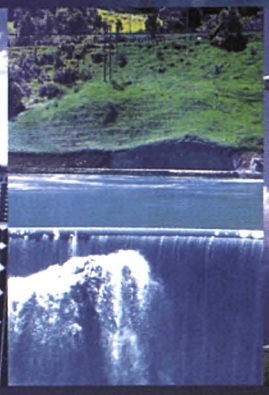
EUROPEAN COMMISSION

THERMIE

The demonstration component of the JOULE-THERMIE Programme






Renewable Energy Sources

Sectoral Report

1995-97

Directorate General for Energy (DG XVII)

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RENEWABLE ENERGY SOURCES

THERMIE SECTORAL REPORT

Overview of THERMIE activities 1995-1997

CONTENTS

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.

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 (the budget between 1995 and 1998 is 1030 MECU), 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

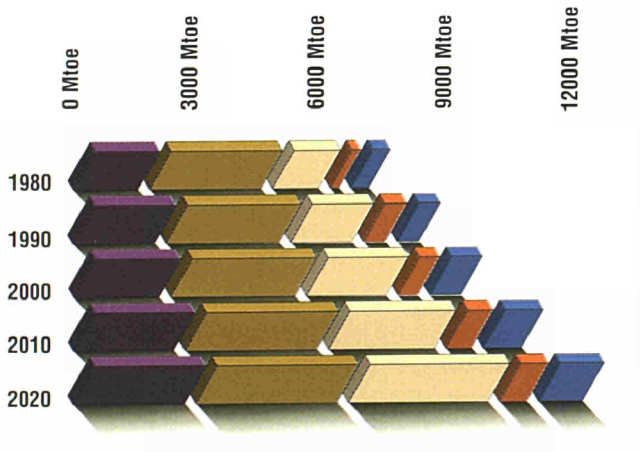
THERMIE is divided into three main sectors:

- 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 renewable energy sources.

World energy trends

World energy demand, currently about 8 billion tonnes of oil equivalent (bn toe) per annum, is predicted to rise to about 13 bn toe by 2020. There is, therefore, a huge and expanding market world-wide for energy goods and services.



World energy consumption 1980-2020
From "Energy in Europe": European Energy to 2020, (Conventional wisdom in case no additional policy measures are adopted).

RATIONALE FOR THE SECTOR - RENEWABLE ENERGY SOURCES

Renewable energy refers to a wide range of naturally occurring, replenishable energy sources. Renewable energy technologies convert the five primary sources of renewable energy (biomass, wind, solar – including photovoltaic and solar thermal electricity[1] – water, and geothermal) into solid and liquid fuels, heat and electricity. These energy sources can then be used to supply energy services to the three main sectors of energy demand, namely buildings, industry and transport.

Helping to meet EU energy policy objectives

In 1996 the European Commission set out its plans for an EU energy policy. The principal aims of the policy proposed are to provide security of supply, to protect the environment and to encourage the development of commercially viable energy technologies. Developing renewable energy coincides with these three aims, and during the 1990s this energy resource has taken on an increasingly important role in European energy policy and development.

However, the renewable energy industry is still a developing industry, and renewables only contribute 6% to Europe's energy consumption[2]. The EC's recent White Paper on Renewables[3] sets an ambitious target to double this share, to 12% of Europe's energy from renewable energy sources by 2010, principally through a large increase in energy from biomass, wind and photovoltaic (PV) sources. This is a challenging target and one which will need substantial financial and political support from the EU and from Member States to achieve.

1. *Solar thermal in buildings is not included in this sectoral report. Details of THERMIE promotion of this technology can be found in the sectoral report on Rational Use of Energy in Buildings.*
2. *Source: EUROSTAT.*
3. *Energy for the Future: Renewable Sources of Energy. White Paper for a Community Strategy and Action Plan.*

Challenges and benefits

There are, nevertheless, many benefits to be gained from supporting renewable energy development that can be balanced against the costs of this investment. These benefits provide the opportunity to develop an economically valuable and environmentally-friendly, indigenous energy resource for the European Union and for many other parts of the world.

Assistance to develop, strengthen and expand the renewable energy industry will improve the industry's competitiveness and promote export opportunities, and can help to promote social and economic cohesion, especially in remote and rural areas.

Europe's renewable energy industry is at the forefront of developing advanced technologies that are already playing an important role in revitalising European energy industries, and in helping to promote competitiveness and successes amongst these new industries. Hand in hand with this, an increase in exploitation of renewable energy sources encourages an increase in employment opportunities and in the development of Small and Medium sized Enterprises (SMEs) which constitute many of the new renewables companies.

The nature of renewable resources means that many of the renewable generating plants are regionalised and decentralised in comparison with the locations of conventional energy production. Decentralised energy systems can offer new, innovative, cost-effective and environmentally-sound solutions to energy needs in remote and rural areas. Such areas may be in Europe, but will increasingly be located outside Europe in developing and emerging economies. Europe's capabilities in developing renewable resources to answer these needs will provide export opportunities for European industries, many of which are world market leaders in their fields.

Finally, renewable energy sources are in general viewed favourably by the general public, who see these new technologies as part of the need for clean, efficient and cost-effective energy sources for the next millennium.

Promoting a new and expanding industry

The renewables industry is a small but rapidly growing industry and is dominated by Small and Medium sized Enterprises (SMEs). These companies often operate in niche markets where they are able to exploit their skills and adapt rapidly to technological and market developments. They offer the potential for employment creation and industrial growth. Many of these companies are world leaders in their field and export successfully to many countries outside Europe. However, SMEs are generally unable to take large financial risks, so continued financial support is very important to encourage continued developments and technological advances.

World markets for renewable energy technologies have been estimated to be about 17 billion ECU annually by 2010[4]. European industry is well placed to take advantage of the opportunities offered by this enormous market potential. THERMIE's involvement encourages continued developments in cost-effectiveness, provides assistance with identifying market opportunities, and helps to promote technologies.

4. *See reference 3 on page 6.*

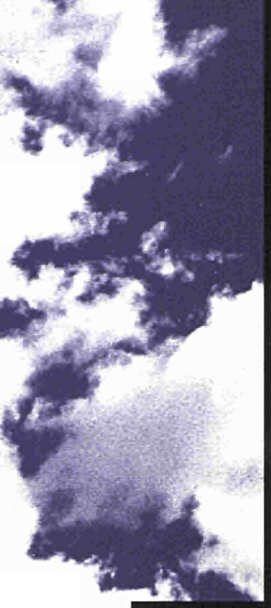
OVERVIEW OF THERMIE ACTIVITIES DURING 1995-1997

THERMIE promotes renewable energy technologies under six broad areas: geothermal energy, small-scale hydro-electricity, photovoltaics, wind energy, energy from biomass and waste, and solar thermal electricity. THERMIE provides assistance for demonstration projects and associated measures designed to accelerate the uptake of renewable energy technologies in the marketplace. This integrated approach is designed to ensure that the experience gained in the successful demonstration of emerging technologies is rapidly brought to the market. THERMIE works directly with companies and technology specialists, supporting them in their work to reach the market with new products and services.

Different renewable energy technologies are at different stages of advancement towards commercial viability. Some renewable energy technologies are already competitive, whereas others could become so within 5 to 10 years. THERMIE helps the accelerated development of these pre-competitive technologies. In particular, THERMIE provides support for projects to demonstrate innovative processes or technologies. The level and nature of involvement depends on the status of the technology in relation to its market deployment.

The focus of THERMIE involvement with demonstration projects is to select innovative processes and technologies that can demonstrate cost-effective energy recovery. In addition, the projects also demonstrate the feasibility of new and innovative systems into which these renewable energy technologies can fit.

Associated measures provide assistance for other activities designed to encourage the rapid uptake of technologies into existing and new markets. For renewable energy technologies, this includes pre-feasibility or market studies, workshops, conferences, training, dissemination measures, as well as a range of technology stimulation measures to encourage and facilitate the participation of Small and Medium-sized Enterprises (SMEs).



THERMIE activities during 1995-1997

THERMIE involvement in the renewable energy sector has resulted in an extensive range of projects covering all of the renewable energy technologies.

