

Successful collaborative research for the coal and steel industry in europe: the RFCS programme

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Abstract – The Research Fund for Coal and Steel (RFCS) was established in 2002 to contribute to the competitiveness of the European Coal and Steel sectors by supporting collaborative research, pilot and demonstration projects. A Monitoring and Assessment exercise of the RFCS programme covering the period 2003–2011 was carried out by an Expert Committee comprising four coal and six steel experts appointed by the European Commission. The assessment exercise involved the analysis of the 198 projects completed during this period, with special emphasis on the benefits for beneficiaries, Sectors and Society. Based on actual fact and figures provided by the project partners, it was established that 1 euro spent in the project budget delivered a benefit of about 2 euros for the project partners. Extrapolated at the level of the coal and steel sectors with very conservative assumptions, the potential benefit of the projects was estimated at about 700 M€/year. To capture this potential benefit, additional efforts and budget must be spent at the company level for implementing the relevant technological solutions.

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1 Historical background

Signed in Paris in 1951, the European Coal and Steel Community (ECSC) Treaty covered a 50 years period from 1952 up to 2001. ECSC initiated five decades of successful collaborative research and technical development in the coal and steel industry, thus sustaining the competitiveness of the sectors and improving health and safety at the workplace. Since then, researchers became more and more accustomed to cooperating in a growing European spirit. The ECSC Research Programme, as the first ever

European research network, has led to some major achievements:

- Development of a European coal and steel community working towards common objectives.
- Implementation of collaborative projects at European level, leading to networking and knowledge sharing.
- Effective synergy for the modernisation of the coal and steel industry and the global challenge.
- Strengthening the European position in a competitive global environment.

The ECSC was financed by levies which most coal and steel producers had to pay based on their production. Over the 50-year period of the Treaty, a Guarantee Fund was built up, constituting the major part of the assets generated. This funding mechanism allowed overcoming the difficulties resulting from several financial crises in the 1970s and 1980s by avoiding stop-go policies on research funding which would have hindered the improvement of the European coal and steel industry's competitiveness.

^{*} On behalf of the Expert Committee appointed for the Monitoring and Assessment exercise of the RFCS programme. The members of the Expert Committee were: Prof. Dr. Rob Boom, Dr. Jean-Claude Charbonnier, Dr. Jürgen Czwalińska, Prof. Dr-Ing. Christoph Dauber, Dr. Jose-Luis Fuentes-Cantillana, Dr. Nikolaos Koukouzas, Mr. Bertrand de Lamberterie, Dr. Jürgen Stahl, Dr. Jean-Marc Steiler (rapporteur for the Assessment), Prof. Dr-Ing Carl-Dieter Wuppermann (chairman).

With the expiry of the ECSC Treaty, the Council of Ministers reached an understanding in Spring 2001 on all issues related to the expiry of the ECSC Treaty and a follow-up regime. The key decision was the establishment of the new “Research Fund for Coal and Steel” (RFCS) and the transfer of all remaining assets of the (expired) ECSC to this new fund. The legal basis of the RFCS was adopted by the Council on 1 February 2003. The Commission was put in charge of the management of the RFCS.

Consequently, the budget of the RFCS programme is not financed by the European Union, but arises from the interests of the ECSC assets which were built up by the European coal and steel industries over the 50 years. The interests lead to an annual budget for funding of over 50 M€ with a distribution of 28% for coal and 72% for steel.

2 Structure of the RFCS programme

The RFCS provides funding for high quality collaborative research projects which support the competitiveness of the European coal and steel industry. The programme covers core production processes, new products and applications, quality control, utilisation and conversion of resources, safety at work, environmental protection by reduction of emissions from coal use and steel production, and related social issues.

The objectives of the Research Programme are:

- For Coal:
 - Improving the competitive position of Community coal.
 - Health and safety in mines.
 - Efficient protection of the environment and improvement of the use of coal as clean energy source.
 - Management of external dependence on energy supply.
- and for Steel:
 - New and improved steelmaking and finishing techniques.
 - RTD and the utilisation of steel.
 - Conservation of resources and improvement of working conditions.

