COMMISSION OF THE EUROPEAN COMMUNITIES

EVALUATION OF THE COMMUNITY DEMONSTRATION PROGRAMMES IN THE ENERGY SECTOR

Directorate General for Energy

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Global evaluation

1. Introduction

1. On 23 February 1982 the Council of the European Communities decided that the Commission, with the Member States, would assess the role of demonstration projects on energy-saving and alternative energy sources in the energy and research policies of the Community and the Member States.

2. Furthermore, according to Regulations (ECC) No. 1302/78 and No. 1303/78, the Commission is required to report periodically on the application of these Regulations to the European Parliament and to the Council. A preliminary report was submitted in July 1981[1].

3. A technical evaluation of the Community demonstration programmes was undertaken by the Services of the Commission, with the help of independant experts. A more succint evaluation of national programmes was carried out by the Services of the Commission, based on the results of a survey in the Member States. From this work an evaluation report of Community demonstration programmes[2] was produced. This present document sets out the main technical conclusions of this report, considers a number of related questions and suggests directions future Community action could take. For further details reference should be made to the evaluation report; cross-references are given in the text.

4. Demonstration links the R&D stage, sometimes tested on pilot plant, and the later investment stage. It differs from the R&D and pilot stages in the industrial scale of the projects, the requirement of having prospects of economic viability, and from the normal investment stage in that the inherent risks are still considered by the entrepreneurs to be too high.

5. Demonstration is an essential stage at both national and Community level. The European Parliament, for it's part, has emphasised in several Resolutions[3] the need for demonstration projects to develop alternative sources of energy and energy saving measures. When the Community regulations concerning demonstration projects were adopted in 1978, only two Member States had introduced support measures for demonstration projects. Initially therefore the Community

1. COM (81) 397 final.
2. COM (82) 324/2 final.
3. – Resolution of 17.11.77 on the 2 draft Commission Regulations.
   – Resolution of 18.02.80 on the energy objectives for 1990.

programme also served to ensure a minimum level of demonstration activity in all Member States.

6. Since that time all Member States, often prompted by the Community programme, have set up national programmes to support demonstration projects. The Community programme — chiefly a stimulant until now — will in future, as in the case of the Community R&D programme, be required to coordinate and supplement national programmes as well.

7. The demonstration programme is not only the logical extension of Community R&D activities: because it provides the opportunity for exploiting projects from national R&D programmes at Community level it also opens up a European scale market for them.

2. The Community demonstration programme

8. This programme covers energy-saving and alternative sources of energy:
Regulation No. 1303/78 on the granting of financial support for demonstration projects in the field of energy-saving lists the following possible fields of application:
- buildings;
- supply and use of process heat and of electricity in industry;
- energy industry;
- transport.

9. Regulation No. 1302/78 on the granting of financial support for projects to exploit alternative energy sources lists the following areas:
- exploitation of geothermal fields;
- exploitation of solar energy;
- liquefaction and gasification of solid fuels;
- exploitation of wave, tidal and wind energy.

Several considerations, including budgetory factors, have lead the Commission to limit action to the first three sectors for the time being.

10. Commitment appropriations in the Community Budget for demonstration projects are as follows:

	Energy-saving	**Alternative energy sources**
1978	4	11
1979	16	16
1980	25	47
1981	24	59
1982	20	21
	89 MECU	154 MECU

Total: 243 MECU

11. At the outset, the Council fixed expenditure ceilings of 150 million ECU for the demonstration programme. In view of the large number of high-quality projects put forward the Commission decided in October 1980 to ask for the original amount to be doubled. On 23 February 1982 the Council asked the Commission to make this evaluation as a basis for the requisite decisions and proposed, in order to give viability and credibility to Community action, to increase the ceiling by 55 million ECU.

The break-down between sectors would be as follows:

	Energy saving	Geothermal energy	Solar energy	Liquefaction and gasification of coal
Original total funding 150 million ECU	55	22,5	22,5	50
Increase: 55 million ECU	26	10	0	19
New total: 205 million ECU	81	32,5	22,5	69

12. In the first three years of operation of the programmes, the Commission issued two invitations to submit projects in the solid fuel liquefaction/gasification sector and three invitations in each of the other sectors. No fewer than 1,432 projects were submitted to the Commission in response to these eleven invitations, corresponding to a total investment of 4,143 million ECU.

13. The Commission was assisted in selecting projects by four advisory committees whose members should be well-acquainted with national programmes because of their positions in national administrations. In some cases, the members of these advisory committees also sat on Community R&D programme committees; they gave the Commission valuable advice in selecting projects for support. Generally speaking, co-ordination between the R&D and demonstration programmes has become increasingly satisfactory.

14. To date the Commission has selected a total of 331 projects for financial support. Subsequently, 49 of these projects have been withdrawn by their proposers, chiefly because of difficulties in financing the part of the investment not covered by Community financial support. In many cases too, the proposers realized only later that the Community system, unlike national systems, imposes repayment requirements: if the project is commercially successful part of the Community support has to be refunded.

15. The selected projects represent total investment of nearly 900 million ECU. If it is assumed that investment projects take an average of three years, the volume of new investments stimulated by the Community demonstration programme is 300 MECU/year.
About one quarter of this investment is provided by Community financial support. The following table gives the main figures for the various sectors:

	Energy saving	Geothermal energy	Solar energy	Liquefaction and gasification of coal	TOTAL
Proposals submitted	991	119	287	35	1 432
Total investment of proposals submitted (MECU)	2 363	544	236	1 000	4 143
Projects selected	186	48	84	13	331
Projects withdrawn by the proposer	30	5	11	1	47
Contracts signed	89	28	40	12	169
Total investment of selected projects (MECU)	273,1	301	78,217	226,261 *	878,6
Average investment per project	1,47	6,27	0,93	17,405	2,65
Financial support granted (MECU)	80,773	28,243	22,915	74,983	206,9
Projects withdrawn (MECU)	10,390	4,885	2,584	4,34	22,2

* First contractual phase only.

16. The financial limit (150 MECU) set for the programme by the Council in 1979, smaller than the budgetary allocation, has caused major difficulties in programme management. Since November 1981 the programme has effectively been hampered as a result of the dispute between the budgetary authorities. In particular, four Commission decisions on new demonstration projects are held up until the intention expressed by the Council of 23 February 1982 to increase the financial limit by 55 MECU (to 205 MECU) is implemented. As soon as an appropriate decision is taken this will align the total funding with the budget allocation at the end of 1981. Budget credits for 1982 exceed the 205 MECU ceiling, but the Council, whilst awaiting the examination of the technical evaluation report, has not taken a corresponding decision.

17. The Commission has dealt in detail with the question of diffusion of results in it's preliminary report of July 1981[1]. Since then, the Commission has published quarterly reviews ("newsletters") reporting on the different programmes. The Commission has also started to establish complete and regular updated computerised documentation on the state of the programme and the results obtained.

3. Evaluation of the results of the Community programme

18. All the projects for which contracts have been signed have been assessed, however only about 60 projects are sufficiently advanced for the results to be clear and for initial conclusions to be drawn[2].

1. COM(81) 397 final.
2. Situation end April 1982.

	Energy saving	Geothermal energy	Solar energy	Coal lique-faction and gasification
Number of projects assessed	91	22	70	4
Number of projects sufficiently advanced for initial assessment of the results	23	22	16	4
Of which projects completed	12	1	3	1

19. This technical evaluation was performed by Commission departments, including the Joint Research Centre, with the help of high-level independent experts. The experts were able to visit most of the projects which had reached an advanced stage.
Since many of the projects are still under way a technical and economic evaluation which is both comprehensive and final is not possible at present. The results already obtained nevertheless enable some valid comments to be made. The main points from the technical evaluation are summarised in the following paragraphs whilst the Commission's political conclusions, taking this evaluation fully into account, are set out in Chapter V.

Energy-saving[1]

20. By 1990 the Community (the Ten) could be saving 130-150 million toe/year, or 12-14% of gross energy consumption at that time.
The Community projects so far approved are expected to yield energy savings of about 700 000 toe/year. These savings are expected to have a multiplier effect, depending upon the nature of the projects and the efforts made to disseminate the results. These projects feature energy savings which vary according to their technological sector. In the industrial sector, for example, one project alone will save a steelworks 100 000 toe/year; the nine projects in the residential building sector will achieve no more than 60 toe/year. This is due to the inherent differences between the sectors and the nature of the projects.

21. The average levels of investment and of support granted are 1 450 000 ECU and 430 000 ECU respectively, in other words an average Community contribution of roughly 30%. This support has frequently been a determining factor in the achievement of the projects, the rate of support is thus considered to be satisfactory.

22. Altough all of the projects are technologically innovative, their degree of economic viability can vary considerably. Out of 23 projects whose results are currently available for assessment, 13 are to be considered completely successful and commercially exploitable. One project has already started to pay back the Community's financial contribution. Results from the other 10 are useful but fall short of the original aims.

23. Of the projects adopted, 14 are based on techniques which had previously received financial support under a national or Community R&D programme.

1. Evaluation report: Pages 1-51.

24. The assessment report suggests that, whilst keeping to the initially very wide range of possible applications of the programme, further action should place more stress on certain technological subsectors with particular promise. In it's own conclusions in Chapter V, the Commission draws heavily on the considerations put forward in the technical assessment report (see point 54).

Geothermal Energy[1]

25. By 1990 geothermal energy could provide 4-5 million toe of the Community's energy needs, and, on some estimates, around 20 million toe at the turn of the century.
The Community's action has prompted many practical plans to exploit geothermal energy sources, previously used only for space heating in the Paris region and electricity generation in central Italy. It has consequently been possible to run demonstration projects in several French and Italian regions, in Greece, the Federal Republic of Germany, the United Kingdom, Denmark, the Netherlands and Belgium.

26. Geothermal energy projects carry a significant "mining risk" in that the resources which can actually be exploited often fall short of the potential estimated before drilling. Exploitation of discoveries is sometimes further hindered by technical problems and by a lack of suitable equipment. This situation is only likely to improve as more experience accrues from proliferation of actions throughout Community regions with a variety of geological conditions.

27. The preliminary results obtained from the 22 most advanced demonstration projects are encouraging and more than half of them are commercially exploitable.

28. Low-temperature sources of geothermal energy (40-150°) are the most plentiful. Their exploitation is crucial to the development of geothermal energy in the Community. The assessment suggests that as in the past, the development of low-temperature sources be also emphasized in the future, though without neglecting the particularly promising high-temperature sources. A special effort should be made to promote projects to tap geothermal energy for agriculture and industry.

Solar energy[2]

29. Although the total solar energy incident upon the Community greatly exceeds our requirements, its low intensity and variable nature mean that we cannot expect more than 40 to 70 million toe from it by the year 2000. This is nevertheless a significant contribution. In certain developing countries the potential contribution of solar energy towards the year 2000 is considerable.

30. The Community programme has dealt with the three main aspects of solar energy use i.e. conversion into heat, photovoltaic conversion and biomass. Solar heating and biomass are technologically more advanced and so more projects were selected in these areas than in photovoltaic conversion. However, only low-temperature applications currently reach the break-even point. Amongst these are solar-heated swimming pools; in this field, the assessment report concludes that demonstration has reached a satisfactory level now.

1. Evaluation report: Pages 67-73.
2. Evaluation report: Pages 52-66.

31. It can be seen from the distribution of **thermal projects** over the Member States that in northern and central Europe solar energy serves chiefly for hot water production and space heating; in the southerly regions agricultural and industrial applications predominate. The evalutation suggests that, in future, the programme should concentrate more on seasonal storage, solar-heated greenhouses and drying processes.

32. The use of **photovoltaic** cells is confined at present to a number of specific applications in telecommunications, telemetry, alarm systems, and electricity supply for remote sites. The assessment suggests that if this sector is to be developed there must be further support at the R&D level; new invitation for the submission of proposals at the demonstration level is not envisaged in the short term. In the medium term photovoltaic arrays yielding a few KW should enable applications at remote locations and in developing countries to proliferate at an acceptable cost. It is with this type of application that the current demonstration programme is concerned.

33. **Biomass** is no doubt one form of solar energy likely to make a significant medium-term contribution to the Community's energy balance. Projects have been supported under both the regulation relating to energy-saving and that concerning alternative energy sources.

34. The evaluation of the solar projects was carried out from the viewpoint of their current application within the Community. The use of the same techniques, often in more favourable conditions in developing countries could greatly influence the level of economic viability.

Solid-fuel liquefaction and gasification[1]

35. Although limited in scope by the funds available, the programme covers most of the major technological fields. The projects are helping to solve the, often severe, technical problems raised by the building and operation of large installations. Only large-scale installations are effectively able to provide, in the event of major increase in oil prices, the possibility of reducing the degree of Community dependance on hydrocarbon imports. Effort applied to the liquefaction and gasification of solid fuels is given special importance in the light of this dependance.

36. While a number of projects are close to economic viability, others are more of a industrial pilot plant nature. In particular, the economic viability of the underground gasification and of liquefaction projects still largely depends on technical advances requiring large-scale installations and on relative oil-prices.

37. All projects for the gasification and liquefaction of solid fuels are large-scale and need long lead times and significant financial resources. Under the present programme Community participation has generally been limited to the opening phases of projects. Considerable public funds will still be needed to enable them to reach the operational phase.

4. The Member States' demonstration programmes[2]

38. In response to the Council's request for an evaluation of the importance of demonstration projects in the energy and research policies of the Member States the Commission undertook a survey by means of a questionnaire.

1. Evaluation report: Pages 74-84.
2. Evaluation report: Pages 88-92.

The results of the survey are set out in the technical assessment report and the Member States' replies in a separate Working Document. In view of the information supplied by the Member States and of time limitations, the assessment was necessarily more succinct than for the Community programmes.

39. All Member States except Italy provide financial support for demonstration projects in the energy sector. In Italy, a law adopted in May 1982 should enable demonstration programmes to begin shortly. Generally speaking, demonstration programmes were not adopted until towards the end of the 1970s. Earlier programmes concentrated on activities closer to the research stage. Support for demonstration projects in the field of energy saving developed in almost all the countries concurrently with the Community programme and in some cases under its impetus. Many of the Member States began their alternative-energy programmes after the Community scheme had got under way.

40. The scope of support measures varies considerably. In energy-saving the chief sectors are buildings and industry and alternative energy are solar heating, wind, biomass, geothermal and coal gasification.

41. From the information supplied to the Commission it emerges that the Member States have granted a total of approximately 815 million ECU[1] in financial support since the inception of their demonstration programmes. A breakdown of national expenditure in 1982 by Member State and by sector is given in Table F of the assessment report. The following table summarises, for the various sectors, the total support granted to date in the framework of national actions and compares this with the financial envelope of the Community programmes.

	National actions	Financial envelope of Community programmes
Energy saving	208	81
Alternative sources	162	124
of — solar	128	22,5
— geothermal	22	32,5
— wind	12	0
Gasification/liquefication of solid fuels[1]	445	69
Totals	815[2]	205

42. The financial contribution depends on the nature of the project; it also varies considerably between Member States. In general it is not less than 25% of the total investment but may in some cases be as much as 100%.

43. The cost of feasibility studies is paid under most of the Member States' programmes (unlike the Community programme). The costs of data-logging and performance measurement are generally paid in full. Repayment does not seem to play a major role in national aid systems.

1. Of which the largest part in Germany (F.R.).
2. Including, for certain Member States, research support.

44. In the energy-saving sector the size of the investments being supported and — consequently — the amount of support is on average much lower than under the Community programme: the exceptions are the Greek programme, which also includes support for research, and the Federal German programme which provides extensive support, at high percentage rates, for district heating. The Commission has not been able, from the information supplied by the Member States, to analyse the exact reasons for this difference between Community and National programmes.

45. Although a large number of demonstration projects have been completed in several Member States, the results do not seem to have been, in general, systematically disseminated or made available. For demonstration programmes to have the desired multiplier effect a great deal remains to be done to disseminate results.

46. No Member State has yet carried out detailed, methodical evaluation the results of demonstration programmes. France has conducted an assessment but it was confined to the energy-saving programme in the tertiary sector. Denmark reported that it had made general evaluation of its programme but supplied no specific information on this subject. The United Kingdom stated that an evaluation would be completed in 1983. The Federal Republic of Germany has not yet assessed the energy-saving programme as a whole; it is to assess the solar and coal-gasification sectors in a few years. All the other contries believe that it would be premature to evaluate their programmes at the present stage.

47. National programmes are often of recent inception and are still evolving. New sectors are being phased in. All Member States believe that demonstration projects have an important role both in their energy and research policies and in their economic policies generally.

5. Continuation of the Community demonstration programme

48. The period since 1978, when the Regulations setting up the Community demonstration programmes were adopted, has seen the Iranian revolution, the war between Iran and Iraq and the oil- price explosion; it has also been marked by continuing economic crisis. In these circumstances the Community's energy supplies are still vulnerable and, as was emphasised by the Council of 16 March 1982, the Community must not relax its endeavours to make more efficient use of energy and to diversify the supply.

49. In its Communication to the Council on investment in the rational use of energy[1] the Commission emphasized the need for the Community and the Member States to promote necessary structural changes, particularly so that demand may be effectively controlled. Such changes require a high level of investment in the rational use of energy. To promote demonstration — an intermediate stage between research and investment — is one way of fostering that investment.

50. The essential role of demonstration was emphasised by the Commission when it made its proposals covering Community demonstration programmes in the fields of energy saving and of alternative energy sources. Furthermore, it is encouraging to note that the importance of demonstration led Member States to follow suit on a national basis so that all Member States now have their own demonstration programmes. However, there is as yet little coherence between these national programmes and the sectoral coverage is patchy. Hardly any in-depth evaluation of these activities has yet been carried out.

1. COM (82) 24 final.

51. The evaluation of the Community demonstration programme reveals that:
- the choice of projects is pertinent;
- the technological coverage is sufficiently wide;
- an encouraging proportion of the projects are likely to achieve or even surpass their objectives, whilst others will achieve useful results;
- many demonstration projects have been supported at the R&D stage in Community or national programmes;
- priority sectors are progressively becoming clear;
- in promoting innovation throughout the Community, the programme has a stimulating effect;
- a good start has been made to a Community-wide diffusion of the results obtained;
- the programme promotes a growing level of cooperation between undertakings in different Member States.

52. National programmes naturally reflect national priorities. On the other hand, the Community demonstration programmes have the role of stimulating and completing national actions in line with the energy strategy of the Community. Projects supported on a Community basis must be capable of encouraging other similar installations in a significant number of Member States and/or be such as to profit from a market of European dimensions. Priority will be given to projects stemming from Community and national R&D programmes.
To argue against Community demonstration programmes on the grounds that recent actions at National level have the same objectives is to reject one of the fundamental aspects of the Community: that of common and joint actions undertaken in many sections of community life.

53. Coordination of national actions and Community programmes becomes from now on an important task, in the execution of which the Advisory Committees could render the Commission effective support. A periodic examination of national actions could be carried out in parallel with the yearly examination of the Member States' energy policies. To this end it would be necessary to set up regular and methodical communication to the Commission of demonstration actions undertaken at national level. It will also be necessary to obtain the reaction of interested parties to the actions of the Community.

54. Priorities for the future have emerged with greater clarity as a result of the assessment of Community demonstration programmes.

In the *energy-saving* programme the original fairly wide spectrum of possible applications should remain, but in future more room should be found for industry, for tertiary-sector buildings[1], and for energy production from waste.

The *industrial sector* is one of considerable potential, particularly the large energy consuming industries such as iron and steel (clearly shown in the results of an "energy audit" recently undertaken by consultants on the Commission's behalf), cement, non-ferrous metals, glass, heavy chemicals and paper.

In the *buildings sector,* demonstration activity should be directed towards projects by large investors, societies and cooperatives, who already manage large public and private building complexes, thus profiting from their potential as experience multipliers.

The use of *combustible waste for energy purposes* also permits the utilisation of the considerable energy resources of low-calorific-value solid fuels and of various waste materials so far unexploited.

1. Public, administrative and commercial buildings.

The energy saving potential in *transport* is very high. The different transport sectors use some 24.5% of the Community's total energy and 44% of total oil supplies. So far, very few project proposals have been received for transport and all of those retained relate to road transport. As the European Parliament emphasized in its resolution[1] of October 1981, it is necessary to work out a strategy at Community level to achieve this energy saving potential. In this context the Commission will more closely define the contribution which demonstration projects can make to this important sector.

In the *district heating sector,* where proven techniques are mostly used, the Commission will concentrate it's efforts on new techniques, particular in those regions where heating networks are not well developed.

On the other hand, in sectors such as *agriculture and some other industrial areas,* the Commission takes the view that, in the light of experience, it is not appropriate to elevate the level of demonstration actions.

55. In the *alternative-energy* programme, work in the *geothermal* sector should continue substantially as at present. Proper development of geothermal energy in the Community is heavily dependent on support from public funds owing to the major financial risk when drilling in new regions. Even if the drilling and operating techniques are not always innovative, their application in varied conditions provides valuable experience for similar circumstances.

56. The *solar* energy programme should be kept open for all the sectors now covered, i.e. thermal use, photovoltaic conversion and biomass. But future effort should be directed at those fields, notably heating and biomass, which have the best prospects of economic application in the short and medium term. There are no plans at present for a further call for tenders on photovoltaics. As to thermal uses, the Commission takes the view expressed in the assessment, that demonstration action concerning swimming pool heating is at a satisfactory level, and does not intend to give further financial support to this type of project.

57. The Commission attaches special importance to projects for the *liquefaction and gasification of solid fuels.* The processes used are directed towards the replacement of gaseous and liquid hydrocarburs by solid fuels, even in situation where the direct use of solid fuels is difficult if not impossible or where the use of electricity may not be the best solution. The exact moment when these procedures could become commercially viable varies from case to case — in some cases this has already happened — and depends on the development of other energy prices. Furthermore, it is probable that certain processes will be applied, at least in the first instance, in third countries rather than within the Community, due to inherent site advantages and proximity to cheaper sources of raw materials. The large industrialised countries, outside the Community, have a diminishing interest in these processes. In this situation, the Commission considers that the Community must itself ensure the development and demonstration of this technology, which it will certainly have need of in it's vulnerable energy situation. Because of their size and long lead times, projects in this sector are particularly costly, there is thus very real advantage in a joint development and demonstration activity at Community level. For those reasons, the Commission intends to persue this action diligently, together with improvements designed to take account of the special features of this sector. Further to those features already outlined, it should be noted (see Para. 36) that the associated projects are either of the demonstration of the industrial pilot plant type. In these circumstances, the Commission considers it necessary to devote a specific Regulation to this sector.

1. Report W. Albers, October 1981.

58. Still within the alternative programme and in response to the request of the European Parliament and of several Member States the Commission intends to extend action in the field of alternative energy sorces to include harnessing energy from the *wind* and the *sea.*

59. It also intends to include in this programme the harnessing of *low-head water-power sources.* The emergence of new techniques gives rise to expectations that sites hitherto unused could be economically exploited.

60. One class of projects which could not be included in present programmes on the scale required by their importance relate to *oil substitution.* In the contect of it's efforts to reinforce the penetration of coal in the energy market, the Commission will propose the inclusion in the demonstration programme of projects concerning *new technologies for solid fuel combustion* and the *disposal of spoils and ash*[1].
The Commission wishes to extend it's action to the fields of the *substitution of oil by electricity* produced from non-hydrocarbon sources, and the *transport, distribution and storage of heat.*
Thus extended, the demonstration programme would acquire a new dimension in full accord with the Community energy strategy.

61. An important task of the demonstration programme is a systematic dissemination of results. The Commission will pursue the action, referred to in point 17, with increased effort, as soon as a significant quantity of results is available. Periodic seminars are proposed, as normally held in connection with the research programme, at which different contractors working in any one sector can meet. In suitable cases, the R&D and demonstration seminars could be combined. Also foreseen is the organisation of conferences on a European scale, at which experiences of both national and Community programmes may be exchanged.
The most interesting final project reports will be assembled and published. Sectoral reports, treating the results of projects in any one sector, will be prepared and widely circulated. Site visits may also be arranged.
The Commission will, in the course of dissemination of the results of the Community programme, include those results of national actions which the Member States agree should be circulated in this way.

VI. Conclusions

62. The Commission is pleased that the Council decided that an evaluation of the Community demonstration programmes should be undertaken now, and that it should be combined with an assessment of actions at national level. This work has proved fruitful and should be repeated from time to time. Future evaluation should go into greater detail. To this end, the Commission will establish an appropriate methodology and will make greater use of outside consultants.

63. The evaluation has demonstrated to the Commission the need for improvements to the existing programmes in the following areas:
1) Closer co-ordination between national and Community actions;
2) Some adjustment of the fields covered by the Community programme: activity should be reduced or stopped in certain sectors and maintained or increased in others: certain new sectors should be included;
3) Community action should allow the support of projects inside as well as outside Community territory if so justified by the nature of the projects;

1. COM (82) final: The rôle of coal in the Community energy strategy.

4) Some aspects of programme management should be modified, such as:
- clearer distinction between demonstration projects and pilot-projects;
- extension of financial support to feasability studies prior to the realisation of projects;
- simplification as far as possible of the reimbursement clauses in the event of commercial success;
- more effective and systematic diffusion of results, by means of publications, seminars and conferences.

64. The Commission proposes that the Community demonstration programme should be pursued on the basis outlined above and that appropriate funding should be made available to do so. As to the necessary financing, the Commission has already made it's views known for the short term though the first draft of the 1983 budget. At the time of the establishment of this first draft, the Commission had most of the elements of the project assessment available; subsequent information has not given the Commission any reason to change it's position. However, supplementary information could be made available to the budgetary authority in the course of the budget approval procedure.

65. In the spirit of these considerations, the Commission will shortly submit to the Council the following proposed Regulations:
- a proposed Council Regulation concerning the granting of financial support to demonstration projects in the fields of the exploitation of alternative energy sources, of energy saving and of hydrocarbon substitution modifying Council Regulations (EEC) No. 1302/78 and 1303/78;
- a proposed Council Regulation concerning the granting of financial support to industrial pilot projects and demonstration projects in the field of liquefaction and gasification of solid fuels, modifying Council Regulation (EEC) No. 1302/78.

66. The Commission considers that the continuation of the demonstration programme along the lines indicated above will not only contribute to the reinforcement of the Community energy strategy but will also assist industry to obtain more advantage from a market of European dimensions.

Sectorial assessment report

INTRODUCTORY NOTE

At its meeting of 22 and 23 February 1982, the Council asked the Commission to make a rapid assessment of the demonstration projects being financed through the Community Budget.

This report relates to Regulations 1302/78 and 1303/78[1] which are intended to encourage industrial and commercial initiatives wih a view to developing alternative energy sources and using energy more efficiently.

The Commission submitted a Preliminary Report[2] on this subject to Council and Parliament in July 1981.

The assessment made in this Report is a sector-by-sector analysis of this aspect of the Community's activities. Account is taken, in the analysis, of the state of the art in the sector of technology concerned, and of similar programmes under way at national level. A detailed description of the contracts now running is attached as Annex I.

The information relating to the national programmes was submitted by the Member States on the basis of a questionnaire drawn up by the Commission departments concerned.

The assessment was carried out with the help of a panel of independent experts, a list of whom is given in Annex II.

The Commission Directorates-General concerned also contributed.

The Community programmes have been assessed :

- on the basis of the results achieved in the case of projects that have been completed or are at an advanced stage of completion;
- in the light of the inter-relationships between the projects and the possibilities which are the most attractive from the technical and economic point of view in the sector to which they belong;
- taking into account previous national and Community research and development activities;
- in relation to the national demonstration programmes; and
- in the broader context of the Community's energy strategy.

Quantitative data relating to the Community demonstration programme are given in Annex III.

1. OJ No. L 158 of 16 June 1978.
2. COM (81) 397 final of 17 July 1981.

1. ENERGY SAVING

1.1. BUILDINGS

I. Introduction

In 1980 the domestic and tertiary sector consumed 252 million toe, or in other words about 35% of the final consumption of primary energy within the Community. This energy was used first and foremost for space heating, ventilation and lighting. Since the potential energy saving for 1990 has been estimated at 20% i.e. 60 million toe, and for the year 2000 at 50% i.e. 160 millions toe, the domestic and tertiary sector holds great energy-saving promise.

The steps at present being taken to reduce energy consumption in buildings may be divided into 3 categories :

- reduction of energy requirements (better insulation, less ventilation, temperature control, etc.);
- rational use of fuels (higher efficiencies, heat pumps, district heating, CHP, energy storage);
- use of renewable energy sources (active and passive solar energy, bio-climatic buildings, fermentation gas for CHP, geothermal energy).

The demonstrable techniques would make it possible (a) to reduce heat requirements to a minimum by means of suitable design of the structure itself and (b) to generate the necessary heat and light under conditions of optimum efficiency or by using so-called «free» sources.

The following is a list, for guidance purposes, of the fields within this category generally considered to be the most promising :

(a) Buildings in general:

Improvements to the structure itself :

- insulation and condensation-control systems;
- elimination of thermal bridges;
- improvement of ventilation systems.

Heat generation :

- improvements to existing systems (boilers, burners, insulation);
- replacement by high-efficiency boilers (condensation and low-temperature boilers);
- boiler regulation.

Heat distribution and emission systems :

- insulation, thermostats, optimizers, remote control, high-efficiency emission systems, domestic hot water (optimization of distribution).

(b) New heat-generation systems:
- heat pumps;
- solar collectors for heating domestic water;
- combined heat and power production;
- district heating.

(c) New buildings:
- bio-climatic buildings;
- radiant heating.

(d) Tertiary-sector buildings:
- artificial lighting;
- ventilation (control of fresh-air flow) and air conditioning;
- heat recovery.

II. Community action and national programmes

In order to spur activity pursuant to Regulation 1303/78, 32 projects concerning buildings, either directly or indirectly, have been adopted or are about to be so. The «building sector» comprises 16 projects (and also project EE/213/80, as yet unadopted) whose principal aim is to improve the thermal behaviour of the structure itself, although most of them also include techniques such as heat pumps and solar collectors.
A total of roughly 9 million ECU has been invested in these projects, including the measurement programmes, and support amounting to 3 100 000 ECU has been granted.
Most of the building projects cover new dwellings and various types of building within the tertiary sector (schools, office blocks), swimming pools, hospitals, etc. Two projects deal with new types of boiler. Where stress has been placed on a specific technology the remaining projects have been divided up into "heat pumps" (8 projects) and "CHP" (9 projects). The projects on low-energy dwellings involve the construction of 157 dwellings in 7 areas in 5 member countries. Two of these projects cover energy saving in existing buildings. It should be pointed out that only 2 projects have so far been completed.
When these projects were selected account was taken of the results and pointers arising from the "energy saving" R & D programme. The 16 projects adopted can be subdivided into 2 categories: residential sector (10 projects) and tertiary sector (6 projects).

(a) Projects involving the residential sector
Of the 10 projects in this sector, 9 are devoted to the construction of new low-energy houses and the tenth (EE/231/79) to a new high-efficiency boiler. Two of these projects also provide for the construction of flats (EE/323/79 and EE/290/80). These 2 projects are, moreover, the only ones also to include the renovation of existing buildings.
The construction or renovation of some 157 dwellings will enable well-insulated detached houses designed for the passive recovery of solar heat and equipped with heat pumps or solar collectors to be assessed systematically and uniformly.
The results obtained with the passive methods (heat insulation) and the various active methods (heat pumps) will be assessed separately. This distinction comes into its own when one remembers the potentially quite short pay-back period for the passive methods as compared with the much longer periods for the active methods.

The structures used in almost all of the projects are better insulated than their traditional forerunners. In addition, almost half of the projects include technical concepts promoting the passive recovery of solar energy.

The unconventional heating systems are mainly based on heat pumps or air-type solar collectors. Generally speaking systems of this type cannot meet a dwelling's full heating requirement and so back-up heating is provided whose nature varies quite widely, depending upon the project.

In most cases hot water is provided by water-type solar collectors (combined with the heating system of the building). Back-up heating is provided for sunless days.

Project EE/231/79 – high-efficiency boiler – is the only project completed in the residential sector. It has enabled the reliability of this type of boiler, yielding a seasonal efficiency of 91 %, to be demonstrated.

Depending upon the project, the energy saving due to the introduction of new heating and hot-water equipment has been estimated at 30-65 % of the consumption in equivalent, conventional buildings. The payback period on the extra investment needed for energy-saving techniques could vary between 6 and 37 years.

(b) Projects in the tertiary sector

There are 6 of theses and they relate to such diverse types of building as offices, sports centres, hospitals, schools and commercial premises.

Generally speaking the purpose of these projects is to determine the effectivness of a number of energy-saving techniques i.e. :

- medium-power heat pump for heat recovery;
- heat exchangers for recovering heat from stale air;
- CHP;
- improvements to remote-control automatic regulation;
- recovery of incinerator heat;
- ozone treatment of swimming-pool water;
- improvements to artificial lighting systems;
- improvement to the seasonal efficiency of boilers by means of fuel-water emulsions.

Some of these projects combine various of these methods in order to obtain major energy savings as compared with traditional buildings.

One of the projects (EE/201/80) includes a large tank for the seasonal storage of hot or chilled water.

These projects will assess separately the various ways of saving energy under actual operating conditions and will determine just what overall savings can be gained from the integration of several energy-saving devices in the same building :

- the project dealing with improvements to the artificial lighting of an office block (EE/215/79) is almost completed and has yielded an energy saving of about 73 % – an excellent result. This will provide some very interesting feedback and the Commission will distribute whatever information is useful in the near future;
- the project for improving the automatic regulation of school heating by remote control (EE/131/80) is likewise almost completed and should also produce tangible results;
- the project on boilers fired by fuel-water emulsions has been completed. It was a success and is now being exploited commercially. This technique can be applied to all existing boilers, whether private or industrial.

As the other 3 projects are still in preparation their results will not be available before 1983.

In conclusion, when compared with equivalent conventional equipment, these 6 projects should provide energy savings in buildings of 11 to 67 %, while the payback period for the extra investment should be 3-31 years.

The building sector is included in all of the existing national programmes except in Luxembourg. Detailed information is contained in the table below.

Table A

Buildings

	B	DK	D	F	GR	I	IRL	LUX	NL	UK	EEC [7]
1. Proposals received							58	18 [3]			255
2. Proposals supported			6 [1]	182	5		2	11		45 [4]	36 [5]
3. Total support (million ECU)			3.46	13.2	4.96 [6]		0.16	0.035		4.3	6.4
4. Support per project (ECU)			577,000	72,500	992,000		80,000	3,200		95,500	178,000
5. Investment (million ECU)				25.8	14.7		2.9	0.19		10.2	17.4
6. Investment per project (ECU)				142,000	2,940,000		1,450,000	17,000		227,000	483,000
7. Contribution to investment (%)			68 [2]	51	34		6	19		42	37
8. Projects completed				47	–			11		1	2

1. Of which 5 are "heat pump" projects.
2. Average support for the entire R, D + D programme in the "household and small consumer" sector.
3. "Heat pumps".
4. Industrial, commercial and domestic buildings.
5. Projects adopted by the Commission, of which 12 are heat pump projects and 2 are boiler projects.
6. Including research expenditure.
7. Community programme.

France is the only country to have supplied assessment results in this sector and the energy saving achieved by the projects themselves amounted to a total of 247,000 toe between 1975 and 1980, whereas the energy saving spread over the entire residential and tertiary sector has been estimated at 5.4 million toe.

III. Conclusions

In view of the rate of building replacement (2 % per annum on average) incorporation of the techniques being demonstrated both nationally and at Community level in all new buildings could cut household energy consumption by 1,800,000 toe per year.
The emphasis of the demonstrations should shift towards projects by the large tertiary investors, companies and cooperatives who manage numerous housing complexes and estates. This would offer several advantages, including the rapid, widespread appreciation of successful demonstrations and the centralization of decision making.
The following specific technologies deserve closer attention in future :

- building techniques enabling the heat requirements of large residential and tertiary buildings to be reduced;
- the use of micro-electronics to manage the energy requirements of existing or future residential and tertiary buildings.

