six complementary methods were used to assess these impacts on the sample of projects:

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52 Annex to the Final report
53 Assessing the impact of energy research, DG RTD, European Commission, 2005, EUR 21354
C.2.1. Desk research and challenge analyses

In order to take stock of the progress achieved over the period covered and the remaining key issues, evaluators carried out in-depth desk research in each area. One of the principal objectives was to analyse the area specific scientific, policy, socio-economic and environmental challenges at different milestones: start of FP5, start of FP6, end of FP6. The results of this desk-study formed the baseline of this evaluation. They were used to support:

- The assessment of the relevance of the programmes: are the objectives and thematic priorities in each of these areas in line with these identified challenges?
- The assessment of the effectiveness of the programmes: to what extent has FP5 and FP6 contributed to managing and “moving forward from” these challenges in each area?

C.2.2. Analysis of FP5 and FP6 NNE RTD project databases and Social network analysis.

Based on the project databases provided by the Commission, statistics were produced (number of projects, participants, financial budgets, EC contribution etc.) by programme and by area.

Social network analyses were also carried out in order to give a picture of research collaboration in FP5 and FP6. This analysis reveals key players (countries or legal entities) and core groups, networks and communities around which each area is structuring.

C.2.3. On-line survey to FP5 and FP6 NNE project participants

An on-line survey was directed to all participants in FP5 and FP6 NNE projects.

Contact databases for FP5 and FP6 NNE projects were supplied containing details of 2,316 participants who had undertaken 2,869 participations in total across the period (1,019 participations in FP5 and 1,850 in FP6). The difference between the number of participants and the number of participations is accounted for by the 353 individuals who took part in multiple projects (mostly only 2 projects), either within or across FP5 and FP6 NNE programmes. These multiple project participants were sent separate requests to complete a questionnaire for each project.

The questionnaire focused on goal attainment, achievements and impacts associated with these achievements, as well as overall satisfaction with the project. The core component of the survey consisted of an auto-assessment of impacts, with a distinction between different ‘layers’ of impacts, according to the impacted beneficiaries (the researcher, the parent organisation, the environment). The questionnaire was also intended to allow free comments from respondents regarding propositions to improve the impact of framework programme projects, and suggestions of research topics that should receive attention in FP7 and beyond in the area.

A good response rate was achieved, with participant numbers surpassing the anticipated level of response. From the sample of 2,869 participations, responses were obtained from 462, representing a response rate of 16%, covering 17% of all individuals and 64% of all projects (see Exhibit 53 below). Over three quarters (78%) of responses referred to projects in FP6 and the response rate for this more recent programme was, perhaps unsurprisingly, considerably better than for FP5.
Good coverage was also achieved across the eight thematic areas of the evaluation, with responses approximately proportionate to the spread of overall participation (see specific Annex report on survey results).

C.2.4. Field interviews

Building upon a first set of pilot interviews and the results of the survey, a list of key issues was produced in order to focus investigation. These key issues were deepened through a campaign of interviews conducted with key Commission staff, project participants and stakeholders (primarily policy makers, but also experts, non participants,…) in the 8 areas for both programmes.

In total, evaluators conducted around 230 interviews within the scope of FP5 and FP6 projects.

The sampling was performed with a view to reaching a diversified set of interviewees in each area, accounting for:

- Programmes (FP5 and FP6)
- The different categories of interviewees (participant and coordinators from research and industries, policy makers,…)
- Member states
- Sub-areas (e.g. solar cell production processes, various types of solar cells and concentrated solar power for the solar energy area)
- Instrument used (e.g. NoE, IP, etc.)