The RFCS Programme supports four types of actions:

- Research Projects: they cover investigative or experimental work with the aim of acquiring further knowledge contributing to the development of products or services and the improvement of the production processes.
- Pilot Projects: they involve the construction, operation and development of an installation or a significant part of an installation on a large scale in order to gather the technical and economic data needed to progress towards the demonstration stage.
- Demonstration Projects: they involve the construction and/or operation of an industrial-scale installation with the aim of bringing together all the technical and economic data in order to proceed towards the commercial exploitation of the technology at minimum risk.
- Accompanying Measures: they address the promotion of the practical use and dissemination of the knowledge gained from the projects.

The RFCS Programme is based on cost-sharing RTD grant agreements. The maximum total financial contribution is up to 60% for research projects, up to 50% for pilot and demonstration projects and up to 100% for accompanying measures.

On average, each research project receives a funding of 1–1.5 M€, comprises 6–7 Partners and has a duration of 36 months. Some pilot/demonstration projects are awarded significantly higher funds. Accompanying measures are much smaller with 0.2 M€ of funding on average.

3 Unique position of the RFCS programme

The Research Fund for Coal and Steel is unique in the coal and steel world from the origin of the fund, from its objectives as well as from the execution of the research programme.

With the RFCS programme, the European Union has thus an active RTD instrument solely dedicated to the two sectors. It is managed by the Commission Services

with intensive consultation of European coal and steel experts and representatives of the member states. From the very beginning and in continuation of the successful ECSC regime, the programme is fully application-oriented and has a clear focus on solving practical problems, while contributing to increase the extent and content of the knowledge basis related to coal and steel problematics.

In Asia, producing about two third of the world steel production, such a continent-wide RTD programme approach does not exist. In China fully state sponsored research institutes are existing, dedicated to the coal and steel industry or metallurgical industry in general. Big steel companies such as Bao Steel in Shanghai and Ansteel in Anshan organise exchange programmes with foreign competitors and leading universities in technology. Japan supports its coal and steel industry through national projects organised by the National Energy Development Organisation (NEDO) or the Ministry of Economy, Trade and Industry (METI). These involve industrial companies and universities, with 50% to 100% national subsidy (in 2007 24 M€, in 2008 19 M€ for all steel projects). The research activities are managed by the Japanese Iron and Steel Institute (JISI) or JCOAL, an association of private Japanese companies involved in coal. In South Korea, as the government hardly supported the steel industry, POSCO established in 1986 Pohang University of Technology (POSTECH) and a year later the Research Institute for Industrial Science and Technology (RIST). In 1993 POSTECH started the Graduate School of Iron and Steel Technology, in 2005 transformed into the Graduate Institute of Ferrous Technology (GIFT), attracting top steel scientist from all over the world to Pohang.

In North-America the Association for Iron and Steel Technology (AIST) has created a strong network in the United States of America and Canada, organising conferences and training courses. The Canadian Institute of Mining and Metallurgy (CIM) has a similar role in Canada not restricted to steel. Large innovative projects have been organised involving the big steel producers and universities, with sponsoring provided

by the Department of Energy (DOE) in USA and National Science Foundations in both countries. Regarding coal, the DOE has focused its activities at funding downstream issues, i.e. clean coal, gasification, carbon capture and storage.

South-America, with Brazil as the leading producer of steel, has no continent-wide RTD programme activities. Conferences are being organised to bring researchers from industry and universities together by associations in Argentina, Brazil and Chile.

Australia has a strong research organisation, the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Earth Science and Resource Engineering (including coal and iron ore) and Materials Science and Engineering (including steel) are important divisions of CSIRO. Funding is done by the Australian government with financial support from industries in dedicated projects and programmes. Regarding specifically coal, hard coal producers contribute to collaborative research by paying 0.05 \$ per tonne to fund the Australian Coal Association Research Program (ACARP). ACARP's mission is to research, develop and demonstrate technologies that lead to the safe, sustainable production and utilisation of coal. The beneficiaries are universities, research organisations and companies only from Australia and the projects are mainly designated to one organisation.