1.2. HEAT PUMPS

I. Introduction

The requirement for low-temperature heat, both for heating premises and producing goods, accounts for more than 40 % of total energy consumption in the Community. It is therefore essential that energy-saving techniques should be applied in this field.
Heat pumps are a particularly appropriate way of meeting the requirement for low-temperature heat.
The conditions specific to each installation are best met by a particular type of system, so that no single technique will be generally applicable.
The key factor determining the success or failure of a given technique is the degree to which the interaction between the different components of a complex installation can be controlled. In practical terms, this means that the source, production and distribution of the heat must be correctly adjusted. At the moment this is possible in a few cases only, although it is the prerequisite condition for reducing investment costs. Only experiment will provide the answer.
Low-output heat pumps are mostly fitted with electric motors, while high-output systems incorporate an internal combustion engine; electric motors can sometimes be economic in the latter case as well. The heat pumps themselves may often be more sophisticated than the auxiliary equipment (heat source, regulation system, hot-water distribution, etc.); it is this equipment, however, which operation of the installation as a whole.

II. Community and national action

In all, twelve projects have been signed in this field, representing a total investment of about 3 m ECU and receiving 1,2 m ECU in financial support.

None of the twelve had been completed prior to assessment. Seven are in progress, being run as demonstration units, when a detailed measurement programme is carried out; the measurement results are not yet available. The other five, are at the pre-project stage.
These twelve heat pump projects may be classified in any of the following ways :
- by the type of drive and the operating principle employed: heat pumps with an electrically-driven compressor – 5 projects heat pumps with an ICE-driven compressor – 6 projects other heat-pump systems – 1 project;
- by type of use: heating of premises and production of domestic hot water – 8 projects industrial applications – 4 projects;
- by the temperature of the useful heat: below 70° C - 8 projects. – above 70° C - 4 projects.

Nearly every project is distinguished by one or other of the following innovations in installation/component design :
- heat extraction from the ground by large-area exchangers (approx. 9,000 m^2);
- recompression of steam by a compressor with an annular water-tube;
- low-output (20 kW) ICE heat pump;
- steam generation by a high-temperature heat pump (110° C).

Three projects are based on R & D work already carried out by a Member State and/or the Community: 00/035/79 - 171-77 EED; EE/011/81 - EE-A4-038D; EE/146/81 - 175-77EEUK, 369-78-EEUK, EE-B1-147-UK.

III. Conclusions

Most of the demonstration projects selected involve current heat-pump techniques and compare their results. The majority of these projects are already economic or about to become so; they are therefore likely to be put on the market.
Some of the projects are based on the results of work carried out under national and Community programmes; others have given rise to subsequent projects.
The Community's prime objective is to halve by the year 2000 the quantity of energy required to produce low – and medium-temperature heat – a reduction of about 20 to 30 % in gross energy consumption (100 to 140 million toe/year). Heat pumps could help to save about a quarter of this amount (25-35 m toe).
The whole range of heat-pump possibilities having been highlighted in the first stage of the demonstration programme, efforts should now be concentrated on those systems which, in the light of the experience gained, are technically and economically the most attractive. The two areas which should receive most emphasis are :
- heat-pumps with a capacity of up to 200 kW in appartment blocks, and
- heat pumps in industry (paper, textiles, foodstuffs, etc).

Several similar projects should be chosen, in each field, so that the most promising techniques in the Community can be compared and, in the medium term, costs reduced and the market developed by harmonizing technical specifications.
As it has been widely demonstrated that heat requirements in detached and semi-detached houses (10-20 kW) can be met by heat pumps with an electric motor, Community support should be limited in future to small ICE pumps and absorption pumps.

1.3. REMOTE HEATING SYSTEMS (including heat storage, power stations and combined heat and power)

I. Introduction

This sector of technology brings together three subsectors which are often closely linked :

(a) Remote heating systems

The benefits of remote heating are :

- scope for energy-saving;
- scope for substituting other energy sources for oil;
- improved security of supply; and
- a considerable boost for employment, the balance of payments, the regional economy and certain industries now having a hard time.

As regards *heat production* for remote heating systems the emphasis is on :

- the recovery and use of industrial waste heat;
- the use of new energy sources (energy from waste, solar energy, nuclear power, etc.); and
- new techniques (large heat pumps, combined heat and power, fluidized-bed combustion, etc.).

Heat storage becomes necessary where production of heat and demand for it in heating systems are out of phase and is important chiefly as a way of taking advantage of intermittent sources of industrial waste heat and of heat also available outside heating periods.

Economic transport of heat over longer distances than at present is essential for the use of many industrial sources of waste heat and for cogeneration in large conventional or nuclear power stations. Any technique that can reduce the cost of heat transport has to be encouraged.

Distribution accounts for much of the capital cost of district heating systems. Further efforts will therefore be necessary to reduce its cost, e.g., by using new materials or new ways of laying pipelines.

At present heat-distribution networks supply only 2-3 % of the Community's low-temperature heat requirements. These, however, are about 40 % of gross energy consumption. The energy saved by reticulated heat-supply systems through the use of combined heat and power and industrial waste heat amounts to 3-4 million toe/year. Systematic development of reticulated heat-supply systems could result by the beginning of the next century in 25 % of the Community's low-temperature heat requirements being supplied by this means. The potential energy saving is believed to be some 50 millions toe/year.

(b) Power stations

Large power stations have now reached a high level of development; potential energy savings on an economic basis – leaving aside combined heat and power – are small. Endeavours to save energy must focus on special techniques chiefly relevant to industrial power plants of limited size.

Some examples are :

- combined cycles, i.e. a steam cycle with an upstream or downstream cycle using a different working fluid (heat-transfer medium);
- organic-fluid cycles; this is an important way of using relatively low-grade waste heat;

- advanced conversion systems (fuel cells);
- techniques for replacing oil and gas (e.g. gas turbines energized by solid fuels);
- reducing the energy consumed by certain ancillaries (e.g. stack gas desulphurization); and
- reducing the capital and operating costs of small hydroelectric plants in order to lower their minimum economic power level.

It is not easy to assess the potential energy savings that these technologies can provide; they will depend primarily on the technological advances achieved. In the medium term they will not exceed a few million toe/year.

(c) Combined heat and power (cogeneration)

Combined heat and power is a formidable means of saving energy:
as much as 30-40% less is consumed than with separate production of the same quantities of heat and power.

Conventional cogeneration techniques are based on:
- back-pressure or pass-out steam turbines; and
- diesel engines, gas turbines and gas engines with exhaust-heat recovery.

Recent years have seen the development of modular units, with internal combustion engines and integral heat recovery; these burn gaseous or liquid fuels or gas/liquid mixtures. The engines drive either alternators, or compressors (e.g. for heat pumps) or other mechanical devices, or a combination of the two. The fuel cell may in the future provide a static means of combined heat and power production.

Cogeneration has grown up chiefly in industry. The need for large quantities of heat and power at the same time and in the same place and at high annual load factors has made cogeneration an attractive proposition. In the early 1970s cogeneration in industry was saving 13-14 million toe/ year in the Community. The fuels used were mostly hydrocarbons (heavy fuel oil in particular) because they give the lowest capital and operating costs. But the abrupt rise in the oil price, the slackening in industrial activity, the relative price stability of electricity produced by the utilities in large coal-fired and nuclear power stations, the high cost of new small and medium-sized coal-fired plants, high interest rates and a cloudy future for industry are all reasons why industry has found cogeneration less attractive.

Few new plants have been brought into service; existing ones are operating at reduced output or in some cases have actually been shut down. We are in a paradoxical situation where rising energy costs have caused a decline in interest in what is nevertheless one of the best ways of saving energy. Up to the year 2000 the potential for energy saving from cogeneration in industry is approximately 50 million toe/year, four or five times the present level. How far this potential can be realized will depend primarily on the economic and industrial climate. Meanwhile, industry must be encouraged to keep up its interest in cogeneration.

Cogeneration for district heating has developed somewhat in Germany and, to a lesser extent, in Denmark and France. Isolated systems, supplied by cogeneration plants are also to be found in Belgium, the Netherlands, the United Kingdom and Italy. The present energy saving is about 3 million toe/year. The potential for energy saving with cogeneration used for district heating is 30-40 million toe/year by the beginning of the next century (60-80% of total potential energy savings form heat-supply networks). Particularly as a result of the substantial aids in some Member States, the use of combined heat and power for district heating is enjoying steady growth.

Cogeneration has also made its debut in the domestic and tertiary sectors. Energy savings from cogeneration in these sectors are now about 50 million toe/year, 1.6% of gross energy consumption in the Community. The potential energy savings (all sectors) by the beginning of the next century will be 80-90 million toe.

II. Community action and national programmes

There are fourteen projects in preparation or in hand under the Community demonstration programme. These projects typically require heavy investment. Two of them are exceptionally large (EE/120/79 and EE/217/79) and will take several years to complete; Community finance has therefore had to be limited – initially – to the early stages.

Financial support for remote heating projects averages 21.4%; for power station projects 28.2%; and for cogeneration projects 34.5%. The sector average is 23%. This figure is relatively low because of the Commission's desire not to exclude big projects from a programme with limited resources behind it. Most projects, moreover, (with the exception of Italy's) receive national aid, which has enabled the Commission to reduce the level of its own contributions.

Most of these fourteen projects needed Community support if additional, national aids were also to be obtained; it also considerably eased the problem of financing that portion of the investment not covered by national and Community support.

At the time of writing none of the fourteen projects has been completed. Only three projects are in operation, and they are in the demonstration phase, during which a detailed data logging and analysis programme is carried out. The results are not yet available. Four projects are under construction. Six other projects are in the design stage or, if design is complete, construction has not yet begun. The contract for one project has still to be signed.

Remote heating, power stations and cogeneration largely rely on conventional, proven techniques. But the rise in energy prices dictates a review of some past approaches and the expedited developement of remote heating as a way of saving energy and replacing oil. This has resulted in new priorities which can be summarized as follows :

(a) In large cogeneration facilities it is necessary :

- to reduce the use of oil products;
- to make more use of waste (both waste heat and waste substances) and alternative energy sources; and
- to adopt technologies with higher performance.

(b) The use of waste heat requires heat to be transported over longer distances and stored for extended periods. Economic ways of doing both must be found.

(c) The development of heat-supply systems and of industrial cogeneration depends to a great extent on the administrative and legal context within each Member State. New policies for the heat market are essential if these techniques are to achieve greater penetration. "Institutional", just as much as technological, innovation must be promoted.

Table I

	Technological innovation in production	Non-oil fuels	Use of waste alternative sources	Advances in heat storage, transmission and distribution	Innovations in the operation of the heat supply network	Incentives for installing new systems; «institutional» innovations
District heating						
EE/028/79 Reggio Emilia	X	(X)	X			X
EE/120/79 THERMOS	X	X	X			X
EE/121/79 Svendborg	X	X	X			
EE/174/79 Frederikshavn	X		X			
EE/217/79 Saarschiene	X	X	X	X		
EE/330/79 Brescia	–	–	–	–	X	
EE/003/80 Modena		X	X			X
EE/066/80 Plaisir	–	X	X	X	X	
EE/100/80 Milano			X			X
EE/163/80 Rouen	X	X	X			X
Power stations						
EE/118/79 Walter	X	X				
EE/134/81 Ruston	X	(X)				
Combined heat and power						
EE/156/80 MAN	X					
EE/014/81 CAMPBELL	X	X				

Only one project is concerned with heat transport (EE/217/79) and only one with seasonal heat storage (EE/066/80).

Innovations in heat supply network operation are to be found in two projects, namely:

- demand modulation (EE/330/79); and
- matching of heat demand to production by means of storage (EE/066/80).

Five projects contribute to the setting up of new heat-supply networks or display "Institutional" innovations.

Two Member States (F and D) have national demonstration programmes covering this sector. Greece has supported a project in the same field. Several Member States also provide aid for capital projects in this sector where they have no particular innovative character (F, D, NL, DK, IRL).

Feasibility studies are also promoted in several Member States.

III. Conclusions

Energy savings currently made in the Community with all the methods and techniques falling within this sector are approximately 16 million toe, or 1.7% of gross inland energy consumption. The potential for energy saving by the beginning of the next century is in the order of 100 million toe (about 8% of gross energy consumption). Combined heat and power accounts for 80-90% of these potential savings. These figures justify the importance of this sector both in the national programmes and in the Community demonstration programme.

Energy saved or produced from alternative sources by these 14 projects amounts to 220,000 toe/year. A project-by-project estimate of the prospects for the construction of similar systems between now and the end of the century shows potential energy saving and production of approximately 2 million toe in the year 2000.
The projects selected for the Community programme have in general considerable demonstration value; most of them are world "firsts".
Lead times for projects in this sector are relatively long, so that few results are yet available. It is very difficult to make any assessment at the present stage.
Even with the small number of projects in this sector it has been possible to cover a fairly wide spectrum of new technologies and applications. The selected projects accord to a great extent with the development priorities for the sector.
Combined heat and power and waste incineration using conventional methods should no longer feature in demonstration programmes. Likewise the use of oil and/or natural gas should be confined to applications where no economic replacement is in view for them in the medium term.
A further effort will be needed, however, in the following areas:

- new technologies for using waste heat and for energy from waste (see also para. 1.6.);
- use of nuclear plants for heat supply;
- new technologies for heat transport at lower cost; and
- new technologies for converting external and internal combustion engines to burn non-hydrocarbon fuels.

Projects in this sector are generally expensive. The innovatory portion often accounts for only a fraction of the investment. With a view to getting the best out of the funds available for the demonstration programme it would be of advantage – where possible – to confine Community financial support to the innovatory elements and direct the "investment" portion towards the other Community financial instruments. In its Communication to the Council [COM(82) 24 final] on investment in the rational use of energy the Commission emphasizes the need to speed up investment in some sectors, in particular heat supply networks and proposes to that end that greater use should be made of the Community financial instruments.
Of the 14 projects in this sector included in the Community demonstration programme at least 10:

- are based on R & D carried out on a national basis; or
- are part of a national demonstration or investment programme; or
- are in receipt of some other form of support from the Member State concerned.
  This illustrates the close integration of national and Community programmes in this sector.

1.4. INDUSTRY

1.4.1. Introductions

Industry is "par excellence" the big energy-consuming sector. Leaving aside the energy content of raw materials, industry's energy consumption in 1980 was 227 million toe, equivalent to 35 % of the Community's final energy consumption.
The possibilities for the more rational use of this energy are any and vary widely, depending on the industrial sectors involved. Nevertheless, two main categories may be identified:

- *"horizontal" measures:* these include improving the heating of buildings, optimizing the efficiency of industrial boilers, using more efficient equipment (e.g. pumps, electric motors, heat exchangers, etc.). The demonstration programme in respect of these measures covers a range of sectors;

- *"vertical" measures*: these mainly concern improvements to manufacturing processes (using techniques to regulate and control energy flows, use of cascade heat) and the recovery of heat, at present lost, for CHP and/or district heating.

The potential energy savings to be made in the industrial sector may be put at 50-60 million toe, i.e. 20-25 % of consumption in 1980.

1.4.2. Specific industrial sectors and Community action

a) *Iron and steel*

I. Introduction

The iron and steel industry is the biggest energy consumer. In 1980, it accounted for 8 % of the Community's primary energy consumption.

There is considerable scope for energy recovery in this industry because not only is the efficiency of modern integrated plants low (50-60 %) but also the production of steel generates significant energy flows, basically in the form of heat. In view of the high process temperatures involved, these heat flows possess valuable thermodynamic properties which not only allow the heat to be recycled but also allow it to be used to generate electro-mechanical power.

The generally high cost of heat-recovery plant, however, meant that not even the most promising recovery systems seemed worth considering when energy was cheap. In addition, the steel makers felt a very understandable aversion to the idea of further complicating the main production operation which was already very complex and costly.

Today the situation is quite different and the potential savings from certain methods of energy recovery are beginning to persuade the steel industry to introduce the most promising techniques even if this means a slight reduction in the reliability of the production apparatus which is inevitable whenever auxiliary plant components are added to the main system.

There are currently 15 major energy-saving options open to steel firms (these options are followed by a + sign where they specifically relate to integrated-cycle steel works and by a ++ sign where they concern furnaces which use scrap):

- rationalization of energy use during the blowing operation (+);
- recovery of heat from the hot-blast stoves (+);
- recovery of energy from the blast furnace gas by means of a turbine (+);
- direct or indirect recovery of heat from the combustion products in the converters during blowing (+);
- recovery of heat from the shells (of the furnaces and converters) and from the steel treatment plants;
- improved operation of electric furnaces (++);
- recovery of heat from the combustion products in electric furnaces (++);
- pre-heating of scrap (++);
- recovery of heat during the warming-up of refractory materials used in casting ladles and other containers;
- conserving the heat from semi-finished products (ingots, slabs, billets, etc.);
- application of heat tratment to semi-finished products (e.g. wire rod) after rolling;
- application of unconventional methods of heat treatment;
- regulation of the rolling force;

- streamlining of the auxiliary services in order to save energy (heat, power and blowing plants; oxygen production, storage and supply installations; coking plants etc.);
- automatic or semi-automatic programming of the production and maintenance operations.

The above options may lead to practical results if use is made of the – often very different – range of technical alternatives available. The scope for action is thus very wide. In the short and medium term, the energy saving may be estimated at 10 or 15 % of current energy consumption, i.e. 7-10 million toe/year.

II. Community action

Contracts for nine projects have been concluded or are shortly to be so, seven of which have been submitted by steel companies, one by a research institute and one by a mechanical engineering firm.

The total investment in these projects is about 26 million ECU and overall financial support 7,200,000 ECU.

In six of the nine cases the projects are in fields of general interest to all steelmakers, i.e. ;

- recovery of heat from hot-blast stoves;
- installation of turbines to extract mechanical energy from the pressurized hot air at the furnace throat;
- recovery of heat from waste converter gases;
- pre-heating of the scrap charge to the electric furnaces by using the combustion products from the same furnaces.

Similar projects – all of great interest – are also being carried out or are planned in a number of other European steel firms.

The areas covered by the three other projects are more specific.

One aims to increase the power of electric furnaces and to achieve energy savings by making suitable alterations. The other two projects being run by firms with no connection with the steel industry and which are of interest to the metal-working industry as a whole, concern the heat treatment of steels by unconventional methods (fluidized bed or recovered heat). In six cases, the projects aim to optimize the efficiency of industrial processes: in the three others (EE/246/81; EE/074/80; EE/270/80) the aim is to recover fuel gas and/or generate electricity.

The research and development phase of project EE/074/80 has been partly financed from central government funds by the Energy Savings Agency.

III. Conclusions

The situation with regard to the nine projects is as follows :

- three are still at an initial stage and it is too early to make an assessment;
- five are in progress. No major problems have been encountered in their execution and, in at least three cases, there is every likelihood that the anticipated energy savings will be achieved;
- only one project has been completed (EE/251/79) and the results are far better than expected : the energy savings achieved are twice the forecast level.

The energy savings achieved by implementing these nine projects amount to about 147,000 toe/year.

b) Non-ferrous metals

I. Introduction

In terms of energy consumption, this sector comprises mainly aluminium, copper, zinc and lead. The consumption of the non-ferrous metals sector represents almost 9 % of the final energy consumed by industry.
The use of energy in this section can be subdivided into two distinct sections :
(1) production of primary metal from raw materials. This process applies essentially to the aluminium and zinc industry and to a lesser degree to lead industry; virtually all European copper production is derived from scrap and imported refined copper.
(2) the melting, casting, rolling extrusion of metal into finished products.
In the aluminium industry, the total energy consumption is about 12 M toe/year and for example, 70 % of the energy demand (mainly electrical) is consumed for primary smelting, the specific energy demand of 30 to 50 GJ/tonne for the subsequent operation.
The energy conservation trend for the primary smelting operation is along the lines for improved furnace minor design changes by the control of electrolyte temperatures, using additives, re-arrangement of magnetic fields, etc., modern design of smelters yield consumptions of 16,000 kWh/tonne compared with older designs of 20,000 kWh/tonne.
In the secondary processes the main activity in energy conservation is involved in converting to continuous melting and processing from batch type operations. It can be shown that significant reductions in energy demand can be achieved resulting from reduced standing losses and better product qualities. Interest is also being shown in pre-heating furnace designs to reduce metal losses due to excessive oxidation.

II. Community action

In the non-ferrous metals sector three demonstration projects have been signed dealing with melting or smelting of aluminium, copper or non-ferrous alloys.
Two projects come from the same proposer, the Electricity Council Research Centre, one from the first call for tender in 1979 and the other from the third call in 1981. Both are follow-up of R & D work done by the proposer and the applications at demonstration level take place in industrial enterprises. Due to the limited investments involved, the EEC financial support is 40 % for each of them. The third one is a joint effort by companies from Belgium and Germany who joined their R & D effort and decided to invest in a large industrial demonstration with a 30 % financial support from the Community. For this project only, the energy savings foreseen are 5,000 toe/year.
For these projects, the EEC support represents about 2.1 MECU for a total investment of 6.76 MECU.

c) Cement & Building materials (bricks, lime)

I. Introduction

Since the processes require high temperatures, the cement, lime and building brick industries are necessarily energy intensive. The raw materials used in these industries are cheap and the major cost of production is the energy used in the high temperature process. Consequently, any energy saving is also a significant cost saving.

(a) Cement & lime

Both production processes involve calcining at temperatures up to 1400°C. In cement clinker manufacture, this is carried out in rotary kilns. Lime is manufactured in rotary kilns or vertical retorts depending on the lime quality required and the production rate. On large installations the principle fuels are pulverised coal and heavy fuel oil, smaller units producing high quality lime use premium fuels such as natural gas and distillate oils.

In the manufacture of cement almost 90% (6,5 GJ/tonnes cement) of the energy used to produce the final product is consumed in kilns to produce cement clinker. It is not surprising therefore, to find that close attention is given to improving the design and operation of these kilns by more efficient firing, recovery of exhausted heat and improved insulation refractory material. With such an energy intensive area of the industry a small improvement in kiln performance represents a significant primary energy saving.

In cement manufacture the following energy conservation measures are currently being pursued:

1) wet to drier process conversions;
2) waste heat utilisation (improved clinker cooling);
3) insulating refractories development;
4) blended cements (p.f.a. and blast furnace slag);
5) slurry moisture additives development;
6) specification changes (gypsum blending);
7) improved grinding techniques and use of grinding aids;
8) fixation of alkalis in kiln dust;
9) use of refuse derived fuels.

The potential energy saving from the above is of the order of 40%. In lime manufacture the potential for energy conservation is more varied due to the wider variety of equipment in use.

The main areas being investigated are:

1) combustion systems development;
2) waste heat utilisation;
3) insulating refractories development;
4) fuel substitution (use of coal gasifiers etc.);

The potential for energy saving is of the order of 30%.

(b) Building Brick Manufacturers

The manufacture of bricks and other earthenware products involves materials preparation, low temperature drying at approximately 120°C and final firing at 800°C-1,000°C.

If hot air from the firing kiln is used in the drier, 80/90% (1.8/2.0 GJ/tonne bricks) of the total primary energy consumed to produce bricks can be used in the kiln. Main areas of interest in energy conservation include the use of carbonaceous wastes as an additive to some clays before firing, the recovery of heat from kiln exhaust and improvement in firing equipment.

The main area for energy conservation is in the final firing which is generally carried out in tunnel kilns.

The main areas being investigated are:

1) recovery of heat from exhaust gas from continuous kilns;
2) addition of carbonaceous wastes to raw materials before firing.

The potential for energy saving is of the order of 30%.

II. Community action

In this sector, 3 projects have been signed, one for the brick industry, where by using pulverised coal energy saving up to 60% can be expected. Normally, fuel substitution from oil to coal leads to penalties in terms of primary energy consumption. In this case, by using the latest technology for burning coal, it is possible to switch away from heavy fuel oil and still obtain significant energy savings. The replication potential is large and many parties have already visited the site of the demonstration project.
The second is in the lime industry and the demonstration is on a vertical lime. Because of the quality requirements of the finished product, many lime kilns use natural gas. A new annular ring burner will be demonstrated on an existing vertical kiln. If successful, the replication potential is large since this type of burner can be used on the existing vertical kilns of the Community.
The last project is in the cement industry and will be demonstrated on an existing cement clinker kiln. For the project, the energy saving envisaged amounts to 1,500 toe/year. With a total production of cement in the EEC of the order of 140 m tonnes, a replication of only 10% of the existing capacity could lead to energy saving of 42,000 toe/year.
For this sector, the EEC support represents almost 500,000 ECU for a total investment of 1,190,000 ECU.

d) Chemical industry

I. Introduction

The chemical industry in the Community consumed 127.4 million toe in 1979[1]; this is equivalent to 40% of the final energy consumption of all Community industry[2]. In 1975 the chemical industry accounted for only 36.5% of final industrial energy consumption[3]. One of the reasons why the chemical industry is a major energy consumer is that the energy products it uses as raw materials account for over half of all those consumed in the chemical sector. In 1979, for example, its consumption of energy raw materials (oil products, natural gas and coal) made up 54% of the total energy consumption in the chemical industry.
The chemical industry's efforts to reduce energy consumption since the first oil crisis have matched those of the rest of the industrial sector. CEFIC puts the energy savings per product unit during the period 1973-1978 at 8%[4]. Savings are probably higher in the important petrochemical sub-sector where drastic energy-saving measures have been taken and consistent investment made since the beginning of the crisis, and in the oil refining sector which is the source of most intermediate products.
As in other industrial sectors, energy savings have been secured in the chemical industry by reducing losses of materials and steam and by means of recycling and heat recovery. There is, however, now, after the remarkable progress made in the last ten years, little prospect of reducing consumption very much further by means of these techniques which have been applied to the energy required in the product manufacture.
Further substantial reductions may be made in unit energy consumption by reducing the specific losses of intermediate energy products. These can be achieved by improving process efficiency or by introducing new chemical reaction systems.

1. European Council of Chemical Manufacturers' Federations – January 1982.
2. 311.2 millions toe. (COM(81) 64 final of 23 February 1981).
3. European Council of Chemical Manufacturer's Federations – December 1980.
4. European Council of Chemical Manufacturer's Federations – July 1980.

To achieve these objectives there must be an adequate R & D basis and, once this has been established, a large volume of funds to invest in new plant.
The largest potential energy savings can of course be made in the heavy chemicals industry which consumes a vast amount of energy in product manufacture and as a raw material. The main areas are fertilizers, chlorine, soda and ethylene-derived intermediates used in the manufacture of plastics, fibres and elastomers.
There is substantial potential for energy saving in other sectors of the chemical industry, including the fine chemicals industry, but this is more difficult to quantify because of the large variety of products concerned, belonging to the following main categories :
- cleaning products for various materials (wood, leather, metals);
- adhesives and gelatines;
- explosives;
- medicines;
- cosmetics;
- pesticides;
- printing inks;
- photographic products.

It is particularly difficult to analyse the energy consumption of these categories of products and of the chemical sector as a whole because :
- the same product may be obtained from different raw materials;
- several manufacturing processes may be used to make the same product from the same raw material;
- the energy characteristics for the same process may differ according to the design of the production unit;
- the products marketed are intermediate products which will be used in further energy-consuming processes.

II. Community action

In view of the scale of the energy requirements of the chemical sector, in particular that of the heavy chemicals industry, the Commission has decided to concentrate on three projects in this sector. The Commission is also providing support for two projects concerned with oil refining which is an important source of chemical feedstock.
The total investment in these projects, of which a detailed breakdown is appended, amounts to 4.4 million ECU of which the Commission is providing 1.3 million ECU.
The first three of these projects which concern the heavy chemicals industry involve :
- a new method of manufacturing urea, which is the main constituent of nitrogen fertilizers;
- the recovery of heat from ash and gaseous emissions produced in the concentration and reduction of hematite;
- a new synthesis process for ammonium nitrate which is also used in the preparation of fertilizers.

The first project has been concluded, the second is still running and the third (which commenced at the end of last year) is scheduled to run until October 1983.
The two projects in the refining sector have been successfully completed and are near the marketing phase. The first concerns the recovery of hydrocarbons in liquid effluent from refineries and the second the reduction of evaporation losses during the filling of tanks in petrol station or tankers.
As a result, three of the five projects supported by the Commission have been completed and have every chance of commercial success. The five projects will lead

to savings of 11,700 toe per year in plants and replication will give a potential of 750,000 toe per year for the Community as a whole. For total Community urea production project EE/274/75 alone could lead to savings of the order of 350,000 toe per year.
Any further Community demonstration projects in the chemical industry should concentrate on other products of the heavy chemicals industry such as ammonia, chlorine, soda, nitric and sulphuric acid and the petrochemicals sector.

e) Glass industry

I. Introduction

The glass industry is one of the energy-intensive industrial sectors in the Community. It can be divided into three main areas of production :
- sheet glass;
- glass bottles and containers and insulation fibres;
- more specialized glass manufacture such as laboratory and instrument glass;
- artistic glassware.

Community production in the soda silica glass (waterglas) sector is slightly more than 1 million tonnes per year and energy consumption is over 170 million m^3 gas per year.
The main measures which can be taken to achieve energy (heat) savings in the glass industry are:
(a) structural modifications to furnaces to obtain heat curves which will reduce the temperature of exhaust gases from the chamber but maintain the quality of the product;
(b) modification to furnace design and management to increase productivity (and hence reduce the specific losses) for the same chamber surface area;
(c) waste heat recovery making it possible to transfer a large proportion of the sensible heat from the furnace gases to the combustion air;
(d) improving furnace insulation;
(e) conserving heat from any intermediate products.

II. Community action

The commission has signed a contract involving a total investment of 0.8 million ECU; the Community contribution is 0.3 million ECU. This project (EE/246/80) concerns a melting furnace. The melting furnaces normally used to manufacture glass from silica sand, powdered soda and potash are "same-way" flow furnaces.
In the demonstration project the firm has used a counter-flow furnace with a daily capacity of 80 tonnes in which the feedstock is introduced on the opposite side to that of the burners. The project is extremely interesting and the experimental furnace is in use.
An experimental furnace was started up in September of last year. There have, however, been a number of hitches and the consumption of natural gas had been higher than expected (140 to 150 m^3 instead of 124 m^3 per tonne). A saving of 15 % instead of 27,5 % has been achieved – as compared with 171 m^3/t – but this is till of interest.
The demonstration project has been practically completed and the energy savings achieved are around half the initial target. Further measures which may not necessarily be very costly should enable this target to be reached.
The results of this experiment may be of wide application in view of the saving of 47 m^3 of natural gas per tonne achieved (which could be extended to all furnaces). This would mean a reduction of 47 million m^3 of natural gas per year.

f) *Textiles*

II. Introduction

The textiles sector has some very specific features. It is easy to define the action areas for saving heat:

- use, for air conditioning purposes, of heat emitted by textile machinery;
- rationalization of steam and air drying operations in sizing machines and similar equipment;
- recovery of heat from the smoke in the stenters (in which fuel is burned) to preheat the combustion air;
- recovery, for use in processes or services, of heat given off by stenters fed by steam or pressurized water;
- use for heating or other purposes of the heat in gaseous emissions;
- using heat pumps or self-cleansing heat exchangers to recover heat from dyeing effluents;
- possibly, the recovery of energy from waste; and
- efficient process management.

It is possible to save electricity; this depends on replacement of the textile machinery stock.

II. Community action

So far the Commission has signed two contracts in the textile sector. The investment involved was some 0.3 million ECU and financial support amounted to some 0.1 million ECU.

The first project (EE/016/79-LANEROSSI) is to recover heat in a dyebath system.

The construction phase had just been completed and the measurement programme had hardly ended and the process been started up than major departures from the forecasts were noted. This was due to poor organization, which has since been remedied. The second project (EE/133/79 - SHIRLEY INST.) sets out to demonstrate how efficient automated control of dyeing operations can give significant energy savings; it is still under way.

Of the two projects which have received support only the EE/016/79 - LANEROSSI project includes an element of technological interest.

g) *Dairy industry*

I. Introduction

The energy consumption of this sector can be evaluated at about 8-10 million of toe/year. The energy intensive areas of milk processing and the manufacture of milk products are mainly:

(1) pasteurization and sterilization (heat treatment);
(2) evaporation;
(3) drying;
(4) refrigeration;
(5) transposition.

The trends towards increased efficiency on energy utilization can be summarized as follows. Heat recovery from spray driers incorporating recovery of product which is presently lost from these devices. Heat recovery from effluent streams. Increasing number of effects in evaporators. Multistage driers. New processes such as reverse osmosis and mechanical vapour recompression to improve efficiency of water removal.

The dairy industry also keeps a keen interest in the developments in the solar heating and heat pump fields where improved performance of the units could prove to be useful.
The energy savings potential can be evaluated at 20-25% of energy consumption of these industrial services, i.e. 2-2.5 million toe/year.

II. Community action

The Commission has signed two contracts in this sector.
The aid granted was some 217,360 ECU and investments 543,381 ECU.
One of the two projects uses heat pipes to recover heat from the air in powdered milk dryers (EE/008/79). The second project (EE/008/80) uses inverse osmosis to concentrate milk.
Only one of the projects (EE/008/79) has been completed. Some 430 toe has been saved: 23% of the energy consumed by the dryers. The second project (EE/008/80) is under way and the early results are encouraging.

h) Miscellaneous industries

I. Introduction

Three of the projects evaluated have been considered under this broad heading since their replication could be applied to any industry where relevant; the first applies to large gas users; the second to compressed air; the third to the utilization of mine gas in an industrial boiler.

II. Community action

In the 1st project (EE/314/79) a glass company wants to demonstrate that this energy can be recovered in an expansion motor to produce mechanical energy to drive a compressor.
The energy contained in the high pressure gas is normally lost during pressure reduction.
Industry uses almost 40% of natural gas consumed in the Community and large users are normally connected to the high pressure gas network. On the other side, gas burners require pressures of a few bars. The project is successful.
The potential for further applications concerns all large industrial gas users receiving gas at medium or high pressure.
The 2nd project (EE/167/80) has very wide applications since almost all industrial enterprises have needs for compressed air. The aim of the demonstration is to prove that part load capacity air compressors can be operated in an efficient way and save energy.
The 3rd project (EE/244/79) aims at the utilization of mine gas in a boiler whose burner had been modified. A regulation system for combustion control has also been developed. The project was successful.
The EEC support for these three projects is 240,000 ECU and the total investment is 600,000 ECU.

1.4.3. Industry Sector — Conclusions

With 27 projects receiving support, industry accounts for a large proportion of the Community's action on energy saving. Total investment amounts to some 41.5 mil

Table B

Industry

	B	DK	D	F	GR	I	IRL	LUX	NL	UK	EEC [4]
1. Proposals received				210 [2]			24				367
2. Projects supported			12	127	–		7			110	90 [3]
3. Total financial support (m ECU)			39	148			0.29			13	43.6
4. Support per project (ECU)			3,250,000	116,500			42,000			118,000	484,000
5. Investments (m ECU)				61			7.09			61.7	135.3
6. Investment per project (ECU)				480,000			1,012,000			561,000	1,503,000
7. Percentage of investment supported			63 [1]	24			4			21	32
8. Projects completed				80						13	9

1. Average for all R&D in the sector.
2. Including agriculture.
3. Including projects on fluidized beds, boilers and industrial heat pumps.
4. Community programme.

lion ECU whilst 12.3 million ECU has been granted in financial support. Nine projects have been completed or are so far advanced that the results can be evaluated. The rest are not yet complete. Six of the nine have fulfilled the original forecasts of energy savings and reliability in operation. In almost all industrial subsectors the projects selected reflect the dominant technological trends.