The types of organisations that submitted projects to the renewables sector included utilities, local authorities and research institutes, but the majority of promoters were SMEs. This high level of participation by SMEs reflects the nature of the renewable energy industry: a young, rapidly-growing industry where small new enterprises are able to exploit innovative opportunities in the various niches in each of the different technological areas. However, SMEs are less likely to be involved where the costs involved are very great, such as with large-scale biomass projects. Here, SMEs may be involved but only as a contributor to the project rather than as the main proposer.

Associated measures addressed the global challenge of diversification of energy supply and sustainable development, and promoted the replication of innovative renewable energy technologies. Many European renewables industries are world leaders in their field, and the reinforcement of the EU market, together with the broad perspectives of the renewable energy market in other countries, helps to maintain and improve this competitive position.

The types of projects selected included the assessment of market potential in various niche markets, the development of sectoral strategies through marketing groups, dissemination of information related to successful EU experiences, training, new financial mechanisms and general awareness-raising actions (in particular directed at local authorities) such as newsletters, exhibition stands, and the production of CD-ROMs.

THERMIE Demonstration projects

	1995		1996		1997*	
	Number of projects	EC Support MECU	Number of projects	EC Support MECU	Number of projects	EC Support MECU
Biomass and waste	6	6.2	6	11.8	10	16.8
Geothermal	8	5.0	7	5.4	9	6.7
Small scale hydro	9	3.5	8	2.4	17	4.9
Photovoltaics	24	5.8	11	7.7	17	10.8
Wind	7	7.6	11	7.7	20	12.2
Solar thermal electricity	-	-	2	2.4	1	1.2
Total	54	28.1	45	37.4	74	52.6

** These figures include the additional support decided early January 1998.*

TECHNOLOGIES PROMOTED UNDER THERMIE

The previous sections outlined the general aims and objectives of THERMIE's involvement with renewable energy technologies. Across all of the renewable energy technologies supported through THERMIE, the principal aim is to encourage the development of secure, reliable, environmentally-sound and cost-effective energy supplies from renewable sources.

Within this framework, THERMIE aims to contribute to the advancement or implementation of innovative techniques, processes or products for which the research and development stages have, for the most part, been completed. There are a number of issues that are generic to all renewable energy technologies that still provide challenges, technical and non-technical barriers to wider uptake of the technologies. These include the nature of renewables' geographical distribution, their small scale, and the diversity of markets, all of which tend to reduce the cost competitiveness of renewables in comparison with conventional generation. In addition, the energy market is inherently favourable towards large-scale conventional energy systems and it is difficult for renewables to compete. Other, non-energy, policies also influence the development of renewables, in particular those policies relating to agriculture and the role of support for production of non-food crops.

Against these challenges are the over-arching issues that are driving forward the development of clean and efficient energy technologies including renewables. Technological development needs to ensure that new technologies are developed and commercialised to meet the needs of the citizen, and to ensure that best use is made of these new technologies. Long-term goals for research and technological development aim to ensure that the new technologies meet the needs of the citizen in ensuring an improvement to quality of life and the environment as well as offering efficient and cost-effective energy services. Renewable energy technologies are at the forefront of addressing these issues, helping to provide clean, quiet, efficient and effective new energy solutions.

The diversity of technologies means that some are near market and approaching commercial maturity whilst others are still at much earlier stages of development. This diversity influences the requirement of each sub-area for THERMIE support. Hence each of the sub-areas has its own set of aims, objectives and targets, which fit in with the overall general aims and objectives of the renewable energy area. These sub-areas are described here in more detail.

Highlights of Success Stories

There have been 173 THERMIE demonstration projects since 1995, and further projects through the associated measures. Each year, new projects are selected as a result of an evaluation and selection procedure to ensure that the highest quality projects are supported. Projects are then managed throughout their lifetime. On completion, project reports, case studies and other promotional material are produced to ensure that the results from the project are promoted widely throughout the renewable energy industry.

In this section we have described THERMIE activities in each of the sub-areas in more detail, and have selected a few examples of successful and interesting projects. The projects selected represent a range of projects completed during the period 1995-1997, including a few that were funded before this round of THERMIE began in 1995 but which have only recently been completed.

Small-scale hydro-electricity

Small-scale hydro is a technology that has been in use for hundreds of years. In recent years it has once again attracted interest because of its advantages in terms of zero emissions, low operating costs, long lifetimes and the use of indigenous resources. Small scale hydro offers advantages compared with the deployment of large-scale plants, where environmental considerations can outweigh the benefits from the power generated.

There are significant unexploited small hydro reserves in many European countries, such as in Portugal and Spain, as well as opportunities for rehabilitating existing sites. In addition, the unexploited potential elsewhere in the world offers opportunities for a mature European industry to compete in this expanding market.

Improvements to the performance of small hydro projects aim to extract more energy from the water by maintaining efficiencies at a wider range of flow rates and input conditions. Better performance can be achieved through improving efficiencies of the turbine generator, better water management and through high technology electronic monitoring solutions to maximise energy recovery.

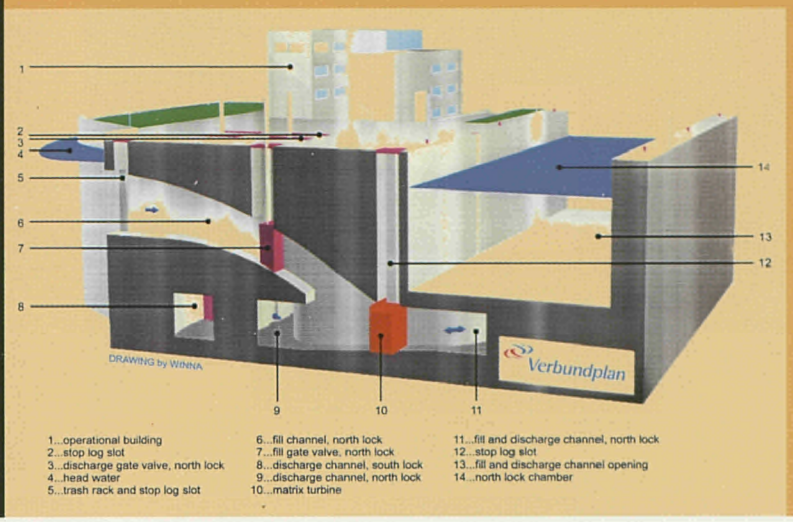
The priorities for THERMIE focus on two main areas: technological improvements to improve performance, and environmental or other conceptual modifications to improve existing or new plants.

Technological improvements to the design and management of the project include improvements to electromechanical equipment such as the development of new materials or innovative turbine designs. THERMIE projects demonstrate improvements to civil engineering and electronics in the plant, as well as more general opportunities for cost reduction through standardisation of equipment and techniques.

Small hydro schemes are often sited in areas of environmental or touristic importance where environmental improvements are mandatory before the project can gain permission. THERMIE therefore supports projects where a significant proportion of the project costs related to environmental improvements could adversely affect the cost-effectiveness of the project.

Small hydro projects can offer additional local benefits such as for flood control, water management or irrigation. THERMIE works with various projects which offer such multi-use applications. It also provides assistance for some rehabilitation projects where an old or disused small hydro scheme is replaced by a modern solution.

In the future, THERMIE will continue to encourage innovative applications of small hydro technologies, especially in low-head technology, remote sensing and control, and through environmentally-conscious operations. The European market is mature but there are substantial world-wide opportunities for further exploitation of the global export market.



Demonstration Project: HY/208/97/AT

The Matrix Turbine

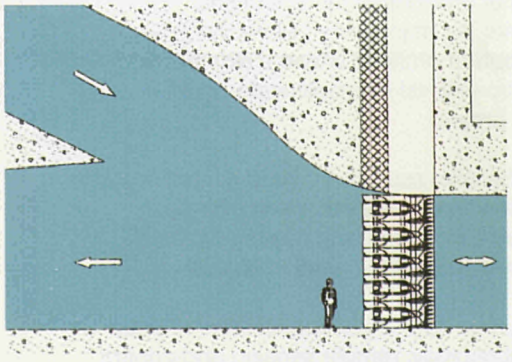
Extracting more energy from the water helps to improve efficiencies of small hydro schemes. In this project, power generation takes place using the water diverged for lock operation, through the application of the Matrix Turbine concept. The project demonstrates that power generation can be achieved by retrofitting of existing schemes as well as equipping new schemes or lock facilities.