We can conclude that coal and steel RTD networking activities are organised in continents outside Europe by governmental bodies, associations and industry. Transnational funds involving multiple partners from different countries and comparable to RFCS do not exist, making RFCS unique in the coal and steel world.

4 Assessment of the RFCS programme

4.1 Scope of the assessment exercise

When establishing the RFCS, the European Council has requested to carry out on a regular basis a Monitoring and Assessment exercise of the Research programme, including the analysis of the benefits provided

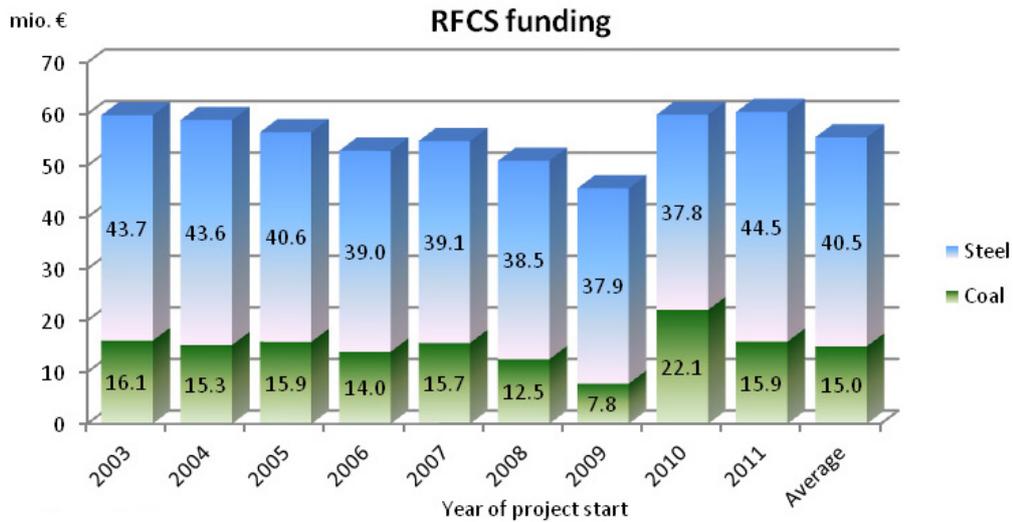


Fig. 1. Annual funding of the RFCS projects.

by the projects to the beneficiaries, the coal and steel sectors and the European Society. The first exercise, covering the period 2003–2011 was carried out in 2012–2013 by a panel of independent highly qualified experts, and the final report has been issued in November 2013 [1,2].

The scope of the assessment exercise is to assess the individual projects of the Research Programme which were completed between 2003 and 2011 and for which the final publishable report has been accepted by the Commission. The assessment encompasses all aspects of the operation and results of the individual projects, with special focus on the analysis of the qualitative and quantitative benefits provided by the projects and on the extent of industrial exploitation of the project results.

The assessment exercise covers a total of 198 projects which were completed during the period 2003–2011. All projects were first screened and analysed by the expert panel. Out of the 198 projects, a representative sub-set of 46 projects was selected for in-depth assessment, aiming especially at the evaluation of the quantitative benefits. The in-depth assessment was carried out by the expert panel by consulting the beneficiaries or other stakeholders of the projects. From the in-depth assessment, it turned out that a group of 23 projects could be identified as providing the most direct and

non-ambiguous financial benefit in terms of increased productivity, new or improved market shares and cost reduction.

4.2 Global outlook of the RFCS programme during the period under consideration

During the period under consideration the cumulated total budget of the RFCS Programme is 500 M€ leading to an average yearly budget of approximately 56 M€ (Fig. 1). There are significant variations in the yearly available funds, ranging from 45 to 60 M€, depending on the actual interest rates of the RFCS assets. Over the 9 years period, 135 M€ (27%) of the total RFCS funds have been assigned to coal projects and 365 M€ (73%) to steel projects.