Steel is foremost among the industries making an obvious technological effort, with many proposals of technological merit. In other sectors such as chemicals, glass, non-ferrous metals and cement, and in spite of some proposals of obvious value, the overall quality and number of projects are not commensurate with the opportunities waiting to be exploited.

There has not been much participation by other industries, probably because traditional technology is still widely used in them and this is a constraint on innovation. Another explanation might lie in the structure of the sectors concerned, which are characterized, *inter alia,* by a large number of small and medium-sized businesses which do not provide potential for major technological research and exchange little information.

Action in the steel sector must be pursued. In other industries that are big energy consumers, action should be stepped up and should demonstrate the viability and economic benefits of the following technologies in particular:

- cement: the dry process, use of derived fuels, use of waste heat, improvement of thermal insulation;
- non-ferrous metals: improvements to preheating and melting furnaces, greater use of electricity for heating, switching from batch to continuous processes;
- glass: raising furnace efficiency, waste heat as a source of low-grade heat, the recovery or elimination of heat losses in intermediate cooling;
- chemicals, particularly bulk chemicals: raising process efficiency and introduction of new chemical reaction systems;
- pulp and paper: better energy management and recovery of heat from effluents, particularly by means of heat pumps, and new paper drying techniques.

In all other industries — having regard to each one's limits and situation — Community action should continue. In addition further action by the Commission, such as the preparation of energy consumption budgets (or "balance sheets") and the dissemination of information, particularly by means of the "Energy Bus", should continue to be developed.

In dynamic sectors, and in those which have not so far been dynamic, these actions on their own cannot impart sufficient momentum to energy saving. A considerable increase in investment, dealt with in other Commission papers, is an essential precondition for achieving the Community's objectives for the efficient use of energy.

As the following table shows, industry is also a key factor in the Member State's demonstration programmes.

1.5. FLUIDISED BED COMBUSTION (FBC)

I. Introduction

The quickest and cheapest way of making more oil available for premium use is to replace fuel oil by coal or by poor and waste fuels. In the medium term the largest growth market for coal is seen to be for industrial steam raising boilers.

In FBC boilers coal is burnt in a hot turbulent bed of ash or sand, fluidised by forcing combustion air up through the bed to maintain fluidity and to promote rapid mixing of coal and the hot refractory particles. It possesses the advantages associated with fluid liquid fuels — high efficiency and ease of control — and many significant advantages over conventional combustion methods. The advantages of fluidised bed systems are:

- *High heat release and efficient transfer* which allows smaller boilers to be constructed at less capital cost for a given heat output.
- *Lower furnace temperatures* effectively controlled below 1000°C which reduce corrosion, and fouling resulting in lower maintenance costs and greater boiler availability. Oxides of nitrogen levels are kept within most stringent emission regulation at no added cost. Non-sintered ash and less erosion of surfaces.
- *Reduced Oxides of Sulfur* are attained by using limestone injected with fuel in the furnace — this is much the cheapest way of desulphurisation.
- *Burn poor and waste fuels* which enables useful heat to be gained from waste materials that would otherwise cost money to dispose of.
- *Flexible systems* matching oil burning equipment in control and performance allow coal representing 50% to 70% of oil costs on a thermal basis to be used in industrial applications to cope with quality variations without loss of efficiency and provide useful heat and/or power. The cost of FBC installations is greater by a factor of at least 2 but the pay back time can be as short as 2-3 years, after wich there are cumulative savings.

All the systems which have reached the demonstration stage are of the atmospheric "fluidised bed" type. A new generation of pressurised systems currently at the R&D stage could emerge during the next few years for industrial applications.

Wherever steam, hot water or hot gas are required, a compatible FBC installation is possible. Examples are: hot water boilers (for group domestic heating networks, the horticultural industry), steam boilers (of all types for general industry, electricity utilities, co-generation of steam/electricity), dryers (using hot gases for crop drying, clay industries, cement and chemical industries), waste disposal (noxious materials with safety and environmental protection, municipal waste and sewage) and combustion of low grade fuels with useful heat.

The economic returns vary with the application but, taking power generation from coal by FBC as an example, typical savings estimated are:

Costs of FBC of coal compared with pulverised fuel electricity generation	% saving on capital cost compared with a pulverised fuel (pf) station		% saving on operating costs compared with pf	
	with Sulphur Removal	without Sulphur Removal	S. Removal	No. S. Removal
	22	12	9	2

Development of the fluidized bed method depends on a number of technical factors.

First of all, it is essential that the fluid consisting of the mixture of inert particles and the particles of fuel is properly stable. In cases where the density of mixture is too variable to allow proper combustion, the required stability is achieved using a double flow of air or unsymmetrical flows of air so as to set up turbulence. Turbulence can also be created by giving the combustion chamber a special shape.

Careful attention then has to be given to problems of corrosion caused by the abrasive effect of extremely hot particles being projected at high speed against the walls of the boiler and the heat exchangers.

In order to ensure that the atmospheric pollutants remain fixed in the ash, combustion must take place at a relatively low temperature, in many cases near the point where the furnace will go out. Low temperatures also result in less fouling of the grates due to the formation of ash agglomerates.

The combustion will thus have to be controlled by a highly sophisticated regulation system which allows of very fine adjustments to the fluidization speed, the temperature and the charging rate.

II. Community measures and national programmes

In this sector there are four contracts demonstrating the application of fluidized bed combustion to the rational use of energy in industrial processes with the objective of establishing their capability for energy saving and economic advantages. The total investment of these projects is 9.3 million ECU and the Community support 2.3 million ECU.

The first (EE/022/79) concerning combustion of waste acid tars, is the only contract completed. The second (EE/027/80) on combustion of shales in fluidized beds, has suffered some delay with the supply of equipment but start-up burning Limburg shale is imminent, to be followed by a two years' test programme of various waste materials.

Technical and commercial demonstration under the last two contracts — (EE/190/80) atmospheric fluidized bed combustion for electricity production and (EE/126/80) fluidized bed combustion in a calcium silicate brick factory — is exptected to take longer and, apart from confirming that they have every prospect of fulfilling the contract terms and proving the common economic and technical advantages of fluidized bed combustion in the rational use of energy, it is difficult at this stage to quantify the particular benefits they will provide.

The aim of the first contract (EE/022/79) is to eliminate acid tars left over from the regeneration of waste lubricants, without harm to the environment. The heat produced helps to generate the steam used in the plant. The other two contracts (EE/097/80 and EE/190/80) cover the burning of coal shales from spoil heaps or coal with a very low LCV containing a high percentage of ash and sulphur. Considerable savings can be made by substituting them for fuel oil for the generation of steam and electricity. The last contract (EE/176/80) deals with the generation of the energy required for the manufacture of building materials by burning coal with a low LCV using fluidized beds. This will save not only energy, as a result of the substitution, but also heat and transport costs, since the hot ashes are incorporated in the structure of the materials manufactured.

There is a district heating network in Denmark which uses the fluidized bed technique. In the Netherlands there are two projects supported by aid amounting to 0.93 million ECU out of an investment of 2.2 million ECU. The UK has recently increased its fund for conversion of boilers from oil to coal from 79 million ECU to 238 million ECU. Grants in aid amounting to 25% of the conversion cost have been available in France for this purpose.

III. Conclusions

The expected energy savings from these projects amount to 21,900 toe a year. If the techniques used in these four projects were applied throughout their various industries, more than 1.5 million toe could be saved in the Community each year — and this is only a small proportion of the possible applications. Further efforts should be made in this sector, particularly in respect of small industrial boilers and the burning of waste.

1.6. ENERGY FROM WASTE

I. Introduction

Urban, agricultural and industrial waste and agricultural by-products are potentially very good sources of energy. In theory, the contribution which this waste could make to the Community's energy supply is of the order of between 100 and 120 million toe a year. Obviously, however, only some of this waste can be exploited economically — possibly some 50 or 60 million toe a year.
The advantages of energy-from-waste techniques are that they make it possible to:

(i) produce energy (heat, electricity, biogas or alcohol) from materials whose discharge at present requires a large energy input if environmental constraints are to be respected;
(ii) obtain by-products which can be used as fertilizers or feedingstuffs (instead of importing them as now);
(iii) reduce the effect of these waste products on the environment;
(iv) improve the energy balance of agriculture.

The various technical options are examined below according to the type of waste involved.

Household waste and similar industrial waste

The are various methods of obtaining energy from waste of this kind:

(a) Incineration with simple heat production or CHP.
This is a method very widely used in all the Member States and is the most cost-effective if there is a large-scale consumer (district heating network, industrial estate, etc.) to use the heat generated.

(b) Manufacture of refuse-derived fuels (RDF) from waste which is rich in combustible material but poor in fermentable material. There are several types of derived fuels:

(i) fuel obtained by using a hydraulic press to separate out the phases in order to increase calorific value;
(ii) American RDF — an unsophisticated fuel which can be burned in combination with coal in large boilers;
(iii) European RDF — more sophisticated since it makes separate use of the organic fraction (as compost) and the combustible fraction, which, once it has been dried and granulated of flocculated, can be stored and transported.

(c) Recovering biogas at the tip: the layers of waste on a controlled tip undergo anaerobic fermentation which produces biogas.

(d) Methane fermentation: the fraction of the waste which is rich in organic matter is first sorted and then may be mixed with the sludge. It can then undergo methane fermentation to produce biogas which can be used for simple (heat) or combined (heat and power) production. This process is complementary to the production of RDF.

(e) Alcoholic fermentation of the cellulosic fraction: after hydrolysis to free the sugars, the cellulosic fraction of household waste (basically paper and board) can be subjected to alcoholic fermentation.

(f) Pyrolysis: pyrolysis is a non-polluting process for the thermal conversion of household waste into fuel-oil or gas.
Currently, the only pyrolysis technique which can be used for demonstration purposes is pyrolysis of tyres.

Seware sludge

The only way of obtaining energy from sewage sludge is by methane fermentation.
Although its use as a method of stabilization is well known, little has been done as yet to exploit the fermentation gas it produces.

Agricultural waste and by-products

(a) With waste and by-products, the most cost-effective method of obtaining energy is governed to a large extent by how wet they are. Dry matter should preferably be burned under boilers to produce heat or heat and power, whereas with extremely wet products the best methods are methane or alcoholic fermentation.

(b) Animal manure (from pigs, calves or poultry) accounts for a large proportion of farm waste. It may be fermented anaerobically to produce fermentation gas (50-75% methane) or may be mixed together, or with other urban or farm waste, before fermentation.

Industrial waste

Many industrial sectors produce waste from which energy can be extracted. Those offering the most potential are:

slaughter-houses:	stercoraceous matter, other waste and effluents
sugar refineries:	pulp and effluent
breweries:	effluent
distilleries:	residuary and unfermented liquor
starch factories:	effluent
lumber yards:	waste
leather:	effluent

These are various methods of obtaining energy from this waste:
- combustion;
- gasification;
- methane fermentation;
- alcoholic fermentation.

II. Community measures and national programmes

To date, the Commission has signed 10 energy-from-waste demonstration contracts for a total investment of 17.2 million ECU. The Community has granted support to the tune of 5.8 million ECU.
There are two other projects — one on the recovery of heat from a plant incinerating household and similar industrial waste (EE/003/80) and the other on the incineration of chaff (EE/121/79) — which are included in the section on "district heating".
The demonstration projects cover several areas:
- the recycling of plastics waste (EE/192/79);
- the production of RDF from household waste (EE/260/80);
- the recovery of fermentation gas from a controlled tip (EE/179/81);

Table C

Energy from waste

	B	DK	D	F	GR	I	IRL	LUX	NL	UK	EEC[2]
1. Proposals received								1			86
2. Projects supported	0		21	3			1		13	16	
3. Total support (million ECU)				2.9	1.5[1]			0.107		2.4	9.3
4. Support per project (ECU)		138,000	500,000			107,000		185,000	581,000		
5. Investment (million ECU)				9.7	3.44			0.952		9.3	28.9
6. Investment per project (ECU)		462,000	1,146,000			952,000		715,000	1,806,000		
7. Contribution to investment (%)				30	44			11		26	33
8. Projects completed							1		1	1	

1. Including research expenditure.
2. Community programme.

- the heating of an airport using fluidized bed combustion of waste (EE/033/80);
- the production of fermentation gas from agricultural waste (EE/260/80, EE/142/80, EE/285/79);
- the production of alcohol and fermentation gas from rice chaff and maize cobs (EE/001/81);
- the gasification of sawmill waste (EE/287/80);
- the pyrolysis of discarded tyres (EE/235/79);
- the incineration of urban waste and sewage sludge (EE/160/79).

All the different types of waste have been covered:

- urban waste (EE/192/79, EE/260/80, EE/179/81, EE/160/79);
- agricultural waste (EE/001/81, EE/285/79, EE/142/80, EE/260/80);
- industrial waste (EE/033/80, EE/287/80, EE/235/79).

Of all these projects, four are in their early stages, four are already in progress and one has been completed. This last (EE/142/80) involved setting up a reference and demonstration centre on anaerobic digestion. The following table shows the level of interest this sector has aroused, as indicated by the national programmes in France, Greece, Luxembourg and the United Kingdom.

III. Conclusions

Much has already been achieved in this field with the help of the Community. The one project which has been completed (EE/142/80 on the setting up of a reference centre) meets a real need in Europe, particularly in respect of summarizing and evaluating the practical applications and research being carried out in the Member States and studying how to use biogas and digestion products — the most important factors which determine the viability of plants.

Community action will undoubtedly enable progress to be made in agriculture, which is often unreceptive towards promising technological innovations.

Exploiting all the resources offered by this sector will require extensive commitments to demonstration and investment projects.

Incineration of household waste and methane fermentation of sewage sludge can now be considered as proven technologies.

Future demonstration projects should concentrate on:

- efficient and cost-effective methane and alcoholic fermentation systems, in respect both of the fermentation process and the uses of fermentation products and by-products;
- the recovery of fermentation gas from small and medium-sized controlled tips;
- the institutional aspects of the use of fermentation products;
- the use of industrial waste by industry itself;
- demonstration projects covering the best ways of incinerating agricultural and industrial waste and sewage sledge.

Demonstration projects will be required in respect of pyrolysis systems — apart from those for tyres — as soon as research has shown that plants of this kind are technically and economically feasible.

1.7. TRANSPORT

I. Introduction

Energy consumption in the transport sector represented in 1980, 24.5% (excluding maritime transport) of the Community's total energy consumption.

With the sole exception of rail traction, where there is a possibility of substitution by electricity, the operation of all transport is 98% dependent on oil.

In 1980 it still absorbed more than 44% of the oil consumed in the Community and forecasts for 1990 indicate that because of the reductions in oil impacts envisaged and because of the recourse that other sectors of the economy will have to

alternative energy sources, transport will account for more than half of the oil consumed in the Community.
As far as energy consumption by sector is concerned, road transport represents 84.4% of the energy consumed by transport (58% for public and private passenger transport, and 26% for goods); air transport uses only 9.9% of the energy in this sector; railways 3.4%, and inland waterways 2.3%. Energy consumption for maritime transport in 1980 was about 26 million toe, or about 16% of overall consumption.
The figures show the interest attached to paying closer attention to this sector which remains the one most vulnerable with regard to oil.
The necessity for and the importance of such efforts has been emphasised recently by the European Parliament in its Resolution of October 1981, and by the Council in December of the same year.
It should be underlined that the most significant energy savings can only result from a transport policy which lays down clearly the guidelines to be followed.
The main technical measures that can facilitate energy saving in the transport sector are as follows:

Road transport

Vehicles

- reduction of drag and rolling resistance (tyres);
- weight-saving without loss of active or passive safety;
- making clutch and gearbox systems more efficient and the introduction of new power transmission systems between the engine and wheels;
- recovering of braking energy, using flywheels or elastomers.

Engines

- reduction of mechanical losses;
- conversion of some vehicles to diesel power;
- combined cycle power plants; use of electric/hybrid propulsion;
- variable compression ratios;
- automatic microprocessor control; stratified charge engines; electronic fuel injection in place of carburettors;
- electronic ignition; monitoring of fuel consumption under varying conditions;
- use of modular engines;
- new supercharging techniques.

Maritime transport

- low-consumption diesel engines;
- use of low-grade fuel;
- slow-running propellors;
- propellors with thin, flexible blades;
- reduction of hull roughness;
- anti-fouling products;
- technical and economic flexibility of on-board electricity generation;
- use of sails as an auxiliary means of propulsion;
- stern design to improve flow of water towards the propellor;
- bow design for lower speeds (economic speed);
- use of shipboard computers to improve fuel consumption.

Railways

- general use of power electronics on traction vehicles;
- extension of recuperative electric braking;
- reduction of vehicle weight;
- improvement of aerodynamics;
- improvement of supply to the catenary;
- suppression of intersections;
- improved methods for regulating traffic flow.

Inland waterways

- reducing resistance to the movement of vessels;
- reducing the unloaded weight of vessels;
- improving the efficiency of the propulsion unit;
  - increased propellor diameter;
  - optimum speed reduction in the drive system;
  - propulsion by multiple propellors;
  - use of nozzles on propellors, in sofar as they do not already exist;
- recovery of residual energy by using exhaust gases to reheat fuel tanks, reheating heavy fuel oil where appropriate, and for the provision of hot water.

Air transport

- improved aerodynamics;
- improved engines;
- improved propellors;
- development of control equipment and use of computers to reduce unnecessary waiting time on the ground and in the air;
- substitute fuels.

II. Community action and national programmes

The Commisson has concluded six contracts of which two are for cars, one is for lorries and three are for electric vehicles. The 6 projects represents a total investment of 5.5 Mio ECU and financial support of about 2.2 Mio ECU.

- **Internal combustion engines**

All three projects in this field are valid, their interest lying chiefly in their post-demonstration scope. Project EE/178/80 concerning a modular engine has now been completed, and the results — consistent with the forecasts — are very valuable. Project EE/262/79 on electronic cold-start systems is still in progress, while EE/221/81 (energy recovery with a Rankine cycle, for use in lorries) has just begun.

- **Electric vehicles**

All three projects concern electrically-powered vans for use as company vehicles in towns. Two projects (EE/85/80 and EE/130/80) will use the same vehicles in different climatic and traffic conditions, while the third (EE/161/80) will use vans with a higher payload (800-1,000 kg). All three are in their early implementation stages.

III. Conclusions

As pointed out above, transport consumes almost one-fourth of the Community's energy. Out of the approximately 990 proposals received in response to the three calls for projects, however, only 75 (less than 8%) were concerned with transport. Of the projects selected, the proportion is still lower — less than 4%.
National programmes show the same relative paucity, except for that of France, where a number of applications for heavy lorries are being demonstrated.
The disproportion between the significance of the transport sector in terms of energy consumption and the number of related projects is the more surprising since transport, in contrast to other sectors of the economy, has exhibited in recent years, a significant increase in oil consumption.
It would be necessary to discuss with the parties concerned the reasons behind this relative lack of interest in demonstration projects by the transport sector.
More particularly, it would be desirable to carry out an analysis with the professional bodies concerned, at the Community level, and particularly in the sector of land transport, related to ways of achieving energy savings that reflect the potential that exists in this sector, and which can reverse the current tendency.

1.8. AGRICULTURE

I. Introduction

Agriculture accounts for nearly 8% of the Community's total primary energy consumption or approximately 76 million toe, broken down as follows: direct consumption 1.9%; indirect consumption (fertilizers and other agrochemicals) 3.7%; industrial processing of agricultural products 2.4%.
Although the opportunities for energy saving are modest in absolute terms, they are still significant in that they could ultimately represent 20% of the sector's total consumption.
From the energy standpoint, the agricultural sector has the advantage of being able to make productive use of low-grade waste heat scorned by industry, which often has difficulty disposing of it. The chief areas for energy saving are:

- drying of agricultural products (fodder, grain, etc.) using appropriate heat-recovery systems;
- improving the efficiency of industrial processing, and heat recovery e.g. in the dairy sector, sugar refining and brewing;
- generating electricity with biogas, in livestock rearing (pig units in particular);
- transfer of low-grade heat to farms, glasshouses, etc., by means of heat pumps; insulation and improved ventilation in the heating of farms and stock-rearing units in particular;
- heating of greenhouses or tunnel cloches with waste heat from industry.

II. Community action and national programmes

The Commission has signed three contracts so far. Investment totals 1,914,000 ECU, with financial support of approximately 703,400 ECU.
The aim of the first project (EE/278/79) is to use waste heat from thermo-electric power stations for agricultural purposes and that of the second (EE/209/79) to use the waste heat from a nuclear station in farming. The differences between them relate to climate, the source of heat and the production of different agricultural products.

The third (EE/002/80) — concerned with improvements to a fodder-drying plant — is more industrial than agricultural. It has been completed and has provided energy savings of 200 toe in the course of a fodderdrying campaign. The others are in progress and their value lies in exploiting waste heat.
Agriculture is represented in all the national programmes. The United Kingdom, for example, is supporting six projects and has provided aid totalling 0.7 million ECU, equivalent to 36% of a total investment of 1.8 million ECU. In Greece three projects with a total investment of 0.8 million ECU have received 100% support.

III. Conclusions

The three projects are in different countries and different sectors of agriculture.
One (EE/002/80) has been completed and is already making substantial energy savings, given its size. If the process were applied to all fodder drying throughout the Community it would save some 10,000 toe/year.
It is to be feared, however, that diffusion of the techniques demonstrated will not be easy because farms are scattered. The demonstration programme is therefore unlikely to bring all the expected benefits, so it is suggested to cut back the programme in this sector. It would be emphasized, however, that many proven techniques may be extremely useful in this sector and also be eligible for support, and Community support in particular, from financial instruments better suited to the needs of farming enterprises.

1.9. ENERGY SAVING — CONCLUSIONS

1. The potential energy savings in the Ten are very large. Estimated savings in 1990 are 60 million toe/year in the building sector; 50-60 million toe/year in industry; 30 million toe/year in the transport sector; and 10-15 million toe/year in agriculture. The potential savings from district heating and the combined heat and power can be put at 50 million toe/year, with a further 50-60 million toe/year for energy from waste. In total terms, bearing in mind a degree of overlapping between sectors, the savings may be estimated at 130-150 million toe/year for the Community in 1990 or 12-14% of gross energy consumption.

2. The anticipated energy saving from Community projects already approved is about 700,000 toe/year. Depending on the nature of the projects and on the efforts made to disseminate the results, an important multiplier factor could be expected.
The characteristic feature of these projects is that the energy savings obtained vary depending on the technology which they employ. In the industrial sector, for example, one project alone (EE/074/80) will save a steelworks 100 000 toe/year; the nine projects in the residential building sector will achieve no more than 60 toe/year. This is due to the inherent differences between the sectors and the nature of the projects. In some sectors, such as building or transport (where each unit has a low energy consumption but is also representative of a large stock or fleet: one-family houses and motor vehicles) the amount of energy save by a given project is small but potentially very high in terms of the number of similar applications possible.
In other cases, for example project No. EE/142/80, for the establishment of a European centre for the re-use of wastes, the importance of the project lies not so much in the potential direct energy savings as in its value as a demonstration and in promoting the diffusion of promising technologies.

3. The average investment and support for the 186 Community projects is 1.47 million ECU and 0.43 million ECU respectively.
Turning to the national programmes, a number of Member States (France and the United Kingdom in particular) tended to support a large number of fairly low-cost projects (914 in France, with an average level of support of 0.034 million ECU; 166 in the United Kingdom, with an average level of support of 0.11 million ECU). One Member State (the Federal Republic of Germany) selected only 30, with support averaging 4.9 million ECU.
As can be seen, Community action falls midway between these two extremes.
This is due to the Community's need (a) to offer - on a fairly limited budget — the same demonstration opportunities to the maximum number of economic operators throughout Europe and (b) to keep within the limits imposed by its ability to manage projects and its coordinating and incentive role.

4. Since the Community programme covered a fairly wide range of possible applications, a large number of proposals was received; this enabled the best to be selected.
The majority of the projects accepted are of a high technical standard. They reflect the predominant technological trends in their fields; often they are a follow-up to an R&D phase financed from national and/or Community sources. Of the 23 projects whose results can be assessed, 13 can be reckoned a complete success and their commercial exploitation assured; the other ten are a partial success; in the case of one project, (EE/022/79) concerning a fluidized bed, repayment of the Community's financial contribution has already begun.

5. Although the programme should offer a fairly broad range of applications, greater attention should be directed in future to industries which are big consumers of energy and to tertiary-sector buildings, to fluidized-bed technology and to energy from waste. In other sectors, such as transport, agriculture, residential buildings, specific industrial sectors and remote (e.g. district) heating, efforts should be pursued within the fairly tight limits imposed by the nature of the sectors, as mentioned in the assessment (evaluation) report.

6. To conclude, when Regulation No. 1303/78 comes to be amended, it would be expedient to extend its scope to projects which, while offering a modest energy saving, are concerned with the replacement of oil by alternative and renewable energy sources or ones in secure and abundant supply.

Table D

Energy Saving Programmes

	B	DK	D	F	GR	I	IRL	LUX	NL	UK	EEC[8]
Start of programmes	1976[1]	1976[2]	1974[2]	1975	1979[2]		1981	1979	1977	1978	1979
1. Proposals received				(827)[4]			95	21	150		991
2. Projects supported			30	914	12		9	12	50	166	186[6]
3. Total amount of support (m ECU)			147.5	30.9	7.6[7]		0.46	0.14	5.4[5]	18.2	80.7[6]
4. Support per project (ECU)			4,917,000	33,800	633,000		51,000	12,000	108,000	110,000	434,000
5. Investment (m ECU)				88	19.5		10	1.14		74.5	273
6. Investment per project (ECU)				96,000	1,625,000		1,111,000	95,000		449,000	1,470,000
7. Support as a percentage of investment			63[3]	35	39		5	12		24	30
8. Completed projects				552	3			12			23

1. Prototype development programme.
2. RD&D programme.
3. Average of all RD&D in the RUE sectors.
4. Excluding Building sector.
5. Budgets for 1977-81.
6. Projects approved by the Commission. Projects withdrawn by proposers represent a total of 10.6 million ECU.
7. Including research expenditure.
8. Community programme.

2. ALTERNATIVE SOURCES

2.1. SOLAR ENERGY

2.1.1. Introduction

Solar energy is clean, inexhaustible and abundantly available; however, its density at the earth's surface is relatively low (a maximum of 1 kW/m^2) and varies considerably according to the time of day, the climate and the season. This energy source is therefore unfortunately only available to us in an extremely irregular fashion.

Although wind and wave energy are also considered to be forms of energy derived from the sun, this chapter discusses only projects for the use of solar energy proper.

Solar energy is used mainly via the following methods:

- the production of heat at different temperature levels;
- the direct generation of electricity by means of photovoltaic solar cells;
- the utilization of biomass.

R&D at both national and Community level have focused on these main lines of development. According to the resources that will be devoted to RD&D and other promotion activities, it can be estimated that the contribution of solar energy at the end of the century will amount to approximately 60 million toe, which represents 5% of the Community's estimated primary energy consumption at that date, namely 1 200 million toe. This figure, which depends largely on the way oil prices are assessed, could be broken down roughly as follows: heating applications: 3%, photovoltaic conversion: 0.5% and biomass: 1.5%.

For the purpose of this assessment, the projects supported by the Commission have been grouped together into three fields according to the extraction technologies applied:

- solar heating;
- photovoltaic conversion;
- biomass.

2.1.2. Solar heating

I. Introduction

The difficulty encountered in applying solar heating technologies resides in choosing the optimum solution from an energy standpoint. The following are the main areas in which such technologies are applied:

- buildings, with passive and active solar heating systems;
- swimming pools;
- agricultural applications;
- industrial applications.

(a) Buildings

Passive solar heating systems fall rather within the scope of architectural design and microclimatic parameters. The most widely-used systems are greenhouses, storage walls (e.g. of the "Trombe" type), ventilation by temperature differential, direct gain through the windows, etc.

An *active solar heating system* requires technical components that enable the solar installation to operate with back-up from devices such as pumps or blowers.

The utilization problem is closely connected with that of storage (day/night, fine weather/bad weather and summer/winter), which normally applies only to small units (the heating of individual dwellings between 100 and 200 m^2 in area, of apartment complexes covering between 1 000 and 5 000 m^2, and the operation of water heaters providing between 300 and 5 000 litres of hot water at approximately 50°C per day).

(b) Swimming pools

The conventional techniques used to reduce energy requirements essentially comprise covers for open-air pools and the recovery of energy extracted from indoor pools.

The following solar systems are in current use:

- simple unglazed collectors, from which the heated pool water is drawn;
- flat glazed collectors with heat exchangers for indoor pools and the production of hot water.

(c) Solar energy applications in agriculture

The main applications in this area are:

- heating of greenhouses;
- crop drying;
- various other energy requirements (e.g. preparation of feedingstuffs).

(d) Industrial or similar requirements

The systems to be demonstrated depend on the process temperatures required:

30°C - 50°C: ordinary flat collectors;

50°C - 120°C: evacuated parabolic through collectors;

80°C - 300°C: concentrating collectors.

Increased use of solar energy in industry depends on certain factors such as the daily process heat requirements, the presence of competent technicians and profitability constraints.

II. Community action and national programmes

The Commission has selected 65 projects in this sector, of which 12 have been withdrawn by the proposers. The 53 projects represent a total investment of 32.5 million ECU and receive financial support amounting to 8.8 million ECU.

The contracts had not been signed for all of these projects when this evaluation took place. Consequently valuable results were only available from the projects from the first call for proposals (11 running contracts). Two of these 11 projects are completed, the others are well advanced.

The 53 projects receiving support can be divided into sub-sectors as follows:

1. Sub-sector		Number of projects
Buildings		19
of which		
– hot water production	4	
– hot water + heating	8	
– heating	4	
– heating + air conditioning	1	
– heating, air conditioning and hot water production	2	
Agriculture		6
Industry		6
Swimming pools		22

According to the technology used, these 53 projects can be grouped as follows:

2. Technology		Number of projects
Passive systems		3
Flat plate collectors	39	
Concentrating collectors	7	
Active systems		46
Active + passive systems		4

This distribution of projects indicates that all the sectors are covered. The high number of projects in the housing and building sector (see also 1.2.) underlines clearly the fact that this sector will be in future the most promising one from the viewpoint of replacing primary energy for heat and hot water supply. It is regrettable that not all the projects in this sector make sufficient use of passive energy conservation systems as a precondition for active systems. The technology used, mainly flat collectors, is mostly well proven. But in spite of this, only very few projects are economic or near the economic threshold.
The application of solar energy for swimming pool heating is the field where solar projects reach the best economic results. Due to the low temperature needed simple and cheap unglazed collectors are normally used for outdoor pools working with excellent thermal heat exchange efficiencies. Pay back periods down to 5-8 years are achieved. More expensive glazed collectors are used for indoor pools or, if used for outdoor pools, permit the extension of the bathing season. This sector covers 55 individual public pools, spread over all Member countries. The annual production by the solar installations of these pools is estimated at about 1,500 toe. The results of the coordinated monitoring programme will stimulate a better design of future solar heated swimming pools. Besides the effect of oil-substitution by the solar collectors the big number of pools (and collectors) permits an industrial mass fabrication and the capability of solar energy is well demonstrated to a large public using the pools.
The agricultural and industrial sector are represented by some projects. The agricultural projects which use simple technologies (flat plate collectors) for the production of process heat at temperatures below 50°C could bring useful results for future economic plants. The industrial projects with temperatures above 200°C use sophisticated technologies which are far from being economic. The following table shows the demonstration projects in progress in the Member States.

Table E

Solar heating

	B	DK	D	F	GR	I	IRL	LUX	NL	UK	EEC[4]
Start of programmes	1978	1976	1978[1]		1979		1980	1979	1978		
1. Proposals received			180				1	10	20		210
2. Projects supported			104	9[2]	4		1	3	15		55
3. Total support (million ECU)			21.1	0.4[2]	1.4[1]		0.29	0.14	1.1		9.5
4. Support per project (ECU)			203,000	45,000	350,000		290,000	47,000	75,000		173,000
5. Investment (million ECU)			21.1	0.8[2]	1.4			0.71	2.2		34.6
6. Investment per project (ECU)			203,000	90,000	350,000			235,000	147,000		629,000
7. Contribution to investment (%)			100	50	100			20	50		27
8. Project completed			ca. 70	6	—			1	5		3

1. Demonstration programme conducted in public buildings (ZIP [forward-investment] programme).
2. AEE programme only; the COMES has a 1979-82 budget for the solar heating, photovoltaic conversion and wind power sectors of approximately 45 million ECU, of which 60% is devoted to demonstration.
3. Including research expenditure.
4. Community programme.

III. Conclusions

In summary it can be said that for this sector the programme in its present conception has certainly helped and will still help the solar industry to find its orientation in the solar energy field, to get confidence in good promising applications and to abandon problematic issues.
Due to the high diversity of technologies applied in the different fields and taking into account the very early stage of many of the projects, it is extremely difficult to estimate on the basis of the results obtained with some projects the possible contribution of thermal solar technologies to the energy balance of the European Community.
The national distribution of the different projects indicates that priority is given in northern and middle regions of the Community to the housing sector mainly due to the high energy demand for heating. A greater interest for agricultural and industrial projects exists in the southern regions where higher daily and yearly periods of sunshine encourage such projects.
There is a high potential for export markets for most of the solar applications demonstrated.
It is a very positive aspect of the Programme that the size of tendering firms varies between very big companies and small private companies.
In future emphasis should be given to projects including:

- passive solar systems and combinations of passive and active solar systems;
- seasonal storage systems;
- solar greenhouses;
- solar drying processes.

Industrial projects with high process temperature (>200°C) should only be supported if simple technologies could be used. Present projects are often very sophisticated leading to very high capital costs which cannot be recuperated durint the life-time of the plant by the amount of solar energy produced.
Preceding R&D should better be integrated in the project design. The contractors should still more take into account and exploit results of R&D on national and international level.
Taking into account the importance of the programme for solar-heated swimming pools presently carried ot by the Commission and the state of commercialisation reached by the technologies applied in this field, it does not seem that there is any need for further demonstration projects in this field.

2.1.3. Photovoltaic

I. Introduction

The direct conversion of solar energy to electricity by photovoltaïc solar cells is one of the most promising of the new solar technologies. Solar cells can make use of diffuse as well as direct sunlight and have the advantage of silence, cleanliness, simplicity, modularity, long life and easy maintenance. Although still expensive, they have become progressively cheaper over the past seven years and there is considerable scope for further cost reduction.
The photovoltaic cell cost being today on the free market about 7-10 $/Wp, a cost reduction down to 1-2 $/Wp in the future might be achieved by using highly automised production lines for producing big numbers of cells (mass production effect) and by cheapening the presently used silicon as cell material. Further cost reduction underneath 1 $/Wp sill require considerable effort in the development of the basic cell material and the application of thin film cell technology.

Solar cells are already economically viable for many remote stand-alone applications like telecommunications, remote instrumentation, navigation lights, radio beacons, cathodic protection of pipelines, highway warning signs, alarm systems, etc. There is a rapidly growing commercial market for such applications. Before 1990, photovoltaics may well begin to compete with diesel generators for such applications as water pumping, disinfection, desalination, irrigation and rural electrification, particularly in developing countries.

II. Community action and national programmes

Out of a total of 25 proposals in photovoltaics received on the two first calls for tenders, 4 projects have been selected for financial aid. These 4 projects represent a total investment cost of 1,085 MUCE and receive a financial aid of 418,401 UCE.

ELF's micro-irrigation project (SE/77/79) is clearly the best of the four. Well conceived, executed and operated, the system has worked satisfactorily since 1979, providing valuable data and publicity which will no doubt help to promote the future optimisation and exploitation of solar irrigation. The involvement of agricultural research institutions has greatly contributed to the success of the project.

