EUROPEAN COMMISSION

THERMIE

The demonstration component of the JOULE-THERMIE Programme

Solid Fuels

Sectoral Report 1995-97

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SOLID FUELS

THERMIE SECTORAL REPORT

Overview of THERMIE activities 1995-1997

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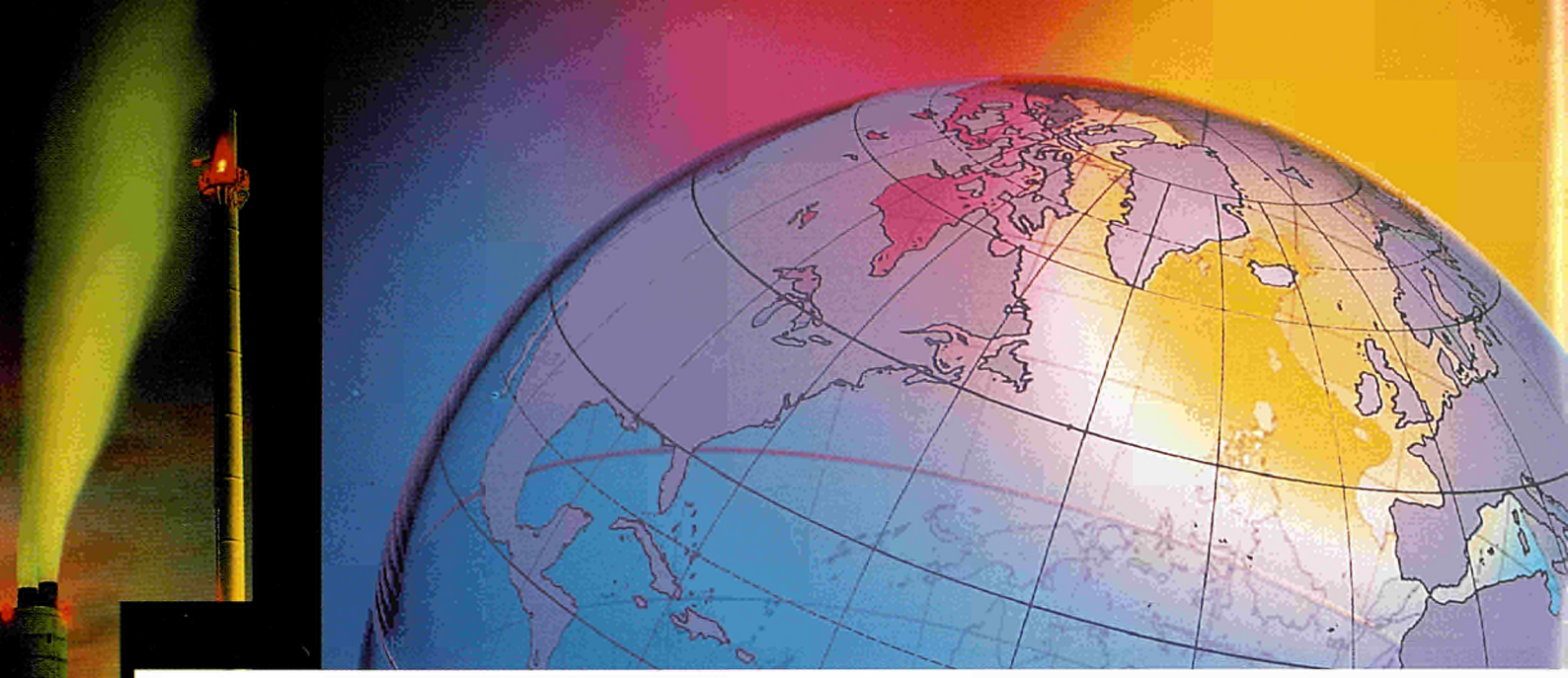


WHAT IS THERMIE?

JOULE-THERMIE was launched in 1995 as the European Union's first "integrated" programme, bringing together the resources of the Directorates-General XII (Science, Research and Development) and XVII (Energy). The aim is to encourage the wider utilisation of non-nuclear energy technologies from research and development, through demonstration, towards the goal of the penetration of these systems into the marketplace. The programme runs until 1998 and has a total budget of 1,030 MECU.

Energy is fundamental to the existence of society, as without it industry, commerce and civil society cannot function. Fortunately, the earth is endowed with considerable energy-giving resources, mainly in the form of fossil fuels, such as oil, gas and coal. These are, however, unevenly distributed globally and are finite, so their use raises questions regarding security of supply and environmental sustainability. The JOULE-THERMIE programme supports research and technological development aimed at addressing these issues through the research, development and demonstration of technologies which enable us to reduce our energy demand, and to use what we need more cleanly and efficiently.

The THERMIE component of the programme focuses on the targeted demonstration of clean, efficient, cost-effective, and environmentally-friendly energy technologies. It participates in actions to prove the technological and economic viability of these technologies and promotes their wider replication and market penetration both within the EU and beyond, particularly in Central and Eastern Europe and the developing world. It promotes the application of a new energy infrastructure which fully utilises renewable energy sources, seeks to improve the efficiency of energy use and makes better use of fossil fuels. It also promotes improvements in the exploration, distribution and transport of hydrocarbons.

THERMIE aims to encourage the development and use of innovative energy technologies to meet EU aims and objectives across a wide spectrum of policy areas - energy, environment, economic, innovation, regional and social.

THERMIE promotes non-nuclear energy technologies through two types of actions. Demonstration projects help to prove the technical viability and economic advantages of new technologies by applying them on a sufficiently large scale for the first time. Associated measures help to prepare and implement the results of the programme by enhancing its impact on the market and its performance. These actions include activities related to strategy, dissemination and to encouraging and facilitating the participation of SMEs.

The final call for proposals under THERMIE was made at the end of 1997. The programme ends in 1998, after which a new programme will be developed as part of the Fifth Framework Programme.

Meeting the needs of the market

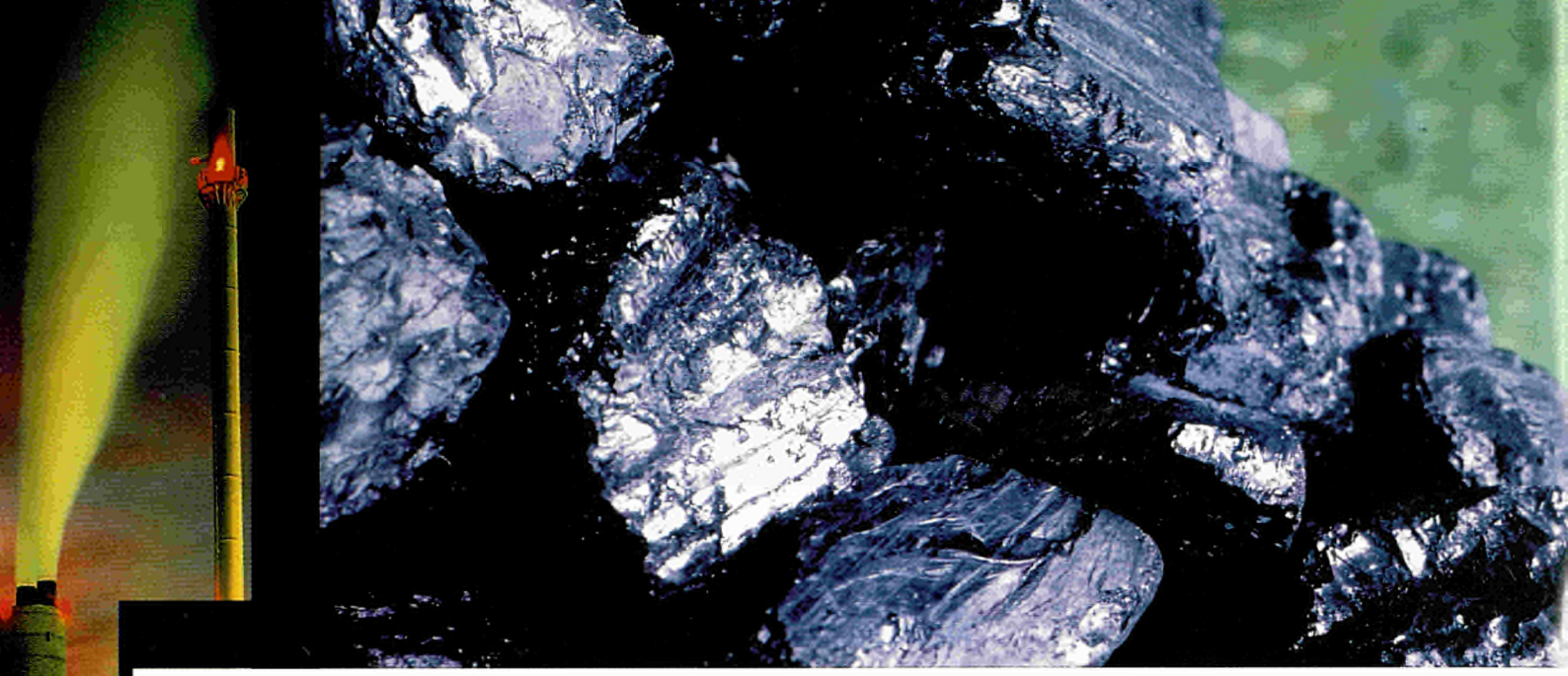
A key element of THERMIE today is that its activities must consider and respond to the real needs of market actors and the final consumer. It is not enough that technologies are developed and successfully demonstrated. A primary objective of the programme is to ensure that technological improvements are truly relevant to the needs of industrial, commercial and domestic society. This will help to ensure the availability of reliable, environmentally-acceptable and durable energy services (such as heating, lighting, transport or industrial processes) at affordable cost.