<table>
<thead>
<tr>
<th>Theme</th>
<th>Nb. projects</th>
<th>% projects</th>
<th>Nb. interviews</th>
<th>% interviews</th>
</tr>
</thead>
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<td>6%</td>
<td>17</td>
<td>7%</td>
</tr>
<tr>
<td>Biomass</td>
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<td>16%</td>
<td>39</td>
<td>17%</td>
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<tr>
<td>Other sources of renewable energy</td>
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<td>4%</td>
<td>25</td>
<td>11%</td>
</tr>
<tr>
<td>Clean fossil fuel CO2 storage</td>
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<td>19%</td>
<td>25</td>
<td>11%</td>
</tr>
<tr>
<td>Energy storage &amp; distribution</td>
<td>67</td>
<td>12%</td>
<td>26</td>
<td>11%</td>
</tr>
<tr>
<td>Socio-economics</td>
<td>56</td>
<td>10%</td>
<td>18</td>
<td>8%</td>
</tr>
<tr>
<td>Hydrogen &amp; fuel cells</td>
<td>74</td>
<td>13%</td>
<td>38</td>
<td>17%</td>
</tr>
<tr>
<td>Total</td>
<td>563</td>
<td>100%</td>
<td>229</td>
<td>100%</td>
</tr>
</tbody>
</table>
Interview guidelines are presented in Annexe D, Annexe E and Annexe F.

The list of interviewees in each area is presented in the annex volume, following each area report.

C.2.5. Thematic workshops

Three thematic workshops with experts and stakeholders in the NNE area were held in order to discuss and expand on the results obtained on some key issues with relevant project participants and stakeholders in the field of energy research and policy. The three specific issues were chosen with the Commission:

1. The impact of the FP5 and FP6 on National Research in the domain of Non Nuclear Energy
2. The added value of FP5 and FP6 socio-economic research in the field of Non Nuclear Energy
3. Best practices for effective diffusion and use of FP and FP6 NNE research results

The three workshop scoping papers and notes are presented in a specific annex report.
Annexe D  Interview guidelines - Project coordinators

Identification of the interviewee

Activities and needs in the non nuclear energy area

- What is your activity in the NNE area?
- Needs for basic/applied knowledge\textsuperscript{54} to support your activity
  - What are your needs in terms of basic/applied knowledge in order to conduct your activity in the domain?
  - How strong are these needs? Is it just about keeping in touch with what happens in the research area or is it more than this? How does this knowledge contribute to what you (or your organisation) is trying to achieve?
- Progress of knowledge in your area in recent years (FP6 period)
  - What is the most significant progress of knowledge in your area (regardless of whether it has changed anything to your activity)?
  - Any example of progress in research which has significantly affected your activity? How?
- Sources of knowledge to fulfil your needs/respond to the challenges
  - What are the main internal and external sources through which you (or your organisation) acquire this knowledge?
  - Is research in the area an important source? What type of research? (what area/disciplines, countries,...)
- Assessment of research in general
  - Do you have the feeling that the needs and challenges you face in your activity are adequately covered?
  - Which needs and challenges are not covered, disregarded, would deserve more research effort?
- Is FP a source of knowledge for you? (transition to FP related issues)

Project level questions

- Involvement in the project
  - Design phase, implementation, valorisation of results, other?
  - How did you interact with project partners?
- What have been the results of the project? (scientific publications, new products or processes, patents or licenses, conferences, etc.)
- (Potential) impacts of the project

\textsuperscript{54} Knowledge is to be taken in a wide sense, according to area specificities.
– Scientific impacts? (contribution to scientific knowledge, enhanced cooperation between research groups, etc.)
– Socio-economic impacts? (transfer and implementation of knowledge in industry, improvement of competitiveness, job creation, rise of public awareness regarding energy issues, education, etc.)
– Policy impacts? (strengthening the knowledge base of policy making, better information underlying policies and regulations, platforms for dialogue between scientists and policy makers, etc.)
– Environmental impacts? (decrease of CO2 emissions, etc.)

**Strengths and weaknesses of the EC strategy/intervention in the non nuclear energy area**

• Relevance
  – How relevant do you think the EC strategy/intervention in the NNE area (and/or sub-area) is?

• Implementation
  – What do you think of the way this EC strategy/intervention is being decided?
  – What do you think of the way this EC strategy/intervention is being implemented?
  – Do you think the FP project portfolios in the energy area (and/or sub-area) are adequately defined? (enough topics covered, good representativeness of areas, etc.)