The other three projects all embody more advanced components, and therefore involve a much greater element of technological risk.

Galileo's project (SE/17/79) would have fared better had they, like ELF, chosen a fixed flat-plate array of proven modules and limited themselves to a demonstration of agricultural cooling. As it is, they have had to contend with serious technological problems in the concentrator system and are now faced with the almost impossible task of obtaining further supplies of the special solar cells.

Louvain (SE/29/79) have also encountered problems in the development and in house manufacture of their advanced low-cost solar cells and modules, which have delayed the construction of the generator for their electric car project. But they have learned a lot and hope to start operating and monitoring the system in June this year. With the elimination of battery changing and the choice of an energy-efficient car with regeneration braking, this could yet prove an interesting and successful demonstration. Economic viability, however, is further off than in the case of water pumping and irrigation and it depends, inter alia, on a marked improvement in the performance and range of electric vehicles.

It is perhaps too early to pass judgement on Ghent's project (SE/147/81) but the conception is good and, if it is well executed, it should provide an excellent opportunity to study and demonstrate all aspects of a grid-connected solar generator. The importance of good public exposure has been realised and the co-operation of the local utility company should be of mutual benefit.

The Netherlands, Ireland and Luxembourg have each adopted a project in this field. The Netherlands envisage the carrying out of an investment of 0.75 MECU with the help of financial support of 0.22 MECU (30%); Ireland is in course of completing a project with financial aid of 1.16 MECU, and Luxembourg has granted 0.1 MECU to an investment project of 0.6 MECU (18%). Greece has supported four investment projects of around 3 MECU with a total of 0.84 MECU (28%).

III. Conclusions

Already the fact that out of 240 solar proposals received, only about 10% were photovoltaic projects and that out of these 25 photovoltaic proposals only 4 i.e. less than 20% were selected, receiving a total financial aid of about 0.418 MUCE, i.e. than 2% of the total sum of 22.5 MUCE provided for 84 projects selected, shows that the photovoltaic technology has not yet reached the same state of development and maturity as it is the case in other fields of solar energy use.

In a short range, commercial application of photovoltaics will be limited to specific purposes and sites with low consumption like telecommunication, remote instrumentation, highway warning systems, alarm systems, electricity supply to remote houses or refuges in high mountains or other isolated areas, etc. However this is a negligible energy supply and is without any tangible influence or consequence on the energy balance of the Community. The technology applied in this field in normally modest dimensions is well developed and needs no more substantial aid in the framework of the Commission's demonstration programme.

In a medium range, photovoltaics may be applied in the field of electricity supply for remote establishments like farms, mountain hotels or restaurants, small groups of remote houses, etc., and this in Community countries, but also in developing countries. The demonstration of the operating behaviour (dynamic behaviour under different load conditions, behaviour under various meteorological and climatological conditions in different geographic areas) of well designed flat-plate module photovoltaic installations in the power range of some KW with adequate power conditioning systems should be the subject of future photovoltaic demonstration projects in the Commission's programme. However besides these technical considerations, a perceptible cost reduction of the cells available on the market is indispensable (necessary).

In the field of large scale electricity production, photovoltaics will have to compete with electricity produced by central power stations, the efficiency and economy of which have been brought to excellent values after a long period of technological development. Therefore large-scale photovoltaic electricity production should be considered as a long-range aim.

The efforts made in the framework of the photovoltaic pilot plant programme run by DG XII presently will make an important contribution to further development of photovoltaics towards the demonstration stage and even further. The results of these pilot projects will be an important help in the definition of future demonstration programmes in photovoltaics.

2.1.4. Energy from Biomass

I. Introduction

The subject of energy from biomass involves the conversion of renewable material of biological origin to useable energy obtained directly in the form of heat or through intermediate solid, gaseous or liquid fuels, and the generation of electricity.

In its treatment as a subject for R&D and demonstration programmes the techniques, which are essentially common to basic types of material, overlap into the subjects of energy conservation and waste treatment.

Though the basic technologies are understood, their feasibility in individual cases depends primarily on economic factors — the opportunity cost of the feedstock, the competitive cost of conventional fuels, and the cost of the equipment. The state of art of the main lines of development in terms of feasibility of different propositions can be summarised as follows:

Combustion

Many possibilities exist for the conversion of fossil fuel plant to use biomass material.

Thermal gasification

There are a number of developments of relatively small-scale equipment in Europe and elsewhere using new and improved designs. Some of these can be regarded as being commercial propositions. An optional subsequent stage to gasification — liquid fuel synthesis — is still essentially at the R&D stage, as is pyrolysis or direct liquefaction to form synthetic liquid fuels.

Fermentation

The technologies of alcohol production for the beverage industries are very well advanced and further advances in the synthesis of alcohol and other potential fuel chemicals are predicted as one of the main thrusts of biotechnology. However, lower value fuel alcohols may prove to be too costly to produce and in some the processes consume more energy than is contained in the alcohol produced.

Anaerobic digestion

This is recognised as being highly suitable for extension to demonstration phase from the very extensive R&D activity now underway on a variety of materials, but particularly cattle waste. A key factor in economic feasibility is seen to be the size of digester or through-put of material.

Energy crop production

There are several prospects for these: catch-crops grown as part of established agricultural rotations; energy plantations of special energy crops grown on land dedicated in the long-term to this form of production, and including short rotation forestry; various sorts of aquaculture using micro-or macro-algae.

Depending on the nature of the material produced either established combustion or digestion methods may be used for conversion.

Considerable R&D has been done and in the case of catch crops and energy plantations some schemes are clearly suitable for demonstration.

The above notes indicate the broad lines of major development potential. However, the wide variety of prospects and the relatively small scale of most projects means that there may be opportunities for individual cases of all kinds to stand on their own merits.

A key point is the often close integration of biomass energy schemes with the sectoral activities with which they are associated. In consequence it is not always possible to separate easily the costs of the energy-conservation components of a scheme from other parts of it. For instance the biomass energy route may be "built into" a waste disposal facility. Biomass routes may also be closely integrated with other renewable alternative energy systems and a number of the demonstration schemes dealt with here are of this kind.

II. Community action and national programmes

Out of a total of 38 proposals in biomass received on the two first calls for tenders, 15 projects were selected for financial aid. These 15 projects represent a total investment cost of 32 MUCE and receive a financial aid of 10.6 MUCE.

For two of the projects selected it was decided not to proceed with the Commission's offer of support.

A wide range of project types is being demonstrated, broadly consistent with the main opportunities perceived and lines of technological development favoured in Europe:

- 7 out of 10 projects are concerned with digestion, 3 of these in association with other alternative energies like solar and wind energy;
- 3 are primarily concerned with combustion and this is a minor component in one other;
- 1 is concerned with gasification;

- 3 utilise cattle waste as the sole feedstock and this is a major component of 3 other schemes;
- 2 are wholy concerned with poultry waste and 1 wit pig waste. These are components in 3 other schemes;
- 2 schemes utilise dry crop waste and this is a component in 1 other;
- 2 prospects deal with energy crops.

Energy contributions vary from a few tens of tonnes oil equivalent saved each year to 11,000 toe/y, and from small more or less continuous electricity supplies to 5 MW main load provision. Successful projects will result in total or part self-sufficiency in energy and in 3 cases there is provision of electricity to the national networks, either arising as a surplus or as the main or major aim of the project.

On the criteria of project cost per toe saved and investment repayment times, projects show considerable differences. This is, however, partly due to the inclusion, in a number of cases, of substantial elements not directly or not fully attributable to the energy generation and supply systems. In some cases the energy-conservation elements are so integral to the system that they cannot be satisfactorily separated out and costed.

The projects are all supported by substantial R&D, usually from a variety of international sources, and, as demonstration projects, are primarily concerned with the new application of proved equipment and techniques in environments ranging from individual farms or agri-industries to communities and national utilities.

III. Conclusions

The importance of biomass in solar energy is underlined by the fact that some 40% of the solar budget is being used to support biomass demonstrations. Two of the demonstrations are particularly important — Bord na Mona and Société d'Energie Electrique de l'Est — and account for approximately 30% of the total solar budget. Although it is yet too early to judge whether or not these two major "energy plantation" projects will provide energy at economic cost, a certain optimism is justified.

Small scale technology is not neglected in the programme and demonstrations at the farm level e.g. Azienda Zooagricola il Prato S.p.A. (226/81) and A.I.R.D. (45/81) offer good prospects. Experience obtained in such demonstrations will allow the development of applications inside the Community and outside in the developing countries.

The biomass research programme of DG XII, particularly the biomass pilot projects, will make a useful contribution in the development of new techniques in the demonstration phase.

Commercial prospects arising from successfull demonstrations will be:
- Energy cost-saving in individual situations that are translatable to major agricultural and industrial sectors both inside and outside the Community.
- Direct contributions to public electricity supplies.
- The promotion of sales of a wide range of specialised and general purpose items of equipment resulting from the creation of substantial new markets, inside and outside the Community.
- Similar major prospects for system engineering expertise worldwide.

In the future, apart from guidelines given in the conclusion to chapter 1.6., demonstration in this area should concentrate mainly on energy crops, including short-rotation forestry and catch crops.

2.1.5. Conclusions of the "solar energy" sector

The Community programme has covered the main utilisations of solar energy; these are the thermal use, the photovoltaic use and the use of biomass. The thermal solar and the biomass technologies are more advanced than the photovoltaic technology, which is shown also by the number of projects proposed and selected in these three fields.

The thermal use of solar energy is at the moment most advanced, especially the application of low temperature collectors for the production of hot water and heating in the building and tertiary sector. Two thirds of the thermal projects of the Community programme cover this sector; the remainder concern agricultural and industrial applications (this latter with more advanced collectors for higher temperatures).
The shortest pays-back periods of 4-5 years are presently reached by very simple low temperature collector systems as they are used for swimming pool heating and for warm water purposes in agriculture.
Emphasis should be given in the short term to the following solar projects:
- passive solar systems and combinations of passive and active solar systems;
- seasonal storage systems;
- solar greenhouses;
- solar drying processes.

Very few photovoltaic demonstration projects are supported by the Commission up to now, mainly due to the fact that this technology is still in full development. Only a considerable cost reduction in photovoltaic cells could bring such projects near the economic threshold. One should wait for the results of the pilot plants realised in the framework of national and Community R&D programmes before further demonstration projects should be started.

The use of biomass is very promising for the future in respect to the substitution of hydrocarbons. One fifth of all Commission solar projects with a financial volume of 40% of the total solar budget cover this sector; most of them produce biogas by anaerobic digestion of animal waste and some of them are based on combustion of solid agricultural waste or energy crops. The combustion and digestion technologies are already now economic or near the economic threshold. Further projects in these fields will be promoted but also those using other technologies (gasification, etc.) when the R&D phase is finished.
The degree of utilisation of solar energy will result in future from the influence of the following main factors:
- cost of installations;
- their reliability;
- support to investment;
- evolution of fuel prices.

The results of the Community demonstration programme will mainly influence the first two of these factors.

2.2. GEOTHERMAL ENERGY

I. Introduction

Two types of geothermal energy source currently lend themselves to exploitation:
- "high-enthalpy" sources comprising reservoirs of steam or water/steam mixtures at temperatures exceeding 150-200°C, mainly tapped to produce electricity;

- "low-enthalpy" sources consisting mainly of reservoirs of water at temperatures lower than those quoted above, which are in the main tapped to provide space heating for dwellings or other premises and to heat greenhouses.

At the current state of the art within the Community the prospects for developing geothermal energy are attractive in several countries. Although in the short term prospects are brightest in France, Greece and Italy, where the exploitation of indigenous energy sources is of special importance in view of these countries' energy dependence, other countries, and in particular Belgium, Denmark, the Federal Republic of Germany, the Netherlands and the United Kingdom could derive medium-term benefit from this energy source.

It is no easy matter to make a quantitative estimate of the likely uses of geothermal energy, in view of the hazards involved in discovering and tapping sources. Nevertheless, broad approximations can be made on the basis of the studies, research and projects under way. In 1990, roughly 2,000 MW of electricity could be derived from geothermal sources and by the end of the century the figure could reach 5,000 MW. Annual production would be about 40 TWh (= 9.2 million toe). The number of dwellings heated by geothermal energy could be about a million in 1990 and 4-5 million arond the turn of the century, or in other words about 3% of all dwellings within the Community. If the equivalent fuel consumption per dwelling is 2 toe, geothermal energy could provide 8-10 million toe for space heating. Overall, therefore, geothermal energy could contribute about 20 million toe per year towards the Community's energy requirements by the turn of the century. These figures could be higher if the research into "hot rocks" could lead quickly to industrial-scale use.

Although this particular source cannot cover much of the energy requirement, it is nevertheless especially important at local level in certain regions of the Community and enables more rational use to be made of energy if only for transmission reasons. In addition, the development of a Community "geothermal industry" may have beneficial effects on industry and on the balance of payments in view of the potential extra-Community market.

II. Community action and national programmes

Since Regulation 1302/78 was adopted three calls for proposals in the geothermal energy field have been published. The 44 projects adopted[1] represent a total investment of 300 million ECU. Community financial support amounts to 28 million ECU.

It must be stated that a typical project is divided into three main operating stages:

- the drilling stage with the sinking of the production borehole or boreholes and, if needed, the reinjection boreholes. The results of this stage are decisive for the future of the project;
- the placing in service of the well or wells, installation of the pumping systems for distribution and reinjection as appropriate;
- the construction and placing in service of the surface facility intended to tap the geothermal energy sources.

In most cases Community support is granted on a stage-by-stage basis. Most of the projects are currently at the drilling stage, which is therefore receiving most support. It should be noted that several of the projects adopted for demonstration purposes had already received Community research support, thus providing a logical link between research and demonstration.

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1. Including the nine projects adopted on 16 November 1981 under the procedure provided for in Article 6(2) of Council Regulation 1302/78.

The state of progress of the projects adopted is as follows:

– exploitation begun	2 projects
– surface facility being built	2 projects
– drilling stage completed	14 projects
– drilling stage under way	7 projects
– in preparation[1]	14 projects

In view of the diversity of the projects and their state of advancement it is not easy to lay down rigid assessment criteria. The projects were firstly grouped together by field of application so that the level of exhaustiveness and representativeness of all the options explored could be appraised, as could the coordination and interaction between the various projects. Secondly, each project, depending upon its state of progress, was assessed from a technical/economic standpoint against the targets and the likelihood of obtaining practical results having general appeal.

The fields in question are as follows:

(a) space heating and the heating of buildings in the tertiary sector;
(b) greenhouse heating;
(c) energy production from brines;
(d) electricity production from endogenous steam;
(e) production of electricity in combination with other activities;
(f) use in industrial processes.

Field (a) comprises 31 projects, field (b) 8 projects — some of which also cover space heating — and field (c) comprises 5 projects, while the remainder consist of one project each.

Projects concerned with space heating and the heating of dwellings, tertiary-sector buildings or greenhouses are by far the most numerous. This is because it is possible to tap "low enthalpy" sources in most of the Community countries, whereas "high enthalpy" is only exploited in Greece and Italy.

Several projects demonstrating the heating of dwellings, tertiary-sector buildings and greenhouses have proved their worth by demonstrating the existence and potential use of sources in regions of the Community where geothermal energy had been unknown. This was particularly the case in certain regions of France (where, following the initial Community projects, others are now under way) of Northern Italy, of Northern Denmark and of South Western Germany.

There are other projects in "geothermally new" regions, but so far no results have been available. Where it has been possible to assess how far the energy sources in all of the projects in this sector can be tapped, one can say that about 60% of the estimated potential of the geothermal energy can be recovered to heat dwellings and tertiary-sector buildings and about 90% to heat greenhouses. These percentages must be interpreted with care since (a) the risk, mainly at the drilling stage, inherent in geothermal energy projects is always high and (b) there is always considerable uncertainty when estimating potential. It must also be stressed in general terms that even where a project is abandoned after the drilling stage, the geological and technical information and know-how acquired are always considerable.

Electricity generation from high-temperature brines holds great appeal. Indeed, this may prove to be a good way of extracting considerable quantities of energy from existing geothermal sources. The results so far obtained from demonstration projects allow it to be stated that about 50% of the estimated geothermal energy can be recovered. The progress made so far by the projects in the other electricity-generation sectors does not enable the recoverable resources to be assessed. The difficulties in exploiting such sources are considerable, but if positive results are obtained the prospects are so bright that the high risk factor can be considered acceptable.

Finally, it is regrettable that the use of geothermal energy for certain industrial processes has so far led to no demonstration projects. The only project adopted, which was highly promising and which involved heating and drying operations in a malting had to be withdrawn by the proposer because of administrative difficulties. In future special attention would have to be given to the promotion of projects of this type.

National action

Although the demonstration stage has now been reached in most Member States, an ad hoc funding programme for demonstration projects only exists in France. In the other Member States there are no special structures for demonstration projects and such projects are funded out of what are virtually R&D budgets. It is for this reason that the Community support scheme has proved of interest to project promoters and it has helped to spur and speed up several projects.

In Italy and Greece the most advanced projects concern electricity generation. This is because high-temperature sources exist in these countries. There are, however, also a number of projects concerned with the heating of residential buildings and greenhouses. It is in these two sectors that other Member States are concentrating. France has a large-scale support programme and Community funding plays an important back-up role. In the Federal Republic of Germany the number of projects is increasingly rapidly although funding problems have halted several projects. The Community funding scheme has been of great interest to local authorities and private promoters in this country. In the other Member States, particularly Belgium, Denmark, the Netherlands and the United Kingdom the demonstration stage has been reached with a number of preliminary projects. Practically all of these have been adopted for demonstration projects at Community level.

As far as geothermal energy is concerned, it should be noted that:

(a) with the exception of France, there are no special funding schemes for demonstration projects in the Community;

(b) in most Member States a system of financial support is needed for demonstration projects albeit at different levels and following prior research work;

(c) initial results have shown that the Community funding scheme acts as an important incentive.

III. Conclusions

At a general level it should be noted that the Community support scheme has promoted several practical projects to exploit geothermal energy sources. These have been confined in the past to the Paris region for space heating and central Italy for electricity generation. The emergence of projects in a number of regions in France and Italy, Denmark, the Federal Republic of Germany, Greece, the Netherlands and the United Kingdom, is a welcome development.

Although the project leadtimes do not make it possible to make a full technical and economic assessment of Community action, it has been found from the study made that:

(a) for projects concerning the heating of residential and tertiary-sector buildings the recoverable geothermal energy is 60% of the estimated potential;

(b) for greenhouse heating projects it is nearly 90%;

(c) for projects concerning electricity generation from high-temperature brines it is 50%.

Geothermal projects entail high drilling risks. The volume of sources which can actually be exploited are often less than the potential estimated before drilling.

Although the number of demonstration projects for space heating may seem disproportionate compared with those for electricity generation this should be seen as a positive development. Low-enthalpy sources are more widely spread than high-enthalpy sources and the development of geothermal energy in the Community is dependent on their exploitation being demonstrated.

From the technical viewpoint, once the geothermal source has been located by drilling, some projects have been delayed by problems such as the clogging up of wells and scaling of surface facilities, corrosion, availability of equipment particularly submersible pumps which can work in contact with fluids which are often of a high salinity and at a high temperature. This is due to the fact that oil technology has been used in the main and this is not always suitable for geothermal energy.
Finally, the preliminary results of the most advanced demonstration projects are encouraging and several of them have proved to be commercially exploitable.
The major share of Community support has been for the drilling stage to locate new geothermal reservoirs. This is a vital stage in development of geothermal energy. Although this stage is well on its way it is not yet completed. There are still a large number of potential areas which have yet to be developed or explored in the Community. A large proportion of the funds available should, however, also be devoted to the development of techniques researched which might improve the exploitation of the sources discovered.
A special effort will have to be made in the future to promote projects concerning applications of geothermal energy to industrial processes such as heating and drying and its applications in agriculture (heating of greenhouses) for which low-temperature sources are particularly suitable.

2.3. LIQUEFACTION AND GASIFICATION OF SOLID FUELS

I. Introduction

Since 1973, there has been world-wide renewed interest in the conversion of solid fuels, particularly coal, into gaseous and liquid products to be used as substitutes for other energy carriers. The latter have become very expensive and their reserves are expected to decrease. This interest is being demonstrated by highly-intensified R&D work, within the Community and other countries, concentrated on the three technical routes of conversion.

I.1. Technology

Gasification of solid fuels

A first stage in nearly all current processes is to gasify coal or other fossil fuels by means of oxygen (or air) and steam to yield a medium (or low) calorific value gas, substantially a mixture of carbon monoxide and hydrogen (plus nitrogen when air is used) and generally called synthesis gas because after purification and catalytic treatment it can be converted into methane (equivalent to SNG), methanol, ammonia and other synthetic chemical entities.
Although the chemical processes for gasification are long established, there are two vital aspects which must be tackled to ensure that the transition to solid fuels is an orderly progression. These aspects which must be demonstrated to ensure success are:
- improved reliability, consistency and overall economics of the process;
- capability of dealing with a wider range of solid fuels and the high proportion of fine coal produced by modern mining methode.

Underground coal gasification

In Western Europe there is evidence that massive coal resources exist either in difficult conditions or deep below land and under the North Sea. Tapping these resources by conventional means is difficult and becomes increasingly more so as the resource base is extended. The idea of recovering the energy values *in situ* processes without employing human effort underground and without bringing waste to the surface is one which has exceptional and universal appeal. The potential rewards, if satisfactory viable techniques can be developed, are enormous and make it desirable to analyse carefully the possibilities and regularly review them in the light of developing technology and economic circumstances. This requires reliable experimental and practical data — notably scarce and inconsistent in the past.

Liquefaction of solid fuels

Solid fuels can be converted to liquid fuels in two ways:
- indirectly by catalytic treatment of synthesis gas, i.e. by the Fischer-Tropsch process used commercially on a large scale by SASOL in South Africa;
- directly by reaction with coal dissolved in a solvent; this means hydrogenation and extraction techniques.

The indirect synthesis process now commercially available suffers the disadvantage of relatively low thermal efficiency and gives a spectrum of products that does not adequately match European market requirements. Thus, more selective processes are needed which make better use of the coal in the European context.
As far as extraction and hydrogenation are concerned, the advantages of these direct liquefaction routes in terms of improved efficiency and a more suitable product slate have to be demonstrated.
Generally, the requirements on coal quality (in particular the ash content) and process parameters (pressure) are much more rigid than for gasification. Thus, the technology of liquefaction is more difficult and sophisticated.

I.2. The potential of solid fuels conversion

The future role of solid fuels conversion is very difficult to evaluate, because:
- the technology is at present only taking its very first steps towards large-scale application, and
- its outlook depends largely on the overall future energy situation, and in particular on the evolution of prices for competing energy carriers, which is difficult to predict with precision.

In any event, there is certainly a long-term need for the conversion of solid fuels, the reasons for which are:
- the huge reserves of fossil fuels, particularly coal, which are used, at present, only to a disproportionate degree;
- the need to replace oil and, in the longer term, natural gas, for tactical and strategic reasons;
- the decreasing direct use of coal in households and industry requires an alternative energy carrier (gas or liquid);
- the conversion of solid fuels offers good prospects for technology export and job creation.

For all these reasons, the construction of large-scale plants is absolutely necessary to gain further know-how and experience, as well as to confirm the results obtained so far.
On the other hand, under today's conditions, which are highlighted by decreasing oil prices, redundancy of oil, budgetary cuts and the abandoning of certain projects, a feeling of reluctance seems to prevail. But, all this could very well be a temporary phenomenon and it would be very dangerous to interrupt promising, long-term development for such short-term reasons.

Therefore, a careful, step-by-step market introduction will be necessary, beginning with products which are already economically acceptable like synthesis gas for the chemical industry, fuel gas for power generation and methanol, whilst leaving the manufacture of higher-grade products like substitute natural gas (SNG) and gasoline for a later stage. A possible sequence of market developments is as follows:

Period	Raw materials	Products
1985-1990	Lignite and hard coal	Synthesis gas for chemical industry, fuel gas for electricity generation
1990-2000	Lignite and hard coal	First plants for substitute natural gas (SNG) and gasoline
After 2000	Lignite, hard coal, other fuels	All products

Such a programme of demonstration or reference plants would permit a steady development of the technlogies in the most economical fashion.
The projects selected for the Community's Demonstration Programme could fit very well into such a scheme and a careful estimation of their production potential showed that they could provide a production capacity of about 13 m. toe per year, after the completion of the demonstration phase.

II. Community action and national programmes

Of the 13 projects, one has been withdrawn by the applicant for unknown reasons.
Of the 12 contracts signed, 2 concern different stages of the French project on unerground coal gasification (LG/02/2/78 and LG/02/1/80), and the two original parts of the British liquefaction programme (LG/03/1/78 and LG/03/1/80) have finally been merged into one project. Thus, the twelve contracts signed in fact cover only ten projects, the breakdown of which is:
Gasification: 5;
Underground gasification: 2;
Liquefaction: 3.
Furthermore, the financial aid granted so far covers only 14.2% of the total costs of the projects. This is a consequence of the fact that, for budgetary reasons, so far only the starting phases of the selected projects have been financed (with two exceptions).
The character of the projects is rather different from most others carried out within the demonstration programme:

- The conversion projects need much more time for completion (the lifetime goes up to 7 years). In general, they are broken down into three main phases: planning/engineering, construction and operation of the plant. The present situation is as follows:
  - five projects are still in the engineering phase;
  - two are now commencing construction;
  - two others have reached the operational phase, one of which is already producing very good results;
  - one project has been terminated, but needs another demonstration step before commercialisation.
- The major part of the selected projects is not yet of a scale which would allow the direct transition to commercial use and, thus they need further development.

- The projects are very costly (in three cases, the total costs are in the region of 100 MECU), mainly because of the high investment necessary for the construction of plants. However, no substantial benefit can be expected from the subsequent operation phase.

These factors have to be borne in mind when judging the programme and the individual projects.

II.2. General evaluation of the programme

The overall results obtained so far can be summarized as follows (see Annex 1 for details):

Gasification of solid fuels

The number of projects in this area reflects the concentration of efforts on coal gasification, which corresponds to the state of art and to economic aspects. The same is true for the nature of projects, whose aim is the production of synthesis or fuel gas with, in some cases, an option for SNG (Substitute Natural Gas).

Some of the projects are very well advanced, others are still in an early stage, but they all tackle the aspects outlined above, in their particular ways. At present, the most successful are probably the British Gas Corporation project on the slagging gasifier (LG/01/6/80), which offers excellent prospects for transforming the first generation Lurgi gasifier into a high-performance, flexible unit which can be used on a commercial basis quite soon. Besides this, Klöckner's project on molten iron bath gasification (LG/01/13/80) has shown very promising results, particularly with regard to gas purity and, hence, to environmental protection. However, the process has still to undergo further large-scale trials before commercialisation. For this second phase of demonstration, financial assistance will be sought in the framework of the German National Programme. The three other projects are still in the engineering phase. Therefore, a detailed evaluation is not yet possible, but it can be expected that they will reach their respective targets.

As far as economics are concerned, the cost estimates for commercialised plants shows that, particularly the process for the production of synthesis and fuel gas, have the chance of competing with similar products made from natural gas or oil, whilst the production of SNG still requires process improvements.

Underground gasification of coal

Two projects are underway using a similar basic technology but different methods for some specific process steps and working under different geological conditions.

The first part of the French project (LG/02/2/78) has been successfully terminated by establishing a linkage between two boreholes, but has now to be continued on a larger scale (LG/02/1/80). The Belgo-German project (LG/02/1/78) reached a decisive stage in April 1982 following a successful first ignition. Thus, more detailed results will be available soon.

In general, the results obtained so far should advance the development of the technology and allow the potential of the processes to be defined with greater accuracy, thus enabling better value judgements to be made.

But, in any case, a number of technical obstacles will still have to be overcome, particularly when increasing the distance between boreholes, the most important condition for economic operation.

Liquefaction of solid fuels

Since liquefaction is generally considered as a more sophisticated and probably less economic technology than gasification, only three projects have been selected, but covering the three process routes of extraction, hydrogenation and synthesis.

At present, none of the three projects is in the operational phase. Thus, no results are available at the moment, which would allow a detailed evaluation. But it is expected that the project on synthesis (LG/03/3/80) will make the process more selective by demonstrating a new catalyst, while the two other projects on hydrogenation of lignite (LG/03/2/80) and extraction of hard coal (LG/03/1/80) will set out to demonstrate the advantages of the direct liquefaction route in terms of improved efficiency and a more suitable product slate.

II.3. Relationships between national or Community programmes

The relationships between the present programme and previous or running national and Community programmes are shown in the table below:

Contract No.	Contractor	Project	Relationship with national or Community programmes
LG/01/2/80	FIAT-ANSALDO	Westinghouse gasifier for electricity production	unrelated
LG/01/5/80	AGIP	Texaco gasification	previous work in Germany on pilot scale
LG/01/6/80	British Gas Corp.	Slagging gasifier	previous work in Germany on Lurgi gasifier
LG/01/10/80	VEBA OEL	Gasification of residues from liquefaction	additional financing by German govt. anticipated
LG/01/13/80	Klöckner	Iron bath gasification	additional financing by German govt. anticipated
LG/02/1/78	IDGS	Underground gasification	co-financing Belgian/ German governments + EEC
LG/02/2/78 LG/02/1/80	GEGS	Underground gasification	co-financing French government + EEC
LG/03/1/78 LG/03/1/80	NCB	Coal liquefaction (solvent extraction)	Research financed by ECSC Demonstration project co-financing British govt. + EEC
LG/03/2/80	RBW	Lignite hydrogenation	Research financed by ECSC First phase of demo-project financed by German govt.
LG/03/3/80	Haldor Topsøe	Coal synthesis	unrelated

The result is that:
- only two cases are unrelated to any other programme;
- two projects are based, to a certain extent, on previous pilot-scale work carried out in the Federal Republic of Germany;
- six projects are receiving or are awaiting co-financing by their respective national government and the Community, in two cases the previous research work was financed within the framework of the ECSC coal research programme.

This proves that the Community demonstration programme is not in conflict with, but is a complement to the national programmes.

III. Conclusions

Summing up, it can be said that the programme on liquefaction and gasification of solid fuels:

- accords with the Community's Energy Policy, i.e. to replace imported energy carriers as far as possible by indigenous alternative sources;
- while limited in scope by the funds provided, the programme covers all areas of technology in the relevant fields and has been chosen so that the projects are complementary to the national programmes;
- will contribute to the further development and to better knowledge, particularly in the operation of larger-scale plants with the coals produced in and available to the Community.

On the other hand, at present, only one of the gasification projects offers good prospects for rapid commercialisation, while the others will still need considerable time before completion, or an additional step in scaling-up to industrial use. This is particularly true for the projects on underground gasification and liquefaction which have even more technical problems to overcome than exist for gasification.

In addition, it has to be emphasised that short-term viability and profitability cannot be expected in all cases. Particularly for the projects on underground gasification and liquefaction, this will depend upon further technical progress, problems of scaling-up and on the way oil prices move.

Naturally, this is only an intermediate evaluation based on the results obtained in the first phases of the projects. A comprehensive evaluation of the programme as a whole and of its repercussions on technology, economic and energy policy can only be undertaken when all projects have finished their operational phase.

Nevertheless, it can be concluded that all projects for gasification and liquefaction of solid fuels are large-scale, expensive and make heavy demands on resources and time. To enable them to reach a reasonable scale ready for the day when solid fuels conversion processes will be necessary to fill the graps left by dwindling natural gas and oil, a continuous further development, at the appropriate technical level, is an urgent necessity.

2.4 CONCLUSIONS ON ALTERNATIVE SOURCES

1. Alternative sources of energy have considerable potential in the Community. As we approach the year 2000, solar and geothermal energy could help to cover energy needs to the extent of some 100 million toe; gasification and liquefaction could add some 10 million toe.

2. Financial support by the Community has certainly acted as an incentive and utilization of these resources has begun or speeded up.

The demonstration projects selected currently number 126, including 12 projects on the liquefaction and gasification of solid fuels, 73 on solar energy and 41 on geothermal energy. Investments on these projects are of the order of 605 500 000 ECU.

Some 80 contracts are currently running, and thus an overall technico-economic evaluation of the Community programme is not feasible at the moment. Nonetheless, several projects have progressed sufficiently to allow an initial assessment.

3. In general, the projects selected for demonstration at Community level cover all the technologies envisaged, both in the sector of gasification and liquefaction of solid fuels and in the sectors of solar and geothermal energy. The projects were chosen to take account of Community and national research and demonstration programmes. In the sectors of gasification/liquefaction and geothermal energy, projects were often chosen to complement national programmes, this being facilitated by the limited number and scale of the projects in certain areas.

4. As regards gasification and liquefaction of solid fuels in particular, it must be stressed that these projects will help to develop Community technologies connected with the utilization of a major source of energy, viz. coal, which is available and produced in the Community in considerable quantities.
However, if these technologies are to be operational when the time comes for coal to replace hydrocarbons on a large scale, financial support is absolutely essential.
Nevertheless, the projects have their own inherent features and are not comparable with those in other sectors, especially the high costs, the relatively long implementation periods and the uncertainty regarding utilization at commercial level.
Future projects of this type should be on an ad hoc basis.
It should also be noted that in the short term commercial viability is not always certain. For projects on underground gasification and liquefaction, for example, viability depends not only on technical progress and the levels reached, but also on the way oil prices develop.

5. In the solar energy sector, projects on the utilization of heat and biomass far outnumber photovoltaic projects, current applications being only in the low-temperature sectors, which reach the threshold of profitability with a payback period of four to five years. Longer payback periods are still an obstacle for those who base their decision to invest in a solar energy installation solely on economic considerations.
The degree of solar energy utilization in future will depend on the joint effects of various factors, especially subsequent R&D results, the cost and the reliability of the installations, financial support and developments in oil prices. It is on this positive development in costs and reliability that the results obtained in the Community demonstration projects must have their main impact.
The positive results already achieved and predicted are an encouragement for the continuation of the demonstration programme, combined with coordination with national programmes and projects.

6. In the geothermal energy sector, Community support and the results of R&D projects have led to numerous firm projects designed to utilize geothermal resources, hitherto limited to the heating of buildings in the Paris region and to the production of electricity in central Italy. The emergence of demonstration projects in several regions of France and Italy, in Greece, Germany, the United Kingdom, Denmark, the Netherland and Belgium is a very encouraging sign.
The initial results of the most advanced demonstration projects are encouraging and for several of them utilization at commercial level is assured.
Part evaluation, based on the results currently available, indicates that the ratio between "toe figures located" after the drilling phase and "toe target figures" is acceptable and, on average, exceeds 60% in the different sectors.

7. Generally speaking, financial support from the Community has played a decisive role in the implementation of the first projects designed to utilize alternative sources of energy, although the technical and economic risks involved are still of a kind to hinder or prevent development. The prospects for utilization of these resources are realistic as long as support for the different types of projects is continued and intensified.

3. NATIONAL DEMONSTRATION PROGRAMMES

1. A summary review of the demonstration programmes on energy saving and alternative sources set up by the Member States is given below, classified under the major headings.
It is based on replies to a questionnaire sent to Member States by the Commission. It makes no claim to be exhaustive but facilitates an assessment of the situation in the individual Member States.

2. Today Member States have demonstration programmes but their scope varies enormously from one country to another.
In France, Denmark and Germany, these programmes play an important role in the national energy policy. In Germany, Denmark and Greece demonstration and research activities come under the same programme.
Ireland, the Netherlands and the United Kingdom also have extensive programmes but their financing is not always commensurate with the potential that could be exploited. In the United Kingdom, the emphasis is on energy saving, while in Ireland, the Netherlands and France more money goes to alternative sources.
In Belgium there are no real demonstration programmes, but a number of demonstration projects financed by different Ministries or by the regions. In Italy a law recently adopted provides for the introduction of demonstration programmes similar to the Community programmes with a budget of 15 million ECU in 1982.