A sectoral approach

THERMIE is divided into three main sectors:

- Renewable Energy Sources
- Rational Use of Energy in Buildings, Industry and Transport
- Fossil Fuels (solid fuels and hydrocarbons).

This sectoral report provides a comprehensive overview of the activities carried out under THERMIE during 1995-1997 to promote the development and deployment of solid fuel technology.



RATIONALE FOR THE SECTOR

The solid fuels sector under THERMIE covers coal, lignite, peat, orimulsion, and other heavy fuels or residues produced by oil refining. These may be used separately, or in combination with biomass, urban industrial or biomass wastes.

The use of solid fuels to generate heat and power currently dominates the global energy market and plays an important part in the energy balance of the EU. Coal and other solid fuels are the source of 40% of electricity production in the EU and 45% world-wide.

It is widely accepted that this world-wide reliance on solid fuels will continue into the foreseeable future. These fuels are, for most countries, more plentiful, cheaper, and more secure in supply than other fossil fuels, and this will ensure that rising world energy demand, driven by rapid economic growth, will continue to rely heavily on energy generated from solid fuels. Whilst coal consumption in Europe is predicted to be in slight decline up to 2020, the World Bank has forecast a world-wide rise of more than 35% in coal consumption by 2010. This is not least due to the fact that many developing countries can use indigenous coal reserves as a cheap, reliable, secure source of power.

In parallel with this there is growing concern regarding the harmful environmental effects of fossil fuel based power generation and its use in commerce and industry, in the domestic sector and for transport. The negative impacts of CO_2, NOx, SOx and particulate emissions from solid fuel power generation plant on the environment and human health are now well understood, and mitigating these impacts is a priority in the energy policies of many nations world-wide. The market for clean conversion technologies, which utilise solid fuels in a manner which is efficient and consistent with environmental protection objectives, is primed for rapid growth. Countries world-wide already see the adoption of this technology as necessary if they are to meet their reduction targets for CO_2 while securing lasting energy supplies.

Commercially proven clean coal technologies were first developed in Europe in the 1980s. Ongoing innovation has led to the current availability of solid fuel based combustion systems with negligible NOx, SOx and dust emissions. Europe currently holds a strong position in the international market, supplying about 33% of the world market for fossil fuelled power plants. It is well placed to maintain and extend this strong market position through continued technological innovation towards the high efficiency, ultra-clean technologies which are necessary and feasible if coal use is to continue in an environmentally-acceptable manner.

European industry will, however, face stiff competition. For example, like Europe, the USA and Japan have for some time been targeting export activities in their power plant industry through comprehensive technological development and demonstration programmes, which help to keep their industries at the forefront of world-wide competition. Continued pre-competitive support for demonstration is imperative if European industry is to offer new, advanced, clean coal technologies competitively, both within the EU and in the rapidly growing markets of Central and Eastern Europe, Asia and Latin America where immense business opportunities exist.

A number of ultra-clean coal technology projects using Integrated Gasification Combined Cycle and Fluidised Bed technologies are now underway in the EU. Many of these technologies are well developed, but investment and operation costs are currently too high to render their widescale adoption as economic when compared to conventional technologies. It is important that projects which investigate opportunities, technologies and techniques which can cut these investment and operation costs are also assisted through pre-competitive support programmes. If European industry can achieve technology cost reductions vis-a-vis those of their competitors, then EU technologies will be able to gain a competitive advantage in the marketplace. Many projects supported under THERMIE are currently concentrating efforts on achieving technology cost reductions. Where these have been achieved, industry is very keen to disseminate information on these successful projects in order to publicise the European solid fuel combustion industry on the world market.

The main limiting factors in the widescale development and demonstration of innovative solid fuels technologies are the high costs and risks that are associated with full, industrial scale demonstration. Operational maturity as well as cost efficiency must be effectively demonstrated before technologies will be adopted by operators at the large scale. This, coupled with the long lead times for new technologies, means that pre-competitive support programmes such as THERMIE are of great help to European industry. These programmes, with their public funding contributions, add momentum to industry and accelerate technology development through risk and cost sharing in demonstration.

OVERVIEW OF THERMIE ACTIVITIES DURING 1995-1997

Considerable progress has been made under THERMIE towards the demonstration and subsequent market penetration of technologies which can contribute to an efficient, cost-effective and environmentally-friendly use of solid fuels. Many projects initiated under THERMIE during this time, and some ongoing projects selected during earlier calls for tender, have started to show impressive results. Examples of successful projects are given later in this document.

In the solid fuels field, the majority of demonstration activities supported under THERMIE to date have involved improvements to conventional pulverised coal boilers and newly developed, innovative clean coal technologies. The main aims of THERMIE with respect to demonstration projects have been to reduce the cost of innovative, clean coal technologies and increase plant efficiency. Several demonstration projects also have a more explicit environmental objective and consider emissions control technologies for solid fuel energy generation plant. A recent focus for the sector has also been the use of alternative fuels such as biomass and/or wastes as a co-firing component with conventional solid fuels. Through these demonstration activities, THERMIE aims to maintain Europe's strong competitive position in the world market with respect to clean coal technologies and where possible increase their market penetration.

Increased market penetration is also promoted directly through THERMIE's associated measures. These provide specific assistance to activities which target barriers which are currently hindering the market penetration of innovative energy technologies, such as the generally poor image of solid fuels in energy generation and the high cost of the relevant technologies. These activities contribute strongly to the development of a strong solid fuels technology industry which is able to compete effectively in the global marketplace and exploit new export markets as they emerge.

THERMIE activities in the solid fuels sector maintained the same broad goal between 1995 and 1997, i.e. the promotion, through demonstration and associated measures, of high quality, cost-effective and environmentally-friendly solid fuels technologies. To overcome the inherent environmental problems which are linked to solid fuel use, and reduce the high costs associated with these technologies are the greatest challenges currently faced by the solid fuels sector.

The use of coal in the EU has been falling in recent years as a result of relative increase in the use of gas for power generation. Europe's vast supply of solid fuel will, however, be needed in the long term to secure low cost energy supply as the cost of imported hydrocarbons will rise in future due to increased global energy demand and reduced availability of finite oil and gas.