• Results/impacts
  – What do you think are the results/impacts of the EC strategy/intervention in the NNE area (and/or sub-area)?
  – Examples of DG RTD NNE projects results that have been used in your organisation in the past?
  – Examples of successful projects? (using scientific, environmental, socio-economic, policy criteria for assessing success)
  – Examples of failures?

• Limitations
  – What are the main weaknesses of the EC strategy/intervention in the NNE area (and/or sub-area)? What are the barriers to exploitation of knowledge?
  – What are the main barriers that hinder impacts of research in the area?

**Suggestions/recommendations**

• What could generally be done to achieve greater impacts of research in the area?
• How could the EC intervention have greater impact on your activity?

Any suggestion/recommendation for
Annexe E  Interview guidelines – EC officers

Identification of the interviewee

The differences and continuity between FP5 and FP6 (and FP7) in the non nuclear energy area

• General history of the area (and/or sub-area) in Framework Programmes (patterns of evolution, changes,...)?
• Differences and continuity in terms of objectives driving EC activities in this area?
• Differences and continuity in terms of budget?
• Differences and continuity in terms of instruments (and the way new FP6 instruments affected the research activities and results) and procedures (the characteristics of the Calls)?
• Differences and continuity in terms of size of project and project participants?

The objectives that drive EC activities in the non nuclear energy area

• What are the area specific scientific challenges (major scientific bottlenecks,...)?
• What are the area specific socio-economic challenges (inc. industrial opportunities)?
• What are the area specific political challenges (relationships with a specific EU regulation, policy,...)?

Overall assessment of FP5/FP6 energy RTD activities

• Do you have the feeling that the needs and challenges of your area are adequately covered?
• Which needs and challenges are not covered, disregarded, would deserve more research effort?
• Do you think the FP project portfolios in the energy area (and/or sub-area) are adequately defined? (enough topics covered, good representativeness of areas, etc.)
• Are there any missing stakeholders/researchers? (categories that are weakly represented, for instance SMEs, organisations from new member state, etc.)

Impacts and results

• What have been the main progresses accomplished during the course of FP5 and FP6 in the NNE area (and/or sub-area)?
• Examples of FP5 and/or FP6 projects with significant impacts
  – scientific impacts
  – socio-economic impacts
  – policy impacts
  – environmental impacts
What are the main barriers and opportunities for the exploitation of results in the NNE area (and/or sub-area)?

Could you identify about 10 projects that you consider as successful or likely to be successful in the future?

Suggestions for improvement

What could generally be done to achieve greater impacts of research in the area (and/or sub-area)?

How could the EC intervention be improved?

Further investigations:

- Suggestions of leading people to interview in the area?

Any project best practice? Any activity beyond/between projects?

How to organise the action of new instruments?

What is the role of the high level group? How influential on activities?

What about strategy? Any thematic priority? Any specific emphasis on policy and/or scientific impacts? How are tradeoffs between different focuses solved?

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55 Mainly FP6 and a few FP5 if possible. This can be done further to the interview, by email. These suggestions will be considered for case studies.
Annexe F  Interview guidelines - Stakeholders

Identification of the interviewee
Activities and needs in the non nuclear energy area

• What is your activity in the NNE area?
• Needs for basic/applied knowledge\(^{56}\) to support your activity
  – What are your needs in terms of basic/applied knowledge in order to conduct your activity in the domain?
  – How strong are these needs? Is it just about keeping in touch with what happens in the research area or is it more than this? How does this knowledge contribute to what you (or your organisation) is trying to achieve?
• Progress of knowledge in your area in recent years (FP6 period)
  – What is the most significant progress of knowledge in your area (regardless of whether it has changed anything to your activity)?
  – Any example of progress in research which has significantly affected your activity? How?
• Sources of knowledge to fulfil your needs/respond to the challenges
  – What are the main internal and external sources through which you (or your organisation) acquire this knowledge?
  – Is research in the area an important source? What type of research? (what area/disciplines, countries,...)
• Assessment of research in general
  – Do you have the feeling that the needs and challenges you face in your activity are adequately covered?
  – Which needs and challenges are not covered, disregarded, would deserve more research effort?
• Is FP a source of knowledge for you? \((transition to FP related issues)\)

Involvement in FP5/FP6 energy research activities

• What is your involvement in:
  – FP programme (programme committee for instance, information canal, expertise, selection committee, etc.)
  – FP project (any coordination/participation, partnerships,...)