3. In general, demonstration programmes were adopted only towards the end of the 1970s. Programmes that started earlier focused on work closer to the research stage. Support for demonstration projects on energy saving has increased in all countries more or less in step with the Community programme — in some cases because of its stimulus whereas many of the Member States launched their programmes on alternative sources some time after the Community programme (see Annex III, Table e).
National programmes are not normally for a limited period, but some of them have a multiannual plan (e.g. Germany, Denmark, Ireland and the Netherlands for alternative sources).

4. National funding for demonstration schemes differs from one country to another. The following table shows the scope of the national programmes in absolute and relative terms. Germany, France and the Netherlands have the highest budgets, but compared to total spending on energy research, the figures for Ireland and the Netherlands are high while those for the United Kingdom and France, which has a relatively high research budget, are low. A comparison of demonstration expenditure with total budgets shows that the proportion going to demonstration projects is small in the United Kingdom (no support for alternative sources), Luxembourg and Italy and relatively large in Ireland and the Netherlands.

It may be concluded that demonstration schemes receive fairly good financial support in France and Germany in the two sectors covered by this report. In Ireland and the Netherlands, this is only true of alternative sources (in the Netherlands mainly coal gasification), while in the United Kingdom energy saving projects predominate. Some special aid goes to both sectors in Denmark and Belgium.
Greece is also engaged on a substantial programme, but it is not possible to draw a clear line between the research and demonstration parts.

5. The level of aid differs from one Member State to another. Support can cover up to 100% of the capital cost in the Belgian schemes (for prototype development up to 80%), in Denmark, in Germany (only 40% for gasification), in the Netherlands (alternative sources only) and in Greece. In France, the investment grant may cover up to 50%, in Ireland up to 33.5% and in Luxembourg and the United Kingdom up to 25%.
In the Netherlands, support for energy-saving projects covers 50% of the costs, half being in the form of a non-repayable grant while the other half is repayable in the event of commercial success. The repayment condition also applies in the Netherlands for alternative sources, geothermal energy and coal liquefaction/gasification and in Ireland for alternative sources. In the United Kingdom a loan can be granted instead of a subsidy. In France there is also a repayable loan scheme (limited to geothermal energy but intended eventually to apply to energy saving as well). Belgian aid for the development of prototypes is repayable in the event of commercial exploitation and the Walloon Region in Belgium also intends to introduce repayment in the event of commercial success. In Germany, repayment is stipulated only for a small number of very profitable energy-saving projects and for coal gasification in the event of commercial success.
No information has been received that repayments have already been made, either because the repayment stage has not yet been reached (e.g. Ireland) or because a decision on repayment has not yet been taken (Netherlands). Apparently repayment does not figure very large in national aid schemes and is regarded as the exception rather than the rule.

6. The costs of measurements are paid in full by most of the programmes, e.g. in Germany, Denmark, France, the United Kingdom and Netherlands. The costs of feasibility studies are regarded as eligible for support in France, the United Kingdom, Denmark, Germany and Belgium.
The average size of the investment projects on energy saving that are receiving support appears on the whole to be fairly small. Some Member States (in particular France and the United Kingdom) prefer to support a large number of relatively inexpensive projects (in France an average of 34 000 ECU for 914 projects and in the United Kingdom 110 000 ECU for 166 projects), whereas one Member State (Germany) has selected only 30 projects receiving an average of 4.9 million ECU. Greece has also granted a relatively high average level of support (633 000 ECU) but research activities are included in this figure.

7. Under the heading of alternative sources, most countries have granted support for solar heating (Belgium, Denmark, Germany, France, Greece, Netherlands, Ireland and Luxembourg) and for wind power (Denmark, France, Greece, Ireland, Netherlands and United Kingdom). Biomass (Germany, France, Denmark, Ireland), geothermal energy (low enthalpy) (Belgium, Germany, Denmark, France, Greece, United Kingdom) and coal liquefaction and gasification (Belgium, Germany, France, Netherlands, United Kingdom) have also received support in some countries.
National programmes on energy saving concern different sectors, but concentrate mainly on industry and building; transport is also important in France and district heating in Germany.

8. The selection criteria for projects to be supported are virtually the same everywhere. Innovation potential, value as a model, potential energy savings, economic viability and technical feasibility are the main factors.
The main reasons for rejecting proposals are lack of novelty and low economic efficiency, but budget restrictions have also played an important part in the selection of projects (e.g. in Denmark and even Germany). A surprisingly large number of projects is rejected, especially in Ireland, the Netherlands and Luxembourg and to a lesser extent in France.

9. In all countries, the projects involve a series of measurements. Although in some countries many demonstration projects have been completed, results were only available for France, which has also embarked on their evaluation, although this is so far confined to energy saving in the services sector.
Denmark also states that it has carried out overall evaluations of its programme but does not give details.
The United Kingdom states that an evaluation will be completed in 1983. Germany has not made an overall evaluation of the energy saving programme, byt in a few years it intends to evaluate the solar energy and coal gasification sections.
All the other countries think that it is too early for evaluation at the current stage in their programmes.

10. Views on the influence that demonstration projects have on the development of markets are generally favourable. In the Netherlands, for example, these projects are considered to have a substantial impact while in the United Kingdom it has been observed that after demonstration other installations have been constructed. In France a quarter of the projects supported have had a widespread influence and it has been found valuable to support several demonstration projects of the same type so as to have a more effective impact on markets, especially those of a regional nature. Germany considers that insufficient time has elapsed since the start of the programmes to allow any great impact on markets.

11. Several countries provide support for the marketing of new products or processes, for example Denmark (10-20% subsidies for the purchase of systems using renewable energy), France (direct marketing aid of about 20%), the Netherlands, Germany (repayable aid of up to 50% to bring energy-saving products on to the market more quickly) or Belgium (aid for the development of prototypes for demonstration and marketing).

12. For dissemination of results, all countries use more or less the same information methods: exhibitions, visits to factories, reports, brochures, seminars, press releases, etc. Only the United Kingdom includes the results of Community projects in its national information system, which is well developed, while Germany has arrangements for the exchange of information between its coal gasification programme and the corresponding Community programme.

13. All the countries stated that the demonstration programmes formed an integral part of their national energy strategies and were regarded as essential to the success of their policies. Ireland and the United Kingdom also pointed out that their programmes had aroused great public interest and that the number of proposals was constantly increasing.

Table F

National demonstration schemes 1982

MIO ECU	B	DK	D	F	GR	IRL	LUX	IT	NL	UK
I. Budget energy saving II. Budget Altern. Sources		3,1 Dem. 2,5 Géo. 1,9 Col. systems	32 Energy Sav. [1] 8,8 Solar 1 Geo. [2] 16,4 Coal Gaseific.	13,7 [3] 20,3 [4]		0,5 2,0			1,9 Energy Sav. 2,2 Solar + Wind 37 Coal Gaseific.	8,1
III. Total Démons. Budget I + II	9	7,5	58,2	37,5	(17,9) [6]	2,5	0,01	15	41,1	8,1 (without Altern.)
IV. Non Nucleair R & D budget (1981) V. III : IV (in %)	29 30	 25-50	270 21	401 10		5 50			40 103	299 2,7
VI. Public budget : Total Current Uses (1982) VII. III : VI (in %)	49,857 0,018	34,606 0,021	285,368 0,020	227,467 0,016	14,059 (0,12) [7]	8,962 0,028	1,620 0,0006	166,971 0,009	74,850 0,055	206,773 0,004 0,009 [5]

REMARKS :
1. 50 % of R & D Budget.
2. 20 % of R & D Budget.
3. 1981 AEE Budget.
4. 60 % of COMES 1981 Budget only.
5. Lower figure : without alternative sources.
   Upper figure : two great projects in alternatives included in 1982.
6. Including Research Expenditures.

ANNEXES

ANNEX I

Energy saving

Contract No.	Proposer	Sector	Page
EE/008/79	Carbery Milk Products	Industry	99
EE/016/79	Lanerossi	Industry	98
EE/022/79	Deborah	Fluidized beds	100
EE/028/79	Agac Reggio Emilia	Remote heating	92
EE/035/79	Kreis Warendorf	Heat pumps	88
EE/038/79	Maison Phenix	Buildings	85
EE/046/79	M.A.N.	Heat pumps	89
EE/049/79	Electricity Supply Board	Buildings	85
EE/068/79	Stichting Bouwcentrum & Ratiobouw	Buildings	85
EE/118/79	Walter & Cie	Power stations	93
EE/120/79	C.E.A.	Remote heating	92
EE/121/79	Svenborg Kommune	Remote heating	92
EE/133/79	Shirley Institute	Industry	99
EE/147/79	The Electricity Council Research Centre	Industry	95
EE/160/79	ESMIL	Energy from waste	101
EE/174/79	Burmeister & Wain A.S.	Remote heating	92
EE/178/79	De Nieuwe Weerdjes	Heat pump	89
EE/192/79	IN.TRA.DEL.	Energy from waste	101
EE/193/79	Beghin-Say	Heat pumps	89
EE/209/79	P.A.G.V.	Agriculture	107
EE/215/79	Gasunie	Buildings	87
EE/217/79	Saarchiene	Remote heating	92
EE/231/79	O.T.B.	Buildings	85
EE/235/79	Foster Wheeler	Energy from waste	102
EE/238/79	Borough of Darlington	Buildings	87
EE/244/79	Crosfield & Sons	Industry	99
EE/251/79	Teksid	Industry	94
EE/262/79	Thomson	Road transport	104
EE/274/79	Montedison	Industry	97
EE/278/79	E.N.E.L.	Agriculture	107
EE/281/79	Agip-Jacarossi-Solar 77	Buildings	87
EE/285/79	Imag	Energy from waste	101
EE/290/79	Novelerg	Buildings	86
EE/301/79	Bonnet S.A.	Heat pumps	90
EE/314/79	Hermann Heye	Industry	100
EE/323/79	Skive Kommune	Buildings	86
EE/330/79	A.S.M. Brescia	Remote heating	93
EE/001/80	Gebrüder Lohlein	Industry	96
EE/002/80	Brian Frank Fraser Smith	Agriculture	107
EE/003/80	Azienda Municipalizzata Modena	Remote heating	93
EE/008/80	De Eendracht	Industry	99
EE/014/80	Hoogovens IJmuiden- Estel	Industry	94
EE/015/80	Nuffield College Oxford	Heat pumps	90

Contract No.	Proposer	Sector	Page
EE/027/80	Metallurgie Hoboken	Fluidized beds	100
EE/033/80	British Airways	Energy from waste	102
EE/043/80	Spach & Fils	Heat pumps	90
EE/066/80	C.E.A. - S.N.E.A.	Remote heating	93
EE/074/80	Usinor	Industry	95
EE/079/80	Department of Health & Social Security	Buildings	88
EE/085/80	Odense Elforsyning	Road transport	105
EE/094/80	Sauerländische Kalkindustrie	Industry	96
EE/100/80	Pirelli S.p.A.	Remote heating	93
EE/125/80	Elf Aquitaine	Industry	97
EE/126/80	De Hazelaar	Fluidized beds	101
EE/129/80	Agip Petroli	Industry	97
EE/130/80	Fiat	Road transport	106
EE/131/80	Tr. Freeman Cambridge	Buildings	88
EE/142/80	E.BI.A.	Energy from waste	102
EE/156/80	M.A.N.	Combined heat and power	94
EE/161/80	Electricity Suppy Board Dublin	Road transport	106
EE/163/80	Spie Batignolles	Remote heating	93
EE/167/80	Compair Industrial	Industry	100
EE/171/80	Creusot Loire	Industry	96
EE/176/80	Balcke-Durr A.G.	Heat pumps	90
EE/178/80	Alfa-Romeo S.p.A.	Road transport	105
EE/190/80	Breda	Fluidized beds	101
EE/201/80	Emporio Ricambi Industriali Udine	Buildings	88
EE/203/80	Fulmer Institute	Industry	95
EE/205/80	Energietechnik GmbH	Heat pumps	91
EE/210/80	Conservateurs Cathédrale d'Iona	Heat pumps	91
EE/213/80	European Heat Pump Consultators	Buildings	86
EE/224/80	Solmine	Industry	97
EE/228/80	Italtractor	Industry	95
EE/246/80	Akzo Chemie B.V.	Industry	98
EE/250/80	Université de Leeds	Buildings	86
EE/251/80	Norddeutsche Affinerie	Industry	96
EE/260/80	Skive-Egnens Energieforsyning	Energy from waste	103
EE/270/80	Maximilianshütte	Industry	95
EE/287/80	Sage und Holzbearbeitungswerk	Energy from waste	103
EE/290/80	South London Consortium for Local Authority Research & Development	Buildings	86
EE/001/81	E.BI.A.	Energy from waste	104
EE/011/81	Fichtel & Sachs	Heat pumps	91
EE/014/81	Campbell Nederlands Groko	Combined heat and power	94
EE/022/81	U.C.B.	Industry	97
EE/034/81	British Steel Corporation	Industry	95
EE/087/81	The Electricity Council	Industry	96
EE/111/81	Elf France	Buildings	86
EE/134/81	Ruston Gas Turbine	Power stations	94
EE/146/81	International R & D	Heat pumps	91
EE/179/81	Comune di Modena	Energy from waste	104
EE/213/81	Cement Roadstone Holding	Buildings	86
EE/221/81	Regionov	Road transport	105
EE/246/81	Thyssen	Industry	95
EE/253/81	Danieli Officine Meccaniche	Industry	95

BUILDINGS

1. Housing projects

EE/038/79 – E.C.L. Maison Phénix – Rhône Alpes (Grenoble) – F
Experimental fitting of 18 houses with air/air heat pumps with back-up gas heating.
The particular advantage of this project is that any additional heat required (e.g. when the outside temperature is too low for the heat pump to operate effectively) is provided by LPG, which can be stored, so that no gas is required from the public network which is already faced with excess demand.
Energy savings are estimated at 4,406 kWh a year.
The measurement programme should be completed in May 1982.

EE/049/79 – Electricity Board of Ireland (Dublin) – IRL
Standard building techniques designed to save energy in Ireland (5 houses)
The aim of the project is to build standard low-energy houses as part of the Irish building programme which strictly comply with local planning restrictions and building regulations, with a view to building large numbers of such houses in the future. Energy savings have been estimated at 22 toe a year.
Building should be completed in August 1982.

EE/068/79 – Stichting Bouwcentrum en Ratiobouw (Rotterdam) – NL
Energy saving in 17 single-family dwellings in Haarlem.
The solar collectors used in these low-energy houses were developed by an R & D project partly financed by the EEC. Some other features of the project, like the recovery of heat from the air extracted, were abandoned for reasons which will have to be explained in the next periodical report. Energy savings are estimated at 715 toe a year. The project is to be completed by the end of 1983.

EE/231/79 – Officine Termomeccaniche Breda – I
This is a new type of domestic heating boiler called the BLUEFLAM 91, rated at between 27,000 and 350,000 Kcal/hour.
The appliance has a number of very important features: high efficiency (always higher than 91% and sometimes as high as 93%) because of proper internal recycling of flue gases; compact modular design; low pollution.
The aim of the project was to install 700 such boilers with different capacities throughout Italy, which is subdivided into six climatic zones. The measurement programme lasted two years so as to allow of comparison between two different heating seasons.
The demonstration project was convincing and BLUEFLAM 91 was shown to be technically superior to similar appliances already on the market. Fuel savings were in the order of 10% compared with the average of similar appliances.
This appliance is now being marketed, although there are a number of difficulties, principally because of the crisis in the building sector.

EE/290/79 – Novelerg (Paris) – F
Low-energy housing meeting the cost criteria of cheap rented accommodation (H.L.M.) (SOLPAC project) (12 houses).
The main aim of this project is to demonstrate the benefits of bioclimatic architecture and the storage of free heat. Differences of opinion with the H.L.M. offices have caused a series of delays and resulted in one of the two proposed sites being abandoned, cutting the number of houses from 24 to 12, (the Commission's share of the expenditure has been cut accordingly).
Energy savings are now estimated at 60 toe a year. Work is in progress.

EE/323/79 – Skive Kommune – DK
Energy saving in 53 houses and flats at Skive (53 housing units).
This project combines a number of the different insulation and heating techniques (solar collectors, heat pumps) known about in 1979 on one single site. A very intensive measurement programme should make it possible to assess the individual advantages of these techniques. The programme is to be completed in January 1983 and has already shown that the insulation measurements were as effective as expected. Energy savings are estimated at 387,897 kWh a year.

EE/213/80 – European Heatpump Consultors (Charlottenlund) – DK
A block of flats heated by a heat pump driven by a gas-fired diesel engine.
This contract has still to be negociated as the contractor is having trouble finding partners.

EE/250/80 – Stephen George & Partners (University of Leeds) (Leeds) – UK
Space heating using solar walls of the Trombe type (five houses).
Demonstration showing how the heat from the sun can be collected using a Trombe wall and a circulation and storage system in all the walls of the building. Energy saving is estimated at 1 toe. The project should be completed in 1986.

EE/290/80 – South London Consortium (London) – UK
Low-energy housing: renovating three houses and converting them into 15 flats and building 20 new houses.
Demonstration project in two parts:
- the rational renovation of three Victorian houses so that they can be used as 15 low-energy flats;
- the building of 20 new houses using bio-climatic techniques and solar collectors.

Energy savings are estimated at 185,000 kWh a year for the 35 dwellings. Work on the flats should be finished by mid-1982 and work on the new houses should begin shortly.

EE/111/81 – Centre de Recherche ELF (Saint-Symphorien d'Ozon) – F
Statistical and comparative experiments on 15 houses fitted with solar roofs and underground heat storage facilities.
Heating by heat pump – with no back-up heating system – connected up to two heat sources: a solar roof and an underground storage system into which heat is fed from the solar collectors when not required to heat the house. Energy savings are estimated at 21 toe. The contract has just been signed and should run for two and a half years.

EE/213/81 – Cement Roadstone Holdings Ltd (Clondalkin) – IRL
Building and assessment of a low-cost low-energy house.
The aim of the project is to show that it is possible in Ireland to build low-energy houses the additional costs of which are rapidly repaid by the savings made. The houses have high thermal inertia, good insulation, warm air heating backed up by solar collectors and a heat storage system. Savings are estimated at 330 toe a year. The project should be completed in 1984.

2. *Projects in the tertiary sector*

EE/215/79 – NV Nederlandse Gasunie (Groningen) – NL

Energy saving in respect of the artificial lighting of offices. Improving the design of lighting systems and their control systems.

The project was completed in December 1981; its main features are described below.

Five different artificial lighting systems were fitted to five floors of an existing office block. A user reaction survey was then carried out, and the electricity consumption of each system was measured for one year and compared with that of one floor fitted with the old lighting system.

The five new lighting systems have the following features :

- they use more efficient 26 mm fluorescent tubes, instead of the old 38 mm diameter tubes;
- there is either overall lighting, of individual desk lamps with overall low-intensity background lighting;
- the intensity of the overall lighting is adjusted in accordance with the intensity of the external illumination. There are separate controls for the inner and outer arrays and there may be either an on/off switch or a dimmer switch.

One of the systems also switches lights off after the occupants have left.

The aim is to save at least 100 MWh of the energy used each year for lighting the building under the old system, which represents an energy saving of some 50 %. (Additional investment costs are amortized in three years for a new building and nine years for an existing building).

- the various systems tested saved between 63 and 84 % of the electricity used for the old lighting system. The annual saving was 132 MWh for the whole building averaged over the five systems tested, so the 100 MWh target for annual energy saving was reached and improved upon. Total savings are calculated at 73 %;
- the two systems which save the most energy are the individual desk lamp with background lighting and a system with lights suspended over desks;
- the automatic systems for controlling lighting in accordance with external illumination proved difficult to perfect. There does not seem to be sufficient technological expertise on the market at the moment.

The user survey showed that :

- occupants do not take to automatic systems for controlling lighting in accordance with external illumination;
- the most popular new lighting systems were actually those which produced the greatest energy savings;
- occupants may be satisfied with lighting conditions which, according to the theories, are considered to be bad (as regards uniformity of lighting, reflection on the working surface).

EE/238/79 – Borough of Darlington (Darlington) – UK

Energy saving by recovering heat and treating the water at the Darlington Sports Centre.

Use of different methods to reduce energy consumption (ozone treatment of swimming-pool water) and the recovery of energy (passing stale air through exchangers and dehumidifying the air using heat pumps). Energy savings are estimated at 2.7 GWh per year. The technical equipment is still being installed.

EE/281/79 – Solar 77 – AGIP SpA. Jacorossi SpA – I

This project is to install and test a new type of static emulsifier.

The chief advantage of emulsion is that it improves combustion, which in turn reduces the emissions of fluegases and the fouling of boilers and improves the average seasonal efficiency.

The advantages of the new type of static emulsifier are its simplicity of construction, reduced bulk and low cost and above all the fact that it can be fitted to existing burners with only slight modifications.

The measurement programme lasted two years. Emulsifiers were fitted to 50 existing boilers chosen because of :

- the wide range of fuel consumption (between 20 and 4,000 kg/h);
- the wide range of uses (24 domestic heating boilers, 11 industrial heating plants, 7 hotel heating plants, 5 hospital heating plants, 2 sports centre heating plants and 1 school heating plant);
- the wide range of climatic regions;
- the wide range of fuels used : gasoil, liquid heating fuel (3-5°E), heavy heating oil (15-20°E and 20-30°E);
- the wide range of types and makes of boilers.

The results were extremely convincing. Energy savings were in the region of 3.5% (in order to take account of the fouling of boilers when no emulsion is used, we have assumed a reduced efficiency of 6% for domestic boilers and 3% for industrial boilers). The emulsifier was found to be extremely reliable and easy to fit to existing systems. There was also a considerable reduction of flue gas emissions, which is a considerable environmental advantage. The stardard maintenance operation were also much reduced.
All in all, the demonstration project can be considered totally conclusive, particularly as the use of emulsified fuel in boilers is rapidly becoming more widespread; the SOLAR 77 system makes it possible to use a small static applicance which can be rapidly fitted to an existing installation for very little cost. Even though the amount of fuel saved in a single installation is small, the number of existing installations which could be converted makes the system extremely attractive. Moreover, even disregarding the major additional advantages already mentioned, it should not be overlooked that emulsification makes it possible to cut the price of the fuel used and maintain the same operating conditions. At the same time, this will widen the range of uses for those oil-derived fuels for which there is least demand.

EE/079/80 – Department of Health and Social Security (London) – UK
Designing and building a low-energy hospital.
Combination of a number of energy-saving measures in a new hospital (CHP, heat recovery, automatic control systems, heat pumps, heat storage, etc.). Savings are estimated at 900 toe a year. This is a long-term project and should be completed by 1990.

EE/131/80 – T.R. Freeman (Cambridge) – UK
Telephone monitoring of energy consumption in Essex schools.
The installation in 20 schools of control systems designed to optimize the operation of heating appliances and linked to a central remote control station by telephone. Energy saving is estimated in the order of 560 toe a year although the savings should be considered as indirect. The measurement programme should be completed in July 1982.

EE/201/80 – Emporio Ricambi Industriali (Udine) – I
Combined production of heat and power, solar collectors and heat recovery linked to a seasonal heat storage system in a commercial building.
The use of a number of different techniques in one office block ; combined heat and power production, heat pump connected to refrigeration plant, incineration and heat storage.
Energy saving should be in the region of 60 toe per year. The project is still under construction and is expected to be completed in March 1983.

HEAT PUMPS

EE/035/79 – Kreis Warendorf – D
Gas-engine-powered heat pump for space heating with heat extraction from the soil.
Heat output = 1,150 kW, heat exchange area in the ground = 9,000 m^2, energy saving ≙ 50% as compared with a conventional installation.

The installation is in service; the project is progressing satisfactorily. It is based on research and development contract No. EED 181-77. New projects have been launched (such as Everswinkel, and the hotel in Bad Reichenhall).
The soil is an extremely attractive heat source since it requires no maintenance. The gas engine and screw-type compressor are not from the Community, but henceforth the components wil nevertheless be available throughout it. The energy targets will probably be achieved, while the anticipated investment expenditure has been exceeded. Payback problems are foreseeable. Annual energy savings : 133 toe.

EE/046/79 – MAN – Neue Technologie – D
Heat pumps powered by internal combustion engines (screw-type compressor) for space heating and domestic hot water production using heat extracted from the air. Heat output: 200 kW, compact sealed layout to optimize damping of noise and vibration.
The installation is being modified and will soon resume service. The technical aim has been achieved but so far the economic target has not, since the specific investment cost of the industrial installation has more than doubled compared with the forecasts.
The sealed layout enables vibration and noise problems to be eliminated. The manufacturer's production structure yields major advantages in operating safety.
IC-engined heat pumps having low heat outputs are too expensive compared with other conventional, rational techniques but they may, nevertheless enable large quantities of energy to be saved for space heating purposes. Projects of this type are now the front runners for national subsidies in the Federal Republic of Germany. Annual energy saving: 64 toe.

EE/178/79 – Nieuwe Weerdjes – NL
Gas-engine-powered heat pump with a heat output of 550 kW intended for the economical production of heat for space heating and the production of domestic hot water (66 flats). The heat source is groundwater.
Groundwater is a very attractive heat source for heat pumps. However, certain important factors concerning water use have to be taken into account before groundwater can be used for heat pumps. For this reason and also for cost reasons, one large installation is preferable to a number of small ones. As a general rule authorizations to use groundwater are subject to the reinjection of the cold water. The installation is not yet in service. One must therefore wait to see whether the technical and economic targets will be met. There are comparable installations in the Federal Republic and in other Community countries but they use electric heat pumps.
Annual energy saving : 87 toe.

EE/193/79 – Beghin-Say – F
Use of waste heat from industrial process (steam).
The technique for producing clean steam by condensing dirty steam and recompressing it in a water-ring compressor is demonstrated by means of a paper industry process. Possibly effective at an (electric motor) output of 135 kW : roughly 1,350 kW in the form of steam.
Steam recompression is not a heatpump process in the conventional sense of the term. The principle is however similar.
This technique is in its infancy, but it seems to offer highly attractive energy-saving prospects in the industrial field and enables the recovered heat to be supplied at temperatures of more than 100° C. This project may be considered exemplary from the point of view of profitability and technology. As the project progressed the operating conditions proved to be better than originally forecast (maximum of 3 tonnes of steam per hour as against 2 tonnes). The payback period for the investment is thus reduced form 3.6 to 1.5 years despite the fact that actual investment are higher than forecast, in particular because the price of energy increased meanwhile.
Annual average energy saving : 800 toe.

EE/301/79 - Etablissements Bonnet - F

Electric heat pump to recover heat from a communal dishwasher.

Temperature range : 30-60°C. Acquisition of additional experience to improve existing installations. Heat output of the heat pump = 31 kW.

The project is progressing as planned. The installation is in service and is apparently giving satisfaction. The project may serve as a model for industrial heat recovery via heat pumps with direct recycling of the heat recovered.

The industrial waste heat is discharged in large quantities at a low temperature. The scope for internal use of this heat is limited because of the mismatch between the lost heat and the heat requirements. The project shows that analysis of the thermal processes by specialists offers interesting utilization potential for heat pumps under marginal economic conditions.

Annual energy savings : 15,5 toe.

EE/015/80 - Nuffield College - UK

Replacement of a heatpump installation dating from the late fifties to heat the college by recovering heat from waste water from the city of Oxford.

Installation fitted with two gas engines, one to drive the heat-pump compressor and the other to generate the electricity used to drive the circulation pumps and provide background electric heating. Heat output is 140 kW; the heat lost by the two engines is used to heat the hot water leaving the condenser. The installation is currently at the project and ordering stage.

The layout of this installation, which uses two gas engines in parallel apparently has the advantage of cutting electricity costs as compared with supplies from the public grid.

However, the use of surplus production in resistive background heating is not rational. The project will yield a return as energy costs are rising slightly. However, the results will not be absolutely representative since the existing heat recovery installation does not involve heavy expenditure.

Energy saving : 33 toe.

EE/043/80 - Spach & Fils - F

Replacement of oil to heat a hotel by using electric pumps recovering heat from surface waters.

The electricity is generated by an existing hydro-electric facility. The heat output of the heat pump is 105 kW.

The project is progressing according to plan. The installation has been in service since the end of 1980. The target has more or less been met. As in other projects, difficulties have been caused less by the new techniques than by ancillary problems (fouling, modifications, corrosion). The installation is economically sound.

Annual energy saving : 41 toe.

EE/176/80 - Balcke-Dürr (Borsig) - D

Development of an advanced heatpump system using a compressor and an ammonia/water solution as the working fluid.

For a given heatuse temperature this system enables the performance coefficient to be increased by a factor of 1.7 or, at an equal performance coefficient, enable the condensation temperature to be raised beyond 90°C. The heatpump compressor can be powered by either gas or electricity.

This concept embodies a known principle. A very recent patent furnishes proof of the practical feasibility of the theoretical principle. The various components of the set are at the design and ordering stage. If the operating capacity of this concept were demonstrated, we would have a new generation of heat pumps.

Annual energy saving : 160 toe.

EE/205/80 - Energietechnik - D
Replacement of oil for space heating by using an electric heat pump with absorption exchangers ("energy wall" for a multi-family house). The installation entered service on time, encountered no problems, and is giving satisfaction.
The heat pump is operated alternately with another system. It provides 60-70% of the annual heating energy. The use of this heat-pump system raises economic problems since the installation for extracting heat from the outside air is relatively costly compared with other installations for extracting heat from the heat source (these problems are independent of the energy needed to drive the heat pump).
The technical aim has been achieved perfectly. The economic target has not been met. A positive factor has been the suppression of ventilation blower noise. This has fired the imagination of several manufacturers.
Annual energy saving :
— multi-family house : 8.6 toe.
— single-family house : 1.3. toe.

EE/210/80 - Iona Cathedral - UK
Use of seawater (Gulf Stream) as a heat source in an electric heatpump installation for space heating and the production of domestic hot water.
Heat output : 310 kW. The project is behind schedule. Installation will take place during the summer of 1982. The provisional economic calculations confirm that electric heat pumps are economically sound under current price conditions. The replacement of oil is the basic aim, as in the other projects.
Annual energy saving : 32 toe.

EE/011/81 - Fichtel & Sachs - D
Heat pump driven by an internal combustion engine for space heating and the production of domestic hot water with extraction of heat from the air.
Heat output : 20 kW, single-cylinder 4-stroke low-horsepower. Acquisition of operating and installation experience. Energy saving 50%.
Installation fully developed technically. The programme covering the production and operation of 40 units is progressing normally (several installations are already in service). To date, the noise problem has not been fully resolved. Significant prior research has been subsidized by the Federal Ministry for Research and Technology and by the Commission.
In practice marginal problems often play a decisive role and it is for this reason that the programme to impove operation and installation know-how is highly desirable. It shows how seriously the programme has been taken.
In actual service small heat pumps powered by internal combustion engines raise particular problems such as noise and pollutant emissions (diesel-engine-powered heat pumps) which have still not been completely resolved. The choice of a 20 kW heat pump is a good one. A serious contender in the electric heat-pump stakes owing to the acquisition of experience and costs which are attractive for commercial installations.
Annual energy saving : 24 toe (40 houses).

EE/146/81 - International Research and Development - UK
Heat pump driven by an internal combustion engine to recover heat from an exothermal process in the chemical industry.
Condensation temperature sufficient to generate steam (600 kg/h). Heat output : 358 kW.
The heat pumps used in the sector referred to offer multiple prospects for use in industry if the payback period does not exceed three years. Since the project is still in its infancy it will be possible to assess it better only when we have some reproducible figures. In point of fact extensive research work subsidized by the Commission has already been carried out.
Annual energy saving : 69 toe.

DISTRICT HEATING, POWER STATIONS AND COMBINED HEAT AND POWER PRODUCTION

1. District heating

EE/028/79 - AGAC Reggio Emilia - I

This plant is equipped with both diesel- and gas-powered motors along with compression and absorption heat pumps for space heating and air conditioning.

The construction work has been completed, and the plant was opened on 3 April 1981. Test measurements are now being made. The initial technical results have been highly encouraging. The urban site has not created any special problems. Studies are now being made for similar projects elsewhere. Plants such as this will encourage further construction of new district-heating systems. An energy saving of 40%, or of 1,375 toe per year, as compared with conventional installations, has been achieved.

EE/120/79 - CEA - F

District heating from the Thernox nuclear reactor (Phase 1).

The preliminary plan for a district-heating system in Grenoble was abandoned in June 1981 for economic reasons specific to the Grenoble site. A new plan is now being drafted for the Saclay plateau, where the economic conditions seem more promising. However, no decision has yet been taken on the ultimate construction of the reactor, which will generate heat equivalent to 53,000 toe per year.

EE/121/79 - Svendborg Kommune - DK

Straw incinerator to supply a district-heating network.

Some 15,000 tonnes of straw harvested in the Svendborg region are to be burned to generate 9 MW for town's district-heating system during the cold season and thereby save 4,600 toe per year. Although the incinerator entered into service on 14 November 1980, it is not yet in full operation due to technical problems. The test measurement programme will not be run until they have been solved. Despite the difficulties — which are bound to be overcome — the project has lost none of its appeal. Similar plants have already been built — or are planned — elsewhere. This type of installation holds considerable potential.

EE/174/79 - Burmeister & Wain A/S - DK

Large-scale heat pump for district heating.

A large-scale diesel-driven heat pump drawing heat from the municipal water-treatment works has been generating 11.5 MW_{th} fot the Frederikshavn district-heating system. At the same time it generates electricity fot the system's auxiliary equipment. Once the initial problems had been overcome, the installations were made over to the customer; they entered into operation in November 1981. Test measurements are now being made. The performance of the system has proved highly satisfactory, with energy savings of 56%, or 4,400 toe per year in comparison with conventional plant. Similar installations are now under construction.

EE/217/79 - Stadtwerke Saarbrücken AG and Fernwärme-Verbund Saar GmbH - D

Recovery of process waste heat for the Saarbrücken district-heating system (Part 1 of the "Saarschiene" project).

This project entails laying a regional pipeline to carry heat along the Saar valley between Völkingen and Saarbrücken. The process waste heat can be recovered from various industrial sources for the Saarbrücken district-heating system.

The detailed preliminary plan has been completed, building permission has been obtained and the major equipment orders have been placed. At the moment the project consists solely of a demonstration programme to develop means of piping the heat over longer distances. Each year 11,500 toe of heat will be carried.

EE/330/79 - Azienda Servizi Municipalizzati - I
Remote-control of regulating valves for consumers connected up to a district-heating system.
This project aims at saving approximately 85 toe a year by selective reduction of the heat supply to a number of consumers connected to the Brescia district-heating system during peak demand periods. This method is similar to the electricity companies' method of regulating interruptible supplies. However, this is the first time that such a selective load-reduction system has been incorporated in a district-heating system. The main problem is to pursuade the customers to tolerate certain limits to their service. However, the first public buildings have now been connected up to remote-control system.

EE/003/80 - Comune di Modena - Azienda Municipalizzata Igiene Urbana - I
Raising steam and generating electricity by incinerating urban waste and sewage sludge.
The purpose of this project is to reuse the heat released during the incineration of domestic refuse from Modena to generate heat and power for a neighbouring industrial estate with a pass-out turbine. This will save 400 toe per year. The detailed preliminary plan has just been completed. One novel feature of this project is that a local authority has seized the initiative to supply an industrial estate with heat from the municipal incinerator.