As an abundant, low cost, and generally secure domestic fossil fuel, coal will remain an important fuel for heat and power production world-wide, both now and in the future. Demand for energy services such as, heating, lighting, and energy for domestic and industrial use, is rapidly rising world-wide and the most cost-effective, efficient and environmentally-sustainable method of providing these services must be found. The development and adoption of clean coal technologies can help offer an effective solution, supplying cost-effective electricity and heat with minimal environmental impact.

New technologies must be effectively demonstrated to prove their cost-effectiveness and suitability against conventional technologies before they will be adopted widescale. The results of demonstration projects must then be disseminated as widely as possible to publicise results and raise awareness in the market of the "state-of-the-art" in clean coal technologies. European technologies must enter the global market as soon as they are proven, to ensure that they are ahead of the intense competition in this field. Activities which promote market opportunities, at home and abroad, and encourage European technology suppliers to approach new markets, are therefore imperative within THERMIE and must take place in association with technology demonstration.

Demonstration activities supported under THERMIE between 1995–1997 have incorporated a wide variety of solid fuels technologies. In the main they have consisted of projects which demonstrate innovative new components such as efficient burners, or pollution control technologies within existing power generation installations. They have also included the demonstration of complete new cycles in innovative plant and co-combustion, such as coal with wastes or biomass.

Typical associated actions supported between 1995 and 1997 include the organisation of promotional workshops, seminars, exhibitions, conferences, training courses and industrial visits to clean coal technology sites. Various studies have also been conducted. The preparation of awareness raising publications which promote interest in advanced solid fuel technologies and improve the image of solid fuels in the EU have also been given priority. In general, activities which are designed to attract the interest of relevant decision makers have been supported in an attempt to encourage the acceptance of clean coal combustion. Projects which encourage the transfer of clean coal technologies to third countries have also been favoured due to the huge potential export market for these technologies.

Project selection for the solid fuels sector is based around the technical quality, cost-effectiveness, innovation, replication potential and relevance of the project to the objectives of the programme in general and the annual publicised priorities for the sector. Projects which are follow-on phases of existing projects or are associated measures to these projects have a high priority so that effective work can be built upon. Projects involving small and medium sized enterprises (SMEs) and the transfer of clean coal technology to third countries have a high priority within the programme.

SMEs

Solid fuel demonstration projects tend to be complex, large scale, high cost projects which involve long design, construction and commissioning phases. As a result they exhibit a significant financial and technical risk for participating organisations. Large companies are more able to accept at least an element of this risk than SMEs and research organisations, and they therefore dominate the projects in this sector. Very few organisations, even those of considerable size, are able to accept this risk alone, therefore solid fuels technology demonstration projects tend to be carried out by consortia of organisations, led by a large organisation, such as a manufacturer, supplier or utility. Each consortium usually incorporates a selection of Europe's main players in the solid fuels technology sector, such as Siemens, Scottish Power plc or Electricité de France, with more limited involvement from SMEs and research organisations. The consortium arrangement allows the risks associated with the demonstration project to be shared between all project partners, giving each an acceptable level of risk and potential reward. The public sector support available from THERMIE can also play an important role in the risk assessment of the project.

Cross-border Collaboration

Cross-border collaboration in this sector is very strong, particularly for demonstration projects. This is mainly due to the size, complexity and high cost of the projects and therefore the large size of the consortia, most of which involve companies from across the major coal using nations of the EU. Collaboration between European organisations in technology demonstration is essential if duplication of effort is to be avoided and cost-effectiveness achieved. Extensive co-operation between the industry and research bodies of Member States will allow the current strong position of the EU solid fuels technology industry in the global market to be maintained and extended.

Third Countries

The international market for clean coal technologies is rapidly expanding in countries with emerging economies, mainly as a result of rapid economic development and rising energy demand. This makes international co-operation and technology transfer in this sector vital, both to address global environmental problems and allow European manufacturers to maintain their current export market share and exploit emerging international markets. To date, THERMIE's actions in the international arena have concentrated upon market analysis, tools to promote EU expertise and technology world-wide and provide help to business partnerships, especially involving SMEs. THERMIE has also supported actions aimed at opening up new markets in non-EU countries. These have usually involved some form of event in combination with a study, publication, seminar/workshop and a business mission. In 1997 selected actions include a feasibility study for the development of clean coal technologies in China.

The table below illustrates the number of projects in the Solid Fuel sector and the financial support granted to these projects which were approved in the period 1995-1997.

	Demonstration projects	Associated Measures
1995		
Number of projects	8	14
Support Received (MECU)	26.5	1.4
1996		
Number of projects	5	7
Support Received (MECU)	18.4	0.9
1997		
Number of projects	9	10
Support Received (MECU)	22.3	0.9

Highlights - Demonstration Project Success Stories 1995-1997

Demonstration projects supported during 1995-1997 focused on the development of clean technologies for solid fuels. Some of these projects are completed, others are ongoing, or just beginning. The results produced by many of these projects seem to be/are very promising. Several projects which have made noteworthy progress to date are described here in more detail:

DEMONSTRATION PROJECT - SF/00010/96 (AT/IT/BE/DE/IE) Preparation of Biofuel for Co-combustion (BIOCOCOMB)

The aim of this project is to demonstrate the use of biomass (non-contaminated wood, bark and forest residues) as an additional fuel (up to 10%) in pulverised coal-fired units.
The BIOCOCOMB process is an efficient method of preparing biofuel in a circulating fluidised bed (CFB) reactor to the minimum requirements for pulverised coal fired systems. The physical principal is partial gasification and grinding by attrition through mechanical and thermal stress ('thermal milling') in a separate CFB gasifier. The gas produced is then fired in the pulverised coal fired unit.
A CFB reactor has been constructed near to the furnace of the boiler and shredded biofuel chips will be fed into this. In the CFB reactor the biofuel will be dried, pyrolysed and partially gasified to produce high temperature biogas, heat and wood char particles. Some of the volatiles driven off during pyrolysis will be burned with the air in order to generate heat for the endothermic gasification process. The wood char produced will be ground by mechanical attrition and thermal stress to a fine powder. These particles are small enough to pass through the cyclone of the CFB and into the furnace, together with the hot gas from the gasification process, where they burn completely. The gas is used as a reburn fuel in the coal boiler, thus helping to reduce overall NOx emission from the combustion process.
Co-combustion with coal does not require a high quality biogas, thus no predrying of the biomass or hot gas cleaning is required. The energy from the biomass in the form heat, low calorific value gas and fine combustible char particles, is thus transported to the coal boiler in what is known as the BIOCOCOMB process. The CFB reactor is not a real gasifier, but rather equipment which prepares the biofuel to the minimum requirements for co-combustion in a pulverised coal-fired system. The efficiency of the boiler combustion system combined with the highly effective flue-gas cleaning system, guarantees a minimal environmental impact. CO_2 emissions are reduced through the use of biomass as a substitute for coal. This process is also economic as the conversion efficiency of biomass to electricity is close to that of large scale, coal-fired power plant.