The Matrix turbine features a number of identical units of turbines and generators arranged in a frame. Within each unit, a specific profile has been developed that provides satisfactory turbine efficiencies for flows through the turbine in both directions. The turbines and generators are pre-fabricated in the factory with the result that the Matrix turbine is ready for operation on delivery from the factory.

Installation in a lock means that power generation declines almost linearly with time from an initial maximum, so the generator is designed to accept high overload for a short period of time to meet this operating characteristic. Under these conditions an economic assessment indicates that the average cost of the power produced could be 0.02 ECU/kWh, at a utilisation factor of 0.22. Under continuous operation the costs could be as low as 0.002 ECU/kWh.

The development of the turbine hydraulic system and the concept of the matrix frame has been completed. The next stages of the project, including design of the steel structures and components, and preparations for integration into the lock's electrical system, are underway.

The system could be replicated at many hydro plants that feature lock gates, especially on the Danube, where seven of the nine power plants feature lock configurations that could incorporate a Matrix turbine.

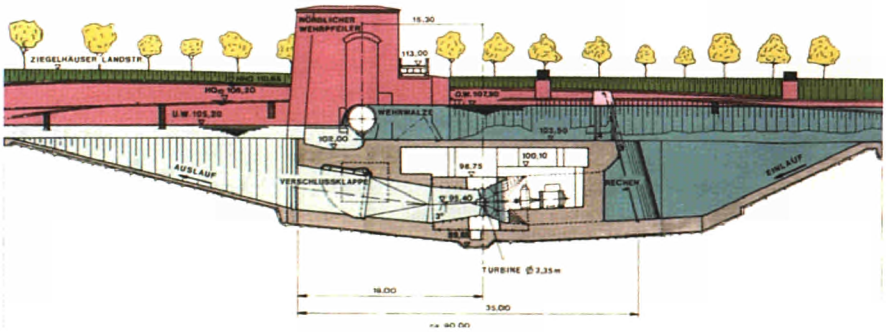


Demonstration Project: HY/314/91/DE

Totally submerged run-of-river hydro scheme on the River Neckar at Karlstor/Heidelberg

Small-scale hydro schemes in scenic locations need to be designed to minimise reductions in visual and acoustic amenities. In this project, a run-of-river hydro scheme has been installed at a weir in the heart of historic Heidelberg. The power house is sited in a cavern downstream from the right-bank weir zone, positioned deeper than a conventional power scheme, and resulting in the cavern being completely flooded. This special design leaves the flood flow unchanged, and minimises any effects on commercial river traffic or any visual and acoustic intrusion. A surface-mounted flap substitutes for a weir slice thus ensuring that floods are diverted without any adverse effects.

The power station is equipped with three tubular turbines with a net head of 2.6 m and a total flow of about 140 m^3/s. The innovation of the project is essentially its integration in the site thanks to the submerged design of the power house. The 3.1 MW scheme is expected to produce an average of 17 MkWh/year, which will feed into the local utility distribution network.



Geothermal energy

Europe has a long history of exploitation of geothermal reserves, especially in France and Italy. To date there is about 1,200 MW thermal district heating installed capacity in Europe, as well as electricity generation in Italy (nearly 600 MW), the French island of Guadeloupe and the Azores.

Exploiting geothermal reserves involves high development risks, especially in predicting the quality of a resource and in achieving end markets for the heat or power. A number of older geothermal projects also need to be updated to improve their productivity, such as through drilling new wells or improving the quality of existing wells.

In many Member States, especially France, Italy, Germany and Spain, and associated countries, in particular Iceland, European industry is at the forefront of developing cost-effective techniques for recovery of geothermal resources, such as in the development of power generation cycles and the installation of district heating.

The priority for EC involvement in proposals for geothermal plants is to promote increased energy efficiency and/or cost effectiveness of the plants. This may be through improvements to the design of the system, better drilling techniques and mitigating corrosion and scaling problems, as well as through developing treatment systems for the discharged water. THERMIE also encourages innovative methods or applications for geothermal energy for district heating or building heating, industry, agriculture or aquaculture.

Demonstration Project: GE/049/94/FR

Rehabilitating a geothermal well to extend its useful life

Renovating existing geothermal systems is often a cost-effective and efficient way of extracting more energy from a geothermal resource. In this project, a new geothermal well will be dug that will be used in conjunction with an older well. Melun l'Almont is the oldest geothermal site of its type in Europe. The existing system was constructed in 1968-1969 and the well has now reached the end of its life and needs to be replaced.

The new system uses a well of a larger diameter (17" instead of 12") with a larger casing (13 3/8" instead of 9 5/8"). It is built with a steel casing and a composite epoxy tubing (preventing corrosion and deposits) that will be used in conjunction with the existing well. The technology used in the new type of well allows continuous monitoring of the state and performance of the well. This new design is better both environmentally and operationally, but will have very little effect on the overall economics and energy costs of the project.

Heat from the well is used by the city of Melun (9,000 inhabitants) and is estimated to save approximately 90,000 tonnes of oil throughout its life, with a payback period of 20 years.

Wind energy

Wind is a valuable renewable energy resource in Europe and world-wide, offering a safe and reliable source for clean and sustainable electricity generation. European wind turbine manufacturers are world leaders in wind energy technology, and have succeeded in reducing the costs of installation and maintenance considerably during recent years.

Wind energy has now been commercially demonstrated and proven over a wide range of climatic and siting conditions. There are, however, more extreme situations typical of some new or emerging markets, or aspects of existing markets, where information and experience is very limited but where there is significant potential.

The main aims of THERMIE support to the European wind energy industry are to maximise the development of wind projects in conventional and non-conventional markets, to improve acceptance of the technology, and to reduce technology costs further.

THERMIE demonstration projects have promoted the development of large MW-scale machines, onshore and offshore, as well as at unconventional sites, especially in cold, hot or dusty regions. This experience has helped in the development of wind energy in non-EU sites. Here, THERMIE has helped with market development, including demonstrating wind projects at sites where climatic or siting conditions are different, developing strategies for implementation, and assisting with technology transfer.

Other innovative applications include the development of hybrid energy projects, such as linking wind with solar, and solutions for overseas or remote areas, and other unconventional applications.

A number of non-technical issues have also been addressed through THERMIE, including issues relating to electrical integration, such as with large or small grids, forecasting, valuation of wind energy to the utility, and demonstration and validation projects.

In the future, THERMIE will continue in its aim to improve understanding of wind resource and characteristics, to improve siting, and to continue to develop wind technology to achieve cost reductions and efficiency improvements. Other issues relate to institutional and policy issues, including grid connection and system issues relating to an increase in wind energy penetration.

Demonstration Project: WE/374/94/ES

A 1 MW wind farm based on two ECOTECNICA 36/500 wind turbines in Tarifa

Tarifa in southern Spain has very good wind conditions for developing wind farms and has been used as the site for demonstrating a number of innovative wind turbine designs. This project demonstrates two new ECOTECNICA wind turbine designs, one 600 kW and one 500 kW, with 44 and 41 m rotor diameters respectively. The turbines were installed in May 1996, and the monitoring programme is comparing the performance of the two configurations to optimise energy yield and efficiencies.