Level of knowledge about the EC intervention in the non nuclear energy area

• What is your level of information on the EC intervention in the NNE area?

\(^{56}\) Knowledge is to be taken in a wide sense, according to area specificities.
• How do you keep informed about the EC intervention in the area?

**Strengths and weaknesses of the EC strategy/intervention in the non nuclear energy area**

• Relevance
  – How relevant do you think the EC strategy/intervention in the NNE area (and/or sub-area) is?

• Implementation
  – What do you think of the way this EC strategy/intervention is being decided?
  – What do you think of the way this EC strategy/intervention is being implemented?
  – Do you think the FP project portfolios in the energy area (and/or sub-area) are adequately defined? (enough topics covered, good representativeness of areas, etc.)

• Results/impacts
  – What do you think are the results/impacts of the EC strategy/intervention in the NNE area (and/or sub-area)?
  – Examples of DG RTD NNE projects results that have been used in your organisation in the past?
  – Examples of successful projects? (using scientific, environmental, socio-economic, policy criteria for assessing success)
  – Examples of failures?

• Limitations
  – What are the main weaknesses of the EC strategy/intervention in the NNE area (and/or sub-area)? What are the barriers to exploitation of knowledge?
  – What are the main barriers that hinder impacts of research in the area?

**Suggestions/recommendations**

• What could generally be done to achieve greater impacts of research in the area?
• How could the EC intervention have greater impact on your activity?
• Any suggestion/recommendation for improvement of the EC intervention in the area?
## Annexe G  Share of EC funding by country, programme and area

Exhibit 55  Country ranking and % of EC funding, by area

<table>
<thead>
<tr>
<th>Area</th>
<th>EU 15 or associated states</th>
<th>New member states</th>
<th>ICPC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Country ranking</td>
<td>%</td>
<td>Country ranking</td>
</tr>
<tr>
<td>CLEAN_FOSSIL_FUEL_CO2_STORAGE</td>
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<td>DE</td>
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<td></td>
<td></td>
<td>UK</td>
<td>16,66%</td>
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<tr>
<td></td>
<td></td>
<td>FR</td>
<td>11,15%</td>
</tr>
<tr>
<td></td>
<td>FP6</td>
<td>DE</td>
<td>18,11%</td>
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<tr>
<td></td>
<td></td>
<td>FR</td>
<td>14,12%</td>
</tr>
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<td></td>
<td></td>
<td>NO</td>
<td>13,61%</td>
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<tr>
<td>ENERGY_FROM_BIO MASS</td>
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<td>DK</td>
<td>11,10%</td>
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<td></td>
<td>NL</td>
<td>9,91%</td>
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<tr>
<td></td>
<td>FP6</td>
<td>DE</td>
<td>18,38%</td>
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<td></td>
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<td>NL</td>
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<td></td>
<td></td>
<td>SE</td>
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<td>ENERGY_STORAGE &amp; DISTRIBUTION</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td>DE</td>
<td>13,36%</td>
</tr>
<tr>
<td>Hydrogen &amp; FUEL CELLS</td>
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<td>DE</td>
<td>22,13%</td>
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<td></td>
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<td>FR</td>
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## Exhibit 56  Country ranking and % of EC funding, by area (continued)

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<th>Area</th>
<th>EU 15 or associated states</th>
<th>New member states</th>
<th>ICPC</th>
</tr>
</thead>
<tbody>
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<td>%</td>
<td>Country ranking</td>
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<td>FR</td>
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