Principal contractor DRAUKRAFT AG

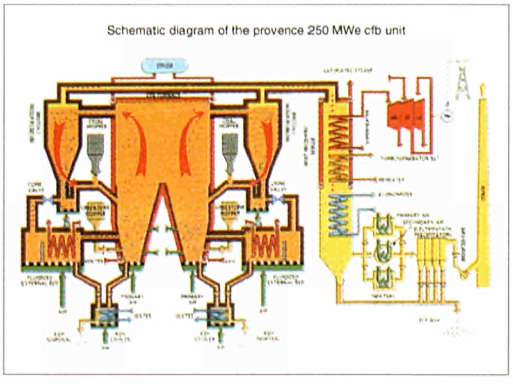
DEMONSTRATION PROJECT - SF/00080/95 (FR/DE), SF/00454/91 (FR/DE), SF/00542/92 (FR/DE), SF/00423/93 (FR/DE)

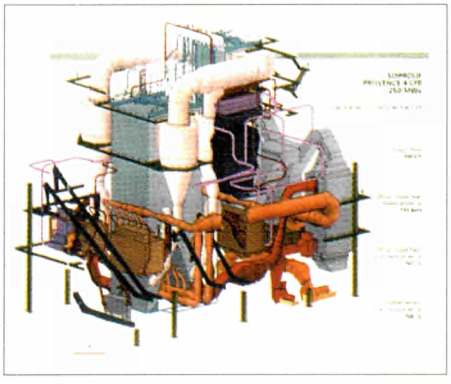
The Largest Circulating Fluidised Bed in the World Utilising Coal and Mine Stone

This project at the Provence power plant of Gardanne - Meyreuil in France, is one of the major THERMIE projects in the solid fuels sector. Its aim was the construction and operation of the world's largest circulating fluidised bed boiler (600 MWth). A single furnace of a size previously unprecedented world-wide has been installed along with four cyclones and four outside beds. The boiler is designed to operate in combination with a gas turbine to further increase the capacity of the plant. Work on the project began in 1993, with reliability tests and commercial operation taking place in 1996. Fine tuning has been conducted and the project is now complete.

This technology enables an option for the use of cheap feedstocks, including coal and low grade fuels such as raw mine products. It is also a highly efficient electricity generation technology manner with low SOx, NOx and particulate emissions. It is one of the most advanced electricity generation technologies currently under development and is a world first in terms of its generation capacity. The Gardanne project is one of THERMIE's flagship projects and could be of great interest in the European market, as well as in the emerging economies of India, China and Indonesia where the market for clean coal technologies in the near future is likely to be enormous.

Principal Contractor Electricité de France.





DEMONSTRATION PROJECT - SF/00002/94 (ES/FR/PT/DE), SF/00422/93 (ES/FR/PT/DE), SF/00198/92 (ES/FR/PT/DE), SF/00337/91 (ES/FR/PT/DE)

DEMONSTRATING AN INNOVATIVE 335 MWE INTEGRATED GASIFICATION COMBINED CYCLE (IGCC) PLANT (PUERTOLLANO)

FOLLOW-ON PROJECT - SF/00200/95 (ES/IT/FR)
Activities to Improve the Economics of Current and Future IGCC

This ongoing project (SF/00002/94) aims to demonstrate the high performance and flexibility of a 335 MWe gross (ISO condition) plant, integrated coal gasification with a combined cycle (IGCC), using a wide range of fuels and with minimal atmospheric emissions. The plant is located in Puertollano, an industrial town in central Spain. The project involves eight electricity utilities from six European countries and three large manufacturers. The follow-on project (SF/00200/95) aims to improve the technological performance while supporting start-up and operation. It also aims to expand the knowledge base regarding IGCC through the utilisation of computer models and simulation techniques to assess and improve the cost-effectiveness of IGCC concepts.

The plant is based on a highly integrated coal gasification and combined cycle, which consists of coal gas generation and treatment, combined cycle and air separation unit. In the gasification system the fuel (50% coal, 50% coke) and lime is pulverised and dried in a preparation unit before entering the PRENFLO gasifier. The gasification process is based on the entrained flow principle. Fuel dust is gasified with oxygen and steam and then quenched with de-dusted warm gas and cooled in a waste heat boiler system. Dust is removed from the raw gas by ceramic candle filter and halogens and alkalis by a venturi scrubber. Fly ash is returned to the gasifier. The de-dusted gas is treated using a catalytic process in the desulphurisation unit.

The clean coal gas is then burned in a combined cycle 190 MWe gas turbine and the combustion gases are utilised through the triple pressure recovery steam generator and a reheat steam turbine of 145 MWe. The air separation plant operates under pressure as a cryogenic process directly fed from the gas turbine compressor outlet. The interface system and the controls have been specifically designed to assure high plant reliability and availability.

The follow-on project focused its activities on the development of tools and systems to support the start-up and operation of the Puertollano plant, as well as assessing current and future IGCC design concepts. It will use information from the Puertollano plant to develop computer simulation models, such as steady state simulation, operations diagnosis, materials behaviour and environmental impact as information becomes available. This will enable the assessment of cost-effective, environmentally-friendly IGCC technology.

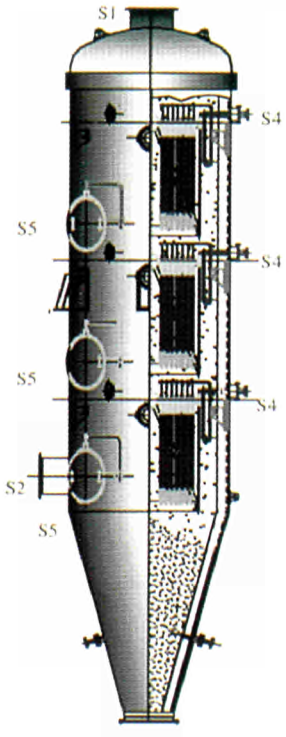
Principal Contractor ELCOGAS SA

DEMONSTRATION PROJECT - SF/03002/93 (ES/DE/UK)
Ceramic Filter Demonstration Plant for Gas Cleaning at Escatran Pressurised Fluidised Bed Combustion (PFBC) Plant

This project demonstrates the performance and availability of a ceramic filter plant that incorporates all the main features of a commercial size filter, so can be directly expanded by increasing the number of modules and the main dimensions, without the need for further demonstration testing. The filter has been connected to a nearby commercial PFBC plant, therefore operating conditions are similar to the future commercial ceramic filter plant.

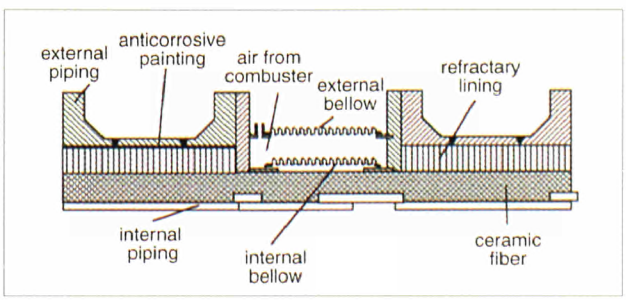
The project tests the main components of the filter over a long time period to determine their lifetime, including the ceramic candles. The filter parameters will also be optimised for the particular requirements of the local coal, (face velocity, pressure drop, etc) and the availability of the ceramic filter plant will also be determined.