EE/066/80 - Société Nationale ELF AQUITAINE and Commissariat à l'Energie Atomique - F
Underground storage of heat for a district-heating system in a confined aquifer.
The seasonal heat accumulator will be connected between the domestic waste incinerator at Thiverval-Grignon (Department of Yvelines) and the district-heating network in the Plaisir area. The heat will be stored approximately 500 m below the surface at 180°C. An annual energy saving of 2,000 toe is expected. The detailed preliminary plan is now being drawn up. Although this project entails considerable risks, it will open the way for exploiting many sources which produce energy all year round, even though there is no demand for it outside the cold season.

EE/100/80 - Azienda Energetica Municipale Milano and Società Pneumatici Pirelli SpA - I
District heating in north-east Milan from the combined heat and power plant at Pirelli's Bicocca factory.
The plan is to tap the current excess boiler capacity at Pirelli's Bicocca factory for combined heat and power production. The heat will be supplied to the districts around the factory, saving 6,500 toe per year in the process.
The detailed preliminary plan is now being finalized. This project demonstrates that industry too can seize the initiative to supply a neighbourhood with the heat which it needs and thereby provide the impetus for constructing a district-heating network.

EE/163/80 - Spie Batignolles S.A. - F
Heating of 15,000 dwellings in a Rouen neighbourhood from process waste heat.
This project will reuse process waste heat from a sulphuric-acid production plant in a new remote heating system in Rouen. The preliminary plans have now been completed and the construction work has just started. The project should save 14,500 toe per year. It is one of the largest heat-recovery projects in the Community.

2. *Power stations*

EE/118/79 - Walter & Co AG - D
Low-energy process for desulphurizing power-station flue-gases.
This is the first time that the new desulphurization process developed by Walter & Co has been applied in a large coal-fired power station (in this case the 475 MWe combined heat and power plant at Mannheim). The process leaves no waste, and there is no need to re-heat the treated flue-gases before they are discharged into the stack. The latter feature saves 8,300 toe per year even on the reduced project scale. Desulphurization in this plan

produces ammonium sulphate, a fertilizer otherwise produced synthetically by a process with heavy energy consumption. The preliminary plan has now been completed and a application for building permission has been made.

EE/134/81 - Ruston Gas Turbines Ltd. - UK

Combined heat and power plant with a gas turbine driven by a heavy fuel-oil/coal mixture.

The novel feature of this system is that a high-temperature heat exchanger separates the compressed gases entering the turbine from the exhaust gases emerging from the combustion chamber connected after the turbine. A ceramic (SiC) heat exchanger is employed. Unlike conventional gas turbines, which are generally fuelled by kerosene or natural gas, Ruston's turbine can be driven by a mixture of heavy fuel-oil and coal. This has considerable advantages in terms of energy consumption, with this project saving 1,050 toe per year.

3. *Combined heat and power production*

EE/156/80 - M.A.N. - D

"Total energy plant", with diesel motor, for a brewery.

Here a 600 kW diesel motor drives both an electricity generator and a steam compressor. The generator supplies the brewery with electricity, while the compressor recompresses the steam recovered from the wort boiler and then re-uses it to heat the boiler that it came from. The heat recovered from the diesel motor dries the malt. This project is a good example of successful integration of a "total energy plant" to an industrial process. The preliminary plans have now been completed. The project will save 1,015 toe per year.

EE/014/81 - CAMPBELL Nederland B.V. Groko Division - NL

"Total energy plant" in a frozen-foods factory.

Four 522 kW gas motors drive the electricity generators plus the compressors in the refrigeration units. This is the first time that this new type of cold accumulator (= 10°C) with an eutectic mixture has been used. The project is a model of sound management of energy resources, making full use of the available methods of accumulating and subsequently re-using heat. It is now being implemented and will save 2,300 toe per year.

INDUSTRY : STEEL MAKING

EE/251/79 - Teksid - Italy

This project concerns the provision around a 150 th UHP electric arc furnace of an outer shell enabling the amount of air ingested by the fourth furnace orifice — and therefore the intake of fresh air — to be reduced.

The shell was completed during the first half of 1980. Unfortunately, the first measurement results show that the reduction in fresh air intake is below forecasts. However, the shell has facilitated much more efficient furnace management (higher oxygen-blowing rate, quicker run-up to full electrical load, etc.) resulting in a drop in specific consumption of about 70 kWh/t (i.e. more than twice the original prediction), together with an improvement in working conditions. Energy savings are about 4,000 toe/year. The project can therefore be considered successful in both technical and financial terms.

EE/014/80 - Estel Hoogovens - Netherlands

This project covers recovery of the heat contained in the combustion products of the blast preheaters in order to pre-heat the combustion air by means of a rotary heat exchanger.

The energy saving is 6,000 toe/year. The project is currently at an advanced development stage.

EE/074/80 - Usinor - France
In this case a system for recovering, storing and distributing LD converter gas is to be installed at the Dunkerque plant of Usinor.
The recovered gas would be consumed within the plant itself. About 100,000 toe/year could be saved. The installation work is under way.

EE/203/80 - Fulmer Research Institute - UK
The project is aimed at energy saving in the heat treatment of steels, by the use of fluidized-bed furnaces.
The energy saving has been predicted at 6 750 kJ per kg of steel treated, which is equivalent to 230 toe/year. The furnace is being installed and it should be possible to start measurements shortly.

EE/228/80 - Italtractor - Italy
This project aims at saving energy in the manufacture of finished steel stampings by replacing the traditional hardening and tempering of steel.
At the same time the simplified treatment enables at least the same quality to be achieved as for hardened and tempered products. The energy saving would be 930 toe/year. The equipment is being installed.

EE/270/80 - Maximilianhütte - Germany
Project for recovering converter gas at the Maximilianhütte steelworks in Rosenberg. The technology used is not the same as in the Usinor project.
In this case it forms part of a more general energy-saving programme and of the rationalization of the Rosenberg plant. Work has not yet begun.
An energy saving of 6,500 toe/year is expected.

EE/034/81 - British Steel Corporation - UK
The project involves pre-heating of the scrap charge for a 110 t electric arc furnace by recovering the heat extracted from the fourth exhaust orifice from the furnace.
The foreseeable energy saving is 43 kWh/t of steel produced, which is equivalent to 990 toe/year. Installation is virtually complete and the measurements will begin shortly.

EE/246/81 - Thyssen - Germany
In order to extract energy from the gas pressure in the furnace throat, the project envisages the installation of a four-stage by-pass turbine having variable guide vanes in the first-stage stator; these regulate the blast-furnace back pressure continuously.
The turbines will drive two 13,000 kW generators, thus yielding a primary energy saving estimated at about 27,000 toe/year. The turbo-alternator set is almost ready and the measurement programme should begin soon.

EE/253/81 - Danieli - Italy
Here the scrap charge for a 45 t electric furnace is to be pre-heated by the continuous heat flux in the hot gas exhausted from the fourth furnace orifice.
In the Danieli project, as opposed to project EE/034/81, the hot combustion products will transfer their heat through a surface-type heat exchanger to an air flow which will heat the scrap.
An energy saving of about 50 kWh/t of steel produced has been forecast; this is equivalent to 1,500 toe/year. The installation is at the project stage.

INDUSTRY : NON FERROUS METALS

EE/147/79 - Electricity Council Research Center - UK
Improved Design of an Electric Induction Billet Heater.

This project demonstrates an increased efficiency electric induction billet pre-heater by better utilisation of the available copper in the windings. Two applications are envisaged, one for aluminium billets (2 t/hour) and one for copper alloys. (2.1 t/hour). Energy saving in terms of primary energy shall be 526 toe/year. Predicted results are being realised on one of the demonstration models, the second one being under construction.

EE/251/80 - Norddeutsche Affinerie - D
Copper Melting Shaft Furnace for Refined Copper Anode Production.
This project demonstrates the energy efficiency advantages of the shaft furnace over the more conventional reverberatory type. The throughpout is 60 t/hour and the energy saving envisaged corresponds to 5,000 toe/year. This project involves belgian and german companies having collaborated in R & D efforts and decided to finance jointly the investment for demonstration.
The payback of almost 8 years would normally be unacceptable. However, using only the furnace equipment costs this reduces to a more realistic 5 years.

EE/087/81 - Electricity Council Research Center - UK
Improved Design of an Electric Induction Furnace for melting Aluminium.
This project demonstrates a new design of electric induction furnace whereby refinements in the channel and throat of the furnace will produce an increased power density and a vigorous stirring action in the molten metal. This should give rise to reduced metal loss and increased efficiency. A reduced metal loss of 1% represents 700 kWh/t and energy saving of 743 kWh/t should bring total energy saving of 1,443 kWh/t or 1,000 toe/year. The envisaged payback period of 1.6 years is good. The project is still in the design stage so no operating experience is known.

INDUSTRY : CEMENT, BUILDINGS MATERIALS (BRICKS, LIME)

EE/001/80 - Gebrüder Löhlein - D
Conversion of Brick Tunnel Kiln to Pulverised Solid Fuel Firing.
This project claims substantial energy savings (60%) by converting an oil fired kiln to solid fuel firing i.e. 1,310 toe/year. Operating experience to date has revealed a higher average specific energy consumption than was first envisaged.
There is certainly a need to spread information regarding the solid fuel firing of brick kilns to encourage organisations to use pulverised fuel technology in this field.
It is a pity that the projected fuel savings were based on work carried out on another kiln. The rue energy savings can only be known by analysis of past specific fuel consumption figures for this kiln. Despite these facts, the energy saving achieved are above 40%.

EE/094/80 - Sauerlandische Kalk Industrie - D
Improvement in Specific Energy Consumption on Vertical Lime Kilns by use of Ring Burner System.
This project demonstrates an improved burner system for vertical lime kilns. The system is claimed to reduce the specific energy consumption and improve product quality by improving combustion and heat distribution within the firing zone. The energy saving envisaged are 1,080 toe/year.
If proved successful, the system could be readly replicated on other gas fired vertical lime kilns.

EE/171/80 - Creusot Loire Entreprises - F
Rotary Cooler with Peripheral Blowing on a Cement Clinker Kiln.
This project demonstrates an improved cooler for a cement clinker rotary kiln to produce clinker which is 300°C lower than the conventional grate cooler. Energy saving envisaged are 1,750 toe/year.

The payback period of 3.25 years should encourage other users of such kilns to use the equipment. However, the maintenance costs charged against this project appear to be rather high and a reduction here would increase the commercial viability of the plant.

INDUSTRY : CHEMICALS

EE/274/79 - Fertimont (Montedison) - Italy
The demonstration project is located in a plan producing urea — one of the main components of nitrogen fertilizers.
The existing process consists of combining ammonia and carbon dioxide. Its efficiency is low and partly responsible for the high energy consumption. The project aims at modifying the unit in order to recycle the unreacted raw materials and thereby to increase reaction efficiency to 55-75 %. This increase in efficiency would yield an energy saving of about 6,000 toe/year. The programme has been delayed by longer delivery periods for the equipment. It was completed at the end of the first quarter of 1982 and the final report is in preparation.

EE/125/80 - Elf Aquitaine - France
The object of the demonstration is a device enabling liquid effluent from oil refineries to be concentrated, thereby reducing consumption of the energy needed to separate the water from the hydrocarbons.
It involves a cylinder coated with a film enabling hydrocarbons to be separated out of water suspensions. The project has been completed and has enabled 2,500 toe to be recovered from the refineries where it has been installed. The contractual aim has thus been achieved and the project is a commercial success.

EE/129/80 - Agip Petroli - Italy
When filling station reservoirs or delivery lorry tanks are filled the vapours left over from the previous load are vented to atmosphere.
In order to avoid hydrocarbon losses and pollution a condenser, followed by a refrigerated condenser, is located at one of the tank orifices. The residual vapours are thus recovered in liquid form. The project has been completed. Although the amount of hydrocarbons recovered is less than the target owing to the climatic conditions during the demonstration, the project has a good chance of commercial success.

EE/224/80 - Solmine - Italy
The aim of the project is to utilize the waste heat from the reduction process in the manufacture of magnetite sinter.
The project is in two sections :
(a) Recovery of heat from the sinter by means of a fluidized-bed cooler.
(b) Recovery of heat from the reduction of gases via incineration and an economiser.
The waste heat will be used to pre-heat the boiler feed water. The energy saving expected is 1,400 toe/year. The project is at the design stage.

EE/022/81 - Union Chimique - Belgium
This is a new process for synthesizing ammonium nitrate which requires no external energy source since it generates enough heat to provide steam which can be used in other processes.
This process also yields a higher yield and enables liquid effluents of sufficient purity to be produced which can either be re-used or discharged directly. One energy saving of 260 toe/year is expected. The general application of the process would enable an energy saving of about 100,000 toe/year to be made at Community level. The programme began on 1 January 1981 and should end on 15 September 1983.

Glass industry

EE/246/80 – AKZO CHEMIE B.V. – NL

A countercurrent glass-melting furnace with heat recovery for sodium glass.

The melting furnaces usually used to manufacture glass from siliceous sand and sodium and potassium powder are of the «undirectional flow» type in that raw materials are charged on the same side as the burners and the convection currents which develop at the bottom of the melt flow in the same direction as the combustion products.

Under the demonstration project, the firm has built a countercurrent furnace which is charged on the opposite side to the burners so that the convection currents in the melt flow in the opposite direction to those in ordinary furnaces. The experimental furnace which has a production capacity of 80 tonnes a day has been fitted with a heat recovery system which heats the combustion air with the residual heat from the flue gases, which are then discharged at only 600°C. When designing the system, the firm was expecting these modifications to produce a dramatic reduction in fuel consumption from 171 m^3 NTP of natural gas per tonne – which is the consumption of an ordinary 80 tonne-a-day unidirectionnal furnace – to 124 m^3 NTP per tonne, a saving of 27,5 % which is equivalent to some 350 toe a year.

The experimental furnace began to operate in September 1981 but unfortunately there were a number of problems and the consumption of natural gas is therefore considerably higher than expected: between 140 and 150 m^3 NTP per tonne instead of 124 m^3 NTP per tonne. This is still a saving of 15 % compared with the original consumption of 171 m^3 NTP per tonne, which is by no means negligible, although not as high as 27,5 %.

Basically, therefore, the project ended up achieving 45 % of the success originally expected. Additional modifications – which would not necessarily be very expensive – could bring this success rate up to 85 or 90 %.

The significance of these results is undoubtedly of very widespread benefit if one considers that just over 1 million tonnes of glass is produced in the Member States of the Community each year. Cutting natural gas consumption from 171 to 124 m^3 NTP per tonne (i.e. by 47 m^3 NTP a tonne) – the expected saving which can be applied roughly to all furnaces – would reduce consumption of natural gas by 47 million m^3 a year, which is equivalent to some 40,000 toe a year. Even the saving of 26 m^3 NTP per tonne already obtained would be equivalent to 22,000 toe a year.

Industry : textiles

EE/016/79 – Lanerossi – Italy

The aim of the Lanerossi project carried out on existing textile dyeing plant in their Schio factory was intended to demonstrate the technical feasibility and energy efficiency of a modification enabling a large proportion of the cooling and condensation water to be recovered as a result of a modified layout for the bath heating and cooling circuits.

The modification consists of separating the heating and cooling circuits and giving each its own heat exchanger, and rearranging the cooling circuit to accept both softened and hard water. With regard to the ratio "kg of bath water to kg of cloth" and to the techniques adopted: it is planned to recover 73,000 m^3/year of soft water at an average temperature of 45°C and 22,600 m^3/year of demineralized (distilled) water at 105°C, i.e. an estimated energy saving of 444 toe/year.

The measurements are under way but are behind schedule owing to technical problems which have been dealt with in the meantime.

The initial measurements revealed very wide divergences in the amounts of water and condensate recovered as compared with the initial forecasts. The causes (coil porosity, valve life) have been pinpointed and eradicated. Consequently, the final results should coincide with the initial forecasts.

EE/133/79 – The Shirley Institute – UK

Project to demonstrate that very strict process control in the textile industry may enable management procedures to be formulated which could yield considerable energy savings.

The programme is under way in a textile dyeing plant having an annual cloth treatment capacity of about 4,000 t. Overall energy consumption would be about 270 TJ (6,500 toe/year) of which 77 % consists of fuel oil, 17 % of gaseous fuels (methane and propane) and 6 % of electricity.

The aim of the project is to reduce the above-mentioned consumption figures by 10 % at the end of the demonstration period (equivalent to about 650 toe/year) by installing suitable measuring instruments, analysing the data recorded and, finally, proposing on this basis suitable modification either to the installation or to the running thereof.

The project it at advanced stage and the tests carried out so far foster the hope that the targets will be met.

Industry : dairy industry

EE/008/79 – Carbery Milk Products Ltd – IRL

This project has been installed and is operating in the premises of Carbery Milk Products Ltd., Ireland.

The project is now complete and the first set of tests have been carried out. The results show that for similar production runs, 23 % of the primary energy input was saved on the production run with the heat recovery equipment installed. This is a little better than first estimates.

The testing organisations have carried out more work to finalise the savings in energy over long term operating and have performed another series of tests with the variables being maintained as constant as is practically possible. The results of these tests have not yet been published, but they are satisfactory.

In conclusion, the project has yielded positive results, the energy savings being estimated at about 430 toe/year.

EE/008/80 – Cooperative Zuivelfabriek en Melkinrichting «DE EENDRACHT» W.A. – NL

This project has been raised to demonstrate the reverse osmosis technique as a pre-concentration unit to an evaporator.

The aim was to increase the solids content of the skimmed milk form 6 – 8 % to 18 % by removing over 50 % of the water in the original feed stock. The energy savings envisaged correspond to 330 toe/year.

The project is not yet completed but first tests have proved encouraging. The main energy saving from this project is claimed to be in the transportation of the end product from the pre-concentration plant to the evaporators. This would no necessarily be realised where both units are ont the same site. The financial submission on the contract needs further examination since the cost of running the equipment appear to be higher than the value of energy saved.

Industry : miscellaneous

EE/244/79 – Joseph Crosfield & Sons Ltd – UK

The project covers the use of gas continuously extracted from coal mines which, normally, is vented to atmosphere. The existing boilers have been modified so that all the coal gas extracted from the mine – and, if need be, natural gas and heating oil – can be used.

The measurements carried out over 12 months have been extremely convincing. The new three-fuel burner and the control system have proved that they operate excellently and are reliable. Boiler ouput has remained virtually unchanged, thus enabling fuel oil and natural gas consumption to be reduced by about 22,000 toe/year.

EE/314/79 – Hermann Heye – Germany
This project demonstrates the use of mechanical energy made available by the expansion of natural gas from its supply pressure of 50 bar to its working pressure of 2 bar.
The energy is used to drive a screw type air compressor and corresponds to an energy production of 806 toe/year. The equipment installed has proved to be cost effective but its use will of course be limited to areas where gas is supplied at high pressure.

EE/167/80 – Compair Industrial Ltd. – UK
This project demonstrates a device by which screw compressors can be operated at part load more efficiently by utilising a two speed drive system.
The energy saving envisaged are 20 toe/year in primary energy. The project has reached the prototype build stage and first estimates of capital costs have been justified. This scheme should prove to be commercially viable when offered as an extra to the company's existing compressor range. Potential for replication is extremely good.

Fluidized beds

EE/022/79 – Deborah Fluidized Bed Ltd – UK
Disposal by combustion of residual wastes from the spent lubricating oil reclamation industry, including usable steam production, without damaging the environment.
The project is intended to provide a two-fold energy gain: the energy needed for incineration and recovery of the energy contained in the wastes.
The installation covered by the contract is a four MW entrained fluidized bed built at Avonmouth in the Tenneco Organics Ltd factory, which reclaims spent oils and produces an "inevitable" by-product in the form of a tarry residue at a rate of 2.5 t/h.
The work has been performed in line with the time-scale laid down both for the construction and for the testing and measuring stages. On completion of the programme the installation was acquired by Tenneco Organics Ltd and a repayment schedule for the repayable part of the subsidy was drawn up.
The development procedure was well suited to the disposal of harmful industrial residues without damaging the environment and yet saving energy. The advantages of the entrained fluidized bed using asymmetrical pulsed air at three levels were demonstrated perfectly by the project. The project also made it possible to demonstrate the reliability of the plant and its relative ease of operation. Its success was put to practical use by launching a commercial operation enabling 1,200 toe per year to be saved and offering prospects of a minimum saving of 150,000 toe/ year throughout the Community.

EE/027/80 – Metallurgie Hoboken – Belgium
An atmospheric-pressure fluidized-bed boiler was built to burn coal shale and mineral residues to produce steam in order to generate electricity in a back-pressure turbine.
The energy thus obtained is to be used in metal-treatment processes within the company. The bed combustion temperature is regulated to permit better fixing of the sulphur in the lime and to reduce nitrogen oxide emissions. A particular feature of the project is that the fluidization air is pre-heated by means of heat from the ashes.
As provided for in the schedule, plant start-up took place in February 1982. The initial combustion tests will cover: metering of the constitutents of the charge, the temperature regulation system, smoke filtration and the recovery of ash heat.
The demonstration proper remains to be carried out after plant assembly and initial testing. Its success depends, in particular, on the reliability of the measures to reduce the risk of plant corrosion and atmospheric pollution. If it is successful the project will yield savings of 8,000 toe/year and will help considerably in making use of low-calorific value fuels such as coal shales.

EE/126/80 – Kalkzandsteenfabriek «DE HAZELAAR» – Netherlands

The project is located in a building materials factory and its purpose is to produce the energy needed to make bricks by burning coal having a large ash and sulphur content.

The fluidized-bed technique enables the sulphur to be fixed in the furnace by injecting lime and to generate sufficient heat despite the high ash content. An original feature of the project consists of recycling the ashes by incorporating them in the brick making charge on leaving the furnace. Since the ashes are at a high temperature they help to reduce the amount of energy needed to heat the mixture to the required temperature and to avoid the expense of storing the ashes of carrying them to dumps. Installation is currently underway; the entry into service of the unit is planned for the end of the year.

The project is expected to yield a saving of 2,700 toe/year. With similar facilities the process could yield a saving of almost 300,000 toe/year at Community level.

EE/190/80 – Breda Termomeccanica Ansaldo – Franco Tosi – Italy

The project covers modification of the boiler in an oil-fired power station to burn low calorific value, high-sulphur coal mined close to the plant.

The planned modification consists in installing a 15 MWe fluidized bed. The particular feature of the plant would be its ability to recover heat from the ashes and use it to pre-heat the fluidization air. The power plant would produce about 80 t/h of steam to drive the turbines.

The design stage has been completed and site work has begun. The installation is due for completion by mid-1983. The fuel saving due to replacement of one fuel by another will be about 10,000 t/year. If successful, the demonstration will prompt the use of low calorific value coal in power plants and large industrial boilers.

Energy from waste

EE/160/79 – Esmil – NL

The aim is to build a plant for the combined treatment of household waste and sewage slugde.

The household waste is burned in fluidized beds, the heat generated being utilised to dry recyclable paper and plastic and recover metals. The sludges from the waste-water anaerobic treatment station are fermented (also anaerobically) to produce biogas. The plant is now being built.

EE/192/79 – Intradel – B

The object is to demonstrate the industrial feasibility of recycling mixed municipal plastic wastes deriving from the threefold selective collection of paper, glass and plastics.

The project is part of a large scheme for treating household wastes, comprising:
- the utilization of the products of selective collection, and
- the automatic sorting of the remaining waste.

The energy saving to the community at large is put at 11,000 toe/year. The installation will be built by the end of August 1982, i.e. with one year's delay.

The overall technical solution adopted for the treatment of household waste at Liège is based on a sensible approach, the activities involved being clearly devided into stages :
- paper, glass and plastic are collected on the same special round to reduce costs;
- the relatively unsoiled materials deriving from selective collection are recycled;
- a fuel is manufactured from the remaining waste collected in the normal way.

The plastics recycling project is an interesting attempt to recycle mixed wastes (mainly PVC and polyethylene).

The project's commercial success will depend principally on the market for mixed waste waste compound.

EE/235/79 – Foster Wheeler – UK

There are two methods, at present, of utilizing waste tyres : retreading and incineration (the latter with heat recovery). The aim here is to demonstrate a third possibility : pyrolysis, leading to the manufacture of marketable fuels.

By subjecting waste tyres to high temperatures in furnaces the contractor plans to recover combustible oils by a distillation process. It may also be possible to use the residue (carbon black and fragments of steel).

Work, which began on 1 January 1979, was suspended at the end of that year on account of the financial difficulties of the first contractor, batchelor Robinson; it was resumed, however, on 1 January 1982, after the latter's rights and obligations had been transferred to a new contractor, Foster Wheeler. The project will continue until 31 December 1983. To date, the equipment specifications have been drawn up and civil engineering works have begun on the site.

The project's programme provides for the treatment of 50,000 tonnes of used tyres per year, giving 16,000 tonnes of combustible oils, 14,000 tonnes of carbon black and 5,000 tonnes of steel fragments.

It is not yet possible to say whether the project will be viable, since there are risks of furnace explosions. If this risk can be obviated, the generalization of the process could save the Community as a whole 200,000 toe in liquid form, 100,000 tonnes of solid fuel and 80,000 tonnes of steel fragments.

EE/285/79 – IMAG – NL

The projects consists in fermenting manure anaerobically at three farms raising pigs, cattle and poultry.

The three digesters (ranging in volume from 100 to 1,000 m^3) will work at temperatures lower than those normally used and have a shorter payback time; they will thus produce more gas and require less heat.

The biogas produced serves to heat the animal stalls and the water needed to clean them. One unit is in operation, having solved certain technical teething problems, and the two others are being constructed. It is hoped to produce eight toe/year of biogas.

EE/033/80 – British Airways – UK

The object is to demonstrate the technical and commercial viability of using the waste produced on site at Heathrow Airport to provide all the energy needed in an airport service building.

The energy generated by burning the waste is supposed to meet the heating and cooling requirements of a building by doing away with heating oil and reducing electricity consumption by more than 30 %.

The annual saving is estimated to be about 1,000 tonnes of fuel oil and 2,300 MW of electricity. The novel aspect is the use of on-site waste for combined heat and cooling purposes.

The project includes the construction of an incinerator linked to a single control system which will allocate the heat produced to three functions : heating; hot-water production; cooling, with venting of the excess air to the atmosphere.

The preparation of the incinerator and the control system specifications started in July 1981, and the stage has now been reached when the specified equipment can be ordered. On-site assembly will begin in the first half of 1983, and the first trials are scheduled for the end of 1984.

EE/142/80 – E.Bi.A – I

The aim of this project is to build a demonstration centre for the anaerobic digestion of animal, vegetable and municipal waste, with biogas production.

This centre offers the possibility of meeting a major requirement which exists in Europe :

- summary and evaluation of the research effort dispersed among the Member States : substrates, fermentation techniques, nutrients, digester and storage engineering;

- study of the conditions under which the biogas and the digestate can be used and which largely determine whether the installations will be economic;
- on-site follow-up at various installations: training, information, assistance and experiments;
- a place where scientists and others of different nationalities can meet.

The centre has now been set up. The trials conducted have shown that the best results are obtained from the following substrates:

1) sewage sludges + organic fraction of household wastes + pig slurry;
2) pig slurry + cattle manure.

The risks attaching to the stage financed by the Community are commercial rather than technical, the objective of that stage being to sell six industrial-size installations. At the moment, an initial project in Modena with a 1,500 m^3 digester to take pig slurry seems certain to go ahead; another project, under study, relates to the commune of Broni which is trying to find the best way of treating the household wastes from the district.

EE/260/80 – Skive Egnens Erhvervsråd - DK

The object here is to build a power station which will generate energy from household and industrial waste, slurry, solar energy accumulated in the ground and energy from the outside environment.

After sorting, the solid household and industrial wastes are mixed with coaldust and compressed into briquettes. Most of these are sold as fuel for solid-fuel stoves or boilers. The rest are burned in the power station, and the heat produced is sold. The liquid household and industrial waste, the slurry and the municipal sewage sludge are processed to produce biogas and compost. The biogas feeds the gas engines driving an electric generator and a heat pump system.

The reservoir of external heat for the heat pump is provided by tubes buried in the ground and panels which draw energy from the outside environment. The electricity, the heat from cooling the engines and from the heat pump are all sold; completing the power station are two wind pumps which drive air compressors used for producing hot water.

The various sources of heat (wind power, heat pump, cooling of gas engines, briquette-fired boilers) operate at different temperatures and are arranged in series. The aim is to produce an annual amount of energy equivalent to at least 6,000 tonnes of oil. The municipalities concerned are reviewing the preliminary studies at the moment, before taking any decision to commit themselves financially.

EE/287/80 – Friedrich Wahl – D

The wood scrap produced by sawmills consists of chips, sawdust an bark.

A general outlet for the first two is the paper and board industry, or the manufacture of agglomerates. It has not so far been possible, however, to use bark, which contains a wide variety of organic matter, has a high humidity level and is soiled by vegetable remains or earth. The aim of the project is to gasify these wastes in closed furnaces and to use the gas to drive the turbines of a power generator. Four units of 120 kWe/h are planned, the power from which will be used to drive the various types of equipment in a sawmill producing about 30,000 t/year of building materials. The cooling water, whose temperature will be raised to 90° C, will also be used in the plant. The expected energy saving will be 230 toe/year.

Shortly after the gas producers were started up at the beginning of 1981, it was apparent that the risks involved in using this type of waste had been underestimated. The gas produced contained water with a high phenol content, the discharge of which, after condensation, was not acceptable in terms of environmental protection standards.

To reduce phenol formation, the contractor tried operating the gas producers at a lower temperature, but this produced tars which blocked the ducts, and the installation was seriously damaged in a test run in May 1981. The contractor is currently busy modifying the installation, so that the bark can be gasified more completely using a fluidized-bed system. This will require further studies and development, and the contract programme, which was scheduled to end in April 1981, will thus be delayed by over a year.

EE/001/81 – E.Bi.A. – I

The object is to show that ethanol (96% to 99.9%) can be produced from low-value cellulose material, seeking the best energy balance in the process.

The projected balance for 7,500 t/year of processed cereal husks is as follows :

- ethyl alcohol : 1,150 toe/year
- available biogas : 350 toe/year
- nutrient meal : 2,000 t.

The available biogas represents only 35% of the total produced : 65% is used as a source of energy for the installation.

The merit of the project resides in its advanced integration and particularly in :

- the favourable raw-material supply conditions (rice husks);
- the optimization of the energy balance by various means :
  - the anaerobic fermentation of the by-products of hydrolysis and alcoholic fermentation, giving more biogas than is required for system heat;
  - the obtention of a 10%-strength liquor from a cellulose substrate, thus reducing the energy consumed during distillation;
  - reuse of the distillation heat in the pre-hydrolysis and hydrolysis stages;
- the use of the methane-fermentation digestate as a protein meal.

EE/179/81 – Comune di Modena – I

This type of operation, often carried out in the United States, involves drawing off the biogas that is formed spontaneously in tip strate and pumping it to a major consumer of thermal energy, in this case a briquetting works 1,200 metres away from the tip.

Heaving peaked in the first year, biogas production will decrease rapidly over the following fifteen years. Mean production will be about 680 toe/year. The plant is under construction.

ROAD TRANSPORT

A. Road transport – Internal combustion engines

EE/262/79 – Thomson – CSF S.A. – F

Optimization of the ignition and carburation of automotive petrol engines during the warm-up period.

Since DEA-TH (the CSF company's automotive electronics department) has already put on the market an integral electronic ignition system and, as a cooperative venture with the Solex company, a carburation control device, Thomson – CSF S.A. has proposed a project to demonstrate a microprocessor-controlled integrated system for instantaneously optimizing the ignition and carburation of spark-ignition engines.

This system would be particularly attractive before the engine was properly warmed up i.e. during the first few kilometres following a cold start.

To provide adequate system flexibility the study would relate to three distinct vehicles having different engine capacities : a Citroen GY (the new GS), a Citroen Visa Super and a Peugeot 504, which would be fitted with adequate engine-parameter display systems (the most important being ignition advance) with a "binnacle" for the manual override and a printer.

The Company predicts that fuel consumption will be reduced by 5-15%, depending on the type of vehicle, or in other words about 0.5 toe/year for the three vehicles in question. This prediction is theoretically feasible, especially for vehicles which, by definition, operate under stop-start conditions (taxis, vehicles driven in city centres etc.). Predictions apart, it is however, not possible at present to say definitely how far the research has gone. We therefore feel that a visit is needed to assess just how much work has been done on the programme so far.

EE/178/80 – Alfa Romeo SpA – Italy

Use of a "cylinder cutout" engine incorporating electronic injection shut-off in a number of cars mainly used in urban traffic (taxis).

Alfa Romeo's EEC demonstration project consists in fitting 10 taxi versions of the Alfetta car with electronically and microprocessor controlled engines. Envisaged energy savings at project level of 2.5 toe/year.

The on-board injection and ignition control unit has interchangeable memories so that it is possible for the engine to operate normally on either four or only two cylinders. In this case "modular" operation consists of being able to initiate combustion in either four or two of the engine's cylinders, depending on the driver's power requirement, with activation or disablement of the relevant injectors.

The vehicles were placed in the hands of a taxi company which used them for about six months. All of the taxis were fitted with tachographs to record the number of kilometres travelled, the number of hours worked and the type of journey made. At the end of each working day the fuel tank was filled up to show consumption. The two cars having covered the greatest number of kilometres are undergoing a complete check-over. The average fuel saving can in any case be taken to be 10% as compared with an ordinary four-cylinder injection engine. However, if a comparison is made with an ordinary carburetted engine, an additional saving of about 10% can be anticipated, not only because of better fuel metering, but also because of the shut-off facility offered by injection engines, which cuts off the fuel supply when the foot is removed from the accelerator.

The saving from cars with a swept volume of more than 1,700 cm^3 – 15% – would be 2,250 m^3 per year i.e. 1,660,000 toe. The path followed by the company is, however, the simplest and most economical and therefore the most acceptable to the market. It can be applied to fuel-injection engines which will certainly be the most widespread before very long, in view of the advantages offered at low cost by the most recent electronic injection systems.

EE/221/81 – Renault Véhicules Industriels S.A. – France

Design, development, and demonstration on board vehicles of a Rankin-cycle system for recovering energy from engine exhaust gases.

The aim of the programme is to use the considerable amounts of heat available from the exhausts of diesel engines used in commercial vehicles to generate further mechanical energy for feeding back into the engine (output) shaft.

Renaul VI intends to link commercial-vehicle internal combustion engines with steam engines, using organic fluids and equipped with turbo expanders, whose power output will be fed into the engine output shafts by means of suitable mechanical transmissions.

The programme has only just begun and its state of progress is unknown. It is expected that the type of engine referred to above, fitted with the recovery system in question, will yield the very low specific consumption figure of 150 g/hp, which has never been attained hitherto. Over the speed range of 75-85 km/h of a maximum-capacity vehicle, whose current engine consumes 34.2-37.2 litres of fuel per 100 km, consumption drops to 30.5-33.5 litres per 100 km if the recovery system is fitted, which means 6.3 toe/year per lorry.

These are figures for motorway driving, whereas the fuel saving is much greater under give-and-take conditions. The turbine configuration in the Renault project is particularly economical, but on the other hand the payback period for the extra cost of the vehicle seems to be quite long despite the fuel saving (4-5 years). The demonstration which the Renault company is performing is extremely useful. Since the experiment is still in its early stages, its state or progress is unknown. The information provided will be very valuable in enabling the usefulness of this type of recovery to be determinated.

B. Electric vehicles

EE/085/80 – Odense Elforsyning – Denmark

The contract which was signed by Odense Elforsyning on 16 December 1981 concerns the use of 5 Fiat 900 E/E2 electric vans in the service fleet of a Danish public electricity supply organisation.

The Danish project can be regarded as an extension of the Italian project, since it involves the use of the same vehicles. However, three features, which are different, permit the collection of additional information and experience. These features are :

- climate – Denmark being the most northerly EEC-member country;
- application within another public service sector in different traffic conditions;
- electricity supply from a combined heat and power station.