The administrative expenditure to run the programme over that period amounts 20.5 M€, equivalent to 4% of the budget. This low percentage results from the strive for simple and efficient rules for the RFCS administration developed in close collaboration between the project beneficiaries and the RFCS unit of the Commission.

The average annual RFCS budget of 56 M€ has allowed to fund an average number of 53 projects per year of which 9 relate to the coal area and 44 to the steel area (Fig. 2).

The overall success rate in the RFCS Programme varies from year to year depending

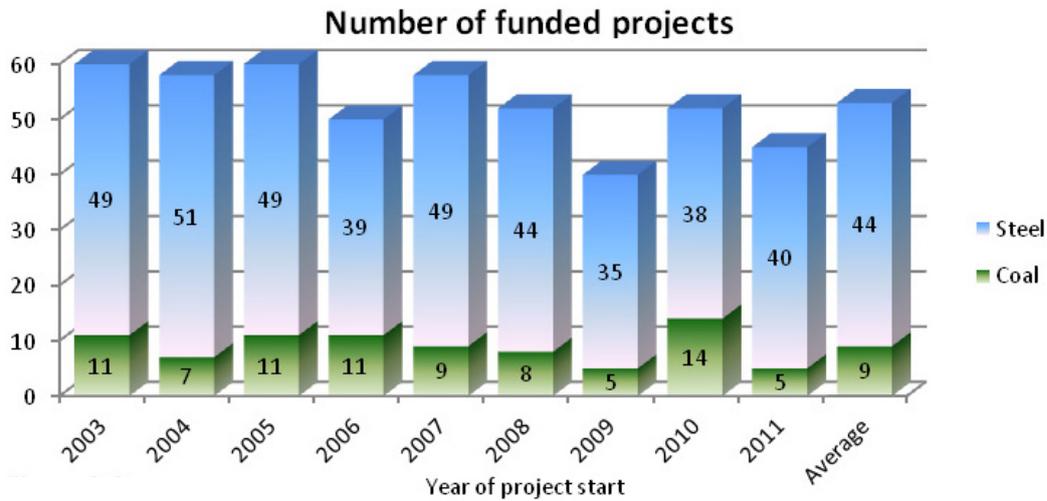


Fig. 2. Annual number of RfCS funded projects.

on the available funds and the number, size and quality of the submitted proposals. In general, the success rate (ratio of accepted to requested funds) is around 33%, significantly higher than for comparable European Framework Programmes for research.

4.3 Achievements of the RfCS programme

The RfCS projects show a wide span of achievements (Fig. 3). All projects generate achievements in terms of knowledge building. Recommendations, new practices, new processes, new products are significant outcomes of most of the projects. Many projects also generate numerical models and new instrumentation: it reflects the increasing degree of sophistication of the coal and steel industry, requiring advanced instrumentation and models for understanding and control purposes.

Below is a short selection of significant outcomes of the RfCS programme: among others:

- in the Coal sector:
 - new mechanisation and automation of the longwall equipment;
 - recommendations, sensors and models for the extension of the life time of coke plants;

- efficiency improvement in coal combustion, including oxy-fuel combustion for easy CO₂ capture;
- development of techniques for improving health and safety in coal mines;
- reduction of NO_x emissions from coal fired power plants;
- production of advanced carbon fibres,
- in the Steel sector:
 - blast furnace process for reducing the CO₂ emissions;
 - improved burner operation, to reduce emissions (NO_x, CO₂);
 - device and models for controlling the liquid flow in the continuous casting mold and reducing defects;
 - new work roll cooling system in hot rolling;
 - new system for on-line detection of roll marks on the strip;
 - new sensors for on-line under-pickling detection;
 - new sensor for on-line measurement of surface waves on moving strip;
 - improved process for X100, X120 grades for plates;
 - optimisation of the properties of TRIP, DP, Q+T, TWIP steel grades for coils;
 - new strain hardening process for Advanced High Strength Steels;
 - new beams for light long-span floors;