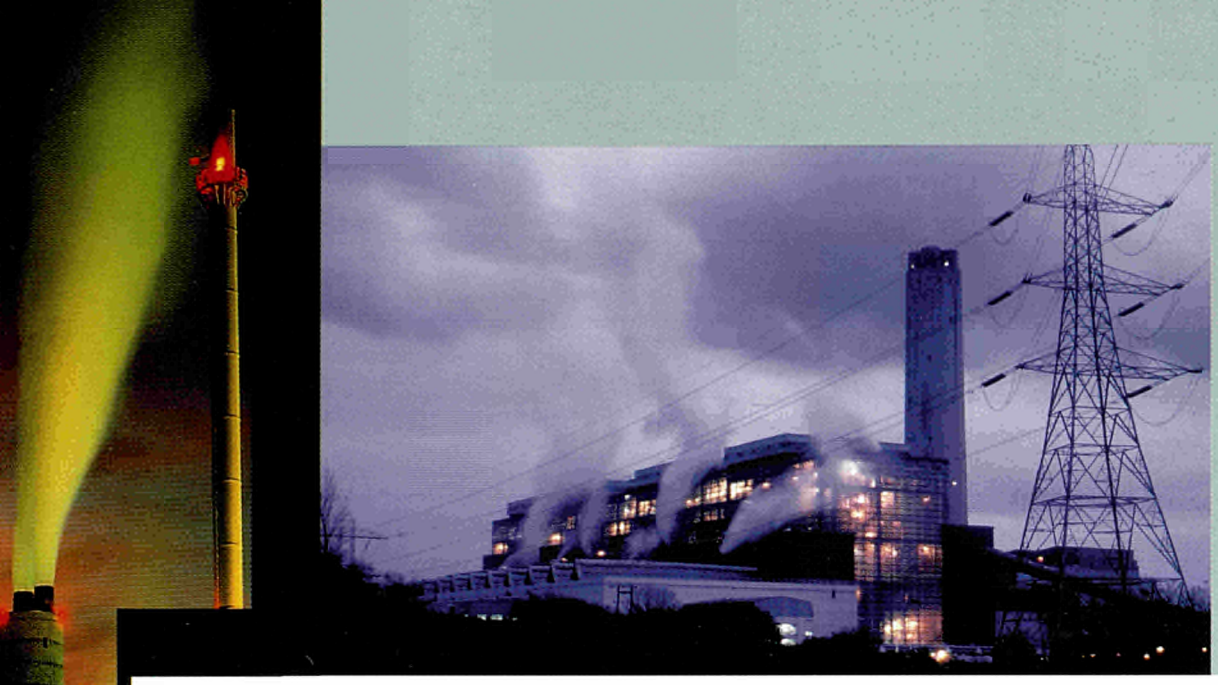
The ceramic filter is installed to treat one ninth of the combustion gases from the PFBC plant at Escatran. Currently, gases from the pressurised fluidised bed pass through nine pairs of primary and secondary cyclone. The secondary cyclone in one of these has been substituted with the ceramic filter. The design of the filter is a new concept of double supported candles from below the clean gas headers, minimising stress in the elements, optimising candle space occupation and tightness of the joint candle header. The filter operates with gases from the demonstration plant at Escatran so that the filter will be subject to the operating conditions of a commercial PFBC plant with respect to gas characteristics, plant operation modes and hours of operation. The filter must also handle dust loaded gases from the burning of local lignites with a high ash content.



The filtration plant was fitted to the power station during November 1997. Operation to date has been satisfactory.

Principal Contractor Babcock & Wilcox Espanola Spa





DEMONSTRATION PROJECT - SF/00394/94 (UK/IE/IT/FR)
Gas Reburn Demonstration Project

The aim of this project is to demonstrate the technical and economic feasibility of using gas reburn technology to reduce the emissions of NOx from large, coal front wall-fired power station boilers with a view to promoting its commercial exploitation in the international energy market.

Gas reburn is a technique for reducing NOx emissions which has been proven on pilot plants and small scale combustion processes, but has not yet been applied to coal front wall-fired boilers in Europe. Its application requires the innovative use of 'state-of-the-art' theoretical and experimental models to a practical situation. It is expected that with 19% gas reburn, reduction of at least 45% in NOx emissions against levels achieved with a low NOx burner, or 70% from the levels without low NOx burners.

Gas reburn will initially be applied to one of the four 1550 MWth front wall, dry bottom pulverised fuel fired boilers at Longannet Power Station. This will apply the gas reburn technique to the greater than 500 MWe range of boilers for the first time. In July 1993 a feasibility study was conducted to assess the technical and economic merits of gas reburn compared to the alternative technology of selective non-catalytic reduction (SNCR). It was concluded that the design and operational characteristics of the Longannet boilers strongly favour gas reburn.

The design process involved extensive use of in-house experimental and theoretical mathematical models to determine the process flow parameters, optimise the position of the gas reburn nozzles and overfire air, and to determine the impact of reburning on the operational characteristics of the boiler. This required the provision and installation of additional fans and associated ductwork. In addition, the requirement for gas injectors and overfire air ports necessitated additional openings to be formed in the furnace walls.

System design, which determined the number, location and elevation on the furnace wall of the reburn injection ports and overfire air ports has been completed using a 3D mathematical model and experimental data from small scale combustion rig testing. Installation is also complete. The project is ongoing.

Principal Contractor Scottish Power Plc.

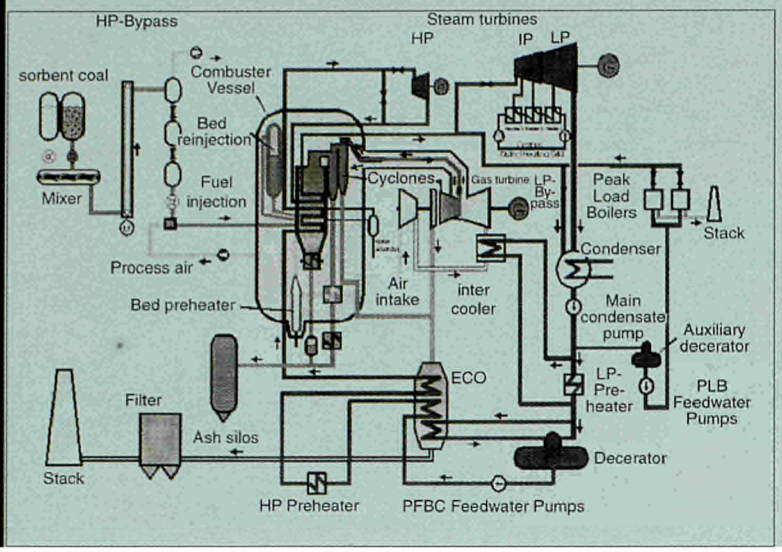
DEMONSTRATION PROJECT - SF/1001/97 (DK/UK/DE/CH/IT/ES/FR/NL/SE/NO)
Advanced Power Plant Design

This is a major collaborative project involving 40 co-contractors from 11 European countries to develop further improvements in clean technologies for utilising solid fuels for power and heat production. The aim is to identify and assess new materials and power plant designs that can enable power plants to achieve steam temperatures above 700°C, to yield high electrical efficiencies.

This contract covers the first six years, in which the project partners will focus on developing new materials and more compact designs, and evaluating their financial and technical feasibility. Subsequent phases will demonstrate the new designs, leading to the construction of a new 400-800 MWe power plant.

The results from this project will help to identify ways to improve efficiency and reduce CO_2 emissions from fossil fuel power stations. The technology will be primarily based on coal, but will be applicable to other fuels such as biomass.

Principal Contractor ELSAMPROJEKT A/S
Plus 39 co-contractors from 11 EU countries.



DEMONSTRATION PROJECT - SF/00264/97 (DE/SE) AND SF/00122/95 (DE/SE)
Second Generation PFBC Co-generation Plant Using Lignite

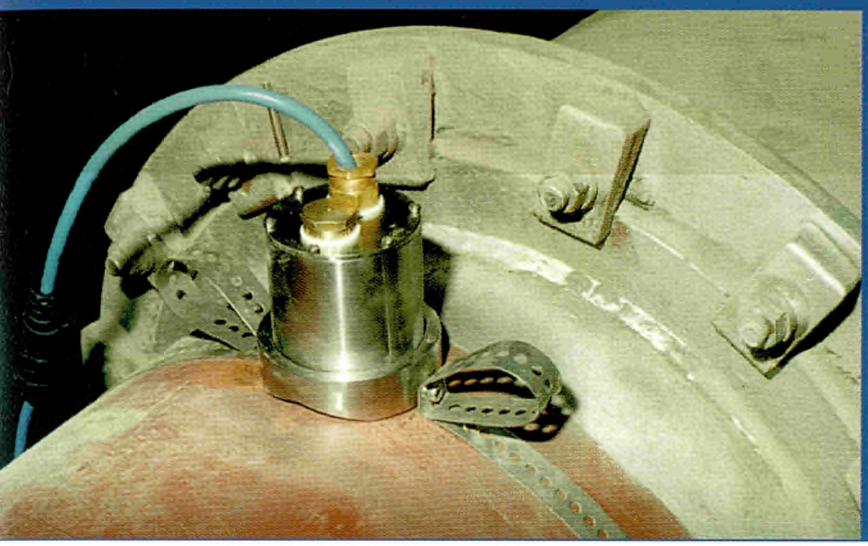
The main aim of the project is to demonstrate the efficient and clean Combined Heat and Power (CHP) production from brown coal in the city of Cottbus using second generation Pressurized Fluidised Bed Combustion (PFBC) technology. The use of brown coal in Eastern Germany can help ensure the continued use of domestic reserves and ensure stability and fuel supply security.