Demonstration Project: WE/069/96/IE

A 3 MW wind farm in a remote area of Ireland with an innovative control system

The remote region of Gaeltacht in the north-west of Ireland has a very weak electricity infrastructure. This project has been designed to demonstrate that wind energy can provide a significant contribution to the region's power supply without causing undesirable fluctuations in the grid. Cronalaght wind farm consists of five 600 kW Vestas wind turbines, rated capacity 3 MW. The high wind speeds have necessitated the use of V39-600 kW turbines, with blades 3 m shorter than those originally selected. This will be the first demonstration of these types of turbines.
The grid in the region is weak and there is a risk that in periods with low consumer load and high wind power production, the output from the wind farm could result in the grid voltage being outside acceptable limits. To overcome this, the wind farm output power is limited depending on the grid voltage. To achieve this, the project includes an innovative Voltage Control Unit (VCU). This continuously monitors the voltage and when necessary adjusts the output from one or more of the turbines if the voltage gets close to the allowable limits for the grid. The turbine output can be adjusted by changing the pitch and speed, which limits the output power to the required value.
The wind farm was commissioned in May 1997, and the VCU installed during October 1997. The cost of the VCU was about 1.8% of the total project cost. Annual net energy production from the turbines will be about 10 GWh. A two year monitoring programme by Risø (Denmark) is underway. The project has already received substantial publicity, with videos and site visits, in particular in relation to the European Wind Energy Conference held in Dublin in October 1997.

Photovoltaics

Europe's PV technology industry leads the world in terms of module efficiency and building integration. However, European PV module manufacturing capacity is considerably smaller than those in Japan or the USA. This results in fewer opportunities for cost reductions through economies of scale, hence European PV industries find it difficult to compete with those from its competitors in international markets.

The key aims of THERMIE support to the PV industry is therefore to raise confidence in the use of PV for power generation and to reduce costs, both of PV modules and of other system components. The cost reductions follow as a result of scaling up the levels of PV use, both in the EU and through increasing international exports, especially to developing countries.

The THERMIE PV demonstration programme has established a yearly cost reduction objective: this aims to achieve a reduction of 10-15% per year in overall project costs from 1995 onwards. By 1997, the costs that proposers were eligible to request had reduced, reflecting the gradual maturity of the technology. In addition, the proposals showed a reduction in the costs of grid connection for the projects and a significant increase in the size of the projects in kilowatts. The projects that were selected showed a growing standardisation of systems and a trend towards service systems.

In addition, a number of technologies developed with JOULE funding (research and demonstration, through DG XII) were then supported in later stages of development through THERMIE, including projects to demonstrate the use of AC modules and multi-functional modules. The excellent progress made by PV towards commercial viability is a good example of how JOULE and THERMIE integration help develop new technologies from research through to success in the market.

Demonstration Project: SE/102/95/NL

Architectural cost-effective integration of PV modules in shading devices and facades of dwellings

Environmental and energy-conscious design of buildings that incorporates passive and active solar and photovoltaic (PV) technologies can help to reduce energy demand. This project supports the construction of 22 low energy homes in the Dutch town of Dordrecht. The homes have a PV shading device that reduces unwanted heat loads during summer while also providing about 35% of the electricity demand of the homes. Both of these factors help to reduce the energy demand of the homes. The PV modules are integrated into the shading devices. These are tilted at an angle of 60° on the south-south-west facade of the house. Each system is rated at 1.03 kWp, giving a total capacity of 22.8 kWp.
The houses were built during 1997. The architects paid special attention to the design of the houses to ensure that the PV shading integrated harmoniously into the house design. A monitoring programme has now started to evaluate the effectiveness of the PV shading system.
Projects such as this one can help to encourage the further commercialisation of PV systems. These types of techniques for low energy systems can apply effectively where a number of new dwellings are to be built, or in office buildings, either for new construction or retrofitting.

Demonstration Project: SE/313/95/DE

A photovoltaic power station at Elbspeicher in Hamburg

This project has been designed to demonstrate that PV can be incorporated into old buildings and facades successfully as well as into new or more modern buildings, without affecting the architectural value of the building. In the Hamburg fish market, a 50 kWp PV generator is installed into a historic 4 storey facade. The 120 year old Elbspeicher building will have two Siemens Solar PV laminates on its roof, one 32.8 kW and the other 17.2 kW, tilted at 25° facing south. The power output from the PV generator will replace some of the power generated from the local CHP system, especially in summer when the CHP plant is less energy efficient.

Energy from biomass and waste

Biomass technologies offer the potential to contribute significantly towards long-term goals for increasing the contribution of renewable sources of energy to generate electricity and heat in Europe and world-wide.

A number of biomass and waste technologies, such as biogas plants, waste incineration, or combustion of wood for district heating, are already commercial processes. Instead, THERMIE focuses its involvement towards technologies for future markets, in particular on advanced and improved processes specifically in the following areas:

- co-utilisation of biomass and/or wastes with fossil fuels
- innovative small and medium scale combined heat and power (CHP) concepts for biomass fuels
- effective systems for the generation of electricity or heat such as IGCC (Integrated Gasification Combined Cycle), based on biomass fuels
- liquid fuels, such as ethanol, methanol, biodiesel and bio-oil, produced from different biomass sources.

Biomass and waste technologies are the only renewable sources that compete directly with fossil fuels because they are both solid fuels and they share similar conversion processes. The main focus for THERMIE support is therefore to encourage innovative processes, technologies and systems which help biomass to penetrate the solid fuel market such as co-utilisation. This is focused in two main areas:

Accelerated market penetration: Market penetration can be accelerated by using complete systems instead of technologies in isolation. Biomass and waste as fuels operate in two types of market: either independently or in combination with fossil fuels. The first market is for local and generally small or medium sized applications, 5-40 MWth. This market is mostly based on industrial wood waste, forestry and agricultural residues and municipal waste, and is heavily dependent on the resource supply, resulting in generally higher costs. In the second market, biomass or waste replace solid fuel in existing installations. Such projects are medium to large size, 30-150 MWth, and the supply of the biomass or waste resource is not a critical factor in the project's success. THERMIE projects work to develop markets for biomass and waste fuels to improve their reliability and cost-competitiveness, through improvements to existing technologies and processes, and through standardisation of fuel specifications.

Cost reductions: THERMIE supports the introduction and application of new technologies for energy recovery from biomass and waste. These include demonstration of co-utilization of biomass with fossil fuels for gasification and combustion processes as well as CHP based on combustion and gasification. All of these new technologies need assistance to demonstrate all aspects of the plant operation, including fuel preparation and feeding, emissions controls and ash disposal.

Demonstration Project: BM/496/93/IT

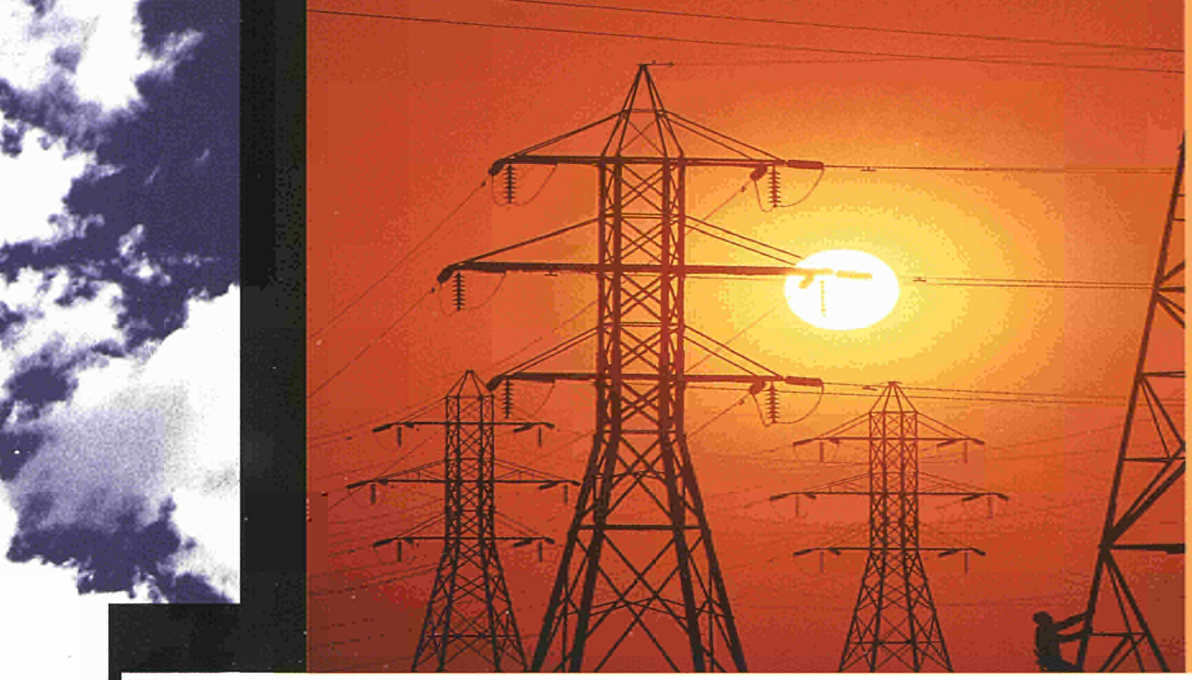
A power plant fuelled by agricultural, agro-industry and wood biomass residues