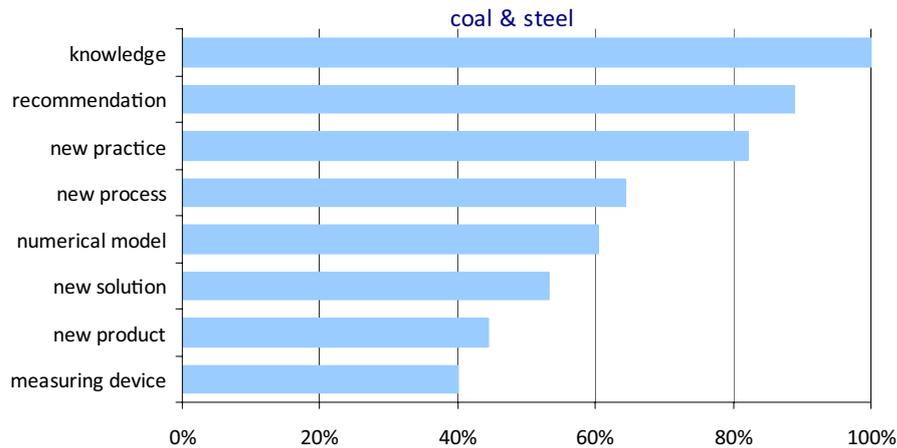


Fig. 3. Major outcomes of the RFCS projects (% of projects delivering a specified outcome).

- new testing procedures for fire-resistance of steel structures;
- new design methods for structural safety of constructions (seismic, explosion resistance);
- development of models and tools for numerical metallurgy design.

The achievements of the RFCS programme are not only research results. Indeed, they can be considered as practically and industrially validated solutions by the industrial partners who implemented the developments during the course of the project. These new achievements contribute to increase in a continuous way the knowledge base which is shared between all the members of the European Coal and Steel community.

A selection of success stories achieved in the frame of the RFCS programme are detailed in Reference [3].

4.4 Qualitative benefits of the RFCS programme

The qualitative benefits were obtained from the answers of the industrial stakeholders to a comprehensive questionnaire.

There is a unanimous consent that the most important benefit from the RFCS projects lies in the development of new knowledge, which can be directly used for the training and education, inside the plants and sectors, as well as in the society. For 100% of the projects the gained knowledge is quoted as excellent or good.

In both sectors, Coal and Steel, the financial returns, in terms of cost reduction, are rated as the second important benefit. It is considered that the efforts and money – Community money and Industry money – invested in the RFCS Research projects produce operational results that effectively contribute to the economic sustainability of the sectors.

In both sectors again, the development of new processes, new solutions, and new products is highly rated. This result indicates the recognition of the significant impact of the RFCS projects on the development of innovation and its deployment in industrial practice. It is recognised as important to keep promoting the innovation character of the RFCS projects.

In the Coal sector, progress on the environmental issues and on safety and health are considered as significant benefits. Indeed several projects are especially dedicated to those subjects, namely safety in underground mining or the development of techniques for the use of coal for clean energy production.

In the Steel sector, the projects devoted to process improvement provide significant benefits in terms of quality mastering as well as working conditions. The latter aspect is important as it is worthwhile to improve the working conditions in a harsh and critical environment, by developing automation, remote sensing and control tools. Environment is also a key issue in the steel production processes. The RFCS projects have provided

numerous solutions for decreasing the environmental footprint of the processes, by direct action on the process itself or by proposing end-of-pipe solutions.

The projects in the downstream area of steel production are in direct connection with the customers. It is recognised that the projects have significantly contributed to develop new products, directly aligned with the customer's needs, and consequently to generate new market shares. Numerous examples are to be found in the automotive market (e.g. high resistance lightweight steels) and in the construction markets (e.g. fire resistant steel structures). The projects directly contribute to maintain, or strengthen the position of steel, in strong competition with other materials, like aluminium, composites, concrete or even wood. The RFCS projects, involving very positive partnerships between competitors in steel production, are a unique tool for promoting the outstanding properties of steel, in a common front facing up other materials.