The existing CHP plant supplies the city with 48 MWe electricity and 230 MW steam for district heating purposes. It consists of four conventional, dry-ash removal, grate fired steam boilers and has an exhaust gas cleaning system for dust, but no NOx or SOx control technology. To meet new environmental requirements the system now needs to be upgraded. The best solution was to replace the equipment with modern, efficient, brown coal-fired PFBC technology, with two natural gas-fired boilers for peak load district heating.

This project aims to manufacture and demonstrate a second generation PFBC technology. This will, for the first time incorporate freeboard firing, i.e., the firing of additional fuel in the region above the fluidised bed, which maintains a high temperature in the flue gas stream, even at part load conditions, to improve desulphurisation and reduce NOx formation. The electrical output from the plant will also be enhanced, as a result of the higher temperature at the inlet to the gas turbine expander of the GT35P machine which drives the air compressors of the PFBC boiler and also generates about 20% of the electricity produced in the plant. The design, manufacturing, procurement and site work are proceeding well.

Significant emissions reductions are expected against the old plant, a 96% reduction in dust, 95% reduction in SOx and a 71% reduction in NOx, making it particularly applicable in populated areas. Experience gained in this project can be used as a basis for further applications of the technology in coal using countries.

Principal Contractor Stadtwerke Cottbus GmbH

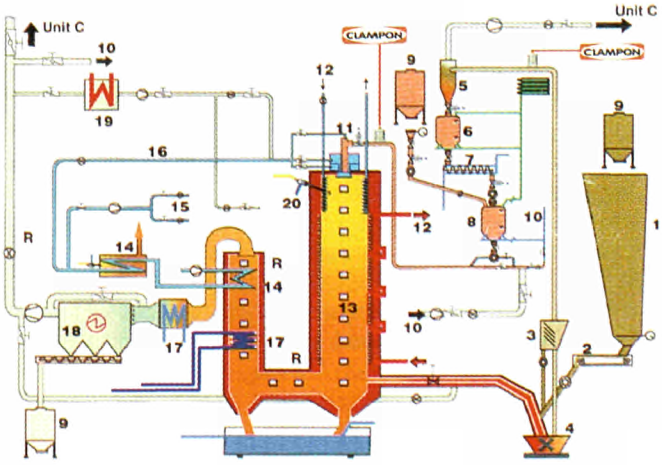


DEMONSTRATION PROJECT - SF/00265/97 (NO/DE/SE)
Clamp-on Solid Fuel Monitoring Technology

The ultimate aim of this demonstration project is to adapt a clamp-on solid fuel monitor, which will enable the optimisation of the combustion process in pulverised coal-fired boilers. The project aims to be the first in the world to develop a non-intrusive technology which continuously measures the amount of pulverised coal in the fuel stream pipeline. It also aims to develop systems for using these measurements to optimise the combustion process of pulverised coal boilers.
The development will be based on adapting existing technology for measuring the content of sand-dust in a well-flow of natural gas. Equipment for such measurement already has a proven track record as a result of work with major oil companies around the world. The passive acoustic methodology used in this project should give better results on quantifying the amount of variation and fluctuation of pulverised coal in a fuel flow, due to higher particle intensity and higher velocity of the flow.
The construction and manufacturing of the instruments is complete and these are soon to be tested.

Principal Contractor CLAMPON AS

Pulverized Fuel Combustion Research Plant
Scheme of Dry Lignite Combustion



1. Raw coal bunker
2. Belt weigher
3. Classifier
4. Beater fan mill
5. Cyclon
6. Dry lignite hopper
7. Cooling screw conveyor
8. Dry lignite hopper
9. Transportation vessel
10. Dry lignite carrier gas
11. Burner
12. Combustion cooler
13. Combustion chamber
14. Air heater
15. Burnout air
16. Burner air
17. Flue-gas cooler
18. Electrostatic precipitaor
19. Flue-gas pre-heater
20. Ignition burner

® Flue-gas analysis chain

Highlights - Associated Measures Success Stories

Associated actions supported under THERMIE between 1995 and 1997 have been those which aim to raise interest in advanced solid fuels technologies and improve the market image of coal as an energy source. Many projects which promote clean coal technologies in the international market and encourage the transfer of technology to third countries have also been supported.

Associated Measure - STR/0723/95
Strategy for the Development of Advanced Pulverised Coal-fired Power Plants

Developments in clean coal technologies to increase the efficiency of solid fuel fired electricity generation are currently being made in Europe. The main aim of this project was the stepwise development of advanced pulverised coal-fired technology using high performance designs to reach steam temperatures of 700°C, thus achieving efficiencies of 55% and above.
This project assessed the market potential for advanced pulverised coal-fired plant and the possibility for the further development of innovative plant to enhance this potential through the optimisation of future steam cycles. A strategy for the future development of both the steam turbine and the boiler are to be developed through the identification of all the design and materials issues which must be resolved. A methodology for the resolution of these problems will be established. Preliminary studies will indicate relevant plant parameters for potential steam cycles and indicate the availability of materials with the required properties and construction techniques of the desired capabilities.
Work to date has shown that it will be possible to demonstrate a pulverised coal plant operating at steam temperatures out of the boiler in the range 700-720°C. The most suitable materials for use in these systems are super alloys for the hottest areas of the boiler, the piping and turbine, and austenites and ferites for the remaining areas. To keep the economics of the plant sound, a revised overall plant structure is necessary. After successful demonstration the advanced technology may be adopted in pulverised coal as well as other applications such as coal gasification or fluidised bed technology. These innovative technologies can then be marketed throughout Europe and exported around the world.

Principal Contractor ELSAMPROJEKT A/S

Associated Measure - DIS/0426/95
Indo-European Seminar on Clean Coal Technology and Thermal Power Plant Upgrading

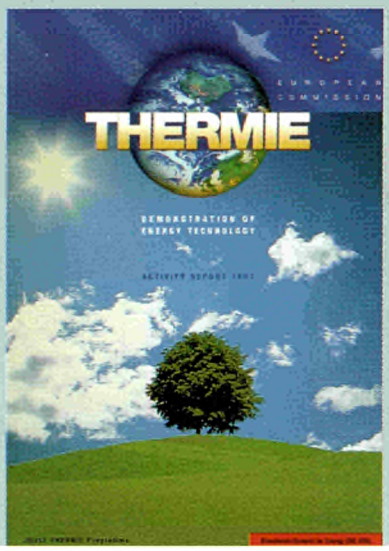
This project supported a seminar on clean coal technologies and the upgrading of thermal power plant.
The seminar involved the high level presentation of European experiences and the promotion of the results of THERMIE concerning the technical and economic aspects of clean coal technologies to encourage the cleaner use of coal in India. European technologies in the fields of clean coal technologies, coal homogenisation, environmental technology, ash deposition and utilisation, thermal power plant upgrading, renovation/lifetime extension and advanced coal-fired power plant technology were presented at the seminar. Discussion was held regarding Indian problems with respect to these.
The achievement of this project has been the promotion of European clean coal technologies having an impact upon environmental pollution issues in the industrial growth regions of India.