Biomass fuelled power stations offer the opportunity to exploit a variety of biomass residues as fuel. This demonstration project is sited in an agricultural area in Italy between Naples and Rome. The plant is fuelled entirely by biomass sourced from agriculture, agro-industry and wood residues, including hazelnut shells, almond shells, olive husks, pine cones or wood chips.
The plant comprises a boiler fed with a mobile grate, with a superheated steam generator and steam turbine. The fuel consumption is 70,000 t per year, generating a net power output of 9.8 MWe and a total net energy production of 75 M kWh/year. The plant generates 43 t/hour of steam with a boiler efficiency of 94%. The plant is currently operating under test (mid-1997 to mid-1998), in particular to characterise and optimise the combustion characteristics using different types of biomass. The power outputs are sold to the national grid company, while the residual heat is used for local industrial and agricultural purposes.

Demonstration Project: BM/015/96/FI

Co-utilization of gasified biomass, refuse and coal in a CHP plant

Replacing coal with non-fossil fuels such as biofuels in coal-fired power stations can be economically attractive and help to reduce SO_2 and CO_2 emissions. However, gasified biofuels produce gas of a low heat value that is difficult to burn under ambient conditions.
In this project, biofuels replace up to 30% of the coal in a circulating fluidised bed power station. The biofuels used in this project include source-separated refuse as well as conventional biomass resources. The hot gas from the gasification of the biofuels is fed directly into the boiler, allowing for co-combustion of the lean gas with the hot gas directly in the boiler to ensure good levels of combustion and the effective destruction of toxic organic compounds. By means of an innovative feeding system it is possible to adjust the moisture content of the fuel mixture and hence the gas heat value. The result is that an expensive fuel dryer is not required. Construction work on the plant, situated near the city of Lahti in southern Finland, was completed by the end of 1997 and performance tests started in 1998. Cost savings as a result of the coal substitution are predicted to be about 1.3 MECU per year.



Solar thermal electricity

Production of electricity through solar thermal technology is ready to be developed on a large scale in southern Europe. The European solar thermal electricity industry is well positioned to assume a world leadership role in the expansion of this technology. THERMIE already participates in the first phase (design) of two demonstration projects (COLON Solar and THESEUS) in European Mediterranean countries. Additional steps are necessary to overcome the current techno-economic barriers to large-scale projects. Providing support for research, development and demonstration helps to improve the technology and reduce costs so that market forces alone may be capable of supporting the solar thermal industry by the year 2010.

Developing economies of scale in the manufacturing of solar thermal plants will help to build a competitive supplier industry. This in turn will support the development of opportunities for export of the technology, by developing markets in the sun-belt countries for export of solar thermal plants and transfer of European technology via co-operative projects.

Demonstration Project: TE/235/96/GR

THESEUS - the first utility scale 50 MWe thermal solar European power station for the Island of Crete, Greece

THESEUS - THErmal Solar EUropean power Station - is the first European utility-scale solar thermal power plant. The project builds on the experiences of the Californian Solar Electric Generating Systems (SEGS) projects, where an accumulated capacity of 354 MWe and a proven record of twelve years of continous operation has proved that solar thermal parabolic trough power stations are a reliable and important renewable source of energy.
The THESEUS project is a 50 MWe solar power plant, with an advanced parabolic trough collector field as the primary heat source. The anticipated site location is on the southern coast of West Crete, which has radiation levels comparable to Saharan locations and almost 90% of the Californian desert conditions. Power is generated using a conventional Rankine-cycle reheat steam turbine, with a LPG-fired heater to supply limited auxiliary support energy to maintain the heat transfer fluid liquid in case of rare cold winter nights. Full turbine output is possible in three modes: solar only, heater only, and hybrid. The project costs 115 MECU, equivalent to 2,200 ECU/kW installed. The resulting electricity costs 0.08 ECU/kWh. Total power output will be about 106,000 MWh/yr. This level of output can reduce Greece's energy import bill by about 4 MECU/year, especially replacing peak and mid-load gas turbine operation that currently cost up to 0.13 ECU/kWh.
The project is currently in the first phase of design, permitting and financing. Procurement, manufacture and installation will take place during 1999-2000, with commissioning due at the end of 2000.

Associated measures

DIS/0358/95/GB

THERMIE-ALTENER Renewable Energy Journal

This publication was targeted at decision makers throughout Europe, to raise their awareness of the opportunities arising from the work of THERMIE and ALTENER, and to accelerate the use of renewable energy technologies. The Journal highlighted developments in the JOULE-THERMIE and ALTENER programmes, including details on successful demonstration projects. It also reported on progress in the development and implementation of renewable energy technologies, including technology status reports, events, diary and publications. Two issues of the Journal were produced, one in November 1996 to coincide with the ALTENER conferences in Sitges, Spain, and the second one in May 1997 at the European Congress on Renewable Energy Implementation in Athens. The Journal was also distributed through the OPET Network, at events supported by DG XVII, and through partners' mailing lists, and successfully publicised the work of DG XVII in supporting renewable energy technology development.

STR/0588/95/GB
Development of an action plan for renewable energy sources in Europe

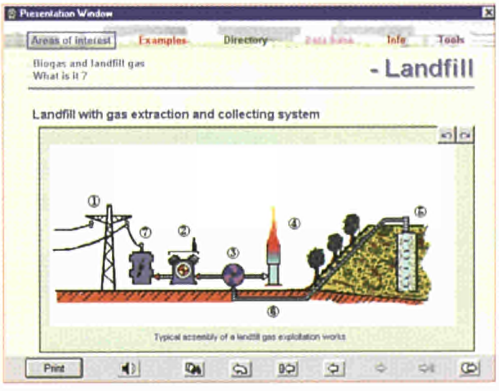
The Conference of Madrid (An Action Plan for Renewable Energy Sources, 1994) set out the framework for future initiatives to develop and implement a strategic action plan for renewables. This action supported a comprehensive review to develop an in-depth understanding of why renewable energy technologies do not contribute to energy markets at the level of potential that they could offer. The review identified the main barriers to implementation of renewable energy technologies. These include political, legislative, administrative, financial, fiscal and technological barriers, as well as barriers relating to information, education and training. An extensive consultation process was carried out with the major actor groups in each of the phases of market penetration. The result was the production of a synthesis report that has contributed to on-going actions to develop renewables, including reports by the European Parliament and the EC's White Paper, Energy for the Future: Renewable Sources of Energy.

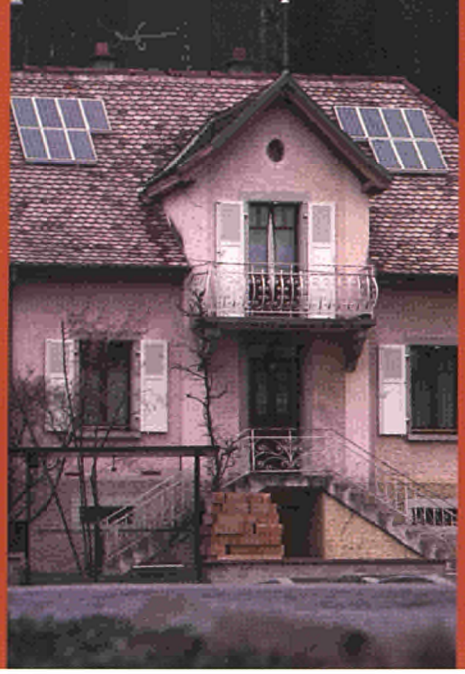
SUP/0940/96/GR
Desalination with renewable energies in the Mediterranean

The EC has supported a number of projects investigating using new and sustainable energy technologies for water production in the Mediterranean. These projects, funded through JOULE, THERMIE and APAS, have resulted in many useful results that now need to be publicised. The current project funded the preparation of the publication A Guide to Desalination using Renewable Energies. The guide is aimed at decision-makers, end users and industrial entities to increase their awareness of the potential of using renewables for desalination, and to encourage uptake of these technologies. It contains detailed, up-to-date and relevant information on all aspects of desalination, including an overview of the technologies available, design methodologies, case studies and financing possibilities. It also contains a directory of projects and EC-funded activities.