Regarding the benefits for society, beside the increase of knowledge, the RFCS projects are considered as strongly enhancing the competitiveness of Europe in the present challenging world market. Regarding the environmental issues, the RFCS programme is acknowledged to contribute to the global mastering of the environmental footprint of the Coal and Steel industry, for the benefit of the European citizens. It also significantly contributes to maintain the competitiveness and sustainability of the European industry, more than just Coal and Steel (steel customers, SME's, technology suppliers, ...).

4.5 Quantitative benefits of the RFCS programme

The quantitative benefits were obtained by in-depth analysis of the 23 selected projects, through extensive consultation of the project beneficiaries and major users of the projects.

The financial returns were evaluated in two steps:

- first the reliable figures provided by the project beneficiaries and industrial partners, resulting from the implementation of the results in their own plant, allowed

to calculate the proven benefits at the beneficiaries level;

- secondly, based on those figures and using conservative assumptions for the dissemination of the results beyond the beneficiaries, the potential benefit for the whole Sectors was estimated.

This method of calculation probably minimises the effects of the RFCS projects insofar as it only takes into account the benefits of the most obvious 23 projects providing straightforward benefits.

At the level of the beneficiaries, the 23 projects have provided an annual benefit of about 100 M€/y.

This figure has been totally endorsed by the industrial partners of the projects. It must be pointed out that the benefit does not take into account the additional costs, namely investment, operational or further research cost, which had to be incurred by the companies to effectively achieve those benefits.

This annual benefit identified by the projects beneficiaries can be compared to the corresponding budget (52.8 M€ over the period of review) or to the RFCS funding (30.9 M€ over the period of review). This means that one euro spent for the RFCS project, on average, provides an annual benefit of about 2 euros, after the results have been implemented and exploited at the industrial scale.

In other words, on average, the industrial partner having spent one euros in a collaborative project supported by the RFCS gets a benefit of about 4.4 euros. This results highlights the fruitful leverage for the companies investing in those collaborative projects.

It must be pointed out that the cost of the project must be spent first, at the start of the project, and that the full financial benefit shows up gradually, after a time lag of some years. In steady state conditions, the annual benefit can be harvested during several years until the effect of the project becomes diluted in the daily operational practice and in the continuous improvement of the plant. This period of time strongly depends on the domain covered by the project and the competitive situation.

At the level of the Coal and Steel Sectors, the analysis of the 23 projects leads to

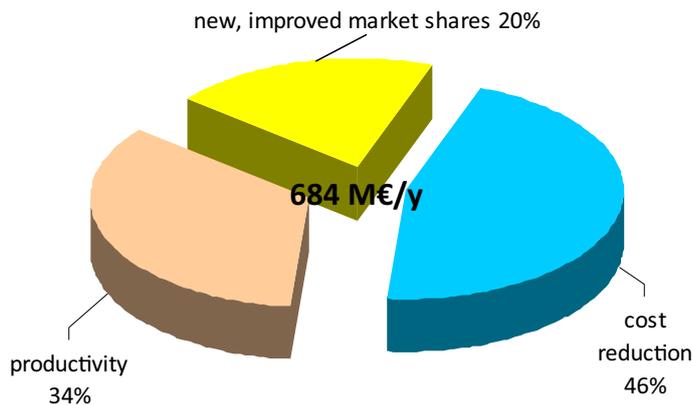


Fig. 4. Potential benefit of the assessed projects.