The 5 electric vans will be delivered by October. One of the 5 vehicles will be fully equipped as a test vehicle and instrumentation in the remaining 4 vehicles will, as a minimum, include on board kWh meters. The energy saving shall be 30% or 2 toe/year. The work on the measurement programme started on the 1st of December 1981. The contractor, together with the collaborating Energy Research Laboratory, is seen to have a very good capability for carrying out the required work in a professional manner.

In addition good contacts with related EEC reserach projects – in particular the DG XII-supported Anglo-Danish project "Advanced Battery Development», COST project 302 (electric vehicles) and AVERE – exist.

EE/130/80 – Fiat Centro Ricerche – Italy

The contract covering a demonstration with 10 Fiat 900 E/E2 vans to replace conventional vehicles in Torino (Turin) telephone installation and maintenance operations formally started on the 1 October 1981. The aim of the project is to demonstrate operational effectiveness regarding both energy and costs.

In terms of energy saving, it should correspond to 4 toe/year. In addition to the 10-vehicle fleet to be operated by the telephone company a test vehicle equipped with sensors and a magnetic recorder for complete dynamic performance monitoring will be operated by the Fiat Research Centre.

The activities are progressing well. During the first year of the four-year programme the following three phases will be completed :

1. manufacture and testing of the "test vehicle";
2. manufacture of the 10-vehicle fleet;
3. start-up of fleet operation.

During the first six months the test vehicle has been manufactured and the procurement of materials and components for the manufacture of the 10-vehicle fleet has been prepared. The test vehicle shows excellent traffic compatibility with full payload. During the next six months the 10 vehicles for the fleet will be delivered.

The contractor is involved in a battery and charger research project under the EEC indirect programme (DG XII), and this offers an excellent opportunity for the establishment of real coordination of the two EEC programmes. In fact a field test of the on-board lightweight charger developed under the research programme is planned to be included in the demonstration programme. In addition, good contacts with COST project 302 (electric vehicles) and Association Européenne des Véhicules Electriques Routiers (AVERE) exist.

The initial proposal was for 70 vehicles but a 10-vehicle fleet is sufficiently large for the direct evaluation of the operational effectiveness in terms of performance, energy consumption and operational costs.

EE/161/80 – Electricity Supply Board – Ireland

A contract covering a demonstration project with 15 large electric vans to replace conventional vehicles in electricity supply, municipal, public transport and post & telegraph service, was signed by the Electricity Supply Board, Dublin on the 12th of November 1981.

In February 1982 two of the intended fleet owners – the Department of Post and Telegraphs and Dublin Corporation – announced their decisions to withdraw from the project for reasons of financial stringency. Consequently, the eventual fleet will total eight, four second generation Daily Electric IVECO 35F8s with a 890 kg payload and four Dodge 50s with a 2,400 kg payload. It is intended to put 4 Daily Electrics and 2 Dodge 50s in operation in the fleet of the Coras Iompair Eireann (CIE). The IVECO vehicle was demonstrated in Suzzara, Italy on the 29 March 1982. It displayed excellent traffic compatibility. The Dodge 50 has also good performance. The energy saving envisaged si 4 toe/year.

AGRICULTURE

EE/209/79 – PAGV – Netherlands

In this project waste heat from a small electricity generating station is recovered to heat the soil by means of buried pipework in order to speed up the growth of plants.

The demonstration covers 1.5 ha of crops divided into plots which on a random basis are either heated to various temperature levels or remain unheated (reference plots). The plan had been to link the generating station with the crop fields by means of a buried pipe about 5 km in length. This pipe was to cross a dyke but in the event the competent Ministry did not authorise this. An amendment to the contract was accepted whereby the temperature of the condenser in the generating station is measured continuously and the values transmitted automatically to the demonstration site where a conventional natural-gas fired boiler reproduce exactly the temperature levels of the waste from the electricity generating station. The project is under way and the first results will be available soon.

EE/278/79 – ENEL – Italy

The aim of the project, by the Ente Nazionale per l'Energia Elettrica, is to use the low-temperature heat contained in the cooling water from conventional or nuclear power plants in order to improve the crops from market gardens of other agricultural holdings.

The hot water will be used either to irrigate or to heat the soil by means of buried pipes, or to heat the air about the crops. It is above all expected that this project will enable production to be increased, germination to be speeded up and seasonal crops to be early. The purpose is to perfect this particular technique by assessing from a technical and economic standpoint the various ways of using hot water from power stations in agriculture and to determine which types of crop would derive most benefit.

Two installations are planned: the first near the Trino Vercellese nuclear power plant on the River Po near Casale Monferrato (Piedmont) and the second near the conventional power plant at Tavazzano near Milan (Lombardy).

The Tavazzano installation consists of seven tunnels, four greenhouses and three plots in an open field. The fields are being planted and completion of the measurements is anticipated for 1985.

The Trino Vercellese installation consists of 6.5 ha of crops in an open field. Experiments are planned using different irrigation techniques involving hot water, sprinkling, trickling, lateral infiltration or flooding. Completion of this installation has been greatly delayed as a result of an extended shut-down of the nuclear power plant for technical reasons.

EE/002/80 – AYLESCOTT DRIERS – UK

The hot air used for drying fodder is recycled instead of being discharged to atmosphere.

Before drying proper, the fodder is passed through a press to squeeze out the juice, which is then concentrated with assistance from the recycled hot air, then added to the cake. This process yields a two-fold energy saving:

- that of the heat recovered; and
- the lower consumption of energy needed to concentrate the juice as compared with the drying of fresh fodder.

The installation is complete and a saving of 200 toe was achieved during the first drying sequence involving 3,750 tonnes of fodder.

ALTERNATIVE SOURCES : SOLAR ENERGY

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SOLAR THERMAL

1. Housing and Buildings

SE/043/79 – Tidcombe Lane First School – UK

Space heating and domestic hot water preparation by 70 m^3 of flat plate collectors, 2 storage tanks of 9 m^3 and 5 m^3, and hot water cylinder of 1.2 m^3.

Space heating system : fan coil heaters and radiators. Construction was finished in September 1980. Monitoring is still going on until September 1982.

No monitoring results are yet available. The performance is expected to be good. The education value is outstanding and the potential for publicity good due to clear design and use for teaching pupils even from other schools. Energy produced per year : 5.4 toe.

SE/131/79 – Glaverbel SA – B

Domestic hot water for a factory.

Flat-plate glass collectors heat the water sufficient for 45 showers per day for the factory workers.

The glass, which is preferentially transparent to visible light, was tested and then, after several breakages, partly replaced by ordinary glass.

The installation has been overdimensioned since requirements have proved to be almost three times below estimates and the (often saturated) storage reservoir has prevented the full recovery of all the energy collected.

Energy produced per year : 1.23 toe.

SE/149/81 – House at Mambour-Demeuse – B
Heating of an individual house.
Solar heating of an individual house by air-type collectors incorporated in the roof and by air/air heat pump. Storage in saline media using the latent heat principle (study of the composition and conditioning to overcome the problems of supercooling and ageing and to optimize the yield from the heat exchange). Estimated solar gain in kWh/year: 10,000. Roof-mounted air-type collectors considerably reduce the extra solar investment cost. The project is well designed; if properly implemented, a noiseless air-heating system is a viable proposition. Latent heat storage using an air-type system is highly experimental and warrants the proposed study, the cost of which is insignificant when compared with the total estimated cost of the installation. It should be pointed out however that, assuming a payback period of 10 years and considering the estimated project costs, the overall cost is very modest.
Energy produced per year : 1.41 toe.

SE/151/81 – Era-Bertin – F
Communal heating.
Solar back-up for the electrical heating of a 23-apartment block by opaque air-type collectors covering the entire south-facing wall. Electrical underfloor heating and convector heaters in each room. Preheating of the fresh intake air by air collectors and by heat exchangers which extract heat from the exhaust air.
Building is over-insulated with a low thermal mass (G = 0.75 W/m^{30}C, including ventilation). Windownless, south-facing wall covered with absorber panels.
It is a pity to cover the entire south-facing wall completely in order to obtain a 33% saving on heating. The extra cost seems rather high compared with the modest solar gain. A building with its main wall facing south, of average thermal mass and with double glazing and insulating shutters would have achieved almost the same solar gain (20% of the energy consumption by direct gain alone and without an active system).
Energy produced per year : 7.2 toe.

SE/152/81 – Unerg – B
Office heating.
A building, part of an administrative complex, has been insulated and fitted with 80 m^2 of unglazed and insulated copper absorbers linked to two 16kW heat pumps serving a 1,000 litre cold storage tank and a 1,000 litre insulated hot-water storage tank. Heat distribution via steel panel radiators (initial temperature = 65°C) located below the windows. Very promising system for two reasons :
(1) The operating principle (heat pump + absorbers alone).
(2) System retrofitted on an existing building.
The three other buildings in the complex will be fitted with monitoring instruments so that comparative energy balances can be drawn up.
Energy produced per year : 2.9 toe.

SE/154/81 – Bouwcentrum Techno – NL
10 Solar houses at Capelle/IJssel.
15 m^2 of air collectors on each home. Storage in a concrete column including a 140 litre domestic hot water tank. Bas-fired back-up heater. Construction will start in Spring 82. The estimated payback period is 60 years (lifetime 20 years, constant gas-prices). The design is simple. So the lifetime of the plant will be longer than 20 years (as assumed in the contract). Serial production will improve economy.
Energy produced per year ; 5.2 toe (10 houses).

SE/155/81 – Bouwcentrum Techno – NL
10 Solar houses, Capelle/IJssel.
3 elements of solar utilization in each house.

a) Greenhouse in front of the living room both triple glazing.
b) Wall-collectors (10 m^2) on all the southern walls. Air circulation by gravity. Interesting wall-operated control system.
c) Active air-collectors (5 m^2) for domestic hot water system. Storage 150 litre The project is still in the planning stage.

The project is an example for the systematic application both of active and passive solar-heating techniques. Long lifetime can be expected. Pay-back period 67 years at constant gas prices, 20 year lifetime. Economy could be satisfactory in serial production.
Energy produced per year : 4.5 toe (10 houses).

SE/156/81 – Centro Ricerche Macchine Tessili – I
The project is conceived for two operation modes :
Summer : Air conditioning and hot water production by an absorption heat pump, fed by solar concentrating collectors. **Winters :** Air-heating and hot water production directly by the solar panels. Supplementary heating by a conventional heating system. The project is still in the planning phase.
Estimated pay-back period : 25 years. The yearly operation time of the high temperature part of the plant will be short. Interesting application for hot countries.
Energy produced per year : 25.2 toe.

SE/160/81 – Usines Pernod – F
Heating and air conditioning of offices and industrial premises.
Using air-type collectors, greenhouses, storage of heat in concrete blocks, a heat pump; these systems serve various buildings (industrial premises, offices and restaurants) and supply domestic hot water to the restaurant. The Pernod plant is located near Lyon. The development of the heat storage system using concrete blocks should be monitored closely since it appears both simple and cheap.
Energy produced per year : 67.7 toe.

SE/163/81 – The Helix Multiprofessional Services – UK
2 semi-detached houses, one of them conventionally heated, the other :

- Construction as "home within a house" using the thermal mass of the wall.
- Direct gains through southern front windows.
- Active air collectors, storage in the walls.
- Fresh air suction in summer by a gravity ventilation through the air collectors.
- Conventional back-up heating system.

Construction is finished. Monitoring equipment will be installed in Spring 1982. The components are straightforward. Interesting comparison is to be made between conventional and the solar heated house.
Energy produced per year : 1.4 toe.

SE/179/81 – Solar Lodgings – UK
33 m^2 of collectors on each house, feeding 3 central heat stores : 1 for domestic hot water, 1 for space heating, 1 for excess heat. The project is not yet in construction, because the building site was not available.
Obviously there are no passive elements utilized in the design of the houses. All possibilities of passive solar utilization should be used before installing active devices. Advantage of the central heat stores : less heat losses. It will be very interesting to have a comparison between the results of a purely active solar house and an active – passive house.
Energy produced per year : 8.9 toe (9 houses).

SE/183/81 – Hotel Banghion – H

A period hotel has to be modernised. The central courtyard will be covered by a glazing thus serving as a greenhouse in winter and as a passive air conditioning element in summer.

Additionally, there will be an area of solar panels on the south-facing part of the interior side of the roof. The project is still in the planning phase.

The project is a very important effort to use passive solar elements in older properties in the Mediterranean. The design will be very difficult. Economy seems to be very favourable (payback period 15 years). The public impact will be high because of the great number of guests.

Energy produced per year : 14.2 toe.

SE/186/81 – Istituto Autonomo – I

Space heating of 5 houses (60 flats, 260 inhabitants) by passive solar utilisation.

Greenhouses on the south-facing walls. Storage of the passive solar gains in the walls and in the floor. The houses are arranged on the site in such a way, that no house will be in the shadow of another one. The domestic hot water is prepared by flat plate collectors. The project is in the planning stage.

The project seems to be very well prepared and carefully designed. The payback period is estimated with less than 20 years.

Energy produced per year : 44.9 toe.

SE/199/81 – Bourneville Village Trust – UK

Two existing houses for old age pensioners are retro-fitted with two different types of flat-plate collectors for domestic hot water production.

Surface areas : 44 m^2 and 113 m^2. Both of the houses have different heat storage systems.

The comparison between the two houses will be interesting, because the two projects are slightly different.

Energy produced per year : 3.0 toe.

SE/207/81 – Terme Etrusche – I

A new thermal bath centre will be built.

The utilization of solar energy is foreseen for:

- heating of domestic hot water;
- heating of the water for the swimming pool;
- mud heating for medical applications;
- clay drying.

Technical data:

- 1,200 m^2 of flat plate collectors divided into 3 independent systems.

The project is in a planning stage.

The design is made on the basis of well-proven technology. The necessary temperature is between 50° C-60° C. The investment costs are relatively high. The public impact will be high, corresponding to the great number of guests expected to use the centre.

Energy produced per year : 54.7 toe.

SE/216/81 – Three Solar Heated Houses – UK

Combination of passive and active solar utilization elements in three houses – 30 m^2 of solar air collectors on each house – 4 m^3 rock-stone consisting of bricks : – greenhouse elements for passive heat gains.

Domestic hot water preparation by the solar installation.

The plant is a well designed combination of greenhouse elements in front of the south-facing living-room, and of active air collectors at the walls of the rarely used second floor room. The payback period is estimated to be reasonably shorter than the plant's lifetime.

Energy produced per year : 1.43 toe (3 houses).

SE/228/81 – Unione Piemontese – I
The use of active and passive solar technology will reduce energy consumption in buldings by up to 60%.
The project is the first step in developing large scale solar technology for residential buildings. Passive part : Careful arrangement of the buildings on the site with respect to the shading effects between the buildings. Careful design of windows and insulation. Greenhouse elements.
– Active part : air collectors to preheat ventilation air.
It is very important to develop a solar technology for large scale buildings.
The project seems to be very carefully designed. The payback period is estimated to be shorter than 15 years.
Energy produced per year : 263.7 toe.

SE/235/81 – GEC Power Engineering – UK
250 m² of evacuated tube collectors are providing hot water for kitchen use in a factory.
The collector circuit is connected with the factory's high pressure water system. (100% solar rate in summer). Collectors are currently being tendered for.
Well-proved technology, medium payback periods. Good example for consequent integration of solar energy.
Energy produced per year : 11.9 toe.

SE/237/81 – "Sol og Vind" – DK
27 single family houses and a communal building are using passive energy conservation elements as far as possible.
The active system consists of 640 m² of solar collectors of two heat-stores with a volume of 45 m³ and 28 m³ and of a wood-furnace. The storage tanks are situated in the centre of the "Village".
Construction was finished in September 1981. The project is one of the first centralized applications of solar energy for a great number of houses. The thermal storage losses will be low because of using only two great storage tanks, but the heat losses will increase due to the long distances between collectors and storage. The pay-back period is estimated to be 25 years.
Energy produced per year : 12.5 toe.

2. *Agriculture*

SE/04/79 – Azienda Floreale Diem – I
A greenhouse for seedling growing of pot plants is heated with solar energy.
The air collectors are mounted above a pebble stone bed which is used for energy storage. The greenhouse was additionally insulated with double glazing (polyacryl). The installation is almost 100% self sufficient. The project is partially finished, namely the small demonstration (271 m² greenhouse) and the planning of the 800 m² greenhouse. Very well designed application of solar energy for greenhouse heating. Short pay-back period. Insulation of greenhouse has to be done before applying such a system.
Energy produced per year : 24.4 toe.

SE/14/79 – Sassari – I
Agricultural by-products are chopped, ground, dried and processed into pellets.
The electric and heat energy for the drying process and the pellet production is provided by two different solar installations :
- 60 m² of flat plate air collectors heat the air for the drying process. Heat can be stored in a pebble stone bed. Collector outlet temperature is 60-80° C.
- Electric energy is produced by a turbine-driven 5 kW generator. The turbine is part of thermodynamic circuit, which is heated by 48 m³ of concentrating (Fresnel Lens) collectors.

The construction of the plant was finished in october 1981, but some parts of the electric generator section are still missing or defective. The drying section of the plant is in satisfactory operation. There are reasonable economic results to be expected. The power generation section demands very high investment costs.
Energy produced per year : 10.9 toe.

SE/15/79 – Adelkam Wine Farm – I
200 m² of concentrating collectors are generating process heat for the following processes :
- Wine cooling by means of an absorption chiller (required temperature 120°C)
- Wne pasteurizing (required temperature 120°C)
- Bottle washing (80°C)
- Space heating (80°C).

The project is not yet in construction because of problems with the purchase of a suitable absorption chiller. The plant is designed on a high technological level and therefore careful planning and a well-trained maintenance staff is necessary. The pay-back period is long (26 years), because the plant is designed to provide almost 100% of the process energy demand. Under conditions of a lower solar percentage a better pay-back could be expected.
Energy produced per year : 7.1 toe.

SE/123/79 – IMAG – NL
Solar-heated water for livestock rearing.
Air-type solar collectors linked an air/water heat exchanger produce hot water to dissolve the milk powder used to feed 600 calves. Anticipated solar gain : 42,000 kWh/year, i.e. 54.5% of requirements. In view of the poor efficiency of air/water exchangers, the use of air collectors for water heating is not the best solution. The solar panels were poorly dimensioned and had been damaged by a storm. Considering also the economic difficulties in rearing calves, the inveytment seems to have been misplaced. Nevertheless, in view of the significant energy requirement, an installation using water-type collectors could have yielded good results.
Energy produced per year : 3.6 toe.

SE/125/79 – IMAF – NL
Solar heating of a methane digester.
Glazed flat-plate collectors produce hot water which is used to maintain the optimum temperature in a tank producing methane from pig slurry. Solar gain : 125,000 kWh/year for a total collector surface of 600 m². The tank "digests" 10 to 15 m³ slurry per day.
The operation of a biodigester is fairly complex, involving the interplay of several parameters. It may well be that a solar installation with a variable output will further complicate a system which is still at a somewhat experimental stage. Generally, part of the gas produced by the digester is used for reheating purposes which reduces investment cost. Since the installation is still being developed, its cost-effectiveness cannot be assessed.
Energy produced per year : 10.8 toe.

SE/188/81 – University of Perpignan – F
Solar-heated corp drier.
A fruit-growing cooperative in the Eastern Pyrenées uses 22 m² of air-type collectors to heat the air in a fruit and vegetable drying tunnel. Output : 5-10 tonnes per day. Back-up heating system : Variable resistance elements totalling 10 kW. The University of Perpignan designed and provided the instrumentation for the unit.
The method uses a fairly abundant local resource, (i.e. the sun) to provide low-temperature warm air. Crop drying accounts for 10% of the total direct energy consumption by agriculture in France, i.e. 500,000 toe in 1980 (source : Agence pour les Economies d'énergie).
The University of Perpignan project will provide more detaied information about the behaviour and efficiency of such systems.

3. *Industry*

SE/09/79 – "Multi-flash" Desalination Plant" – I

Parabolic through collectors are used to generate pressurised water at 90-100° C.

The multi-flash desalinator was tested before being installed on the Island of Lampedusa, to the south of Italy. The plant did work for testing during several months in 1981. It has to be redesigned for future use. The field of application of desalination with solar energy has a high potential.

Energy produced per year: 21 toe.

SE/176/81 – AGIP Nucleare – I/MAN – D

1,728 m^2 of parabolic concentrating collectors are heating a thermal oil circuit.

Steam production by means of a heat exchanger. Collector outlet temperature: 280° C. Two axis suntracking system. Supplementary heating by an oil-fired steam boiler. The project is in the engineering and manufacturing phase.

The technology of the plant is very complicated. The mirrors are very sensitive to dust. High maintenance. Poor economy. Economy may improve slightly under conditions of serial production.

Energy produced per year: 108.9 toe.

SE/182/81 – Technotessile – I

100 m^2 of evacuated tube through-type collectors are producing steam for a textile factory.

Collector outlet temperature: 220° C. Two heat stores of a relatively small capacity, because the solar-produced steam is continuously used to supplement the conventional heating system. The project is in the engineering phase.

The technical concept is good. Solar gains can be used immediately without great storage volumes. Long payback period.

Energy produced per year: 6,9 toe.

SE/185/81 – La Metalli Industriale – I

Treatment of industrial effluent.

Oil-in-water emulsions – polluting residues from the engineering industry – are heated, via a heat exchanger, by hot water produced by glazed flat-plate collectors. The emulsions are then passed to an evaporation column where they are concentrated and their volume considerably reduced, producing an oil which is sufficiently concentrated (99 %) to be used as a fuel. The plant is designed to treat 400 m^2 emulsion per year. The contract is being negotiated.

The principle is interesting and deserves more detailed technical study. The industrial uses for low and medium-temperature heat are numerous, disparate and poorly understood. They represent a significant proportion of a country's energy consumption.

Energy produced per year: 1.4 toe.

SE/222/81 – Production of process heat – I

Production of thermal energy by the conversion of solar energy collected by 48 trough-type collectors with a total surface area of 168 m^2.

The value of this installation, which is incorporated in an operational industrial plant, is that it will enable the true efficiency of this system to be assessed.

Energy produced per year: 10.4 toe.

SE/227/81 – Valdadige Brick Factory – I

A new brick drying plant is planned with a wide integration of energy conservation and solar energy: 700 m^2 of air collectors will preheat the air (max. 80° C) for the brick drying and brick kiln process.

Heat storage by the clay depositary itself. The project is in planning stage.

The project is an excellent example for the possibilities of industrial energy conservation, combined with an efficient low-temperature utilization of solar energy.

Energy produced per year: 66.6 toe.

4. *Swimming Pools*

EE/61/79 – Uchaud Swimming Pool – F

Heating of a swimming pool and sports facilities.

Solar heating of an open-air swimming pool and a gymnasium. Production of hot water for the showers. Glazed flat-plate collectors, 15 m^2 hot water storage tank, anti-freeze/water exchangers, gas back-up heating.

Gymnasium (with roof-mounted collectors) due to be completed at the end of 1982. Work on the swimming pool due to begin at the beginning of 1983 as soon as municipal funds received. Total investment (collectors plus storage facility) is FF 2,541 per square metre of installed collector. A systematic attempt should be made to harness the same installation for two complementary uses (heating of the swimming pool in summer and of the gymnasium in winter) in order to get a better return on the water-type collectors. It is planned to cover the swimming pool at night. The payback on this project may make it a test case since it involves the optimum use of glazed flat-plate collectors (year-round use, fairly large scale facility, sunny area, proven techniques).

Energy produced per year : 25.5 toe.

SE/126/79 – Bundesinstitut für Sportwissenschaft – D

Rational use of energy in the construction of swimming pools.

Various energy saving concepts are demonstrated in three different public swimming pools (Stadtsteinach, Unna, Ahaus). Pool cover, heat recovery and solar energy. The collector's surface is equal to the pool's surface. Four different solar systems are demonstrated, glazed, closed loop, unglazed with heat pump, glazed open loop and unglazed open loop.

The fitting of the solar systems will start in May 82.

Advanced overall technology, rather expensive, collector surface to pool surface rather large. Extensive monitoring system should yield exact results for pool's energy consumption and supply.

Energy produced per year : 147.8 toe.

SE/P/3/81 – Indoor Swimming Pool – B

Heating of one of two indoor swimming pools and hot water for showers; surplus heat is fed into the air system.

Two fields of single glazed collectors with selective copper absorber. Closed loops with heat exchangers. Comparison between solar and conventional energy for pool heating is possible.

Energy produced per year : 16.4 toe.

SE/P/4/81 – Indoor Swimming Pool « De Thermen » – NL

Solar heating of an indoor swimming pool during the warm season.

Plastic unglazed collectors (FAFCO U.S.A.). Two fields 45° and 60°. Total area 578 m^2. The back of the panels is covered with corrugated plastic sheet, as support and wind protection. The collector's surface is appr. 90 % of the pool's water surface. The solar plant is installed, the monitoring campaign will start in May 1982.

An adequate technique for heating a swimming pool is used. The investment costs are relatively high due to the collector's subconstruction.

Energy produced per year : 27.8 toe.

SE/P/13/81 – University of Exeter – UK

Data-logging at a solar-heated swimming pool. Open-air pool measuring 10 x 25 m, operating since 1978 and open from May to September.

Polypropylene tubes sunk in the asphalt of a tennis court represent an original type of solar collector, the efficiency of which is to be measured. The swimming pool, which, for 1,140 hours of the year is heated by gas to a temperature of 24° C, consumes 180,000 kWh per season (no insulating pool cover).

It is planned to cover the pool in order to reduce heating requirements. The payback period for the solar installation should be between four and five years. The request for EEC financing relates only to the instrumentation and experimental monitoring of the system over two years by the University of Exeter. Several swimming pools go to make up the sports centre, which also includes tennis courts. If the collector monitored under this project functions properly and at reasonable cost, it would provide a neat solution to the problem of the amount of land needed for water-type collectors used to heat open-air pools.
Energy produced per year : 2.5 toe.

SE/P/17/81 – Piscine de Plein Air – B
Single glazed flat-plate collectors are used in a closed loop to heat the pool water supply, hot water to the showers and to a 100 m^3 storage tank.
This tank can be used by a heat pump as a source of low temperature energy. Total solar surface 2,100 m^2. The extensive monitoring system should yield good results. The solar field is installed. The monitoring system will run from May 82 onwards.
The high quality collectors used may be too expensive to be economically viable for this kind of application.
Energy produced per year : 86.4 toe.

SE/P/18/81 – Project by the General Secretariat for Sport of the Greek Government – H
Three solar-heated pools in Greece.
Three outdoor olympic pools (25 m x 50 m), open throughout the year and built between 1974 and 1978 and heated by oil, are in future to be heated (showers included) by between 1,800 and 2,600 m^2 glazed flat-plate collectors operating in an open system.
Solar energy contribution : 590,264 to 820,030 kWh/year (70 to 87 %).
Back-up heating : electricity (pump) and existing boiler – all the pools are fitted with a wind-break during the winter and will have an insulating cover at night. Basic payback period is between 6 and 7.6 years. This project is the first example of EEC aid being requested by Greece. If the project is successful, the fact that it has received EEC support should have a considerable impact on the future pattern of aid applications in Greece.
Energy produced per year : 176.9 toe.

SE/P/19/81 – Commune of Verona – I
Heating of the pool water, showers and general space heating of the indoor pool at Verona by means of a total of 750 m^2 of Pirelli solar collectors.
A number of energy-saving devices have been linked to this solar installation, i.e. : heat recovery units, heat pumps, radiant heaters. The feasibility study has been completed and is in the ready for signature. Work should begin shortly.
This is an excellent and well-designed project and those responsible (CREAIES) appear fully to have overcome the difficulties. The extensive data-logging programme planned should yield vital information on the true viability of the system.
Energy produced per year : 41.8 toe.

SE/P/20/81 – Robinson – UK
Eight solar-heated swimming pools.
Eight pools are to be fitted with Robinson unglazed collectors to heat the pool water primarily during the summer. The total insolation between April and September is 713 kWh/year (KEW weather station). The annual solar gain is 808 MWh for a total collector surface of 1,704 m^2 (total volume of the pools is 4,782 m^2; each year, 870,000 visitors will use at least one of the eight pools).
Low-cost unglazed collectors are particularly suitable for the summer-time heating of swimming pool water. The average payback period is six years (2.7-11 years) which is satisfactory.
Energy produced per year : 69.5 toe.

SE/P/22/81 – Eton College Swimming pool – UK
The project concerns the instrumentation and experimental monitoring of a solar-heated pool which is covered during the school year and is already equipped with a solar-heating system.
Solar gain : 32,000 kWh/season, i.e. 14.5 % of the pool's heating requirements (approximately 9 % of total requirements); the pool has an insulating cover over it at night.
Energy produced per year : 2.8 toe.

SE/P/23/81 – Albertslund " Badesøen " – DK
Solar heating of outdoor swimming pool with unglazed plastic collectors (ROBINSON, UK).
The pool will not be covered by night (circular pool with an " Island "). The collector area of 1,612 m^2 will be approx. 60 % of the pool's area. The collectors will be mounted on nearby roofs at an angle of 25° facing East/West. Extensive monitoring system planned. Unfortunately, the shape of the pool is such that it can not be covered.
Energy produced per year : 51.6 toe.

SE/P/25/81 – Electricity Supply Board – IRL
Indoor pool.
The pool, located in Dublin, measures 10.5 x 25 m and is open throughout the year; since 1979, it has been heated by an air/water heat pump operating on exhaust air. Electrical back-up heating for showers, pool and space heating. It is planned to save 8 % on the total energy consumption by installing flat-plate solar collectors in series to heat the incoming water supply.
Energy produced per year : 3.7 toe.

SE/P/26/81 – Horsens – DK
Heating of an open-air swimming pool with unglazed plastic collectors (ROBINSON UK).
Outside the swimming season the pool serves as an energy source for a heat pump. The latter will supply an indoor swimming pool with energy during October, November and March, April.
The system is not optimized concerning pool's surface (1,050 m^2) and collector's surface (300 m^2) which is 3/10, it should be 5/10 – 7/10.
Energy produced per year : 8.6 toe.

SE/P/29/81 – Stichting Sportfondsenbad Amersfoort – NL
The water of a large indoor swimming pool (200 m^3/d) is preheated by unglazed polypropylene collectors.
As the water temperature from the mains is 9-10° C, the energy gain is boosted if the ambient air temperature is higher (April-October).
A simple and useful application for preheating large quantities of cold water. Potentially high public impact (600,000 visitors per year).
Energy produced per year : 18 toe.

SE/P/30/81 – Stichting Zwembad Gouderak – NL
Solar heating for an outdoor swimming pool.
Unglazed plastic collectors (ROBINSON UK). The pool is covered by night. 344.6 m^2 collector surface is equal to 50 % of the total pool area. Simple monitoring system planned. The adequate technic for summer swimming pool should yield economical results.
Energy produced per year : 24 toe.

E/P/31/81 – Agip petroli – I
Heating of the water for an indoor pool and showers by means of 229 m^2 of solar collectors (with selective surface).
Priority is given to the heating of the pool water. The feasibility study is nearing completion.

The project is well designed but the choice of selective surface collectors seems inappropriate in view of the temperature requirements of the pool.
Energy produced per year : 10.3 toe.

SE/P/32/81 – Ronciglione swimming pool – I

Solar heating of the two pools and showers at a new indoor swimming pool by means of 330 m² of liquid-type flat-plate collectors linked to a water-to-water heat pump and heat-recovery units which extract heat from the waste water.

Space heating is provided in equal proportions by a heat pump which extracts heat from the exhaust air and by the direct solar gain from skylights in the roof.
A complex but well-conceived installation. The use of an auxiliary heat pump is very promising. The data-logging programme is very extensive and will be carried out by a competent centre.
Energy produced per year : 13.6 toe.

SE/P/33/81 – COMES – F

24 swimming pools.

COMES is acting as Contracting Authority on behalf of 24 French communes in response to the calls for submission of projects concerning the solar heating of swimming pools. The pools are divided up as follows : 17 open air; 3 mixed and 4 indoor pools. All the preliminary studies have been carried out by the Technip Consultancy Bureau; the Veritas Bureau is responsible for the data-logging programme. The solar-heating method used for open-air pools involves the use of low-cost, unglazed plastic collectors which offer an excellent economic return. For the indoor pools, glazed collectors have been used; even here, the economic return is good in view of the low operating temperatures and the simplicity of the systems used (the pool acts as a heat store). The design of the installations and the robust technology involved make the project highly suitable for demonstration purposes. The five and a half year payback period (of the solar installations alone) ensure a high economic return on the project. Since the majority of the pools are open to the public, the impact on the public at large is likely to be very effective.
Energy produced per year : 215 toe.

SE/P/35/81 – Torrevecchia swimming pool – I

School and public swimming pool with recycled supply; roof and southern facade retractable.

Three pools (1,111 m²; 24-26° C) are heated by 450 m² of Yazaki selective surface solar collectors. The annual heating requirements of 1,705 MWh for the pools are met as follows : 31 % by heat exchangers located on the filtration circuit; 16 % by the solar collectors and the remainder by an oil-fired boiler. In summer, the collectors supply 28 MWh for the showers, i.e. a total solar gain of 280 MWh/year.
The stated overall payback period of seven and a half years is accurate.
The covering of the pool and the recovery of heat are highly efficient devices which may mask the poorer returns on the expensive and fragile selective surface collectors.
Energy produced per year : 23.8 toe.

SE/P/41/81 – Bundesinstitut für Sportwissenschaft – D

Rational use of energy in the construction of swimming pools.

Various energy concepts are demonstrated. (See SE/126/79.) Two additional pools are chosen, Uelzen North; Ihringen South-West.
The estimated costs for heat recovery systems are high. In reality they might come down at least for the solar part.
Energy produced per year : 520 toe.

SE/P/43/81 – Commune of Urbino – I

Heating of the pool and shower water in an existing indoor pool measuring 25 x 10 m (306 m²) by means of a solar heating installation comprising 234 m² of glazed solar collectors.

Supplementary heating provided by an oil-fired boiler. There are two storage tanks for domestic hot water.
The feasibility study is nearing completion. The design of the installation is satisfactory and the overall payback period should be about 10 years which is normal for the type of technology involved.
Energy produced per year : 16 toe.

SE/P/46/81 – Naples Municipal Swimming Pool – I
It is planned to install 2,100 m² of Pirelli rubber absorber collectors, 1,300 m² of which are unglazed, to heat the indoor municipal pool at Naples.
The solar gains more than cover the total heating requirements of the pool. The excess heat gain could be used to heat the shower water at a nearby sports centre. The collector array is too big, which reduces its efficiency and hence its economic viability. No details have been given as to whether other effective measures to reduce consumption have been taken (covering of the pool, exchanger to recover heat from exhaust air, etc.) which would have allowed of the use of a smaller collector surface area.
Energy produced per year : 105.6 toe.

PHOTOVOLTAIQUE

SE/017/79 – Officine Galileo – I
The objective is to demonstrate how a 30 kWp photovoltaic generator enbodying concentrating devices can provide power for an agricultural cold store for cut flowers and heat for a greenhouse.
The generator consists of 28 1.1 kWp modules, each comprising 7 plano-parabolic reflectors of 2.5 m aperture x 1 m long, giving a theoretical concentration of x 25. The photovoltaic receivers are modular elements 2.1 m long, each consisting of two paralled series strings of 40 specially designed solar cells bonded to an actively cooled heat sink, to maintain them at a temperature of 75-80° C. Each 2-module unit is rotated during the day about in inclined N-S axis to follow the sun. The system includes 1-day battery storage, a dc/ac inverter and monitoring equipment. Initial design of all generator components and sub-systems completed. Other than the solar cells, all components are ready for the construction of 4 kWp prototype for design qualification. But only 1 kWp of solar cells are available and Ansaldo, the suppliers, do not wish to manufacture any more.
Because of the difficulties of solar cell procurement and serious technological problems with the concentrating system, it is unlikely that the project as it stands can be brought to a successful conclusion. In retrospect, a flat-plate array would have been a better choice. Such an array providing power for an agricultural cold store, would be a good demonstration, having the necessary elements of innovation, good publicity impact and good market potential in the near future.
Energy produced per year : 22.3 toe.