SME/1462/97/GR
Integrated solid waste management in Aspropyrgos: waste separation and RDF gasification

This project provided funding for a technical and economic feasibility study for a RDF gasification plant in Greece. The proposed project is the first large-scale RDF gasification plant in the world. The gasification cycle offers significantly higher efficiencies compared with incineration, and an innovative catalytic cracking process removes tars and HCl from the fuel gas.
The feasibility study identified and characterised the waste streams for the proposed plant, and carried out comprehensive specifications of the process flowsheets of the RDF production plant, the gasification plant and the power plant, to demonstrate the practical and economic viability of the scheme. This feasibility study was then used in a successful proposal for THERMIE Type A funding to build the scheme as a demonstration project. The project will open up new markets and prospects for gasification technologies, as well as providing the first modern waste treatment facility in Greece.





DIS/0450/95/EU
PV Information System for Architects (PISA)

The PISA project aimed to design an information system on photovoltaics for use by architects. It is anticipated that PISA can encourage a wider awareness of PV use in buildings and a better understanding of the barriers to uptake of PV and how to break down these barriers.
The project involved a Europe-wide consultation process. Representatives of the architectural community were consulted on their attitudes towards sustainability with regard to buildings, their perceptions on PV technology and their information needs. The main barriers to PV implementation were: cost, lack of design expertise and lack of information for architects. As a result, representatives from the Architects Council of Europe are contributing to the project by providing design expertise and detailed information on a Europe-wide basis. The end result will provide all architects interested in considering PV for their building design with access to appropriate information on PV integration.

SUP/0995/96/ES
Universal standards for solar house systems

Technical standards for solar house systems, including PV modules, are not consistent. The diversity of standards presents problems for the European PV industry, especially in its efforts to promote European capabilities in export markets. This project aims to establish standards for PV modules and systems that can be used to maintain and improve quality standards.
The project will compare existing technical standards, and then propose revised technical standards that can be used throughout the industry in Europe.

SME/1509/97/AT
Study on the technical and economic feasibility of a low pressure jet turbine

Small hydro-electric plants often operate at the limits of economic viability, so improvements to the efficiency of a plant can often provide an important improvement to its cost-effectiveness. This project supported a study to prove the technical and economic feasibility of a new design of low pressure hydraulic turbine.
The study involved setting up a test bench to produce prototypes, calculation of efficiencies and of production costs and market analysis. The novel design offers lower initial costs and better efficiencies compared with similar jet engines already in use. Its successful demonstration could therefore provide opportunities for economic refurbishment of older small hydro schemes.

STR/0939/96/GB
Understanding the risks of financing wind farms

The main aim of this project is to reduce the cost of wind-generated electricity, by using an understanding of the risks associated with wind farm projects to develop risk management techniques. The project will identify areas of risk involved with a wind farm project, then assess each of the risk areas in detail. These assessments can then be used to develop a database that addresses the different forms of financing which have been employed in real wind farm projects and to establish a "risk register". A handbook will be produced which can be used for risk analysis of wind farm projects, using a methodology that has already been demonstrated at existing wind farms.
The results of this project will help expand new business opportunities in wind energy projects through encouraging successful financing and performance of future wind farms.

SME/1555/97/DE
Innovative geothermal techniques for modernisation of the district heating network of Máko in Hungary

The geothermal district heating system in Máko services buildings, schools, the library, council office buildings and a number of other municipal buildings with space heat and heat for hot water. However, the system is currently very inefficient and in urgent need of modernisation. This feasibility study, supported through THERMIE and INCO, will evaluate the costs and benefits of using new technologies for the reinjection of cooled-down thermal water, as well as the technical requirements for modernising and extending the heating network.
The economic and environmental benefits demonstrated through this feasibility study will then be used to prepare a detailed proposal for the modernisation of the system, to be submitted for future THERMIE funding.
This district heating network is typical of many heat supply systems present in Hungary and Romania so the technical solutions proposed in this study are likely to benefit modernisation proposals for heating systems in other cities in the region.

SME/0003/95/BE
Production of a SME- and SMO- oriented CD-ROM on energy from biomass and waste

DIS/0161/95/BE
Production of a CD-ROM on bioclimatic architecture

SME/0792/96/BE
Production of multimedia, interactive, SME-oriented CD-ROM on wind energy technologies

SME/1539/97/BE
Production of a SME-oriented multimedia, interactive CD-ROM on biomass combustion

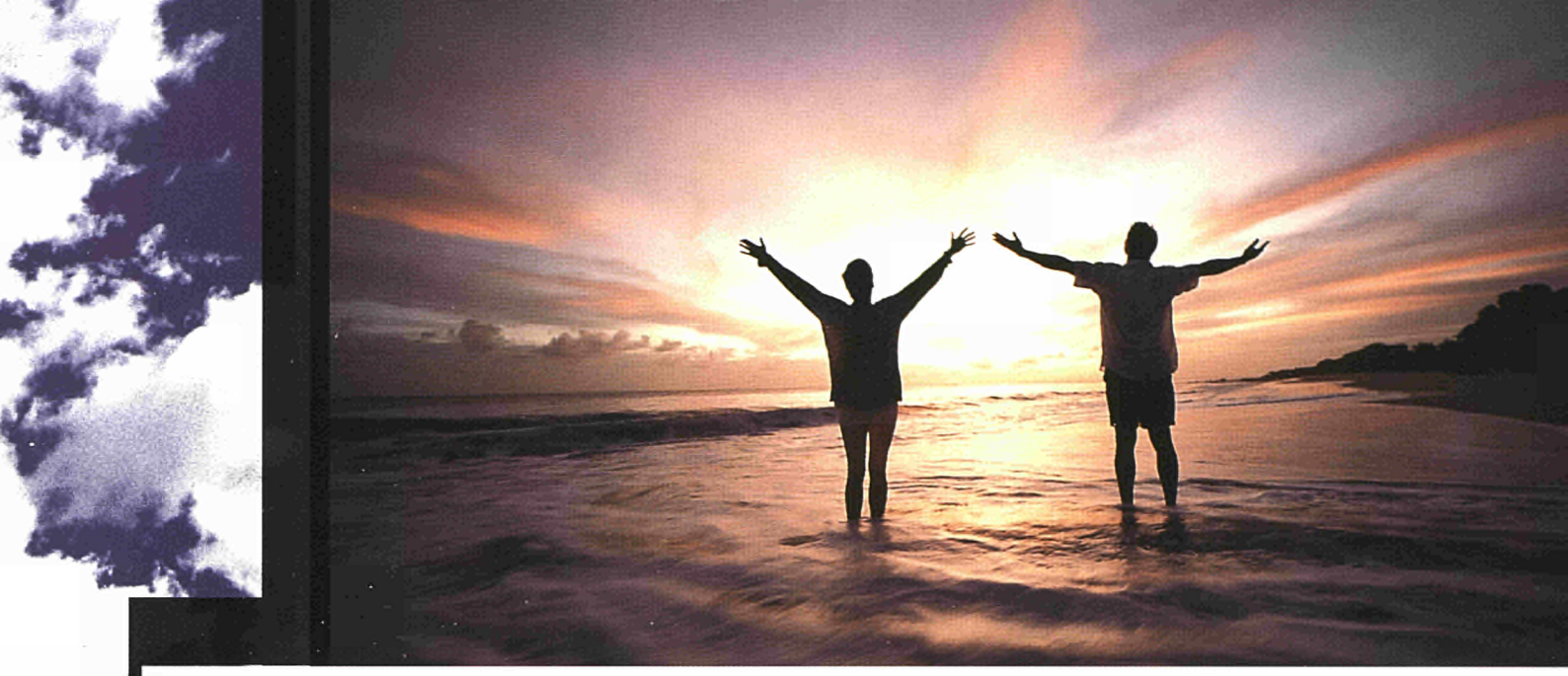
The EC has supported a wide range of projects and actions to encourage the development of renewable energy technologies. It is important that the results from these actions are publicised as widely as possible throughout the renewable energy industry in Europe to encourage a rapid uptake of new developments and technologies.