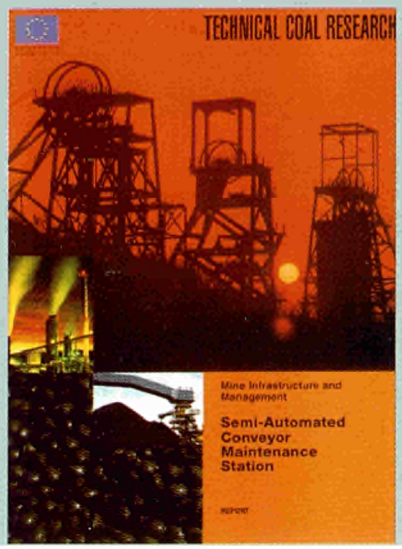
Principal Contractor	KFA BEO
Partners	Kema
	VGB

Associated Measure - STR/1121/96
European Action Plan for the Implementation of the Carnot Programme

The main aims of this action was to develop an implementation plan for the Carnot programme and set up a European Clean Coal Forum. This study consisted of a review of world-wide clean coal programmes which identified and assessed the current barriers to the uptake of European clean coal technologies. The study also established a rigorous commercial market potential for European clean coal technologies and analysed economic, socio-economic and environmental impacts and benefits of the take-up of these technologies. A dissemination strategy for the clean coal technologies in European has been prepared as have recommendations for the support of world-wide market uptake of European clean coal technologies. The study also developed the rationale and recommended activities for an integrated European Clean Coal Programme.

Principal Contractor	ETSU
Partners	CIEMET
	KFA BEO
	NOVEM





Associated Measure - STR/1014/96
Clean Coal Utilisation for Electric Power Generation in Latin America

Coal using countries are becoming increasingly aware that the uptake of clean coal technologies is necessary if targets for efficiency and emissions reductions, especially for CO_2, are to be reached. Latin America is a significant coal using continent, which offers a considerable market for such clean coal technologies. This study therefore made an analysis of the prospects in Latin American countries for the implementation of clean coal technologies, and their willingness to implement them. This will involve the organisation of a seminar in one site in Latin America, with the assistance of technicians and decision makers from all interested parties. A feasibility study will be conducted for one clean coal plant at a selected site.

Principal Contractor	Ocicarbon
Partners	Escan
	Partex-CPS

Associated Measure - DIS/1236/97
Clean air IV. International Conference on Technologies and Combustion for a Clean Environment

Increasingly severe emissions restrictions in developed countries force technologists to find ever more efficient solutions to reduce emissions from combustion equipment. Concerns about rapidly developing countries who are not yet in a position to apply the latest pollution abatement methods have now become paramount.
This conference provided a forum for discussion on new technologies and combustion for a clean environment, and on issues and barriers to the implementation of these new technologies, especially in Eastern European and emerging economy countries. It promoted and disseminated new European energy technologies, especially the results of EU projects, including those funded through the THERMIE and JOULE programmes. It also encouraged the interchange of ideas between the European energy sector and the rest of the world, especially the US, Japan, Central and Eastern Europe and newly emerging economies.

Principal Contractor	Instituto Superior Tecnico
Partner	The Imperial College of Science & Technology

Associated Measure - DIS/1491/97
Evaluation of Flue Gas Desulphurisation for Chinese Coal-fired Power Plants

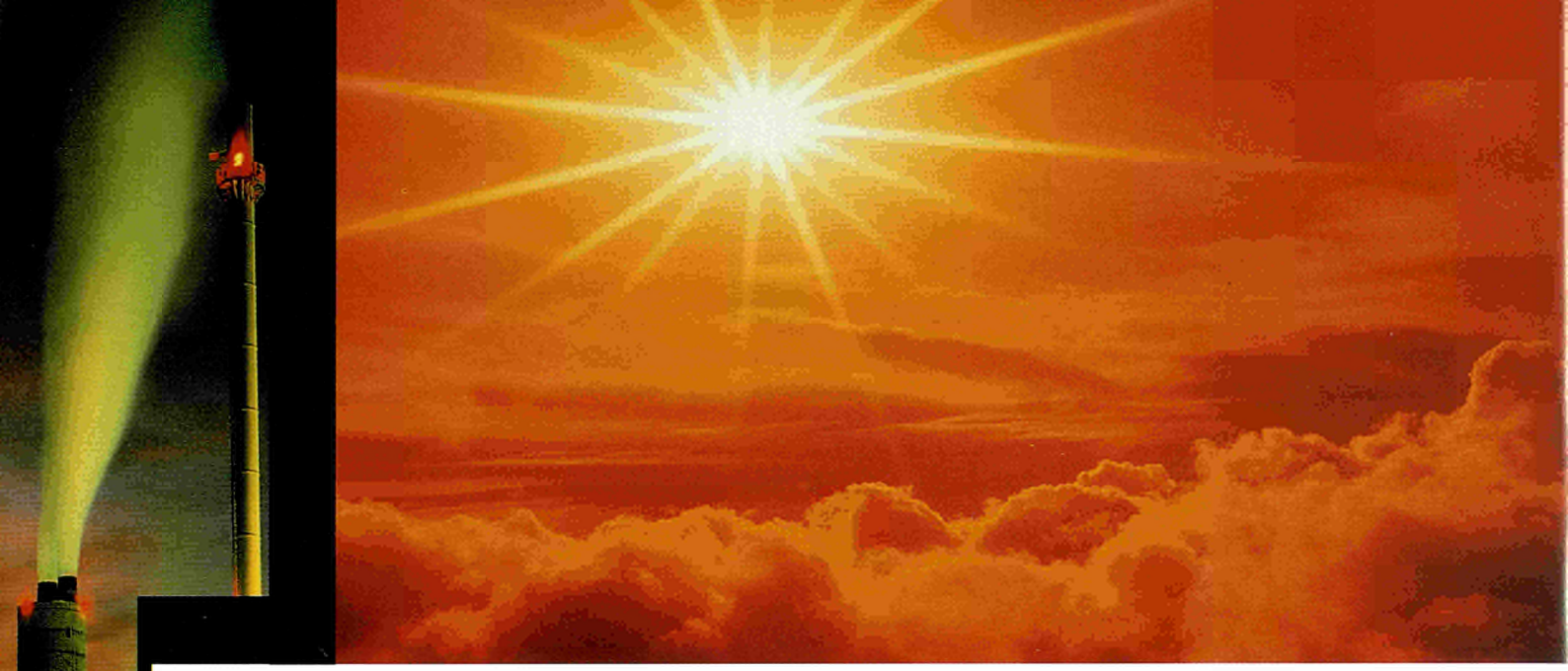
Flue gas desulphurisation (FGD) technologies are well developed and widely manufactured in Europe. A huge international market for these technologies exists in the coal using, emerging economies of India and China, as these technologies have not yet been adopted widescale in these countries.
This project aims to analyse the market for FGD technologies in China. It will assess and determine the suitability of various European FGD technologies to the Chinese market and will determine the effect that the installation of these technologies will have on emission reduction in China. Its ultimate aim is to open up the Chinese market to cost-effective European FGD technologies and stimulate their export. This will generate additional employment within the European industry and also offer the benefit of reduced SOx emissions from power plants in China.

Principal Contractor	CRE Group
Partner	VTT ENERGY ESPOO

Associated Measure - DIS/1162/97
Assistance in Retrofitting coal-fired Power Stations in the Buryatian Republic - Assessment and Training

Existing coal-fired power plant in the former Soviet Union is, in many cases, highly inefficient and polluting. Numerous technologies are available which can be retrofitted onto these plant and greatly improving their operating efficiencies and reducing pollution.
The main aim of this project is to help local institutions to undertake successful joint actions between EU companies and the Buryatian Utilities for energy efficiency and environmental control by implementing retrofitting measures in existing coal-fired power installations. The project should enable good links to be established between the Buryatian utilities and potential investors from the EU. It should also lead to significant energy efficiency and environmental conditions for coal-fired power stations.

Principal Contractor	INNOTEC SYSTEMANLYSE GmbH
Partners	ESBI International Ltd.
	ADEME



A VIEW TO THE FUTURE

Despite the fact that the use of gas for power generation has increased during recent years, coal, as an abundant, reasonable cost, secure fossil fuel, will remain the major fuel for heat and power production for the foreseeable future, particularly in Central and Eastern Europe and in Asia. Despite the fact that coal use in the EU has declined in recent years due to the widespread availability of oil and gas, Europe's significant solid fuel reserves will be needed in the long term to secure low cost energy supplies when imported oil and gas prices rise as a result of increased energy demand. Demand for energy services is increasing world-wide at a rapid rate and the most cost-effective, efficient and environmentally sustainable method of producing the energy required to provide these services must be found. Clean coal technologies can help offer effective solutions.