SE/028/79 – Katholieke Universiteit Leuven – B
The objective is to demonstrate the use of photovoltaic solar energy conversion to charge the batteries of an electric car.
A 1.8 kWp flat-plate photovoltaic array installed at a test site on the university campus charges the batteries of a 5-seat electric car throughout the day.
During the night, the car is used for security patrol purposes on the campus, travelling a total distance of about 35 km. The system includes a simple battery charge control unit, a facility for switching automatically to the grid supply when there is insufficient solar energy and a comprehensive data monitoring system.
About three-quarters of the solar cells have been made by the University but no modules have yet been assembled. The car has been delivered, the array structure and the shell of the control room built and the monitoring equipment is available. Delays have been due to problems with cell development and manufacture, the withdrawal of ENE, who were to

have assembled the modules, car procurement difficulties and planning delays. The expected completion date is now 1 June 1982.
Despite the delay, this could be an interesting and successful demonstration of the use of solar energy in electric vehicles which are not in use during the main part of the day. The concept is far from commercial viability at present but could find future application in sunnier countries, provided solar cells costs continue to fall, fuel cost to rise and the performance and range of electric vehicles are improved.
The solar cells have many innovative features, designed for high performance and low cost.
Energy produced per year : 0.5 toe.

SE/077/79 – Elf Aquitaine – F

The objective is to demonstrate the use of a photovoltaic solar water pump with microjet distribution to irrigate a plot of land in southern France and evaluate its effects on water consumption and crop yields in comparison with conventionally irrigated and non-irrigated plots.

A 924 Wp flat-plate photovoltaic array supplies current to a dc electric motor driving a 5-stage centrifugal pump, which transfers water from a borehole to a 30 m^3 overhead storage tank. Water from the tank is fed through manually operated valves to an experimental micro-irrigation network, which waters a 6,000 m^2 plot of land, divided into four sections. The experimental plot is adjacent to a 7,400 m^2 conventionally irrigated plot and two 400 m^2 non-irrigated plots. Data from all the plots are transmitted to a centre in Toulouse by satellite.
The installation was completed in 1979 and was monitored with maise crops in 1979 and 1980. For economic reasons, a change was made to asparagus in 1981. Because this takes two years to mature, no data were gathered in that year. It is proposed to continue monitoring until 1985. The project has aroused interest among agricultural research centres in France and has been visited by authorities from developing countries.
The plant has worked well, except for a single failure in 1980 (breakage of the pump drive shaft). Which caused a week's shut-down. Had it not been for this, the solar pump would have supplied about 80 % of the 1,012 m of irrigation water required during the growing season. It has been shown that irrigation increases crop yields by a factor of more than 3. The preferred microtube system produces more maize and uses only about one fifth of the water consumed by the conventional sprinckler system. A well conceived, well executed project, which is demonstrating an application of photovoltaics which may soon be economically viable, particularly in developing countries. The investigation and development of more efficient irrigation techniques is an important element of the project.
Energy produced per year : 0.3 toe.

SE/146/81 – Rijksuniversiteit Gent – B

The objective is to investigate the technical, economic and safety aspect of operating a 5 kWp grid-connected photovoltaic generator, supplying a simulated domestic load. To demonstrate the system to the public.

A 5 kWp flat-plate photovoltaic array, installed in a public place near the centre of the town, connected to an artificial load simulating the electrical requirements of an average 4-person Belgian household and with facilities for taking back-up power from the grid and feeding excess power to it. The system includes a 3-day storage battery, a dc/ac inverter and data monitoring equipment. The array voltage and tilt angle are adjustable for experimental purposes.
Work is in the early stages, the contract having been signed only three months ago. The electrical design of the system is complete. Modules and batteries have not yet been ordered, although suppliers have been selected. The array structure has yet to be designed and two experimental types of inverter, PCR and PWM, are still under development. The system, complete with monitoring equipment, is not expected to be fully operational until the end of 1983.

If well executed, a good demonstration project, providing an excellent opportunity to study the technical, economic and safety aspects of small, on-site, grid-connected solar generators. Has many innovative features, notably the low-cost solar cells developed by the Catholic University of Leuven and the Ghent inverters. Inclusion of such features incurs a certain risk and it remains to be seen whether the hardware will prove to be reliable.
It will probably be many years before roof-top solar cell arrays become economically viable for grid-connected residences and in Europe there are many non-technical obstacles to overcome before a market can be established.
Energy produced per year : 1.1 toe.

BIOMASS

SE/054/79 – Plessis Belleville – F
This is for the installation of a new type of fluidised bed gasifier using flax waste.
Use of the large quantity of material available could save up to 364 t/y conventional fuel, making the plant self-sufficient in electricity and oil and allowing a considerable off-site sale of electricity. Gasification as an alternative to combustion is applicable to a very large dry crop residue resource in the Community. The technology is well developed, and commercial plant is available and highly appropriate for demonstration in this context.
The scheme has good economic prospects in the French agricultural-industry context with a substantial potential national and Community market for the equipment. There is a possibly larger overseas market in developing countries and part of the research supporting this project has been promoted with that prospect in mind.
Energy produced per year : 364 toe.

SE/100/79 and SE/205/81 – Bord na Mona – Phases I and II – IRL
This very large project is for the establishment of 600 ha of short rotation forestry, development of management and harvesting systems, and the conversion of a power station to utilise the material.
The project target is for the supply of 15,000 t/y of short rotation forestry and supplementary material to supply a 5 MW generating system forming an element in the national electricity supply. The project is largelly based on the unique opportunity presented in Ireland by very extensive peat-lands, but it will be a crucial demonstration of the concept of energy plantations, applicable to other land-types in the Community and elsewhere.
It is supported by extensive long-term research and development which is now being scaled up to a commercial-sized operation. The main demonstration is of the overall concept as the component techniques do not involve any drastically new developments. Economic prospects are in-line with those of comparable peat extraction schemes, which, in the long-term, short rotation forestry is expected to replace.
Energy produced per year : 1040 toe.

SE/111/79 – S.E.S. – I
This is a demonstration of renewable energy systems, of which the main elements are a biogas plant and solar collectors, integrated into farm production systems to provide a large proportion of the energy requirements.
The biogas digester uses cattle waste and electricity and hot water are provided for drying units, aquaculture and greenhouses as well as for general farm requirements. Total contributions of about 50 toe/y are obtained for a reasonable investment cost and repayment time.
The demonstration uses commercially available equipment to utilise what are major potential sources of alternative energy for Community agriculture. Both digester and solar thermal technologies are at a suitable state of development for demonstration and of reasonable pay-back times will assist the expansion of the market for commercially available equipment.
Energy produced per year : 53.4 toe.

SE/145/81 – A.I.R.D. – B

The scheme is to carry out trials of digester technology using new materials and methods and to extend this work to the construction and operation of six, relatively small-size, digester installations in working environments using a variety of animal wastes as feedstocks.

This will assist in the demonstration of cost-effective biogas technology applied in different situations, some having considerable additional environmental and waste disposal benefits. The proposers have long experience in this work. The scheme is concerned with a key area of bio-energy development and, in animal waste, with a major energy resource in the Community. As such it should promote biogas technology in general and the associated market for equipment and engineering services.

Energy produced per year : 180 toe.

SE/177/81 – Baring-Asperup Co-operative – DK

The project is for a community energy scheme the main item of which is a district heating network supplied to a large extent by a biogas digester and solar collectors but including other alternative energy techniques including wind and combustion of wastes.

It could supply 700 to 800 toe/y; it exploits the large European biomass energy opportunity in animal and crop wastes, and is particularly appropriate to Danish conditions.

The state of art in component systems is well developed and they are appropriate for scaling-up to this level. The low temperature distribution system may be a considerable innovation. Prospects for economic operation are good and a successful demonstration will considerably boost the market for the various alternative energy system components and systems engineering. In the wider context the demonstration of a large measure of self-sufficiency at a community level will have important implications to energy policy both nationally and in the Community.

Energy produced per year : 619 toe.

SE/194/81 – Société d'Energie Electrique de l'Est – F

The project is for the installation of a very large generating capacity based on the combustion of sugar cane residues (bagasses).

By utilising the large bagasse resources available, not only will the energy requirements of the processing factory be met, but a large contribution can be made to the public electricity supplies of the island of Réunion. The substitution of over 10,000 toe/y of fuel is proposed by the application of well-proved technology and short pay-back times are envisaged. There is considerable scope in the developing countries for this kind of approach and energy supply strategy, using cane or other crop waste at a large scale.

Energy produced per year : 11,750 toe (47,000 MWh el.).

SE/200/81 – Ansaldo Impianti – I

This is a large digester utilising cattle waste contributing fuel savings of 160 toe/y or so and supplying most of the farm needs for hot water and electricity.

Surplus electricity in the summer months is used for irrigation in this way removing some of the problems of inbalance of supply inherent in digester technology in Europe. In cattle waste the scheme uses one of the largests and most immediately promising biomass energy resources in the Community and is of a size which should guarantee economic feasibility. Investment costs per prospective toe saved per year are low and there is a good pay-back time.

As is the case with other digester programmes the state of art of the technology is appropriate for it to be applied in practice at large scale. There is a large number of cattle units in the Community of sufficient size to justify installation of digester units which also have waste disposal advantages. Developments of equipment and systems are expected to reduce the minimum economic size of the units for which digesters can be justified, thus rapidly expanding the market for equipment and systems engineering.

Energy produced per year : 49.9 toe.

SE/220/81 – Marshall – UK

The scheme will burn poultry litter in a specially adapted boiler to produce the heating requirements for 20 per cent of the units of a large chicken-rearing enterprise.

It is projected to save 1,500 t of conventional fuel a year in this way. This large energy contribution is for a relatively low cost and consequently a short pay-back time of less than 4 years is projected. The state of technical development gives little cause for concern as modified standard equipment is to be used. With poultry waste the project addresses a more limited resource base than cattle waste, but there are numerous opportunities for extension throughout the Community.

Such a practice could have a considerable impact on the profitability of the poultry industry and expand the market for specialised boiler equipment.

Energy produced per year : 1,500 toe.

SE/226/81 – Azienda « Il Prato » – I

This is a demonstration of a digester system using poultry waste with the biogas used for electricity generation supplying most of the farm needs.

Hot water from the total energy modules will also supply a proportion of farm needs for this, including for heating greenhouses that are included in the system. Total energy contributions could be as much as 125 toe/y. The project is in the high-potential area of digester technology, though poultry waste is a relatively small component of total Community waste resources. The extensive R & D base in anaerobic digestion includes work on chicken manure and the technology is ready for demonstration at farm-scale. Successful demonstration could lead to considerable cost-saving in agriculture in general, and this is particularly important in this and other regions of Italy.

Energy produced per year : 760.5 toe.

SE/231/81 – Reveninge Co-operative – DK

This is a large, multi-unit biogas system established on a community basis with its own gas distribution system.

Over 300 toe/y are expected to be generated contributing towards the self-sufficiency of a 300-strong community. The scheme shows an original feature in proposing to be interconnected with the national natural gas distribution network for back-up purposes. The scheme will use part of the large supply of digestible farm and other waste available in the Community. R & D in digestion is well advanced in Denmark and demonstration at this particularly large scale, using mixed materials in modular units is particularly appropriate.

There are good prospects for economic viability as oil prices rise and there are major implications to national and Community energy strategies if a high degree of self-sufficiency can be demonstrated.

Energy produced per year : 322.5 toe.

SE/234/81 – B.M.A. – D

This demonstration is of a new form of pigsty utilising the animal wastes, solar heating, and heat recovery and exchange technology to supply a large part of its own needs for temperature control and electricity.

The light-weight construction closely integrates all elements necessary for pig-rearing and optimises energy aspects. The total energy production from biomass is small, partly due to the low energy needs inherent in the system. Pig slurry is one of the most amenable materials for digestion and represents a considerable and readily useable resource in the Community. There are unique features in the project in combining the biogas system with other energy conservation techniques. The energy conservation aspects are just one of the elements of this new approach to pig-rearing which could lead to a major new market if the demonstration is successful.

Energy produced per year : 19.5 toe.

SE/240/81 – C.E.A. – F

The project aims to develop techniques for the production of potential energy crops using industrial waste heat and solar heating in double-wall greenhouses, with most of the facility already provided.

The techniques require close climatic control with air temperature regulation and soil heating with closed ventilation and heat recovery.

There is considerable potential in Europe for the development of low-grade industrial waste-heat sources and combined with solar heating this makes an interesting prospect. The energy conservation aspect is in the saving of conventional fuel in the conduct of the trials, and in the longer term in the possibility of producing economically feasible energy crops by these methods. Markets may arise for the new system in horticulture in general if the demonstrations are successful.

Energy produced per year : 3.13 toe.

ALTERNATIVE SOURCES : GEOTHERMAL ENERGY

(a) Space heating

GE/002/79 – AGIP – I

The production and reinjection wells are now complete.

Although the flow-rate and temperatures have proved lower than forecast, the deposit is nevertheless exploitable. The extremely high salinity could cause unexpected corrosion and erosion problems. A way must also be found to recover the substantial amounts of methane dissolved in the fluid and the reliability of the submersible pump under those conditions also remains to be assessed. In conclusion, the initial results have been relatively satisfactory, even though certain problems remain to be solved.

The field is expected to be exploited at 60 m^3/h and 66° C.

Expected yield : 850 toe/year.

GE/005/79 – Dansk Olie and Naturgas A/S – DK
The production well is now complete.
Technical and geological problems have ruled out exploitation of the primary target; however, a secondary, less promising, reservoir closer to the surface is suitable for exploitation. Consequently, the best results which can be expected will fall short of the initial highly optimistic targets.
The geothermal fluid obtained has proved highly saline.
The secondary reservoir is expected to be exploited at 80 m^3/h and 74°C once the reinjection well has been completed.
Expected yield : 1,720 toe/year.

GE/008/79 – EPA Ville Nouvelle de Cergy Pontoise – F
The production and reinjection wells have now been completed.
Although the primary target cannot be exploited, a promising exploitable reservoir has been struck in a secondary target area closer to the surface. Results to date have been encouraging. Partial exploitation has already commenced and the possible benefits of installing heat pumps to increase the energy savings are also to be assessed.
The field is expected to be exploited at 175 m^3/h and 55°C.
Expected yield : 2,800 toe/year.

GE/010/79 – Ville de Jonzac – F
The production well has struck exploitable reserves, though with a lower flow-rate than forecast.
This slight setback has been counterbalanced by exploiting the field without reinjection but with a heat pump coupled with other renewable sources of energy instead. Initial exploitation without a heat pump started in 1981. The field is now being exploited at 40 m^3/h and 65° C.
Expected yield : 910 toe/year.

GE/011/79 – SOCALMIG – F
The production well has now been completed.
It proved impossible to tap the primary target for technical rather than for geological reasons. No assessment could be made of the exact potential of the reservoir because the drilling operations were badly conducted. The field is not expected to be exploited.
Possible yield : 550 toe/year.

GE/012/79 – Office Public d'Aménagement et Construction de l'Oise – F
The production and reinjection wells have now been completed.
The results obtained are appreciably higher than forecast. Despite the addition of a hospital to the grid, the potential still exceeds current requirements. Further studies into ways of stimulating consumption have led to slight delays in the construction of the supply lines. The well is excepted to be exploited at 130 m^3/h and 47°C. However, it has the potential for up to 250 m^3/h.
Expected yield : 2,300 toe/year.

GE/015/80 – Intercommunale IDEA – B
The reservoir is closer to the surface than expected and has far surpassed the forecasts.
From both the technical and economic point of view, this puts the project in an even more favourable light than the encouraging forecasts in spite of certain delays in the construction of surface plant.
The field is excepted to be exploited, without reinjection, at 350 m^3/h and 68°C.
Expected yield : 6,700 toe/year.

GE/016/80 – SOGECLER – F

The production well is now complete.

The primary reservoir has failed to live up to the forecasts and has proved virtually impossible to exploit. Unfavourable local geological conditions were to blame for the poor results. The well is unlikely to be exploited. Flow rate : 25 m^3/h at 75° C.

Possible yield : 550 toe/year.

GE/017/80 – SBRU – F

The potential of the primary reservoir has exceeded the temperature and flow-rate forecasts.

This integrated project has proved a viable proposition from both the technical and economic points of view. Initial exploitation, to supply almost half of the network, has already started. The well is expected to be exploited, without reinjection, at 150 m^3/h and 53° C.

Expected yield : 2,400 toe/year.

GE/021/80 – AGIP – I

The production well is now complete.

The primary reservoir has reached the very high target set. Subject to confirmation from the reinjection well, this reservoir appears to have great potential with the water temperature being particularly favourable. Once the reinjection well has been drilled, the field is expected to be exploited at 250 m^3/h and 101° C.

Expected yield : 3,400 toe/year.

GE/046/81 – SAHLM « La Gironde » – F

The production well has now been completed.

The reservoir has revealed a greater potential than forecast. The project appears promising and a success from both the technical and economic points of view. The reservoir is expected to be exploited, without reinjection, at 200 m^3/h and 50° C.

Expected yield : 1,600 toe/year.

GE/064/81 – SEDMA – F

The production well is now complete.

The primary target has fallen short of the forecasts and proved virtually impossible to exploit because of the unfavourable local geological conditions. Given the current yield, the field is unlikely to be exploited, even without a reinjection well. Flow-rate : 20 m^3/h at 40° C.

Possible yield : 150 toe/year.

GE/067/81 – Town of Saulgau – D

The production well has now been completed.

Production tests have revealed exceptional potential, which should be particularly easy to tap since no reinjection is needed. The surface plant is now being made ready. The geothermal water with its low mineral content will replenish a surface reservoir whose current output is inadequate. The well is expected to be exploited, without reinjection, at 180 m^3/h and 40° C.

Expected yield : 1,300 toe/year.

GE/069/81 – Southampton City Council – UK

The production well has struck a reservoir with the forecast potential, but with high salinity.

Although drilling of the reinjection well has yet to confirm the nature of the reservoir — and hence the success of the project — the geothermal potential has been established and the project can therefore be considered a success. The field is expected to be exploited, with reinjection, at 75 m^3/h and 74° C.

Expected yield : 2,400 toe/year.

(b) Heating of glasshouses

GE/006/79 – GOM – B

Drilling of the production well has now finished, without, however, striking the reservoir, which is considerably deeper than forecast.

Nevertheless the geology of the region is still promising, particularly at the southern tip where the reservoir is at a more accessible depth. No exploitation is possible as yet.

GE/009/79 – GEOVAL – F

Work on the production well, the reinjection well and the surface plant has now been completed.

The potential of the reservoir has lived up to expectations. Full exploitation has already commenced, though it has been somewhat delayed by the unreliable pumping gear. Since the production well currently has greater capacity than the reinjection well, a further study is to be made to increase the maximum possible reinjection rate. On the whole, the project can be considered a success despite the problems encountered. The well is now being exploited at 165 m^3/h and 70° C.

Yield : 2,900 toe/year.

GE/019/80 – GACG – F

The production well has struck a reservoir with the forecast potential.

The project has therefore achieved its objective. The plan now is to tap those resources in two consecutive stages. The first phase of the construction work on the surface plant is about to start. Although the final phase is slightly behind schedule, the project as a whole has been a success. The field is expected to be exploited, without reinjection, at 175 m^3/h and 58° C.

Expected yield : 3,200 toe/year.

(c) Generation of electricity from wet steam and brine

GE/001/79 – GE/018/80 – AGIP – I

The two production wells have now been completed.

Production tests are now being conducted, without reinjection. Long-term production tests with reinjection are planned for the near future, before a 3 MW set is installed on an experimental basis. The very fact that an exploitable reservoir has been struck is reason enough for continuing the project, which holds out promise of successful commercial exploitation; it is expected that the field will be exploited. Capacity of the two wells : between 4 and 5 MW.

Expected yield : 8,000 toe/year.

GE/029/80 – ENEL – I

The two production wells have now been completed.

One of them has struck an exploitable reservoir, but the other is dry. The next phase of the project will be to carry out long-term tests before installing an 8 MW unit. The entire project has proved a technical and commercial success, which gives every reason to carry it on. The field is expected to be exploited. Capacity of the productive well : 4 MW.

Expected yield : 7,000 toe/year.

GE/031/81 – PPC – H

The three production wells have now all been completed.

They have shown exceptional potential; the initial results have been extremely encouraging. The incentive to take advantage of the energy savings and to tap the available potential in future will be all the greater since facilities for consuming some of the energy generated on the island itself and for transferring any surplus to neighbouring islands are also to be constructed. Both the technical and economic prospects are favourable. The field is expected to be exploited. Aggregate capacity of the three wells : between 5 and 8 MW.

Expected yield : 9,000 toe/year.

(d) Generation of electricity from endogenous steam

GE/004/79 – ENEL – I
The production well at the roof of the potential reservoir has run up against many of the problems associated with drilling in extremely hostile, very hot and highly corrosive environments.
It looks as though they will be hard to overcome with today's technology. Although the technical and commercial prospects are, therefore, inauspicious, it nevertheless seems worthwhile continuing the field studies and field work with a view to defining methods of tapping the resources, which offer great potential once the necessary techniques have been mastered. It is uncertain whether the field will be exploited.

(e) Power generation combined with other uses

GE/003/79 – GE/063/81 – ENEL – I
The pair of production wells has now been completed.
One struck an exploitable reservoir, the other cannot be exploited because the fluid is too saline. The reservoir struck is, however, large enough to ensure the success of the project, although not all the exploitation problems have yet been overcome. Finding answers to them would be a major technical advance since this well contains precisely the type of geothermal fluid found in most of the reservoirs left unexploited today on technical grounds. Consequently, approval must be given to continuing this project, which also incorporates a major innovation in its approach to the recovery of mineral salts. It is expected to lead to commercial exploitation. Capacity of the productive well : 3 MW.
Expected yield : 5,000 toe/year plus the mineral salts recovered.

ALTERNATIVE SOURCES : LIQUEFACTION AND GASIFICATION OF COAL

1. Gasification if solid fuels

LG/01/2/80 - FIAT ANSALDO - I
Fluidised bed coal gasification demonstration plant for the generation of electric power in a gas/steam combined cycle.
The aim of the project is the design, construction and operation of a gas/steam combined cycle power plant (140 MW, 55 t/d coal) using two fluidised bed gasifiers (Westinghouse Electric Corp.).

The project is still in the beginning of the engineering phase. Thus no evaluation is yet possible, but technical problems with low rank coals in a fluidised gasifier can be expected. Nevertheless, if successful, the project would provide a useful means of upgrading such types of coal.
Combined cycle operation does offer the prospects of increased efficiency with full environmental protection.

LG/01/5/80 - AGIP CARBONE - I
Coal gasification demonstration plant.
The subject of this project is a gasification plant (Texaco entrainment gasifier) having a coal throughput of 200-400 t/d to produce synthesis gas from high ash and high sulphur coal (Sulcis, Sardinia).
The project is in the middle of the engineering phase. Gasification trials with Sulcis coal have been carried out at the Montebello (US) and Oberhausen (Germany) plants and have shown that the Texaco gasifier can gasify such types of coal successfully. Even if no detailed evaluation is yet possible, the results of the gasification trials are promising. On the other hand, the project's feasibility depends, apart from technology and economics, on the development of the Sulcis mine itself which will have to provide the coal.

LG/01/6/80 - BGC - I
Demonstration of a commercial scale slagging gasifier.
The project aims at extending the application of the Lurgi fixed-bed gasifier by converting it to slagging operation and increasing the fines content of the coal feed, in order to prove its commercial viability for SNG production (600 t/d coal throughput per unit).
The work is well underway and has led to some very promising results with the injection of fine coal in the tuyères of the gasifier. With a view on the whole project, the process plant development and performance are eminently satisfactory. The first generation Lurgi gasifier can now be transformed into a flexible unit capable of matching the performance claimed for newer second generation processes which still have to be proven. In the remaining programme, data will be acquired to assess the full commercial advantage of this important development. Success with proposals to gasify run-of-mine coal could further enhance the technical and economic advantage of the gasifier.

LG/01/10/80 - VEBA OEL - D
Production of hydrogen for the hydrogenation of heavy oil and coal.
The construction and operation of a full-scale unit is foreseen for the gasification of soild fuels or residues (360 t/d throughput) to produce synthesis gas for further processing to hydrogen needed for coal liquefaction.
The contract covers the feasibility studies, which are completed, and the basis engineering which is well advanced. Based on trials on an existing 1 t/h pilot plant, a novel device has been developed and shown to be satisfactory. This new pressurised coal feed system, CONTINUA, incorporates a double screw extruder which works well with the materials to be gasified. As this process to make hydrogen has some novel engineering features and uses cheap residues among other fuels, it has potential for lowering the cost of making liquid fuel from coal and oil processing. The project is well conceived, is making good progress and shows every prospect for a successful conclusion to the basic engineering phase according to schedule.

LG/01/13/80 - Klöckner Stahlforschung GmbH - D
The aim of the project is long-term trials for the gasification of 400 t/d coal in an existing OBM molten iron bath reactor (Oxygen-Bodenblasen-Maxhütte, originally a novel steelmaking process developed by the contractor) with a view to the construction and operation of a demonstration plant (3,600 t/d coal throughput).
The project was terminated on 30 September 1981. The work carried out in an existing converter at the Maximilianshütte showed that different types and sizes of coal can be

gasified successfully, particularly with regard to the low content of harmful substances in the gas. The work contracted for has been satisfactorily completed. The installation performed well and much valuable information was obtained from the instrumentation. The data obtained should be carefully evaluated in terms of energy and mass balances, costs, etc. in order to assess the full economic potential of the process. As a means of gasifying coal, it has many advantages, some of which are : high degree of coal conversion, good quality gas, low environmental impact. It also has decided advantages in steel plants in processing, as a ready supply of gas on site and in replacing mineral oil often used in this connection. The chances of largescale application of the technology are good.

2. Underground coal gasification

LG/02/1/78 - IDGS -

Belgo-German experiment on in situ gasification.

The aim of the project is the large-scale test of a new process for underground gasification of coal, characterized by alternating pressure (20-60 bar) of the gasifying agent (air and oxygen) and the depth of the seam to be gasified (900 m and below). Initially, it is planned to produce a gas of medium c.v. which will be burnt in a combined cycle power station (including a gas turbine).

The work on the project started in 1979 at the test site of Thulin (near Mons). After the completion of a first borehole to discover the geological conditions, three additional boreholes have been sunk, around the first one, at a distance of 35 m. All boreholes reached the seam to be gasified (Léopold-Charles) at a depth of about 670 m.

Subsequently, several trials were carried out to improve the natural permeability of the seam by injecting water, nitrogen or helium under pressure. A considerable increase in permeability was obtained, particularly in the direction of natural coal fissuration.

After having reequipped the site, the trials to establish a channel between two boreholes (linking by reverse combustion), began in April 1982 and ignition was accomplished.

The results obtained so far in improving the seam's natural permeability should allow the establishment of a sufficient linking between the boreholes by reverse combustion, which is a decisive step for the process. But even if this is successfully carried out and gasification itself takes place, a large number of problem remain to be solved before commercial application.

LG/02/2/78 - GEGS -

Underground coal gasification at great depth I.

The projects aims at the application of the pressurized underground gasification process at great depth for the production of different gases and, thus, exploitation of coal reserves which cannot be mined by conventional means. For economic reasons, the preliminary trials are to be carried out starting from existing mine roadways.

The project was terminated on 31 March 1981 and achieved its targets : establishment of a linkage between 2 boreholes by hydrofracking, ignition and reverse combustion. The tests of linking boreholes, ignition and retrocombustion and gasification made at Bruay I and II have provided interesting and promising results. While this is an encouraging beginning, and by any standards can be regarded as a success, it is only a beginning. There is still a long way to go, and many obstacles to overcome.

LG/02/1/80 - GEGS -

Underground coal gasification at great depth II

This is the large-scale continuation of the previous project. It is planned to drill boreholes from the surface, to establish the linking between the boreholes and to proceed to gasification.

The sites for large-scale trials have been chosen. No technical evaluation is yet possible, in view of the early stage of the project. Nevertheless, the results of previous work (see evaluation of GEGS I, above) gives hopes that the project will reach its target to make successful use of large coal deposits which cannot be mined by conventional methods.

3. Liquefaction of solid fuels

LG/03/1/78 - NCB -

Supercritical gas extraction pilot plant.

This project aims at the design, construction and operation of a pilot plant (25 t/d) for the liquefaction of coal by supercritical gas extraction and the conversion of extracts to high-grade liquids.

The design has been completed (February 1982). The project was then mergered with the new project «Coal liquefaction demonstration facility» (LG/03/1/78) in view of a temporary concentration on the liquid solvent extraction technology. Thus, the design and experience will be available for application as necessary in the following project.

LG/03/1/80 - NCB -

Coal liquefaction facility.

The aim of the project is the design, construction and operation of a coal liquefaction plant (25 t/d coal) using the technique of solvent extraction. The coal extract is converted to distillate oils suitable as feeddstock for aromatic petrochemicals, transport fuels, etc. It is provided to include at a later stage, also the supercritical gas extraction process (see above).

The design phase has been completed (February 1981). Construction work will not start before the financing of the whole project is secured. At the present stage, no evaluation is possible, but it is expected that the coal extraction technology can successfully be used to procedure high-rank liquid products (chemical feedstocks, transport fuels, etc.) from coal.

LG/03/2/80 - Rheinische Braunkohlenwerke AG - D

Hydroliquefaction of lignite.

The design, construction and operation of a demonstration plant for the hydrogenation of lignite (360 t/d lignite, 72 t/d products) is foreseen to obtain high-rank products (motor fuels, chemical feedstocks, etc.). The basic engineering phase is completed and was partly financed by the Federal Government whilst the detailed engineering phase started on 1 October 1981. The work was concentrated on the dimensioning of apparatus and machinery, the pretreatment of coal and the hydrogenation reactor.

A technical evaluation is not yet possible since the project is still in a very early stage. Nevertheless, the project seems to be promising because the technology chosen is not very high-risk and the raw material (lignite) is cheap.

LG/03/3/80 - Haldor Topsøe - DK

Demonstration project for selective hydrocarbon synthesis.

The aim of the project is a mobile plant (1 t/d products) for the manufacture of gasoline from coal-based gas by a novel selective synthesis process.

The contract covers phases 1 and 2 of the project and the engineering and design work (phase 1) is completed. Ordering of equipment is underway so that the unit can be assembled and tested in Denmark during 1982. Then, the plant will be dismantled, shipped to Houston (USA) reassembled (phase 2) and operated (phase 3). No technical or economic evaluation is yet possible but the process will probably find its place in several applications, particularly because a significant reduction of pressure in the synthesis stage is envisaged.

ANNEX II

Name and address	Technological Field
Soc. NIFES Consulting Engineers National Industrial Fuel Efficiency Service Ltd. Malvern House Mapperley Road **UK-Nottingham NG3 5AQ**	Industry
Prof. Carmelo CAPUTO Direttore dell'Istituto di Macchine Università degli Studi di Roma Via Eudossiana **I - Roma**	Road Transport (except electric vehicles) Agriculture Industry: boilers
M. Gagnot METRA 16-18, rue Barbès **F - 92126 Montrouge**	Energy from waste
Mr. MARQ Marq & Roba 221, Boulevard Léopold II **B - 1080 Bruxelles**	Buidings
Dr Gibson National Coal Board Store Orchard **UK - Cheltenham GL52 4RZ**	Fluidizeds beds Gasification and liquefaction of Coal
Dipl. Ing. P. Müller VEW-Hauptverwaltung Abtlg. Energieanwendung **D - 4600 Dortmund 1**	Heat Pumps
Mr Jensen Director of Research Energy Research Laboratory Odense University **DK - 5230 Odense**	Electric vehicles
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ANNEX III

Figures for the Community demonstration programme

Table (a) - Energy savings (situation at 10 may 1982)

Investment (ECU)	**I. Call for projects**	**II. Call for projects**	**III. Call for projects**	**Total**
Proposals received	326	303	362	991
Total investment for proposals received	976,756,000	502,704,000	833,839,000	2,363,308,000
Projects selected	53	60	73	186
Projects withdrawn by the proposer	14	15	1	30
Contracts signed	39	42	8	89
Total investment for projects selected	78,960,000	88,300,000	105,840,000	273,100,000
Financial support granted	21,425,000(1)	27,130,000(2)	32,217,762(3)	80,772,762(4)

(1) Of which 4,938,670 ECU are for projects that have been withdrawn.
(2) Of which 5,042,555 ECU are for projects that have been withdrawn.
(3) Of which 408,525 ECU are for projects that have been withdrawn.
(4) Of which 10,389,750 ECU are for projects that have been withdrawn.

Table (b) - Solar energy

Investment (in ECU)	**I. Call for projects**	**II. Call for projects**	**III. Call for projects**	**Total**
Proposal received	135	105	47	287
Total investment for proposals received	108	99.2	29.2	236.4
Projects selected	26	36	22	84
Projects withdrawn by the proposer	8	1	2	11
Contracts signed	17	21	2	40
Total investment for projects selected	26,582	38,406	13,229	78,217
Financial support granted	6,354(1)	13,229(2)	3,332(3)	22,915(4)

(1) Of which 2,31 MECU are for projects that have been withdrawn.
(2) Of which 0,95 MECU are for projects that have been withdrawn.
(3) Of which 0,18 MECU are for projects that have been withdrawn.
(4) Of which 3,44 MECU are for projects that have been withdrawn.

Table c) - Geothermal energy (situation at 10 May 1982)

Investment (M ECU)	**I. Call for projects**	**II. Call for projects**	**III. Call for projects**	**Total**
Proposals received	36	33	50	119
Total investment: for proposals received	140	163	241	544
Projects selected	13	17 (a)	18 (b) (5)	48 (c) (5)
Projects withdrawn by the proposer	1	6 (d)	0	7 (d)
Contracts signed	13	11	4	28
Total investment for projects selected	70	132	99	301
Financial support granted	9,026 (1)	10,047 (2)	9.17 (3) (5)	28,243 (4) (5)

(1) Of which 0.6782 MECU are for projects that have been withdrawn.
(2) Of which 4,207 MECU are for projects that have been withdrawn.
(3) Of which 0 MECU are for projects that have been withdrawn.
(4) Of which 4,8852 MECU are for projects that have been withdrawn.
(5) Excluding a series of eight projects where a decision is pending.

(a) Of which 3 are continuations of projects already selected.
(b) Of which 1 is continuation of projects already selected.
(c) Of which 4 are continuations of projects already selected.
(d) Of which 2 are continuations of projects already selected.

Table (d) - Liquefaction and gasification of coal
(situation at 10 May 1982)

Investment in ECU	**I. Call for projects**	**II. Call for projects**	**Total**
Proposals received	12	23	35
Total investment for proposals	276,819,000	723,824,000	1,000,643,000
Projects selected (1)	4	9	13
Contractual stages selected (1)	4	16	20
Contractual stages withdrawn by the proposer	1	—	1
Contracts signed	3	9	12
Total investment for projects selected (1)	107,560,000	443,079,000	550,639,000
Total investment for contractual stages selected	39,517,000	184,744,600	226,261,600
Financial support granted	22,404,000 (2)	52,579,000	74,983,000 (2)

(1) In this field, given the size of the investment involved in each project, it has been possible to grant Community support only to certain stages and not to the whole project.
(2) Of which 4,340,000 ECU are for stages that have been withdrawn.