For this reason, the EU has supported the production of a series of four CD-ROMs. These present, in a multimedia format, a wide range of technical, economic and practical information concerning the renewable energy technology, especially those which have been demonstrated successfully in the framework of support by EC programmes. The CD-ROM format provides all interested users with useful information on the most advanced R&D projects, the best available market technologies, developers, suppliers and innovative projects in the sector. It also provides details of the economics of the technologies and their environmental benefits.

To date, CD-ROMs have been produced in the following areas:

- biogas from waste and waste water treatment
- bioclimatic architecture
- wind energy technologies
- biomass combustion.

The audience for these CD-ROMs are the key decision makers in each of the technological areas, to whom the CD-ROMs provide easy access to up-to-date information about the technologies and increase their awareness of the opportunities available from these new renewable energy technologies.



CONCLUSIONS AND RECOMMENDATIONS FOR A FUTURE STRATEGY

Continued involvement with renewables

The future direction of research and technology support has been the subject of intensive debate over the last three years. The European Commission's White Paper on Energy stressed the need for a research and technological development strategy - an integrated approach to applied research, development, demonstration, dissemination and implementation of energy policy. The Renewables White Paper presented challenging targets for deployment levels of renewable energy and identified a campaign to promote renewables, designed to achieve these targets. In particular, this study identified key actions to be promoted during the campaign: targets of 1 million PV systems, 10,000 MW of large wind farms, and 10,000 MWth of biomass installations as priority technologies. It also proposed integrating renewable energies into 100 communities, where combinations of technologies and applications can be implemented in such a way that they can achieve 100% energy supply from renewables.

Estimated contributions by sector in the 2010 scenario [5]

Type of energy	Share in the EU in 1995	Projected share by 2010
Wind	2.5 GW	40 GW
Hydro	92 GW	105 GW
• large	(82.5 GW)	(91 GW)
• small	(9.5 GW)	(14 GW)
Photovoltaics	0.03 GWp	3 GWp
Biomass	44.8 Mtoe	135 Mtoe
Geothermal		
• electric	0.5 GW	1 GE
• heat (incl. heat pumps)	1.3 GWth	5 GWth
Solar thermal collectors	6.5 M m^2	100 M m^2
Passive solar		35 Mtoe
Others		1 GW

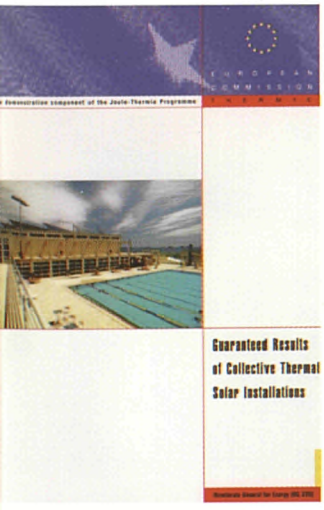
Mtoe - million tonnes of oil equivalent

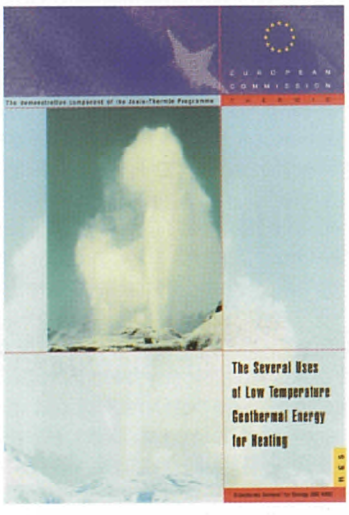
5. *See reference 3 on page 6.*

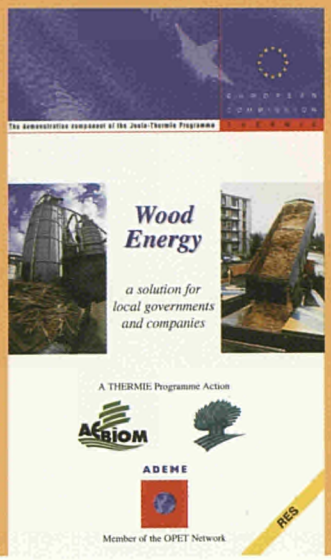
In parallel with these initiatives, the Commission is developing the Fifth Community Framework Programme (FP5) for Research and Technological Development (1998-2002). This five year plan, developed in close co-operation with research and industry, includes elements aiming to improve the exploitation of innovative energy technologies in Europe.

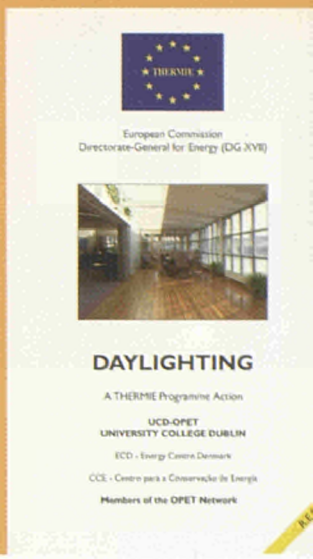
Community support for renewable energy links closely with this wider framework for support to energy technologies in Europe. This framework includes provision for identifying common principles, priorities and guidelines that apply across all energy technologies, to achieve an effective, comprehensive and coherent strategy for energy technologies that benefits all levels of European society.

FP5 identifies the need to continue to support the development of clean energy systems to minimise the environmental impact of the production and use of energy in Europe. Renewable energy development helps to address this need. It also stresses the need to ensure reliable, efficient, safe and economic supplies to Europe. This approach benefits citizens, improves the functioning of society and helps industrial competitiveness.









Overcoming the barriers

Renewable energy technologies can make a significant contribution towards achieving these aims. However, there are still many obstacles preventing renewables achieving their technological potential. The ATLAS Study[6] identified a number of barriers that apply to most renewable energy technologies that need to be overcome before renewables can compete effectively against conventional energy technologies, and where further Commission support is needed.

These market barriers include the problems relating to costs and pricing structures for renewables compared with conventional energy technologies, as well as the general lack of confidence still apparent from investors and other institutional organisations. Renewables often suffer from being small or isolated sources and in this form can seldom compete with larger conventional energy plant. All of these barriers can be overcome as long as there is continued support from the EC to work with the renewable energy community to ensure the future success of renewable energy as a clean, safe and affordable energy supply for the next century.

THERMIE participation in the development of renewable energy technologies has been invaluable to encourage a more rapid uptake of new and innovative technologies, systems and markets. Nevertheless, there are still many barriers to the full deployment of renewable energy in Europe and outside Europe that will ensure that support from the EC will be a necessity for a number of years. THERMIE's involvement with renewables has developed and evolved, taking on board new goals and identifying new research and technological development needs and initiatives as the technologies mature.

THERMIE has already achieved a great deal for renewables. It has helped to demonstrate a variety of renewable energy technologies to show their potential for wider application in Europe and world-wide. It has encouraged the continued development of established technologies to demonstrate cost reductions and efficiency gains. It has also ensured that the technologies supported under the Commission's research and development programmes (JOULE) can be further supported as demonstration projects as part of their transition from a research project through to technical and commercial viability.

THERMIE's involvement with renewables has helped the development of the positive policies currently being proposed for energy markets and supplies into the next century, by demonstrating that renewables can offer a cost-effective and reliable energy resource to compete effectively against conventional energy sources. THERMIE helps to build confidence in the market by demonstrating and promoting successful applications of technologies and ensuring that market "pull" can operate to encourage uptake of these technologies.

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6. Energy technology: the next step. December 1997.