In the main, it is the reduction of environmental impact that is the key to ensuring the acceptance of coal as a long-term power resource world-wide. EU-wide development and demonstration of cost-effective, clean coal technologies is therefore of primary importance both for their application in the EU, and also for their capacity to generate export earnings and employment, by taking advantage of the enormous emerging markets abroad.

To date, THERMIE has achieved a great deal in the solid fuels sector. It has brought a wide variety of energy technologies nearer to the market through demonstration and associated measures, offering considerable environmental and commercial benefits to the EU. With its long history of excellence in coal technologies, the development of innovative fossil fuelled generation plant offers Europe a major source of employment and export earnings if the market can be successfully exploited. This economic growth must, however, comply with the EU objectives of economic development and industrial competitiveness that respects the environment and quality of life.

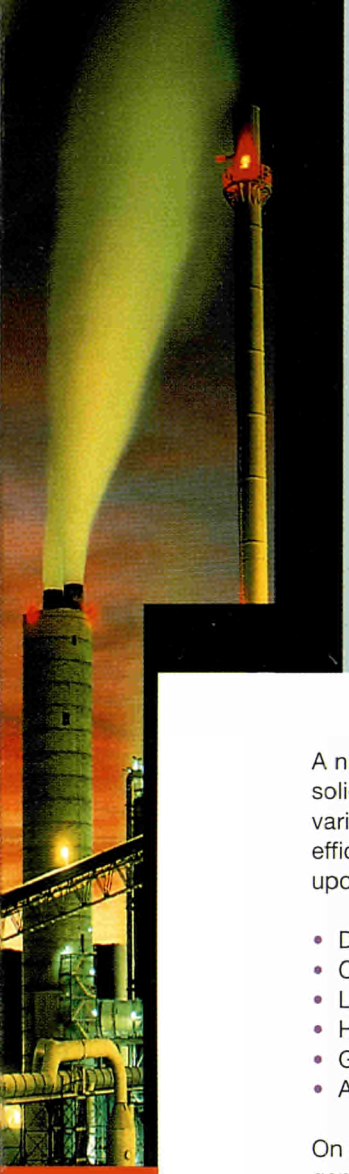
The strategy for solid fuel technology research and technological development (RTD) and demonstration under THERMIE has undergone a process of continual evolution, and the next steps for a future strategy will need to take due consideration of the priorities of the Fifth Framework Programme (1998-2002), the proposed Energy Framework Programme and RTD strategy in general. Europe is moving towards the realisation of a comprehensive, coherent and effective energy technology strategy with common principles, guidelines and priorities. Such a programme will draw together existing or proposed instruments, including THERMIE, to ensure the most effective delivery of energy technology activities.

Clean coal technologies can only see widespread introduction in the EU and international markets if they receive acceptance from both the utilities and consumers on environmental acceptability and cost grounds. Demonstration to prove and promote their economic and environmental advantages is therefore required and should continue to focus on three main priority areas:

- Increasing plant efficiency (to reduce CO_2 emissions and conserve solid fuel resources).
- Reducing investment, operation and maintenance and energy production costs, to ensure competitive power generation and strengthen the position of European manufacturers in the world market.
- Reducing emissions (SO_2, NOx and particulates).

In the solid fuels domain the majority of RTD in the EU to date has involved the improvement of pulverised coal technologies which currently form the backbone of solid fuel electricity generation. Now, however, a wider variety of clean coal technologies are under development. The ATLAS study - Energy Technology: The Next Steps 1 - considers the major potential solid fuel technologies expected to be available for industrial scale demonstration in the near future, or longer term basis:

- Advanced Pulverised Combustion Fuel (PCF)
- Fluidised Bed Combustion (FBC)
- Combined Cycles, Integrated Gasification Combined Cycle systems (IGCC)
- Pressurised Fluidised Bed Combustion (PFBC)
- Pressurised Pulverised Combustion Cycle (PPCC)
- Integrated Gasification Fuel Cell systems (IGFC)
- Magnetohydrodynamic electricity generation (MHD).



A number of key components are also important in the development of advanced solid fuel power generation systems. They either have multi-purpose applications in various advanced systems or they are key components in achieving higher efficiency targets. Therefore RTD and demonstration activities should also focus upon these techniques:

- Drying processes for low-rank coals, biomass and recovered fuels
- Co-utilisation of coal, biomass and recovered fuels
- Low cost combined heat and power generation
- Hot gas clean up
- Gas turbine development for coal derived fuel or flue gas
- Advanced control systems.

On a world-wide basis, the absolute contribution of solid fuels to electricity generation is expected to increase by 35% by 2010. In contrast, the relative share of solid fuels in power generation in the EU is likely to fall, at least in the short and medium term. As a result of efficiency improvements, solid fuel consumption per unit of electricity generated in the EU has already fallen from 0.55 tonnes of coal equivalent (tce)/MWh during the last two decades, to 0.29 tce/MWh and there is potential for this to be reduced further, to around 0.25 tce/MWh or less, with associated reductions in CO_2 emissions. In the light of the climate change debate, solid fuel based electricity generation will need to record higher efficiencies than are attainable today. Efficiencies of at least 50% need to be aimed at and are feasible in the medium term. Major investments in RTD and demonstration will, however, need to be made if this is to be realised.

A further key issue in RTD strategy for the development of clean coal technologies concerns the fact that, for many years to come, existing solid fuel fired plants are expected to maintain a significant share in EU and world-wide electricity generation. It is important to make efficiency gains and technological improvements in these plant, as well as in new plant. The development of new components and processes for retrofit into existing plants (e.g. the retrofitting of PFBC processes) should therefore be supported. There is huge world-wide demand for such modernisation technologies, particularly in the coal-intensive markets of Eastern Europe, China and South East Asia, and European companies should be well placed to exploit this export potential.

Currently a diverse range of energy technology development and implementation activities exist in Europe. It should be a key priority for the EU clean coal industry to find a focus for these activities if they are to maintain and expand their market share in the face of growing competition from the USA, Japan and other emerging economies in the export market, particularly in Asia. Growth forecasts for Asian coal fired generation capacity state that this is likely to triple between now and 2010. This equates to an additional capacity requirement of 360,000 MWe during this time period and a total growth rate of 20,000 MWe per annum. This offers a huge opportunity to the manufacturers and suppliers of clean coal technologies.

It is likely that solid fuel technology work under the Fifth Framework Programme will focus on large scale generation of electricity and/or heat with reduced CO_2 emissions from coal. It will also focus on co-firing with biomass or other fuels, including their use in combined heat and power (CHP) generation. Small CHP systems utilising solid fuels mixed with biomass or wastes, are an attractive generating technology for use at a local or regional level - particularly in less developed regions of the EU and in third countries.

THERMIE can demonstrate significant success in the solid fuels sector. It has helped the European solid fuels industry move forward with the strength, competence and confidence required for it to remain strong and improve its position in today's highly competitive international market. By working closely with all market actors to accommodate both technology-pull and market-push, THERMIE has played a vital role to date in accelerating the uptake of clean, energy efficient solid fuel technologies which are necessary to provide the energy services required by industry, commerce and society at large in an environmentally-friendly, efficient and cost-effective manner.

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The overall objective of the Community's Energy Policy is to help ensure the security of energy supplies for European citizens and businesses at competitive prices and in an environmental compatible way. DG XVII initiates, coordinates and manages energy policy actions at European level in the fields of solid fuels, oil and gas, electricity, nuclear energy, renewable energy sources and the rational use of energy. The most important actions concern the security of energy supply and international cooperation, the integrity of energy markets, the promotion of sustainable development in the energy field and finally the promotion of energy research and technological development through demonstration projects. DG XVII manages several programmes such as SYNERGY, SAVE, ALTENER and THERMIE. More information is available on DG XVII's pages on EUROPE, the Commission's server on the World Wide Web.

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