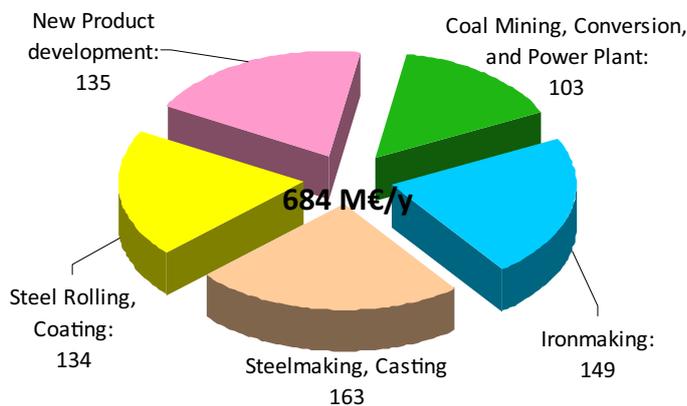


Fig. 5. Potential benefit (M€/y) of the assessed projects in the different areas.

an overall annual potential benefit which is estimated at about 700 M€/y.

Again it must be pointed out that this benefit is only potential, as its realisation depends on several factors which are in the hands of the industrial companies of the Sectors, like the opportunity and willingness to implement the project results, strongly dependent on the local situation, the associated investment and operational cost, the industrial strategy, the market situation etc. In other words, the RFCS programme is opening the way for the industrial Sectors to harvest this benefit, providing scientific and technological solutions which must then be adapted and fine tuned according to the local situation, on a case by case basis. In general additional cost must be incurred by the industrial companies to implement the results of the projects and get the corresponding benefit.

This annual potential benefit can be compared to the budget of the projects. In this case the budget to be considered as a reference is the overall budget of all projects under review in the frame of the assessment exercise (308.1 M€ or 182.6 M€ RFCS funding), and not only the budget of the 23 projects. Indeed the benefit provided by the most effective 23 projects resulted not only directly from those projects but also from several other projects addressing related issues or providing knowledge development or not quantified outcomes. This method warrants a conservative approach of the assessment.

Accordingly, it can be estimated that one Euro spent in a RFCS project opens the possibility of an annual potential benefit of about 2.2 euros/y for the Coal and Steel sectors. The ratio is quite similar to the one calculated above on the basis of the real benefits at the beneficiaries level. Incidentally, this also shows that the extrapolation rules used to estimate the potential benefit at the sector's level were quite consistent and not over-optimistic.

These figures must be considered very carefully and as only indicative, as the benefit is only potential and the additional cost, beyond the project cost, to implement the results are not taken into account.

Nature of the potential benefits

The reduction of production cost, including energy and raw materials savings, accounts for slightly less than 50% of the potential benefit (Fig. 4). A significant contribution arises from the improved use of the assets, predominantly due to the extension of the life of coke batteries and blast furnaces. The improvement of productivity is the second important source of benefit, at 34% of the total. The increase of market shares resulting from the development of new products accounts for about 20%. This is quasi-exclusively due to the new steels for the automotive market and, to a lesser extent, the construction market.

Contribution of the different areas to the benefits

The respective contributions of the different production areas to the potential benefit are

shown in Figure 5. The coal projects account for about 15% of the total. In the Steel sector the potential benefit is almost equally distributed between the four areas. Ironmaking, Steelmaking and Casting account for about 45% of the total. This is due to the large impact of cost reduction, energy and raw material savings in those process areas.

To capture these potential benefits, it is obvious that additional efforts must be pursued at the companies level for implementing the technological solutions provided by the RFCS projects.

5 Conclusions

The Research Fund for Coal and Steel has a unique position in the coal and steel world, regarding the origin of the funds, the objectives and the execution of the programme covering research, pilot and demonstration projects. With the RFCS, the European Union has an active RTD instrument solely dedicated to the two sectors.

The major outcomes of the projects are primarily the development of new scientific and technical knowledge shared in the coal and steel sector. New practices, new process and new products, as well as numerical models and instrumentation tools are significant outcomes of the projects.

The quantitative benefits provided by the projects cover the cost reduction (reduction of energy and raw material needs,

life time extension of the assets), the increase of productivity and the development of new steel products, especially for the automotive and construction markets.

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