Current and projected (2010) electricity production in the EU by renewable energy source (TWh) [7]

Type of energy	Actual in 1995 TWh	Projected for 2010 TWh
Wind	4	80
Hydro	307	355
• large (incl. pumped storage)	(270)	(300)
• small	(37)	(55)
Photovoltaics	0.03	3
Biomass	22.5	230
Geothermal	3.5	7
Total	337	675

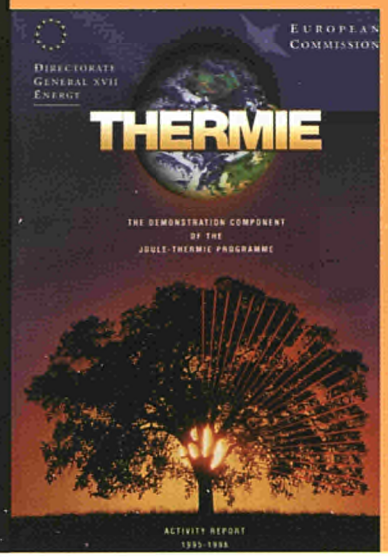
Technology-specific targets for renewable energy sources

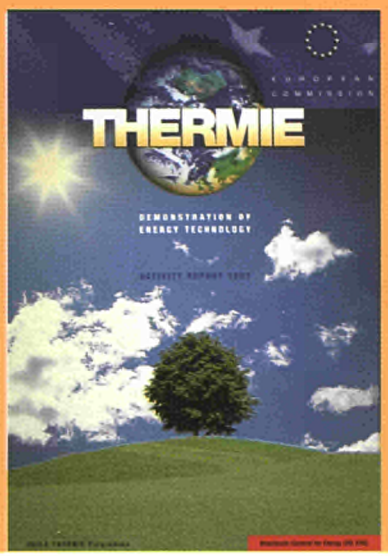
Biomass and waste: Innovative biomass technologies will continue to be developed and improved that can provide high quality solid biomass fuels for large-scale power generation plants. Advanced conversion technologies need to be demonstrated widely to show how the technologies can reduce costs and improve efficiencies, especially in IGCC plants as well as in CHP installations. Further demonstration of co-combustion and co-gasification of biomass with fossil fuels will ensure that these technologies offer cost-effective options for both large and medium-scale installations. Much of the support both now and in the future will be to overcome non-technical barriers to the widespread uptake of biomass technologies. This support will include the development of markets, fuel specifications and quality, to reduce the risks inherent in these newer enterprises. This support applies not only to markets for solid biomass fuel but also to encourage the widespread development and deployment of liquid biofuels.

Small-scale hydro-electricity: Only about 20% of the potential resources of small-scale hydro power (<10 MW) have been exploited in Europe. There are also substantial opportunities for developing small-scale hydro plants outside Europe, especially in Asia. Barriers to further uptake are both financial and environmental, so further support is needed to continue to reduce costs and improve performance.

Geothermal: Opportunities in Europe are restricted by the numbers and locations of suitable sites. These are mainly in France, Italy and Portugal (The Azores). Nevertheless, there is potential to exploit deeper reservoirs and to enhance the productivity of existing fields, which could double the current capacity by 2010.

7. *See reference 3 on page 6.*

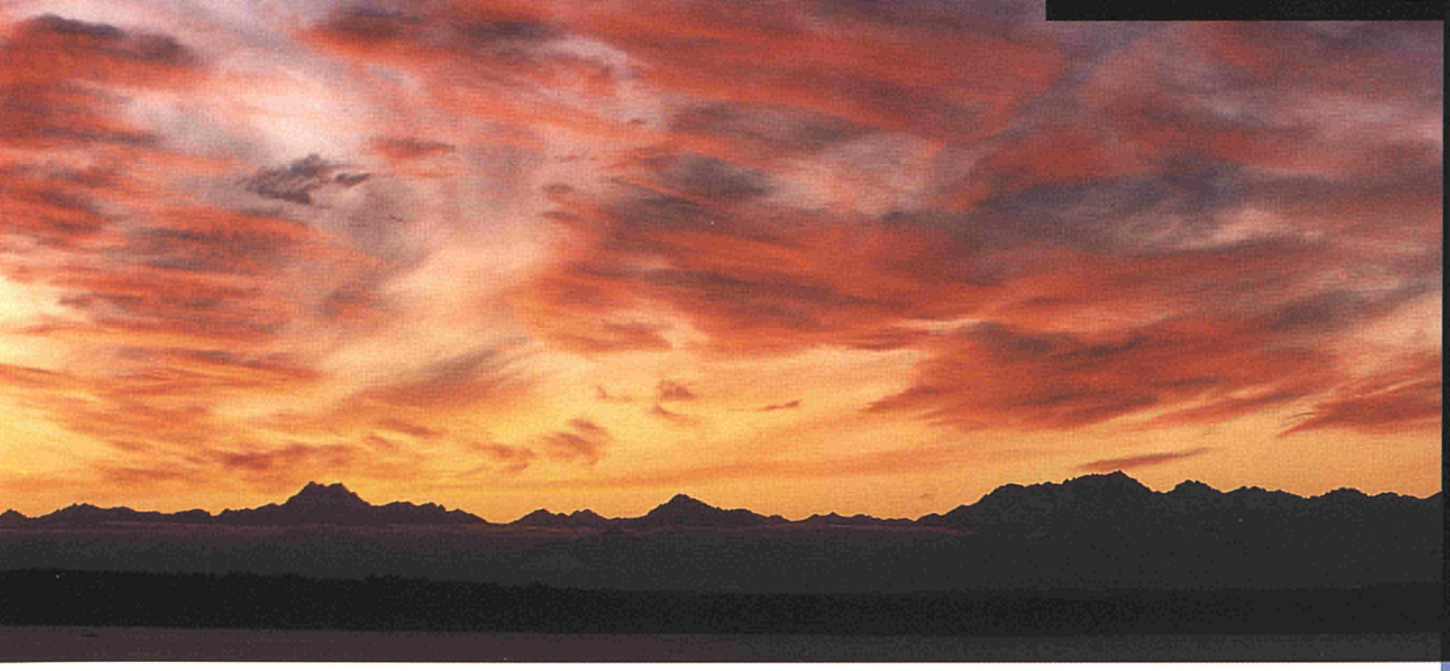




Wind: The Renewables White Paper identified up to 40 MW wind capacity that could be exploited by 2010, one of the largest achievable renewable energy resources in Europe. Work continues on the development of larger and cheaper turbines, especially for use in offshore wind farms, and on ways to reduce noise and other environmental impacts. Key technology innovations are now focused on offshore designs where construction costs need to be greatly reduced and long term reliability is vitally important. The opportunities not only for a huge expansion in European wind capacity but also to develop wind markets outside Europe mean that these developments to improve cost-effectiveness and performance will benefit competitiveness of the European wind energy. There will also be continued demonstration of innovative technologies sited in difficult locations and connections to weak grids or as standalone machines.

Photovoltaics: PV systems today are only really cost-effective in niche markets where conventional grid supplies are not available. However, the world-wide PV market is growing at about 15% per year, so Europe's industry needs to become ever more efficient to remain competitive. EU support to the industry will continue to encourage cost reductions and to provide confidence in the market through large-scale deployment and market stimulation programmes. These will include support for project financing, the provision of maintenance and user support, and product certification and testing to control the quality of systems and components.

Solar thermal electricity: Current solar thermal power plants of 80-100 MW capacity can be supplied for about 2,500 ECU per kW, including fossil fuel backup to provide firm capacity. More advanced plants, currently under development, combined with large-scale manufacturing, are expected to halve these costs and to become fully competitive, offering good opportunities for developing international co-operation activities and export markets for this new technology.



Renewables to 2010: achieving the targets

The White Paper on Renewables has identified challenging targets for deployment of renewable energy technologies by 2010. The European renewable energy industry, with support from the European Commission, must now strive to meet these targets. The White Paper identified the need for a coherent approach to the technical and non-technical challenges faced by the renewables industry that delay or prevent technology implementation at a faster rate than at present. These need to be overcome through the continued development and improvement of innovative technologies, encouraging the development of markets for renewable energy products, and identifying and working towards technology-specific targets for each source of renewable energy.

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